

STREAMBANK REVEGETATION AND PROTECTION

A Guide for Alaska
Revised 2005



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Cover: Pictures display the before and after streambank revegetation conducted on Willow Creek, Alaska at Pioneer Lodge adjacent to the Parks Highway. Four hundred fifty-feet of riverbank was revegetated with root wads, brush layering, vegetative mat and a native seed mix. Partners included the Alaska Department of Fish and Game (ADF&G), U.S. Fish and Wildlife Service (USFWS), Natural Resource Conservation Service (NRCS) and Pioneer Lodge.

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A Guide for Alaska

Revised 2005

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Alaska Department of Fish and Game
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This project has been accomplished by the contributions of many individuals including the professional staff at the Alaska Department of Fish and Game (ADF&G) and the Alaska Department of Natural Resources (DNR), Plant Materials Center. A special thanks is extended to Frances Inoue, cartographer, who produced drawings, graphics and layout for the guide.

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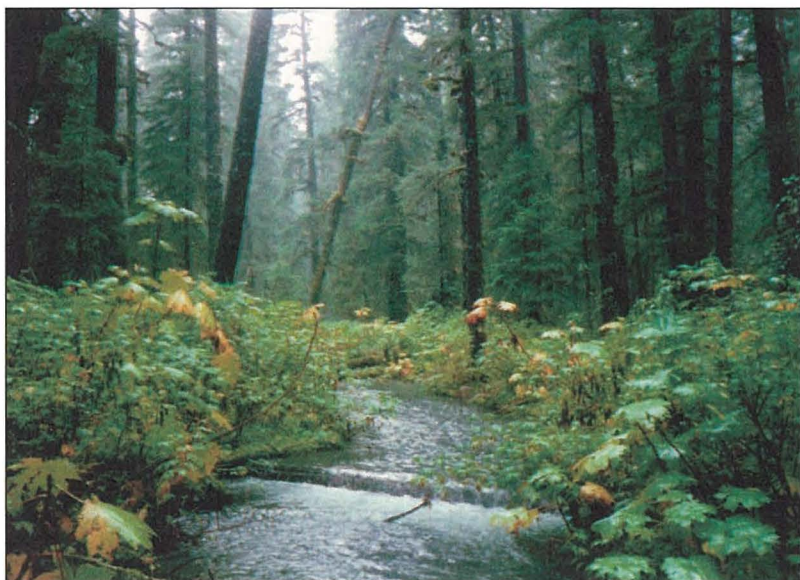
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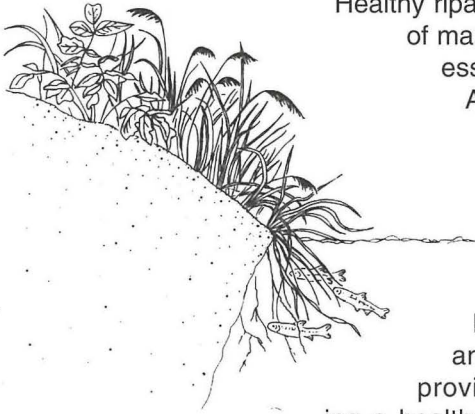
Crescent River drainage



Stream on Montague Island

Introduction

Healthy riparian systems function to the benefit of many species, the ecosystem, and are essential for sustainable populations.



Although natural riparian areas make up a relatively small portion of the available landscape (<1%), they support an abundance of life and provide a significant amount of nutrients compared with adjacent upland areas. A stable vegetated bank also benefits the landowner and visitor by preventing land loss, providing natural beauty and promoting a healthy environment for sustainable fish

and wildlife populations. Revegetation of riparian areas involves replanting native vegetation adjacent to lakes, streams, and creeks for the benefit of the species utilizing the system, watershed and associated uplands.

Different fish species require different in-water habitat features dependent on their life cycle stage. Research has shown that riparian vegetation is beneficial to salmonid species by providing food, shelter, and shade that correspond with fish camouflage. Riparian vegetation influences nearshore water temperatures, decreases nearshore stream velocities and provides resting places for juvenile fish. Naturally occurring undercut banks and nearshore areas with large woody debris are preferred habitat for certain juvenile salmonids when compared to rock rip-rap structures and non-vegetative areas (Peters, 2004; Peters *et al.*, 1996).

Juvenile chinook salmon primarily inhabit areas with water velocities between 0.09 and 0.6 ft/s and rarely use areas with velocities 2.1 ft/s or greater (Burger *et al.*, 1982). This and





Crescent River watershed

other preference factors mean that in large rivers such as the Kenai River, an estimated 80% of the young chinook salmon are within 6 feet of the bank where water velocities are less than 1 ft/s (Hauser and Weiss, 2001; Liepitz, 1994; Burger *et al.*, 1982). In a habitat selection study, it was found that juvenile chinook salmon utilized habitat with water velocities less than 20 cm/s, depths of 20-80 cm, and were closely associated with undercut banks (Hillman *et al.*, 1987). Another study showed most salmonids studied (Dolly Varden, coho and chinook salmon) selecting focal point velocities between 0.0-0.9 cm/s and preferring

large woody debris for cover (Dolloff and Reeves, 1990). Even a small change to juvenile salmon habitat water velocities and depth may decrease habitat values and salmon survival (Liepitz, 1994; Burger *et al.*, 1982; Alaska Department of Natural Resources, 1986). Survival of early life stages of salmon is imperative to productive returns of adults.

Potential benefits of vegetated buffers to wildlife include: increased species diversity, increased foraging sites, wildlife dispersal corridors, escape from flooding, hibernation sites, breeding and nesting sites, decreased disturbance, and decreased predation (Groffman *et al.*, 1991). The habitat values of revegetation techniques far exceed the rock rip-rap, plastic, cement, metal or bulkhead alternatives. While the non-vegetative "bank stabilization"

(rock rip-rap & bulkheads) projects may provide some bank protection, they also increase nearshore water velocities, provide little to no fish and wildlife cover, provide no living nutrient addition to the water column and do not simulate riparian functions. Addition of rock rip-rap to the riparian zone changes the sediment transport capacity and this in turn may cause movement outside the normal range of bed load size and particle distribution for a particular stream reach (Beschta and Platts, 1986). Since salmonids rely on diverse and particular particle sizes for food, cover and spawning, this may decrease their survival. As example, the densities of coho salmon, juvenile steelhead, and cutthroat trout declined following installation of rock rip-rap in four streams in western Washington (Knudsen and Dilley, 1987).

A native species revegetation project also has the advantage of requiring less maintenance over time once vegetation is established. The goals of these projects are to mimic natural vegetation and provide fish and wildlife habitat while reestablishing the functions of a riparian ecosystem. It is important to remember that native vegetated banks in riparian systems change over time with the ebb and flow of the aquatic systems they represent. Streambank stability is dependant on a healthy riparian and wetland system, which provides proper channel morphology, natural stream flow and good water quality. Deformable streambanks are therefore a consideration when discussing revegetation of riparian areas and recognition is necessary that lateral streambank erosion is a natural process that needs to occur for healthy ecosystems (Miller, 1999; Rosgen, 1994).

Riparian vegetation also provides bank protection and erosion control through water transpiration, tensile strength of roots, mechanical integrity of roots by forming arches and buttresses, and vegetation mats above the soil line that lock soils. Above ground, vegetation disperses rainfall and helps to prevent run-off by incorporating water into the soil and into the water column, decreases run-off velocity and water channelization and dissipates flow. A study comparing 748 river bends concluded that non-vegetated riparian bends were five times more likely than vegetated river bends to have undergone detectable erosion, and major bank erosion was thirty times more prevalent on non-vegetated bends than vegetated bends (Beeson and Doyle, 1995). Revegetation has been performed around the world for centuries as a cost effective water body protection measure, documented first in the 15th century in Europe. Since that time, revegetation techniques have proceeded to increase in acceptance and structural integrity.

Many threats exist for our riparian areas with the increase in developmental and recreational access pressure to our creeks, lakes and rivers. Riparian vegetation is decreasing at an alarming rate in areas throughout Alaska. A decrease in riparian and wetland vegetation translates into a decrease in water quality, decrease in riparian functions and an increase in sedimentation of our water bodies. In fact, a compilation study confirms the importance of vegetated buffers, concluding that a 50m buffer is effective at removing approximately 75% or greater of the run-off sediment and certain pollutants, while providing only minimal general wildlife habitat. In contrast, a 600m water



Naturally vegetated bank of Kenai River

body buffer provides approximately 99% sediment and certain pollutant removal and excellent general wildlife value including supporting a diverse community and protection of significant species (Desbonnet *et al.*, 1994). Increased suspended sediment into our water bodies may affect salmonids by covering spawning areas, decreasing feeding success, decreasing fertilization rates, decreasing growth rates, increasing displacement, and decreasing overall survival (Cook-Tabor, 1995). Soil particles may irritate fish gills potentially causing infection and death. Decreased water quality also endangers aquatic organisms, a major food chain component, which in turn has negative affects on higher levels of the food chain. Sedimentation prevents light from filtering through the water column, which lowers photosynthesis.

Some bank stabilization techniques do not involve revegetation with native species. This book specifically focuses on native species revegetation in riparian areas. We have decided to include some revegetation techniques, which may be utilized in upland and other wetland areas. Please note that all of these techniques should be used in consultation with a revegetation specialist with Alaskan plant species experience. Successful Alaskan stream-bank revegetation and protection projects have provided the foundation for this guide. As new streambank revegetation and protection challenges are met, this science will continue to evolve.

How To Use This Guide/Site Considerations

The following pages describe revegetation and protection techniques and their installation. We recommend that you use this guide only as an aid in the creative process of selecting a combination of techniques that will effectively accomplish the revegetation goals of your project.

We have found that successful projects begin with a careful evaluation of site characteristics. Each site is unique. Project planning is enhanced when a cooperative effort between land owner/managers, biologists, permitters, streambank revegetation professionals, hydrologists and engineering consultants is established. A team approach can provide diverse perspectives and expertise with which to develop an effective plan.



Bank trampling/sloughing upstream of Slikok Creek Recreation Site, Kenai River

When selecting and designing a revegetation project, here are some of the questions, which should be considered and answered via team resource consultation:

- What problem are you trying to solve? What is the intended goal of the project?
- Are you committed to a bio-technical solution to your bank or erosion problem?

- What is the water velocity at the site? How does this velocity affect the streambank or project area? How is flow oriented to the bank?
- Where is ordinary high water level located and what does this mean to your project?
- Where is the thalweg and bottom contour along your stream stretch?
- Determine any upstream and downstream structures and channel modifications that have occurred along your stream stretch. How might these affect your project presently and in the future?
- How is the stream morphology affecting your site? How will it affect the site in the future?
- Is the site area dry during the construction period? Is it possible to dewater or isolate the work area?
- Are there seeps and springs in your bank? How will this affect erosion before, during and after construction? What plant species are best suited for a seeping bank?
- Determine the soil type on site. How will the soil type affect your bank, present erosion, and erosion during construction?
- What measures do you need to consider and implement for erosion control? Have you prepared an erosion control plan?
- What is the erosion potential at your site? What is the present site slope? What should be the natural site slope?
- What is the toe-of-slope erosion rate and shear stress?
- Determine present vegetation on-site and the health of that vegetation. If impacted, what is causing the impact? Is this an impact that will continue and/or increase? What native species are naturally occurring along your stream? What species are best suited for your site? Consider whether your site is fresh water, brackish or salt water and choose those species best suited for the conditions. Please see *Plant Species Selection Lists*.
- Who will collect and care for plants? Who will install the project?
- How will access be provided to your site during and after construction? Will you be able to protect the revegetation site?
- For what on-site recreational activities would you like to provide access?
- What local, state, or federal permits will you need to acquire before starting this project? Be sure to give yourself enough time to consult and apply for permits.
- What are zoning restrictions in your area?
- Who owns the land, including rights-of-way for site?

-
- What is the project cost? Is there funding available for your revegetation project? Please see funding links in the *Restoration Grants/Web Links* section.
 - Are there particular species of native fish or wildlife for which you would like to provide habitat, food or shelter?

Restoration projects may require prior approval from state, federal and/or municipal agencies. We recommend that you contact the permitting agencies early in your planning process (one year before project, in spring or summer) to allow ample time to secure necessary permits, acquire grant funding if applicable, and to acquire assistance. Permit processing will take at least 30 days after filing application, much longer depending on project and agency permitting stipulations. Technical assistance can be obtained by contacting the Alaska Department of Fish and Game, Division of Sport Fish or the Alaska Department of Natural Resources, Plant Materials Center (see *Contacts*).

In our experience, the best treatment for a streambank is to prevent problems from the very beginning. If at all possible, leave native vegetation intact within the floodzone.

Lessons Learned

- Watering plants at least 2 times a week (deep soak watering) significantly increases survival of installed plants, especially in dryer soils and/or in dry years.
- Watering plants immediately after installation and before installing the next layer helps to compress the soils in each installed layer and removes air pockets around plants, ensuring better plant to soil contact.
- Plant willow with 1/4 of the stem length above the ground and 3/4 the stem length below the ground for live staking and brush layering.
- Trim shoots of harvested transplants to compensate for root loss and to promote root growth. As an example, vegetative mat should be trimmed by 1/3 of the shoot length to compensate for root loss and to promote root growth.
- Store plants in snow banks or by refrigeration through their dormancy period to increase survival when planted.
- Cuttings should be soaked in water, out of direct sunlight, from one to four days prior to planting.
- Allowing plants to stay in direct sunlight or to dry out dramatically reduces plant survivability.
- All dormant cuttings should be used within four days of removal from refrigeration and as soon as possible in the spring that they are harvested (from after ground thaw to no later than July 1).
- Fall plantings should occur as the plants are returning to the dormant state and before the ground is frozen.
- Acclimate potted plants for spring plantings by hardening plants near the planting site. These plants should be kept moist during this "hardening," then watered to capacity prior to planting. Do not allow greenhouse plants to be exposed to freezing temperatures while in pots during this hardening process.
- Plants are dormant in the fall when at least 50% of the leaves fall off or change color.
- Fertilizers are generally not necessary for native species revegetation of streambanks, especially for woody plants.
- If fertilizer is needed, use carefully as fertilizers may spread off-site into the adjacent stream and be harmful to fish and other aquatic organisms.

Consultation with a Streambank Revegetation Specialist before installation of any revegetation or protection technique is necessary to gain site specific information (see *Contacts*).



Trampled bank at the mouth of Willow Creek



EROSION CONTROL



Centennial Park erosion control, Soldotna, Alaska

Stormwater Pollution Prevention Plans, or SWPPP, are required due to National Pollution Prevention and Elimination System (NPDES) requirements of the Clean Water Act on project sites where more than 1 acre of sediment will be disturbed (See EPA's website at <http://cfpub.epa.gov/npdes/stormwater/swphases.cfm>). The plan requires a site description, including a map; a description of sediment and erosion controls used on-site, including stabilization practices (e.g., seeding, brush layering, dewatering, mulching) and structural practices (sediment traps and silt fences). The SWPPP must also include a description of Best Management Practices (BMPs) to control stormwater run-off after completion of the construction project; and BMPs to control solid material and other construction waste. Maintenance and inspection practices must be described. The plan must be submitted to the EPA for review. An erosion control plan in the SWPPP format for any revegetation project is a good plan format to follow.

Schedule restoration work to avoid soil exposure during the rainy season or heavy snow melts. Reduce the length of time and the amount of surface area exposed, especially where erosion potential is high.

If disturbance is unavoidable, grade site to fit the surrounding terrain, soil type and native vegetation. Do not create steep slopes. The greater the

slope, the more difficult it is to prevent soil erosion. Some erosion techniques will not withstand steep slopes or other conditions. It is important that you contact an erosion control expert regarding appropriate techniques to utilize for your site.

Run-off should be minimized by directing water outside disturbed site and onto holding areas or vegetated areas. Using energy dissipating and water infiltration techniques, such as utilizing a buffer zone, temporary or permanent native seeding, ground cover, plastic sheeting and matting will also help decrease soil run-off. Covering exposed soil with properly weighted plastic sheeting will help prevent temporary construction site sediment loss.

Monitor for erosion control success regularly. Site inspections should be performed a minimum of once per week on active sites, once every two weeks on properly maintained active sites, and within 24 hours of a 0.5 inch rainfall (Wright, 2001). Plan on maintenance within your project budget. Many erosion control devices (including silt fences) are not designed to withstand snowfall weight and icing. Be sure sediment is secure, meaning revegetation of site is accomplished, including a good strong root structure of all plant material, or sediment covering which will not leach soil, before snowfall. It is recommended that all seeding and planting be completed before August 15 for Southcentral Alaska. Check the *Contacts* section to determine appropriate timing in your area.

In water work must correspond to state, federal and local permit stipulations and time windows.



Excavator working at rivers edge with erosion control measures in place



EROSION CONTROL



PHOTO BY JEANNE WALTER, COURTESY OF USFWS

Bank failure due to extremely steep unvegetated slopes with erosion control measures unmaintained through the winter

Leave native vegetation on-site to prevent erosion of surrounding area. Try to decrease damage to surrounding vegetation by limiting heavy equipment work on it whenever possible. Vegetative mats will be salvaged from site as often as possible before construction and will be replanted on-site (See Vegetative Mat under the *Plant Care and Preparation* section). The root/soil structure of the plants for each mat must be salvaged to the depth appropriate for the species present. At least 1-2 feet of root material should be harvested. Remember to keep harvested material cool, moist and out of direct sunlight.

Protect water bodies and wetlands from sedimentation by utilizing the above techniques and silt fencing (See *Silt Fence Installation Step-by-Step*).

Hydraulic applications of native seeds may be applied in one application step including placement of seed, fertilizer, mulch, tackifier with the following minimum applications:

- Wood fiber mulch applied at 2,000-3,000 lbs/acre, depending on site situation (soil type, area, etc.).

- Bounded Fiber Matrix (BFM) applied at 3,000-4,000 lbs/acre, depending on soil conditions.
- The slurry shall be mixed continuously as ingredients are added and for at least 5 minutes following the addition of the last ingredient before application begins. Slurry will be continuously mixed until used and application will end within two hours of the last addition.
- We recommend using natural biodegradable products whenever possible and care should be taken when applying material to prevent erosion, particularly of fertilizers.

Trap and remove run-off sediment, which is caused from construction on-site. Remove built-up sediment on silt fence upon reaching 1/3 the height of the silt fence. Reuse sediment in project or dispose at an approved upland site. Maintain erosion control devices until site is functioning with no sediment-laden run-off and plants have a well-established root structure, then remove silt fence. If proper erosion control devices are utilized and maintained, there should be trace sediment erosion off-site.

Proper installation of a silt fence to isolate worksite from soil erosion off-site is shown in the adjacent step-by-step. Commercially available silt fences are available from suppliers.

Follow all manufacturers instructions for proper installation. Stakes should be placed closer together in situations where heavy sediment laden run-off or flow is expected. The range of stake placement is between 4-10 feet apart depending on expected flow, run-off area, and sediment amounts.



Jersey barriers and silt fence isolating the work area, Willow Creek



SILT FENCE INSTALLATION

SILT (SEDIMENT) FENCE INSTALLATION

When installing a silt fence, first choose the appropriate place to set up a silt fence by considering site terrain and slope, water flow and projected soil disturbance during construction.

Set the silt fence perpendicular to the slope of the land, curving the fence inward towards slope.

Place the silt fence spaced away from the toe-of-slope, leaving enough room to accumulate sediment and to perform work.

Dig a six to eight-inch trench (either V shaped or flat-bottomed) directly up-slope or upstream of the silt fence. On the downstream edge, drive in wood stakes, rebar or steel stakes at least 1 foot down into the sediment. The stakes or rebar should be long enough to accommodate the trench depth and height of the silt fence fabric.

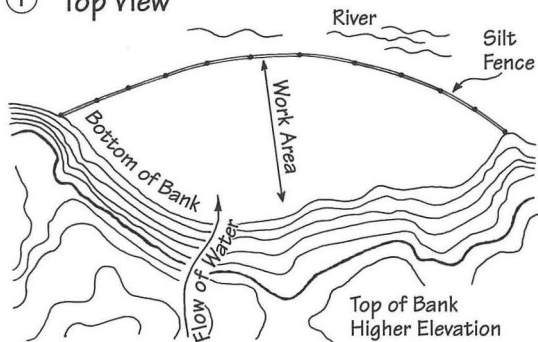
Run a continuous length of fabric along the inside of the stakes and secure with nails, staples or zip ties allowing at least 1 foot to line the trench. Extend termination points uphill one full panel length.

Use a continuous fabric piece for the silt fence. If one is unavailable and a joint is necessary, overlap the fabric at least the width of one stake spacing and secure in place using a wooden lath, staples, zip ties or nails.

Cover the trench with backfilled and compacted soil, gravel or rock.

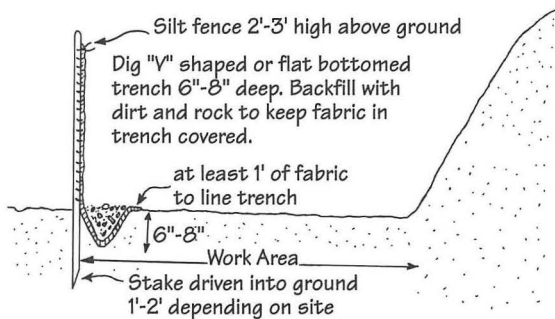
Maintain the fence by checking the fabric for damage, failure of fence to withhold sediment, and damage to posts. Install additional back-up silt fence if needed.

① Top View



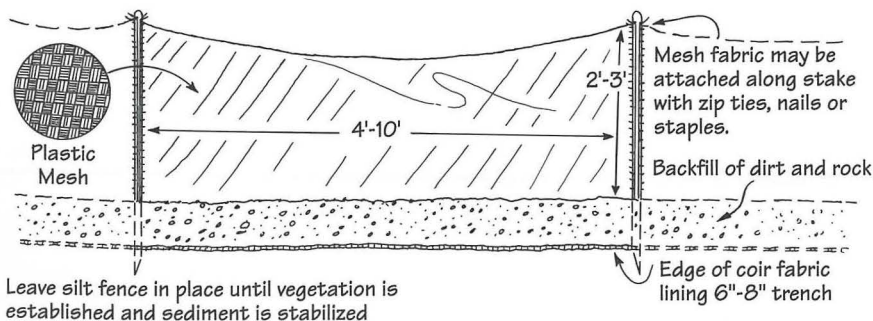
Prepare a stormwater pollution prevention plan. Set up silt fences according to terrain, soil and run-off consideration. Prevent soil migration by decreasing soil exposure, steep unvegetated slopes and construction time. Revegetate as soon as possible in the SAME SEASON.

①a Side View Detail



Monitor integrity of installed silt fence and remove sediment before it reaches 1/3 the height of the silt fence. It is especially important to monitor during and after rain and break-up events.

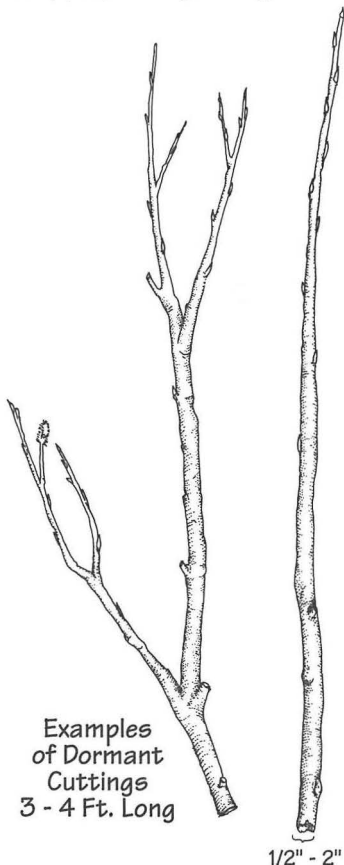
①b Front View Detail (One Section of Silt Fence)





CARE AND PREPARATION OF PLANT MATERIAL

The success of your revegetation project lies largely in your ability to properly select, collect, and prepare the appropriate vegetation for site installation. There are many opportunities to revegetate different types of habitat, from wetland or riparian areas to upland areas, depending on the availability and identification of donor species and your site specifications. Always select a healthy plant community as a donor community and gain permission from the landowner before removing plant material. For harvesting plant material on state land, check the State's site for fees associated with commercial harvest [http://www.dnr.state.ak.us/mlw/hottopics/draft_regs/filed_regs.pdf p.4 11AAC 05.010(a)(22)]. Please consult an expert when identifying donor plants for use in revegetation projects so the correct species will be planted in appropriate growing environments.



DORMANT CUTTINGS

Dormant cuttings are the primary plant material used in revegetation techniques including: live staking, brush layering, live siltation, brush mat and bundles (fascines). Dormant cuttings are harvested from living woody plants in a dormant (not actively growing) state. The cuttings are collected from plants that can root easily, without special treatment, such as certain willow species, poplar and cottonwood (see *Plant Species Selection Lists, Shrubs and Trees*) suited for dormant cuttings. Dormant cuttings may also be purchased from vendors (See ADNR website in *Contacts* section).

Locate a harvest site and obtain permission to collect cuttings. Harvest sites are easier to identify when leaves are present. It is beneficial to locate harvest sites in the spring/summer or by utilizing an Alaska Willow guidebook (Collet, 2002). Do not over harvest site. The site should contain at least 3 times the needed harvest material or you should harvest from several sites.



Collect cuttings during winter/early spring before leaves appear, preferably before March 31, if they are to be used for spring and early summer plantings. For fall plantings, collect cuttings in the early fall of the same year, after plants have gone dormant (at least 50% of the leaves have changed color or have dropped). Cuttings may be tied in bundles with colored twine for ease in identification and carrying. Label each bundle with species, date collected, and number of cuttings.

Select cuttings with leaf buds near the top of each cut line. Avoid flower buds (“pussy willows”) if possible; these buds typically occur at the tips of branches produced during the last growing season. These branch tips tend to be smaller than 1/4 inch in diameter.

Select branches 1/2 to 2 inches in diameter and at least 3 to 4 feet long. If necessary, branches can be cut to a shorter length at the time of installation. The potential for drying during storage is reduced when the cuttings are stored in longer pieces.

Store cuttings properly to maintain viability. If collection occurs while daytime temperatures remain below freezing, freeze at no colder than 0°F or refrigerate the cuttings until planting. If daytime temperatures are above freezing during collection, cuttings should be refrigerated between 31°F to 40°F and 60 to 70 percent humidity. Frozen cuttings can be stored with a small amount of snow to help reduce drying. No water or burlap should be added to stored frozen cuttings. Monitor the condition of the cuttings regularly to detect problems such as drying, sprouting or mold.

Only the plant material required for each day should be removed from storage, and placed in water, particularly if the weather is windy and/or warm at the revegetation site. Cuttings may be soaked in cool/cold water from 24-48 hours directly before planting to improve survivability. On site, the cuttings should be stored away from direct sunlight, heeled into moist soil, or stored in water until planting. Do not have cuttings in water for more than 4 days.

Plant dormant cuttings as soon as the soil has thawed and no later than July 1 or plant in late summer/fall before the ground freezes. The ability of plantings to become established and resume growth the following spring declines quickly for plantings made after July 1. Do not use cuttings if they have begun to root, mold, appear dry or leaf out. If the project is delayed and rescheduled for fall, do not try to store the cuttings that were collected in the spring until fall. Plan on preparing new cuttings once the plants have gone dormant.

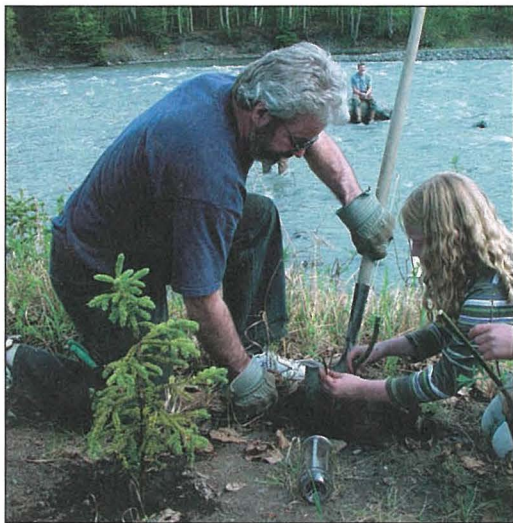


WETLAND REVEGETATION

There are many areas defined as wetland in Alaska, including streambank or riparian areas. Use of wetland plants for erosion control, stormwater and sewage treatment, and revegetation are increasing. Unlike other forms of revegetation, direct seeding is not a preferred planting method for frequently saturated wetland conditions. Wetland environments are characterized by saturated or flooded soils and fluctuating water levels. Seed dispersed in this environment could float and move about freely according to wind and water movement. Reproduction by seed in wetland plant communities is generally considered to be secondary to vegetative reproduction.

TRANSPLANTING

Transplanting is a revegetation technique that removes a plant, or plants, containing roots and shoots from one site to be replanted at another.



Ravenwood School project in the care and maintenance of live rooted native transplants

Transplanting can take several forms generally distinguished by size: vegetation mats, plugs, sprigs and transplants (single plants). All forms require careful selection and handling in order for the transplanting effort to be successful. The important points are to keep the plant material moist and away from direct sunlight and wind while preparing and transporting the vegetation to the planting site. Harvest only the vegetation that can be planted the same day. Refer to the Plant Species Selection Lists for plant material suggestions.

Locate a donor site and obtain permission to harvest plants. In cases where plants are going to be destroyed by construction, consider salvaging the plants that would otherwise be lost. The conditions of the donor site need to be relatively similar to those at the transplanting site. The best time to transplant is when plants are dormant. It is essential that the plant materials stay moist and covered while in transport. Transplanting efforts can be

mechanized. Trim shoots of transplants by at least 1/4 of shoot length to compensate for root loss and to promote root growth.

VEGETATIVE MAT (VEG MAT)

A vegetative mat is the largest transplant. Dimensions of the veg mats vary from one to several square feet and may contain woody and/or herbaceous vegetation. The greatest benefit of this transplanting technique is that vegetative cover is provided immediately after the veg mat is placed at the new location. The veg mats often contain many plant species, including native plants that cannot be obtained elsewhere. Often, the main expense will be for labor and machinery used for moving and installing the veg mat.

Harvest a vegetative mat by cutting the shoots and root/soil mass into a block. The root/soil mass is cut as deeply as possible. The mat is then lifted from the ground by hand or with mechanized equipment and transported to the planting site.



Harvesting vegetative mat using bobcat



Placement of vegetative mat after harvesting



PLANT CARE & PREPARATION

Prepare the planting site by creating a depression in the soil that will accommodate the dimensions of the veg mat. Scarify or add soil as necessary to the plant site to promote root growth, then add veg mat. The sides of the veg mat should be covered by soil. If the veg mat is placed adjacent to other veg mats, make sure that the edges of the mats are not left exposed to the air, which would dry and damage the roots. If needed, soil should be placed in the spaces between veg mats to cover and protect the roots. Tap down the veg mat so that it is in direct contact with the soil, and water the entire veg mat thoroughly. Trim the veg mat shoots back by 1/4 to compensate for root loss and to promote root growth. Depending on site conditions, the veg mat may need regular watering after planting.

PROPAGATION OF VEGETATED WETLAND MATS

These mats are created in a controlled environment in a greenhouse or outdoors. Generally at least one growing season is required to create a vegetated mat.

A vegetated mat can be made to any size. A biodegradable fabric made of coir (ex: North American Green's C125BN) and biodegradable twine is cut to the appropriate size and covered with a light layer of soil. If the mat will be grown outside, a bed can be created on the ground, framed with 2x4's and lined with an impervious liner. These beds will retain water. Mats grown in a greenhouse should be placed in trays that do not drain.

The mat is then sprigged with small wetland plants or seeded with stratified wetland seeds. Many of the wetland species have complex dormancy requirements to overcome and the seed is stratified (treated to enhance germination) prior to seeding. Check this website for germination protocols <http://nativeplants.for.uidaho.edu/network> or call the Native Plant Nursery at 907-746-7241.

The mat must be kept moist throughout the growing season. If the mat has been seeded, it must not be flooded until the seeds germinate. As the plants grow, their roots and rhizomes replace the structure initially provided by the coir fabric.

When the planting site is ready, the mat can be rolled with the plastic liner or folded and transported to the site. Keep the mat moist while transporting. Once the mat is installed at the planting site, with the plastic removed, it can be staked in place and allowed to grow. These vegetated mats provide instant plant cover and protection to a site.

PLUGS

Plugs are smaller than vegetative mats and often contain only one plant species. Plugs can be harvested from a donor community with hand tools and transported easily to the planting site. Plugs are particularly well suited for planting in wetlands, constructing grass rolls or being divided into sprigs.

Dig a plug with a shovel. A plug may range from 2 to 10 inches in diameter. It is important to include as many roots and as much soil as possible with each plug.

Plant plugs so that the new soil level matches the soil level of the donor site. If the planting site is dry, the plug should be planted in the center of a small depression that will catch and retain water. The soil around the plug should be pressed firmly into place.



Plugs harvested for installation at the mouth of Willow Creek



PLANT CARE & PREPARATION

SPRIGS

A **sprig** is the smallest transplant unit, consisting of a single shoot with roots. Grasses and sedges are often transplanted as sprigs. Species with a rhizomatous (underground stem) growth form are most suited for sprigging. Sprigs are often planted in wetlands.

Prepare the site for planting. If soil is compacted, scarify soil. If soil is denuded of nutrients, consider adding a fertilizer. Be sure any fertilizer does not leave site.



Digging transplants may occur throughout the growing season. However in the early spring, the ice that is still in the ground limits digging. Digging transplants can occur after the ground has thawed and before frost (preferably before mid-August to promote root growth). New roots need time to develop before the onset of winter. Carefully dig and separate the plants into sprigs (a shoot with roots and a rhizome). Trim shoot, especially if it is flowering or setting seed.

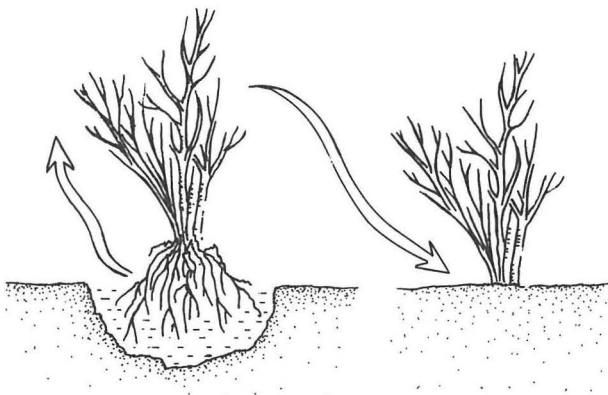
Place newly harvested sprigs in a bucket with water. Do not pack plants too tightly to avoid breaking roots or rhizomes. Be sure to keep the sprig moist and out of wind and sunlight during transportation. Harvest only the number of sprigs that can be planted the same day.

Plant a sprig by sticking a shovel in the ground perpendicularly, push it forward to create a small opening, place the sprig in the opening, remove the shovel and then firm the ground around the sprig. Care should be taken to ensure that the entire root system is covered by soil. A more extensive discussion of sprigging is found in *Beach Wildrye: Planting Guide for Alaska* (Wright, 1994).

TRANSPLANTS

Transplant generally refers to a single plant that is relocated to a new site. Trees, shrubs and well-established perennials are candidates for transplanting. Transplants are most frequently used in landscaping applications;

however, transplants can add diversity to revegetation projects. Transplants provide a means to include species that do not root readily from dormant cuttings in revegetation plantings; for example, they can be planted on a stream-bank before a brush mat is installed.



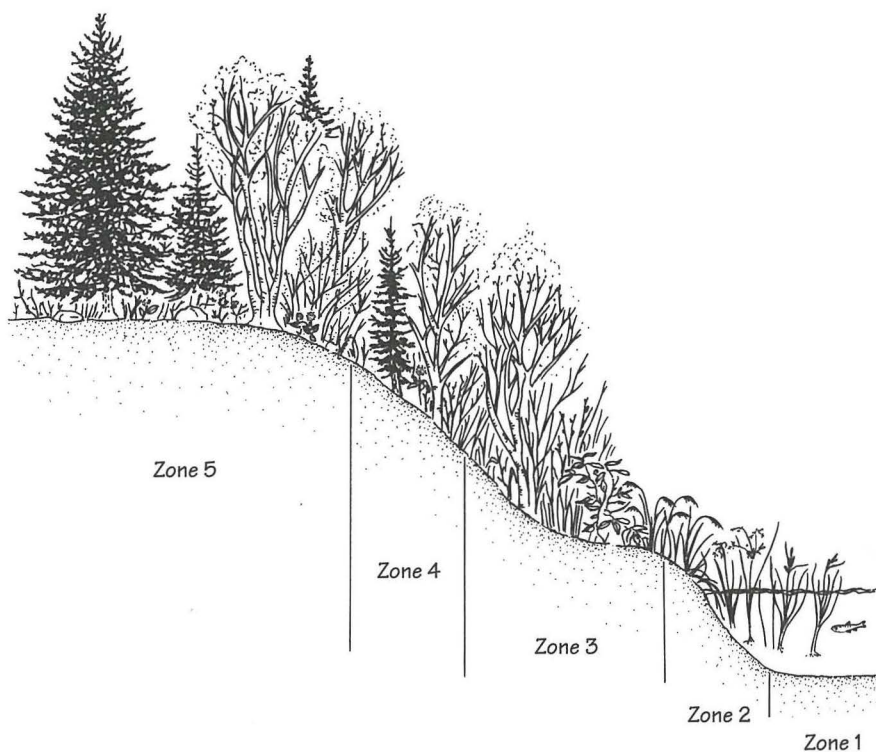
ROOT PRUNING

Prepare transplants by root pruning plants in the spring, or if possible, an entire year before moving them. Select plants less than 5 feet tall. To root prune, place a shovel perpendicularly into the ground approximately 1 foot deep, slightly outside the drip line of the tree or shrub. Skip a shovel width, cut again and continue working in a circle around the plant. Root pruning causes roots to grow closer to the center of the plant and increases the success of the transplanting effort.

After waiting for root pruning to take affect, dig up the selected transplant. Keep as much soil and as many roots as possible with the transplant. Keep the transplant moist at all times. Trim some of the shoot to compensate for root loss.

Prepare a hole for the transplant that is slightly wider and deeper than the root ball. Place the transplant into the hole and backfill over the root system without covering the stem higher than the original soil depth. Slightly compress the soil, creating a shallow depression around the transplant. Water the plant generously to help reduce transplant shock.

Streambank Revegetation Zones



This graphic depicts zones of vegetation types that reflect typical moisture regimes along the transition from edges of lakes or rivers to the uplands. When revegetating these shorelines, use undisturbed plant communities for plant suggestions. The following listing provides generalized plant material recommendations for each zone. Many of these species can be found in more than one zone. Commercial availability of species varies.

Zone 1

Hydric soils - relatively slow flowing open water along stream or lakes
- emergent vegetation:

- Water sedge - *Carex aquatilis*
- Lyngbyaei sedge - *C. lyngbyaei* (brackish water)
- Bulrush - *Schoenoplectus sp.*, *Scirpus microcarpus*

Zone 2

Hydric-mesic soils - fluctuating water levels subject to boat or wind driven waves:

- Egan American Sloughgrass - *Beckmannia syzigachne*
- Bluejoint Reedgrass - *Calamagrostis canadensis*
- Alyeska Polargrass - *Arctagrostis latifolia*
- Kenai Polargrass - *A. latifolia*
- Beach Wildrye - *Leymus mollis*
- Norcoast Bering Hairgrass - *Deschampsia beringensis*
- Nortran Tufted Hairgrass - *D. caespitosa*
- Sweetgale - *Myrica gale*
- Sedges - *Carex sp.*
- Sandbar Willow - *Salix interior*
- Feltleaf Willow - *S. alaxensis*
- Pacific Willow - *S. lasiandra*
- Sitka Willow - *S. sitchensis*
- Thinleaf Alder - *Alnus incana ssp. tenuifolia*

Zone 3

Hydric-mesic soils - floodway terrace, in addition to Zone 2 plants.
Also consider:

- Red Osier Dogwood - *Cornus stolonifera*
- Little-tree Willow - *Salix arbusculoides*
- Diamond-leaf Willow - *S. pulchra*
- Undergreen Willow - *S. commutata*

Zone 4

Mesic soils - seasonally variable moisture regimes:

- Prickly Rose - *Rosa acicularis*
- Raspberry - *Rubus idaeus*
- Labrador Tea - *Ledum sp.*
- Dwarf Birch - *Betula nana*
- Poplar/Cottonwood - *Populus sp.*
- Gruening Alpine Bluegrass - *Poa alpina*

Zone 5

Mesic - xeric soils - upland benches:

- Paper Birch - *Betula papyrifera*
- White Spruce - *Picea glauca*
- Black Spruce - *P. mariana*
- Quaking Aspen - *Populus tremuloides*
- Highbush Cranberry - *Viburnum edule*
- Dwarf Dogwood - *Cornus canadensis*
- Lingonberry - *Vaccinium vitis-idaea*

Plant Species Selection Lists

The following pages provide suggestions for native plant species to be used in streambank revegetation projects. Most grasses are available commercially (See the "*Directory of Alaska Native Plant Sources*" at <http://www.dnr.state.ak.us/ag/NEWintroduction.htm>). Sedges and other wetland plants may be commercially available in future years. Other plant species may be suitable for specific project sites and may need to be obtained through custom seed collections and plant propagation efforts.

Seedling production of willows, poplar and aspen can be challenging because the seed maintains its viability for only 10-14 days. Seed needs to be collected, cleaned and seeded into pots or placed in a plastic bag and stored in a freezer. Experience has shown that willow seed can be kept frozen for 2 years and maintain its viability.

The willows and other species suited for dormant cuttings are listed. Alders, poplar, aspen, Bebb Willow and Scouler Willow **are not** suited for dormant cuttings even though they are common plants in Southcentral Alaska. As rooted plants, they can be used for hedge-brush layers or transplants.

Aspen is a clonal plant and sends new shoots up from the roots. Segments of roots with buds (root cuttings) can be used to propagate this species.

Birch, White, Black and Sitka Spruce should be used only as transplants or grown as seedlings. Their trunks cannot be buried above the original soil level.

Consult Viereck and Little's *Alaska Trees and Shrubs*, 1972, for plant descriptions of species found within range of the project site.

The wetland indicator status is listed for the woody plants suited for dormant cuttings. The information is derived from the U.S. Fish and Wildlife Service's *National List of Plant Species that Occur in Wetlands: Alaska (Region A)*, *Biological Report* 88(26.11), 1988. The document describes 5 indicator categories, three of which apply to the plant list, facultative wetland (FACW), facultative (FAC), facultative upland (FACU). A plant that is FACW occurs 66-99 percent of the time in a wetland. A FAC plant occurs either in a wetland or non-wetland environment. A FACU plant usually (67-99 percent of the time) occurs in non-wetland environment, but can occur in a wetland environment 33 percent of the time or less.

STREAMBANK REVEGETATION PLANT SPECIES SELECTION LIST
SHRUBS AND TREES^{1,2} SUITED FOR DORMANT CUTTINGS

Species Suitable for Dormant Cuttings	Revegetation Uses-for Plants ³	Range ^{1,2}	AK Wetland Indicator ⁴	Description ^{1,2}
Feltleaf Willow <i>Salix alaxensis</i>	DC, LS, B, BL, L, H, RC, T, S	Throughout Alaska/Arctic coast to Wrangell in S.E. Alaska, S.W. to Unalaska.	FAC	Tree-like shrub on gravel bars, floodplain terraces of rivers, lakes, and streams. Has dense, white felt-like appearance to underside of leaves.
Pacific Willow <i>S. lasiandra</i>	DL, LS, B, BL, L, H, RC, T, S	Interior Alaska, S. Central Alaska, Northern S.E. Alaska.	FACW	Tree-like shrub found on sand, silt bars and alluvial deposits in forested areas. Has lance shaped leaves with glassy upper surface.
Barclay Willow <i>S. barclayi</i>	DC, B, BL, H, RC, T, S	Eastern Aleutians to Hyder in S.E., Alaska. Rare in interior lowlands.	FAC	Common thicket forming shrub along small streams and, forest openings. Sometimes has willow gatis or roses at end of twigs.
Sitka Willow <i>S. sitchensis</i>	DC, LS, B, BL, L, H, RC, T, S	Pacific coast of S.E. and Southern Alaska to Kodiak Island, North to Anchorage.	FAC	Tree-like shrub along streams and beaches or open spots in forest. Underside of leaves have a silky appearance.
Undergreen Willow <i>S. commutata</i>	DC, LS, B, BL, L, H, RC, T, S	Central Alaska Range, South to Kodiak, Aleutian Islands, Northern S.E. Alaska.	FAC	Low to medium shrub forming thickets along streams and rocky slopes. Densely hairy when young. Often found with Barclay Willow.
Little Tree Willow <i>S. arbusculoides</i>	DC, LS, B, BL, H, RC, T, S	Central Alaska, North Slopes of Brooks Range, Kenai Peninsula.	FACW	Tall shrub to small tree found in openings of mixed forest and along streams. Has slender glossy leaves. Best mixed with other willows for revegetation.
Diamond Leaf Willow <i>S. planifolia ssp. pulchra</i>	DC, LS, B, BL, H, RC, T, S	Most of Alaska, Northern S.E. Alaska. Absent from remainder of S.E. and Western Aleutians.	FACW	Medium shrub, forms thickets along streams, lakes, and in alpine tundra. Slender twigs root readily. Best mixed with other species for bulk.
Balsam Poplar-Cottonwood <i>Populus balsamifera</i> <i>P. trichocarpa</i>	DC, LS, B, BL, H, RC, T, S	Balsam Poplar-Widespread in Alaska to North of Brooks Range in limited areas. Cotton wood lowlands of coastal forests.	FACU	These trees occur on floodplains and openings in forests. Balsam Poplar is a medium sized tree and Cottonwood is the largest broadleaf tree in Alaska. Appearance and habitat of two species overlap.
Red Osier Dogwood <i>Cornus stolonifera</i>	DC, LS, B, BL, H, RC, T, S	Lower and central Yukon to Southeast Alaska.	FAC	Red-barked medium tall shrub with opposite leaves, white flowers and berries. Moist soils on floodplains and forest openings. Best mixed with other species for revegetation.

1 Argus, G.W. 1973. The genus *Salix* in Alaska and the Yukon. The National Museum of Canada, Ottawa. 279 pp.

2 Viereck, L.A. and E.L. Little, Jr. 1972. Alaska Trees and Shrubs. U.S. Dept. of Agriculture Handbook. 410. 265 pp.

3 Key to suitable revegetation technique for each species:

DC - dormant cutting

B - bundles

L - live siltation

RC - rooted cuttings

R - root cuttings

LS - live stakes

BL - brush layer

H - hedge layering

T - transplants

S - seed

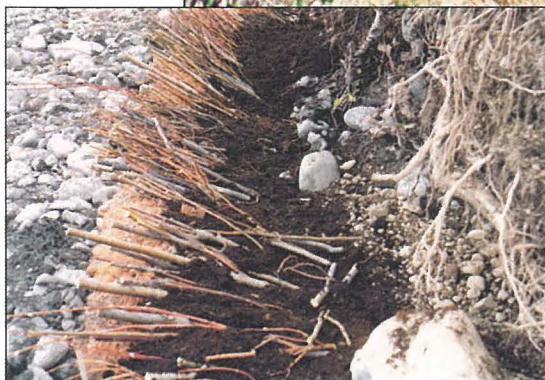
4 Discussion of wetland indicators found in introduction to this section.

STREAMBANK REVEGETATION PLANT SPECIES SELECTION LIST
GRASSES AND SEDGES

Species	Commercial Availability	Application	Characteristics	Fishery/Habitat Value
Bluejoint Reedgrass <i>Calamagrostis canadensis</i>	limited seed supply transplants (sprigs) from wild	seed – grassrolls sprigging plugs	dense fibrous root system, forms overhanging banks, slightly rhizomatous	high
Bering hairgrass 'Norcoast' <i>Deschampsia beringensis</i>	seed available high demand	seeding	tufted growth form, tolerant of moist sites, adapted to wide range of conditions	low to moderate
Tufted hairgrass 'Nortran' <i>Deschampsia caespitosa</i>	seed available good substitute for Norcoast	seeding	tufted growth form, tolerant of moist sites, adapted to wide range of conditions	low to moderate
Beach wildrye common <i>Leymus mollis</i>	sprigs from natural stand seed not available	sprigging	strongly rhizomatous, tolerant of brackish water, tidal flooding	moderate
Red fescue 'Arctared' 'Boreal' 'Pennlawn' <i>Festuca rubra</i>	seed available	seeding	forms seed adapted to wide range of conditions, tolerates flooding and foot traffic	low
Polargrass 'Alyeska' 'Kenai' <i>Arctagrostis latifolia</i>	Alyeska seed available	seeding	moist-wet sites, rhizomatous	high
Sloughgrass 'Egan' <i>Beckmannia syzigachne</i>	seed available	seeding	wet ground, restricted distribution	low
Water Sedge <i>Carex aquatilis</i>	contract seed collections	sprigging, seeding	rhizomatous – shallow water along rivers and in marshes	high
Lyngby Sedge <i>Carex lyngbyaei</i>	contract seed collections	sprigging, seeding	stoloniferous – salt marshes	low to moderate



REVEGETATION TECHNIQUES



Brush layering and cabled spruce trees, Kenai River

Detail, coir log toe protection



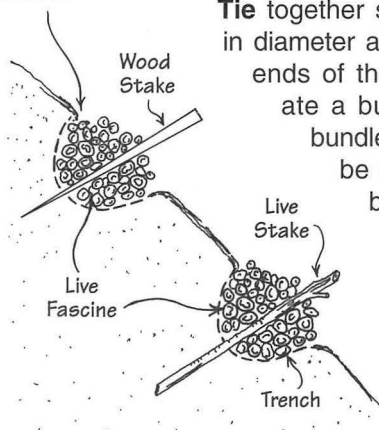
BUNDLES (FASCINES)



Ravenwood Elementary School class with their prepared bundle for installation at Eagle River, Alaska

Bundles (fascines) are a group of dormant branches bound together to create a log-like structure that will root, grow and provide plant cover quickly. The bundle is used to revegetate and stabilize slopes, break-up slope length, and/or provide a transition from one revegetation technique to another (e.g., a brush mat to a live siltation). Bundles create small terraces that encourage native plant seed collection and growth.

EXAMPLE 1.
Trench is filled with soil until bundle is partially covered.



Side view of multiple live bundles in a bank. Live bundles are partially covered with soil. Slope of bank can vary.

Collection, storage and hand planting information are described under *Dormant Cuttings* in the *Plant Care and Preparation* section.

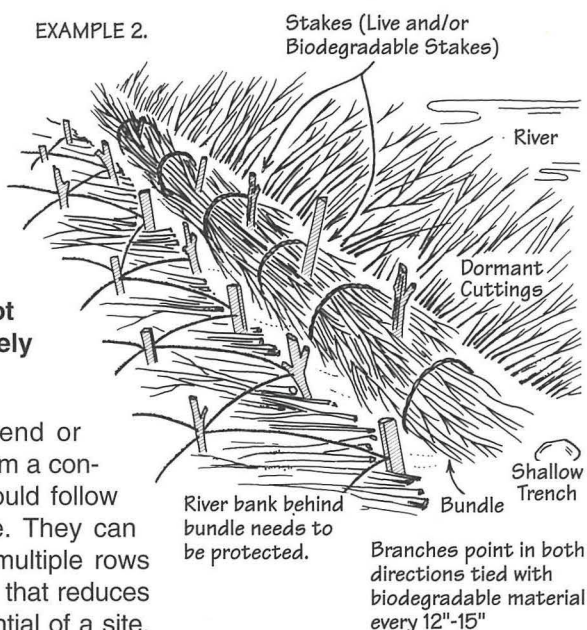
Tie together several dormant branches 1/2 to 2 inches in diameter and at least 3 to 4 feet long. Orient the cut ends of the branches in opposite directions to create a bundle with a uniform diameter. Typically, bundles are 4 or more inches in diameter and can be constructed to any length by overlapping branches as the bundle is formed and tying it tightly together with biodegradable twine, approximately every 1 to 2 feet.

Use a shovel or pick axe to dig a trench that slopes diagonally down and back into the hill. Install bundles by placing them horizontally in a shallow trench, burying approximately 3/4 the depth of the bundle diameter with soil, water and tamp in place to remove air pockets. Drive at least two 18-inch wooden stakes

or live willow stakes through the bundle to secure it firmly into the trench. If the slope is steep and the erosion potential is high, drive additional stakes down-hill and immediately in front of the bundle. **Do not cover the bundle entirely** so it will be able to grow.

Place bundles end-to-end or slightly overlapping to form a continuous planting that should follow the contour of the slope. They can be planted in single or multiple rows or in a staggered pattern that reduces the surface erosion potential of a site. Fascines may also be placed in a "smile" configuration, with the fascine ends turned upslope. Location and spacing of the bundles will vary with site conditions and the overall revegetation design.

EXAMPLE 2.



One application using live bundle with brush mattress and live siltation for bank protection.

Advantages:

- In low velocity systems, this technique provides good density of vegetation and root matter
- Breaks up slope length
- Can be cost effective
- Easy to construct and install
- Provides terraced area for soil and seeds to settle
- Provides fish and wildlife habitat

Disadvantages:

- Requires a lot of willow
- May require additional toe-of-slope and bank stabilization using techniques listed in this guide



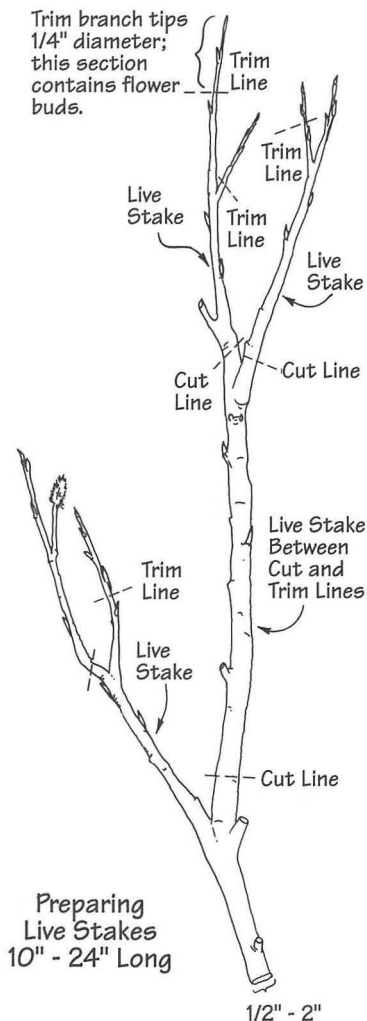
LIVE STAKING

Live staking is a simple technique that installs a dormant cutting (see *Dormant Cuttings* under *Plant Care and Preparation* section) directly into the ground. This technique is often utilized where single stem plantings will provide adequate plant cover, slope stability and fish habitat. Live staking should be combined with other revegetation techniques; these may include anchoring bundles, brush mats and erosion control fabric.

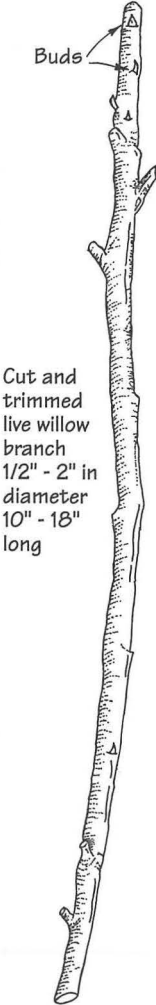
Collection, storage and planting information are described under *Dormant Cuttings*.

Prepare several live stakes from one dormant cutting. Cut stakes 10 to 18 inches long, 1/2 to 2 inches in diameter (slightly larger diameter cuttings will also work). Discard flower buds ("pussy willows"). Flower buds typically occur at the top 2/3 of a branch that was produced during the past growing season. At least one or two leaf buds that are smaller than flower buds must be present near the top of each live stake.

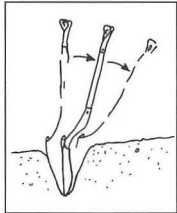
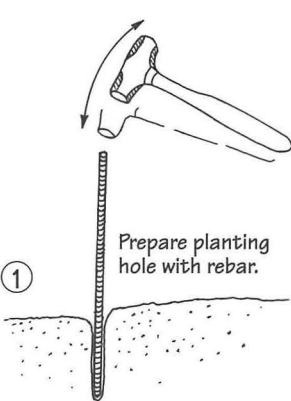
Select planting sites carefully since live stakes **require moist soils**. The bottom 6 inches needs to be in permanently moist soils. If planted on drier slopes, survivability will decrease. Watering could increase survival and promote plant growth. Occasional deep watering is more effective and encourages deeper rooting than frequent light watering. Water during the first 6 weeks after planting if in non-permanently moist soil.



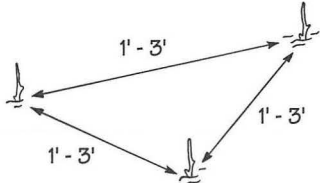
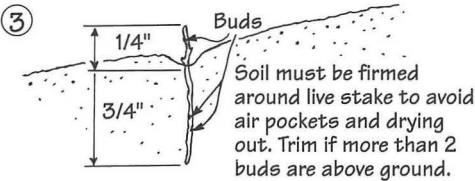
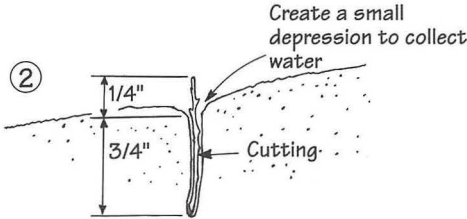
Live Staking Step-by-Step



Cut and trimmed live willow branch
1/2" - 2" in diameter
10" - 18" long



Shovel Installation Method





LIVE STAKING

Use rebar, 3/4 inch or less in diameter, to create a planting hole for longer stakes, particularly when planting in compact and gravelly soils. A shovel or hydraulic drill may also be used. Tightly pack the soil around the stake so that no air pockets remain. Plant stakes upright 1 to 3 feet on center. Stakes should be planted as vertically as possible, placing at least 3/4 of the stake below ground so that only one or two leaf buds are left exposed above the ground. The intent is to maximize the surface area for rooting so a good root system can develop and support a healthy shoot system. If more than one or two buds, 1/4 of the stake, or 4 inches of the live stake is extending above the soil surface, trim the stake.

Water to help remove air pockets and increase contact between the soil and surface of the live stake. Moist soil is needed during the period the live stake is rooting and becoming established, at least 4 to 6 weeks after planting. Topsoil is not required. Survival rates for drier sites may be increased if larger cuttings are used along with increased watering.

Advantages:

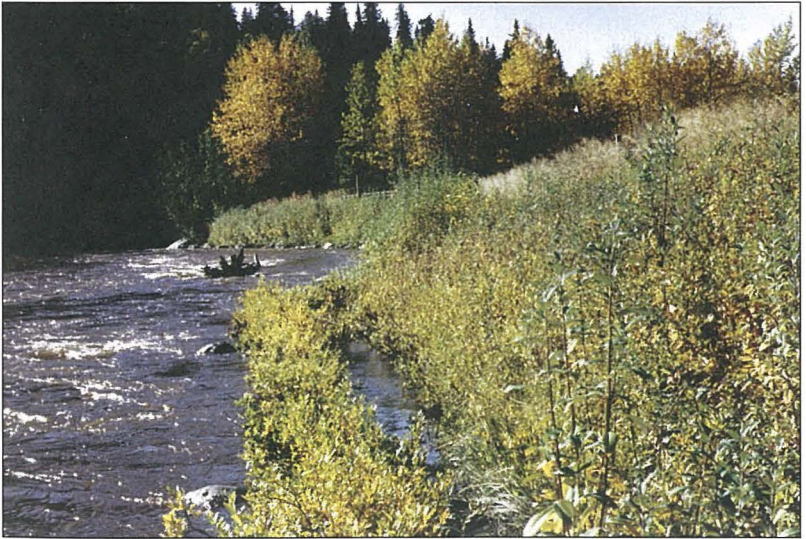
- Inexpensive
- Not labor intensive
- Low tech
- May plant in high densities

Disadvantages:

- Low survival compared with other revegetation techniques discussed
- Should be used in conjunction with other revegetation techniques
- Ease of planting is dependant on soil type and site condition
- Should only be used at sites with moist soils, or prepare to water extensively



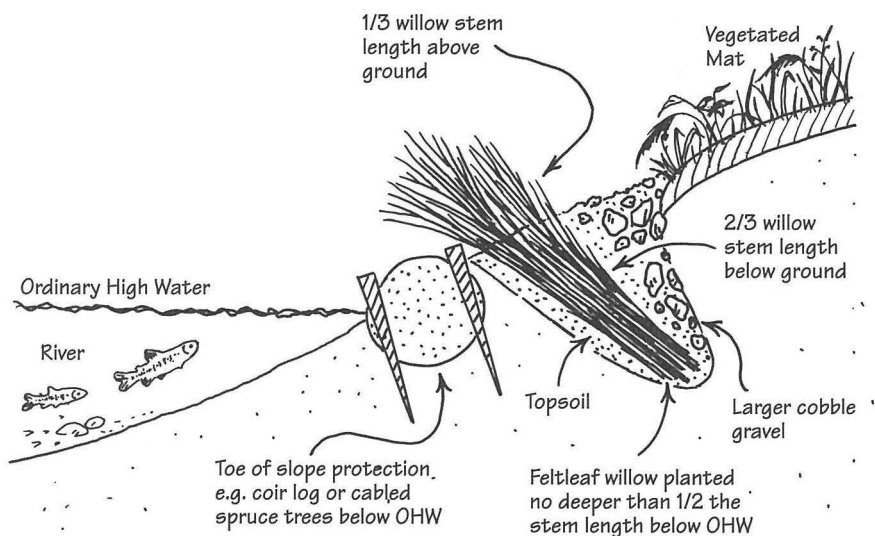
Deep Creek 1993: Severely eroded streambank at popular recreation site.



Brush mat and live siltation after three growing seasons (August 1996).



LIVE SILTATION



Live siltation is a revegetation technique used to secure the toe of a slope, trap sediment and create fish rearing habitat. This technique may be installed behind other toe-of-slope protection. The practice can be constructed as a living brushy system at the water's edge. This technique is particularly valuable for providing immediate cover and fish habitat while other revegetation plantings become established.

Collection, storage and planting information are described in *Dormant Cuttings* under the *Plant Care and Preparation* section. The dormant branches need to be a minimum of 3 feet long with side branches still attached. Feltleaf, Pacific or Sitka Willow is recommended for dormant cuttings (see *Plant Species Selection Lists, Shrubs and Trees*).

Construct a v-shaped trench above the ordinary high water (OHW) level, with hand tools or a backhoe. Excavate a trench so that it parallels the toe of the streambank and is approximately 2 feet deep. Lay a thick layer of willow branches (8-10 inches before compaction) in the trench so that 1/3 of the length of the branches are above the trench and the branches angle out toward the stream. Place a minimum of 40 willow branches per yard in the trench. Of the 2/3 buried willow, not more than 1/2 should fall in permanently moist soil.

Backfill over the branches with a gravel/soil mix and secure the top surface with large washed gravel and/or bundles (see *Bundles/Coir Logs sections*). Both the upstream and downstream ends of the live siltation construction need to transition smoothly into a stable streambank to reduce the potential for the technique to wash out. More than one row of live siltation can be installed.



Live siltation during construction

Advantages:

- Provides good fish habitat
- Provides bank stability in low velocity areas
- Provides good riparian vegetation

Disadvantages:

- Requires shallow water and slope
- Requires relatively low velocity
- Critical to know OHW (ordinary high water)



LIVE SILTATION



Brush mat and live siltation constructed at Deep Creek in 1994. Note bundle was used to provide a transition between the two techniques.



Live siltation and brush layering at the Little Susitna River



BRUSH MAT



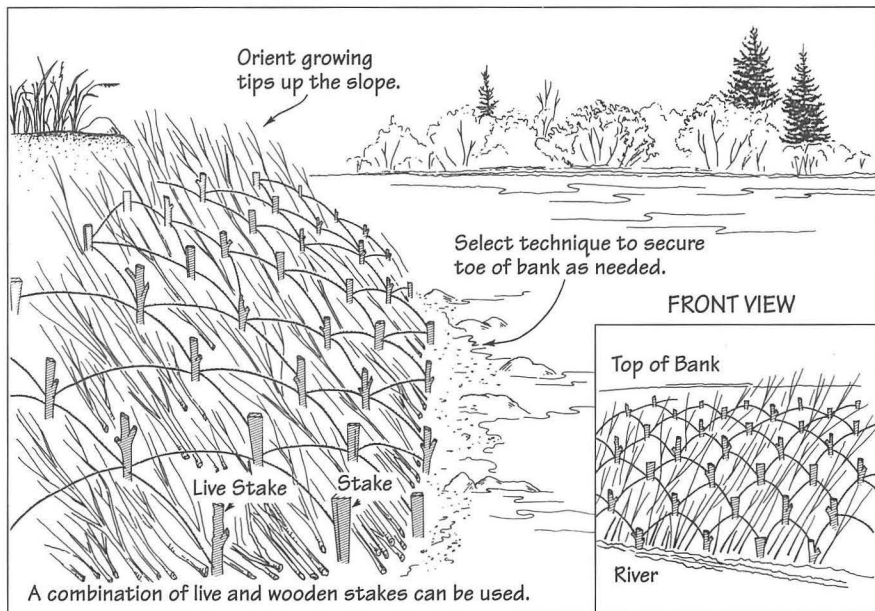
Brush mat - note the criss-cross pattern of the jute used to anchor the mat to the bank.



Live siltation protecting natural bank. Note partially buried coir log on riverside of live siltation.



BRUSH MAT



A **brush mat** is a revegetation technique that provides a protective vegetative covering to a slope as soon as it is installed. A brush mat can be constructed with dormant branches that will root and grow (see *Plant Species Selection Lists, Shrubs and Trees*) and is often combined with other revegetation and/or protection techniques which are used to secure the toe of the slope including root wads, live siltation, bundles, coir logs and spruce tree revetments.

A **brush mat** is recommended over an erosion control mat without vegetation because it provides erosion control while also providing quality fish and wildlife habitat. The brush mat may grow and provide plant cover, and the small pockets created by the overlapping branches will trap native seeds and provide an environment for germination and growth. During high water, a brush mat may trap sediments and eventually the plant growth on the stabilized streambank will provide fish habitat. If the original bank is denuded of vegetation and the soil is compacted, be sure to scarify the bank and deposit soil before installing brush mat. Additional toe-of-slope protection may be necessary.



Collection, storage and planting information for a living brush mat are described under *Dormant Cuttings* in the *Plant Care and Preparation* section. Brush mats require large quantities of plant materials. The availability of plant material should be carefully evaluated before including this technique in a revegetation design.

Install branches flat on the bank and perpendicular to the stream with branches slightly crisscrossed. The large end of the branch is placed at the toe of the slope. Add branches until the soil surface below the branches is covered. Brush mats can be installed over rooted plants and live stakes that are planted on a slope.

Stake the mat in place with stakes or live stakes and biodegradable twine or rope. Place stakes on 3-foot centers, attach twine around each stake to form a criss-cross pattern, and then drive the stakes into the substrate as deeply as possible pulling the branches tightly against the soil (see *Live Staking* section). Add a small amount of soil over the mat so that the lowest layer of branches is partially buried to encourage rooting. Water brush mat lightly to compress the added soil; then add more soil if necessary. The completed compressed mat will be approximately 3-4 inches thick. If high water occurs before the brush mat becomes established, the topsoil on the lower portions of the mat may wash away. A *light* seeding of native grass may help prevent/reduce the loss of topsoil.

Advantages:

- Provides good plant coverage and erosion control
- Promotes good soil stability
- No geotextile or metal left in bank

Disadvantages:

- Labor intensive and may be technically challenging

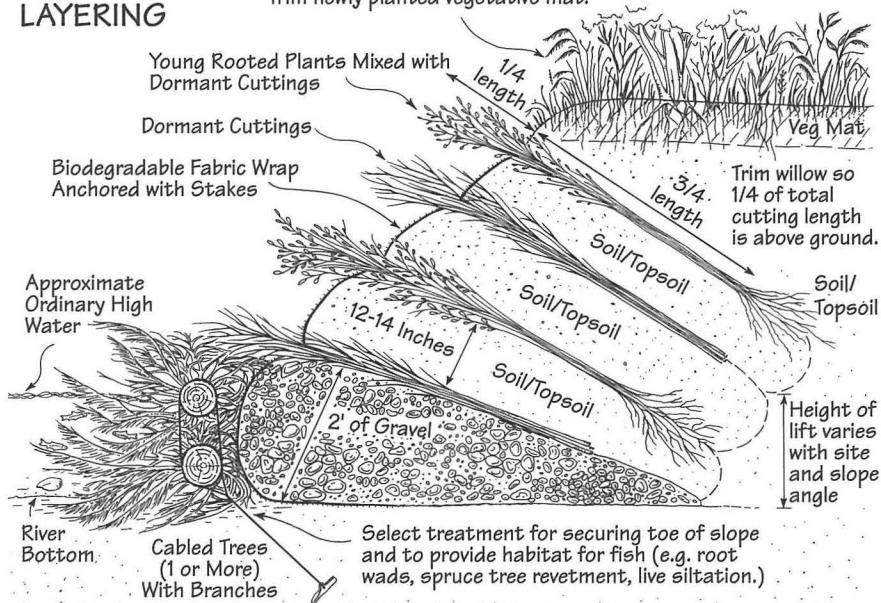
Consultation with a Streambank Revegetation Specialist before installation of any revegetation or protection technique is necessary to gain site specific information (see *Contacts*).



BRUSH/HEDGE BRUSH LAYERING

HEDGE BRUSH LAYERING

Revegetate with native woody and/or herbaceous plants.
Trim newly planted vegetative mat.



Brush layering is a revegetation technique, which combines layers of dormant or rooted cuttings (see *Dormant Cuttings* under *Plant Care and Preparation* section) with soil to revegetate and stabilize both streambanks and slopes. A larger variety of plant species may be utilized with a hedge brush layer (dormant cuttings and rooted plants) than with a simple brush layer (dormant cuttings). Rooted plants of species that do not root readily, such as alder, Scouler and Bebb Willow, can be included in the plant layer. A mixture of species may allow the revegetation project to blend with existing vegetation. Branches are placed on an angled bench that follows the contour of the slope and provides reinforcement to the soil. Steep slopes and streambanks are better stabilized when a biodegradable revegetation fabric is used to hold the reinforced soil lifts in place between the plant layers. Plant material placed using brush layering provides fish habitat and nutrients to the adjacent water body.

Collection, storage and planting information are described under *Dormant Cuttings* in the *Plant Care and Preparation* section. Different species of woody cuttings that root easily (see *Plant Species Selection Lists*, *Shrubs*

and Trees) can be mixed in the layers; rooted plants can also be added to create a hedge-brush layer (see *Root Pruning* under the *Plant Care and Preparation* section). Rooted plants may be planted throughout the growing season from spring through early fall. Dormant plants, if collected in the spring, should be planted before July 1 of that year.

Choose a technique such as root wads, live siltation, coir logs, or cabled spruce tree revetments to secure the toe of the slope. Consult streambank revegetation professionals and evaluate site conditions to determine the treatment of the toe-of-slope. Perform all construction activities during periods of dry riverbed, dewater area, or isolate the work area (see *Erosion Control* section). Along a water body, the first brush layer typically occurs at the OHW (ordinary high water) level, often identified by the line of growing vegetation (plus other factors).

Prepare a bench, which corresponds to the bank depth necessary to stabilize the slope, either through excavation or building up the slope, so that it angles slightly down and into the bank. It is important to note the upstream and downstream riparian species and slope height and angle when designing a brush layer project. Specifications should try to represent the local native environment as much as possible. If the surrounding area has been greatly impacted, observation further upstream and downstream may be necessary. Place fifteen dormant branches on the bench per foot or ten rooted cuttings per foot, slightly crisscrossed (see *Hedge Brush Layering/Brush Layering, Step-by-Step*). A mixture of dormant cuttings and rooted plants may be used. The cut or rooted ends are placed into the slope with the tips extending beyond the edge of the bench **no more than 1/4 of the total branch length**. Place 2 to 4 inches of soil on top of the branches, water and tamp into place.



Installation of brush layering, Little Susitna River, Youth Restoration Corp.



BRUSH/HEDGE BRUSH LAYERING

The reinforced soil lift is placed directly on top of the brush layer, pulling the next step back according to the designed bank angle. Two revegetation fabrics are used in reinforced soil lifts to keep soil in place when a brush layer is installed on steep slopes and streambanks. The first fabric layer, a fine mesh fabric (example: Bon Terra's® ENC2, North American Green's C125 BN, or equivalent) is placed inside the larger mesh fabric (example: Bon Terra's® CF7, North American Green's CCM-700, or equivalent). Next, 12-14 inches of soil-topsoil mix is placed on top of the fabric, watered, compressed and 2-3 feet of fabric is rolled over the top and secured in place with wooden stakes. Follow this step by another layer of dormant cuttings/rooted plants.



Brush layering installation prior to trimming, Centennial Park, Kenai River

Repeat the branch, topsoil, wrapped soil/topsoil mix layering sequence until the desired bank height is achieved (see *Hedge Brush Layering/Brush Layering, Step-by-Step*). Trim plants back to 1/4 of the planting above ground, 3/4 of the planting below ground. A vegetation mat may be placed on the top layer of the bank after the last brush layer is installed and over-topped with soil. The vegetative mat should be harvested and installed according to the *Transplanting* section and the shoots should be cut back by 1/3 to compensate for root loss and to encourage new root growth.

Higher density plantings are needed for more erosive sites and if the diameter of the plant material is small. Sites with a shallow slope and low erosion potential can have wider vegetation spacing than sites with a steep slope and higher erosion potential. This technique can be easily mechanized, layer-by-layer, if it is installed during construction of a fill slope. On cut slopes and existing banks each layer must be excavated.

Advantages:

- Prevents soil erosion and stabilizes bank
- Provides fish habitat and native vegetation
- Reestablishes healthy riparian zone functions
- May be used in higher velocity systems, dependant on toe-of-slope protection
- High success rate
- No permanent geotextile fabrics or metal left in bank

Disadvantages:

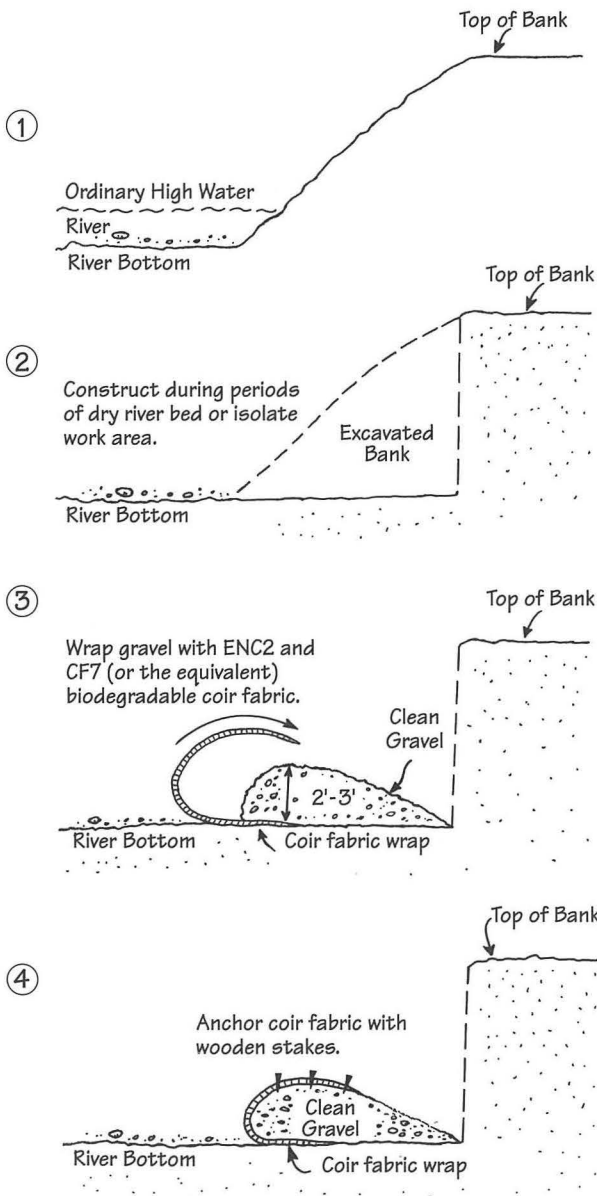
- Relatively expensive
- More technologically challenging, requires expertise
- May require heavy machinery
- Requires isolated work area to prevent water body siltation
- Very stable, dependent on toe-of-slope stabilization
- May require significant training



Rootwad and brush layering bank stabilization, Centennial Park, Kenai River

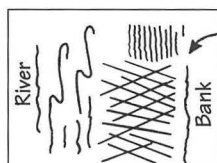


Brush/Hedge Brush Layering Step-by-Step

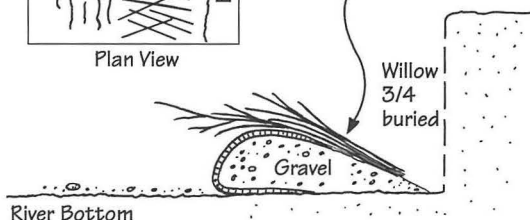


⑤

Crisscross layers of 15 dormant cuttings per foot or 10 rooted cuttings per foot. Deposit topsoil over cuttings and water liberally. Compress soil to 2-4 inches.

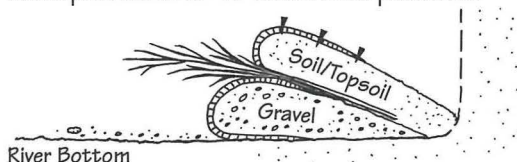


Plan View



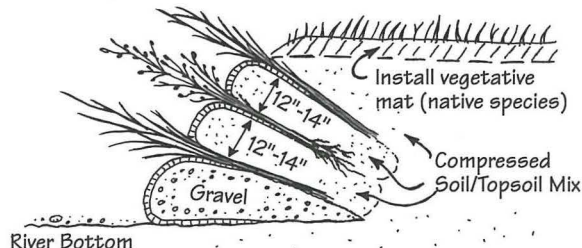
⑥

Wrap second layer of soil/topsoil mix with ENC2 and CF7 coir fabrics (or equivalent) 2'-3' over topsoil and stake fabric into place. Water each layer liberally and compress soil/topsoil mix to 12"-14" before willow placement.



⑦

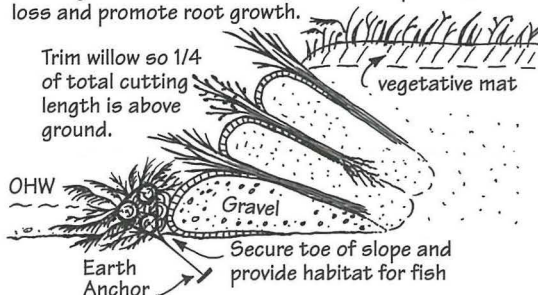
Repeat steps 4, 5, 6 until desired bank height is reached.



⑧

Trim vegetative mat shoots by 1/3 to compensate for root loss and promote root growth.

Trim willow so 1/4 of total cutting length is above ground.



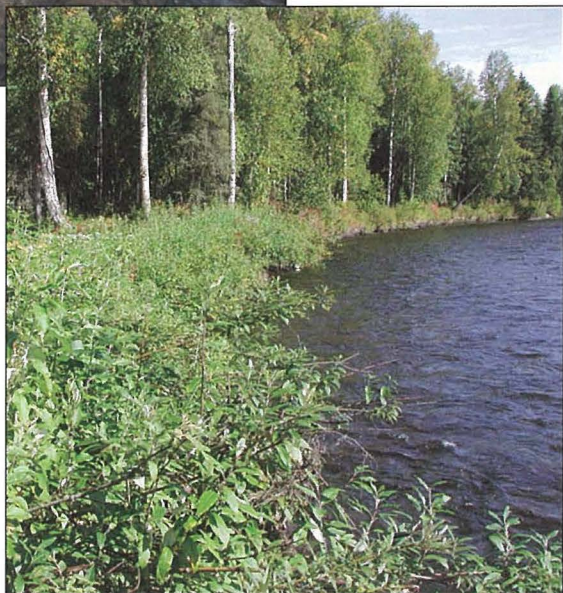


BRUSH/HEDGE BRUSH LAYERING



*Root wad brush layering
restoration project on Willow
Creek – Before*

*Willow Creek Project
– After*



*Little Susitna Recreation Site
– Before Restoration*

*Little Susitna Recreation Site, cabled
spruce trees and brush layering,
three months after installation.*





BRUSH/HEDGE BRUSH LAYERING



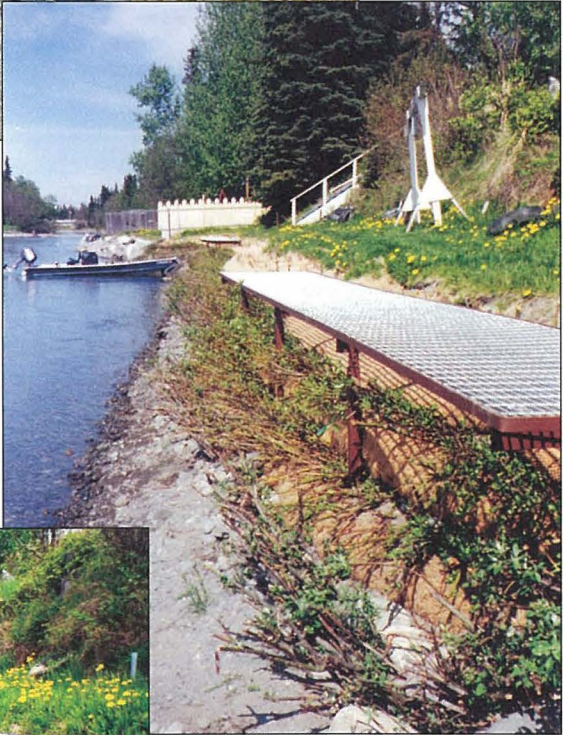
Little Susitna Recreation Site – Before



Little Susitna Recreation Site two months after brush layering and live siltation was installed



Creosote wood bulkhead prior to removal/restoration, Kenai River



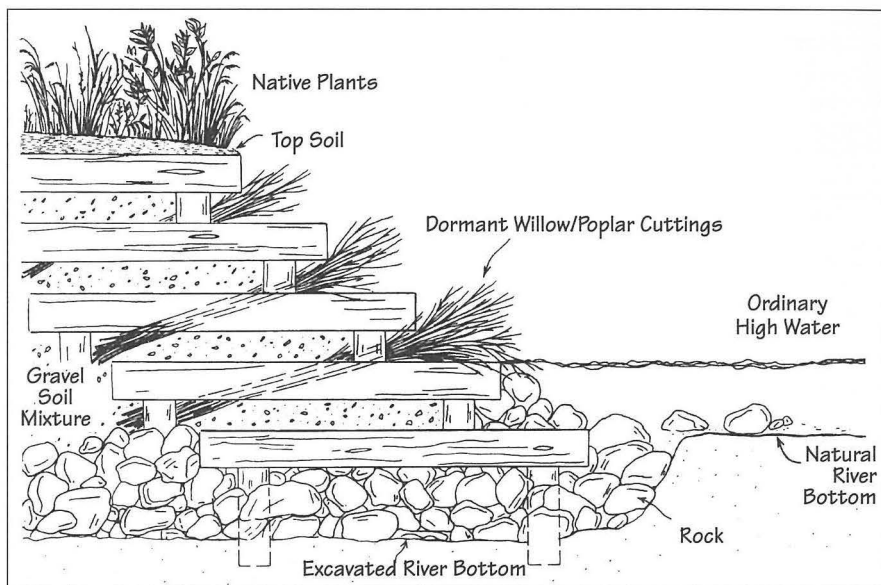
Live siltation and brush layering one month after construction, Kenai River



Project after one growing season



VEGETATED CRIBBING



Vegetated cribbing is a technique reserved for use at sites where other revegetation techniques may not provide sufficient protection from erosion.

This technique combines layers of reinforced soil lifts and plant material similar to brush layering with the addition of a protective cribbing (see adjacent drawing). Untreated timbers are notched and keyed into each other to create a crib-like structure. Cross-timbers are periodically installed to increase stability.

Layers of cribbing can be added to reach desired height of bank. The layers can be built vertically or stepped back into the slope with deep or shallow steps. Exposed soil should be seeded to protect from erosion.

Advantages:

- Stable
- Prevents soil erosion of bank
- May provide some fish habitat, may be used in higher velocity situations

Disadvantages:

- Very expensive
- Technically challenging
- Requires large machinery



Vegetated cribbing project under construction. Note cross timbers. Kenai River.



Vegetated cribbing three weeks after installation



GRASS ROLLS

Grass rolls are often used to revegetate lake shores and streambanks where grasses and grass-like plants have been the primary vegetation type and where seeding is impractical due to fluctuating water levels. Clumps of grass sod are placed tightly together, side by side with shoots

pointing up, in a sausage like structure and held together with biodegradable fabric and twine. The roll is then anchored in place. This technique reintroduces herbaceous vegetation to a site while simultaneously providing some structural stability. Ultimately, the sod will form a dense root system along the streambank and provide structural protection to the site. When the grasses go dormant at the end of each growing season, their leaves hang over the streambank and provide rearing habitat for fish.



PHOTO BY JOE CONNOR, COURTESY OF USFWS

Grass roll installation, mouth of Willow Creek

Construct a grass roll by laying out a length of the biodegradable fabric; place clumps of sod tightly together in the middle of the fabric.

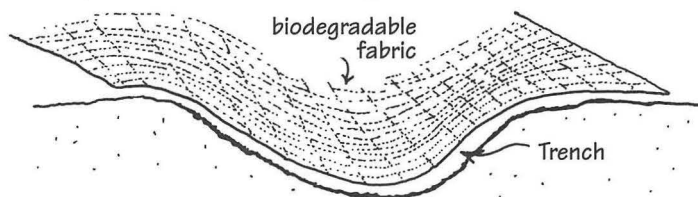
Bluejoint reedgrass, *Calamagrostis canadensis*, is the primary grass used for this technique and should be collected from sites away from streambanks. Beach wildrye, *Leymus mollis*, has also been used for streambank plantings, and although it produces a strong rhizome it does not form the dense sod characteristic of Bluejoint. Beach wildrye is also suitable for brackish water.

Wrap the sides of the biodegradable fabric over the sod clumps to make a sausage-like roll. Tie the roll every few inches with twine. Cut holes in the biodegradable fabric wrap to expose the sod shoots. Try to create the grass roll on-site so that the length of the roll(s) matches the length of the area being planted.

Constructing Grass Rolls

Step-by-Step

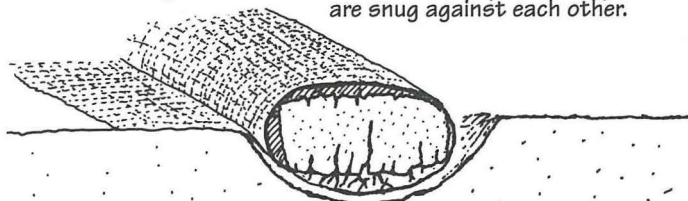
- ① Dig trench and line with biodegradable fabric.



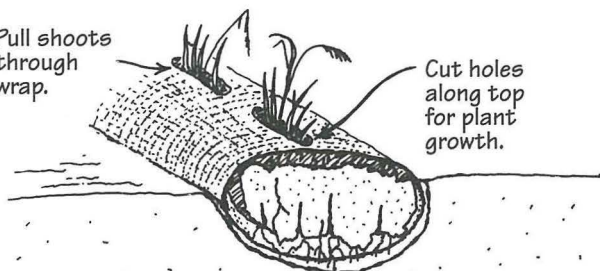
- ② Fill with grass clumps.



- ③ Fold biodegradable fabric over grass clumps so clumps are snug against each other.

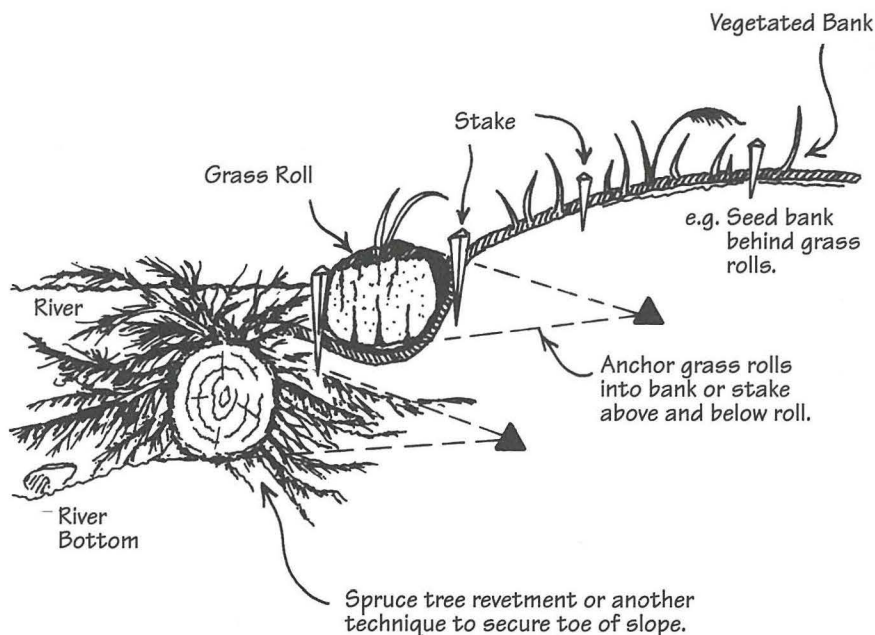


- ④ Pull shoots through wrap.





GRASS ROLLS



Dig a shallow trench in which to install the sod roll along the ordinary high water (OHW) level after the toe of the slope has been protected. Grass rolls may also be constructed on-site in trench using transferred sod. Anchor the grass roll securely into the bank. Earth anchors will be required for installations along streams and rivers. Stakes may be adequate for anchoring a grass roll in low-energy environments such as protected lake-shores. Revegetate adjacent areas, if necessary. Both the upstream and downstream ends of the grass roll need to transition smoothly into a stable streambank, undisturbed vegetation, or other revegetation technique.

Grass rolls can also be used for wetland revegetation. Several sedge species are suitable for this application; they include for freshwater, *Carex aquatilis*, *C. saxatilis*, and for brackish water - *C. Lyngbyaei*.

Grasses and sedges are particularly sensitive to foot traffic and should be protected by elevated walkways or planted in areas with restricted access to encourage survival.

Advantages:

- Inexpensive
- Uses simple material requiring little mechanized work
- Little training required
- Reestablishes natural condition
- High survivability
- Best around lakes and low velocity areas
- Provides erosion control

Disadvantages:

- Not recommended for high velocity environments
- Requires protection from trampling



Detail, grass roll installation, mouth of Willow Creek



PROTECTION TECHNIQUES



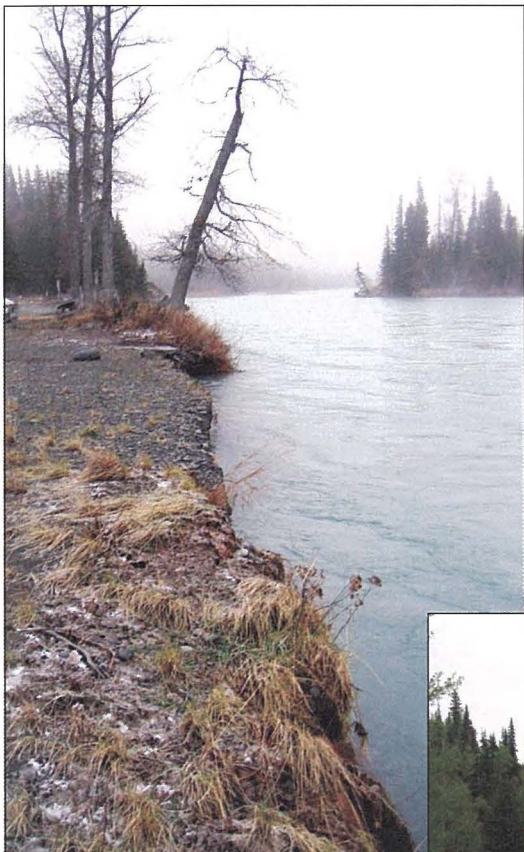
Pinning root wads with rebar, Jim's Landing, Kenai River



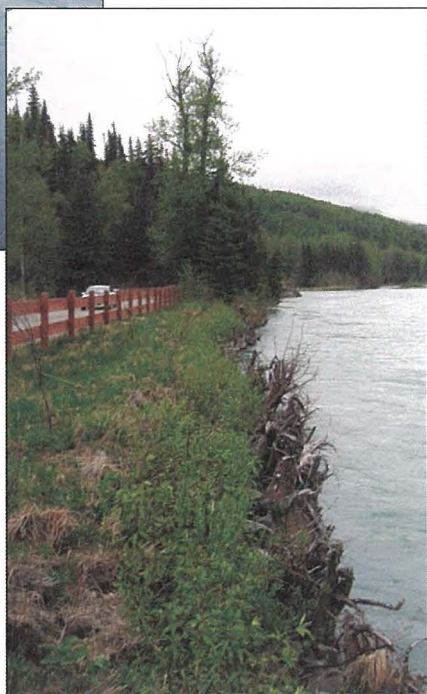
Installation of brush layering over root wads, Willow Creek



Root wad installation at Centennial Park, Kenai River



*Jim's Landing site prior to construction,
Kenai River*



*Jim's Landing brush layering/
root wad installation, Kenai River*



COIR LOGS

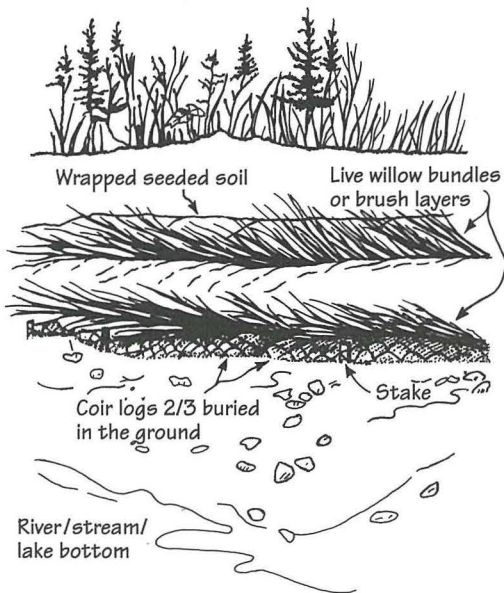


Sherman family moving coir log to site at Big Lake, Alaska

PHOTO BY SHERMAN, COURTESY OF USFWS

Coir logs are constructed of interwoven coconut fibers that are bound together with biodegradable netting. Commercially produced coir logs come in various lengths and diameters. The product needs to be selected specifically for the site. Fiber logs composed of other sturdy biodegradable materials may function equally as well.

Applications for coir logs occur in many streambank, wetland and upland environments. The log provides temporary physical protection to a site while vegetation becomes established and biological protection takes over. The logs can provide a substrate for plant growth once the log decay process starts and protects native and newly installed plants growing adjacent to the log. This technique can be used as a transition from one revegetation technique to another and used to secure the toe of a slope in low velocity areas.



Both the upstream and downstream ends of the coir log(s) need to transition smoothly into a stable streambank to reduce the potential for wash out.

Install the logs to ensure contact with soil along the entire length. In most cases, excavate a shallow trench to bury the log 2/3 into the soil. At no time should the coir log span any open space that may occur between rocks, logs or uneven ground. Tie logs together that have been placed end-to-end and staked into place every foot (dependant on site conditions) on both sides. Wooden stakes or live stakes with biodegradable twine may be used to securely anchor these logs by interweaving supports and driving them into the bank. To provide fish habitat, use coir logs in conjunction with spruce tree revetment (see next section) and/or revegetation techniques.



During installation with coir log toe protection, Eagle River

Advantages:

- Requires minimal training
- Biodegradable toe-of-slope protection
- Easy installation

Disadvantages:

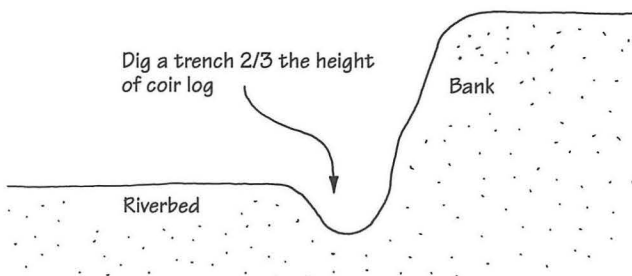
- Moderately expensive
- Least effective toe protection of techniques listed in this manual if used by itself
- Not recommended for high velocity areas



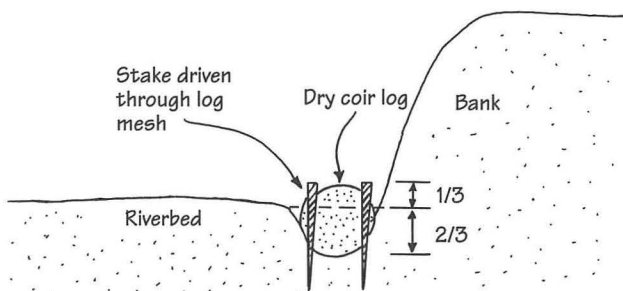
Coir Logs Step-by-Step

Install coir log during periods of dry riverbed or isolate area (see *Silt Fence Installation*). Secure log with wooden or live stakes woven through coir log mesh and driven into earth. Stake log into place every foot on both sides. Tie adjacent logs together with biodegradable twine. Compact soil around log. Secure the upstream and downstream ends by positioning coir logs so they transition smoothly into a stabilized bank.

①



②

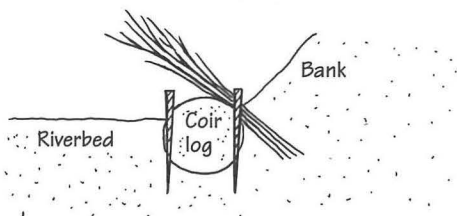


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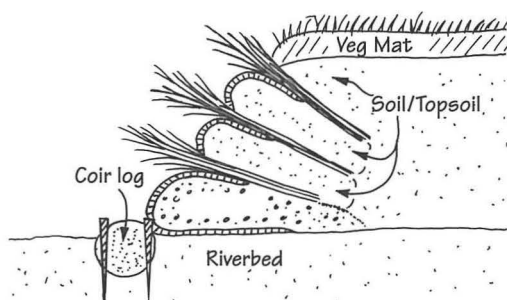
Alternatives using coir logs for securing toe of slope depending upon site:

a

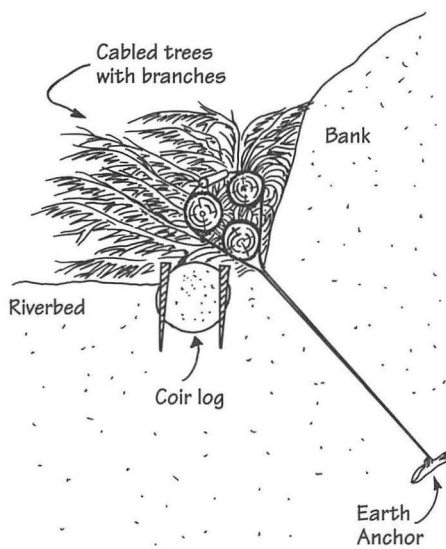
Crisscross layers of dormant cuttings 15 stems per linear foot (See live siltation)



(b) Brush Layering



(c) Spruce Tree Revetment





SPRUCE TREE REVETMENT



Cabled spruce trees and brush layering immediately after installation, Ciechanski Recreation Site, Kenai River

Spruce tree revetments protect streambanks from erosion and provide increased bank protection. This is a relatively inexpensive and functional bank protection technique. Spruce tree revetments trap sediment, and over time, aid in rebuilding bank structure and establishing long-term bank stability. The tree limbs reduce near-bank water velocities; provide protection from scour and erosion, provide cover for juvenile fish and act as a source of organic debris.

Spruce tree revetments are often used in combination with revegetation techniques. They provide immediate cover for fish until living plant cover is provided by the revegetation techniques. Consultation with a streambank revegetation specialist is necessary to determine site needs and revetment design. Spruce tree revetments may involve a single layer of spruce trees, multiple spruce trees cabled together, or single layers stacked. All revetments require an adequate cable and anchoring system. Selected spruce trees should be green and limber with many branches. When collecting, be careful not to damage surrounding vegetation when harvesting and transporting spruce trees. Anchor spruce tree revetment into well-vegetated and non-sloughing banks at both upstream and downstream ends.

Install 4-6 inch diameter spruce trees parallel to the streambank and overlap 1/3 to 1/2 of their length in a shingle fashion. The top of the tree should be orientated downstream. Care should be taken to avoid unnecessary damage to, or removal of, tree limbs. The trees are secured tightly to the bank with 1/8-inch cable and earth anchors, every 4-6 feet. (See *Spruce Tree Revetment Step-by-Step*). In higher velocity systems, 3/16 cable and larger and more frequent earth anchors may be used.

Maintain spruce tree revetments by adding new trees every 1-3 year(s). Fresh, bushy trees may be cabled directly in front of the original revetment. Spruce trees must be anchored securely and checked yearly to replace cable and add new trees. Remove excess cable and retighten any loose cable around trees. If the trees are not maintained and the trees deteriorate over time, any visible cables or anchors should be removed from below ordinary high water.



Sediment in cabled spruce trees, Kenai River

Advantages:

- Easily installed, no heavy equipment needed
- Materials readily available
- Inexpensive
- Provides soil erosion protection and fish habitat
- Least intrusive of bank protection techniques

Disadvantages:

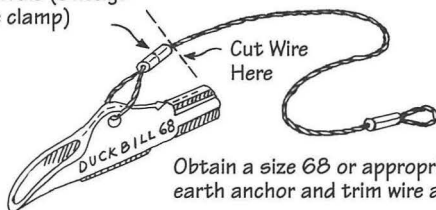
- Maintenance required every 1-3 year(s)
- Must remove excess cable/visible anchors and add new trees as necessary



SPRUCE TREE REVETMENT

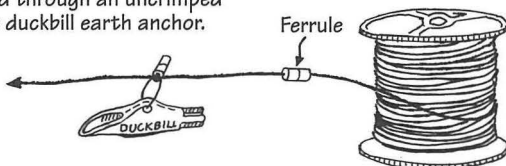
Spruce Tree Revetment Step-by-Step

- ① Cable ferrule (Swedge or cable clamp)

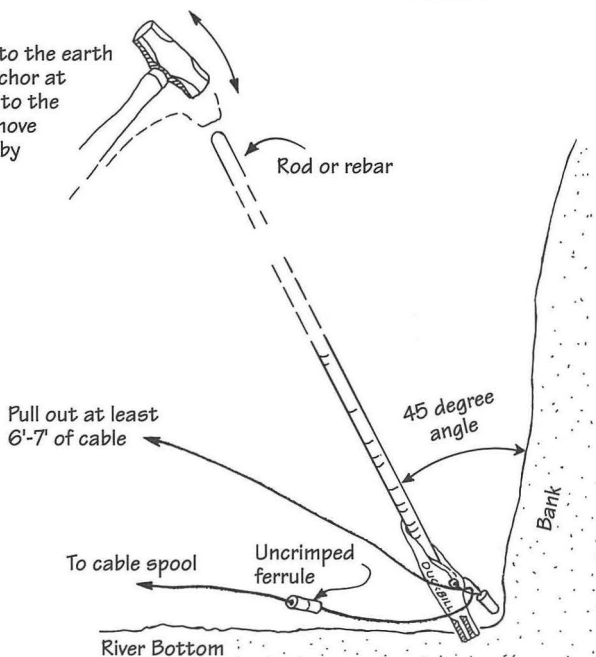


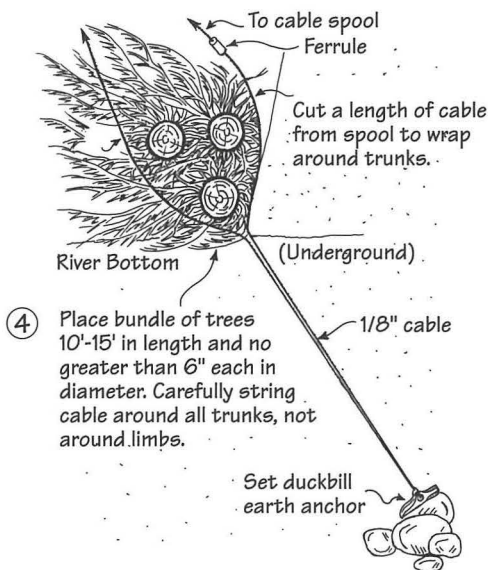
Obtain a size 68 or appropriate duckbill earth anchor and trim wire as indicated.

- ② Obtain a spool of 1/8" diameter stainless steel cable and thread through an uncrimped cable ferrule then the duckbill earth anchor.

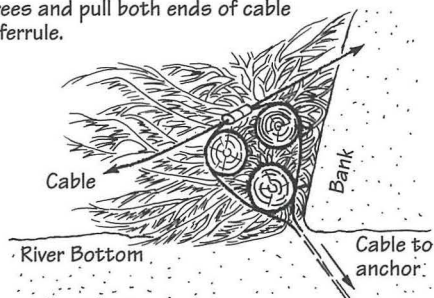


- ③ Insert driving rod into the earth anchor. Drive the anchor at a 45 degree angle into the bank to refusal. Remove rod and set anchor by pulling the cable.

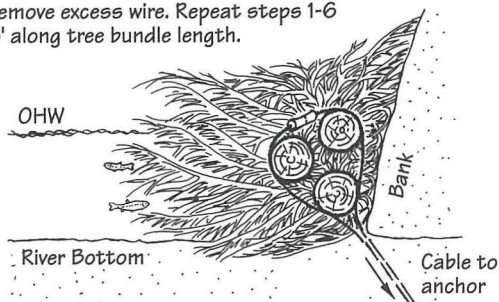




- ⑤ Thread loose end of cable through ferrule, compress trees and pull both ends of cable taut. Crimp ferrule.



- ⑥ Cut and remove excess wire. Repeat steps 1-6 every 4'-6' along tree bundle length.





ROOT WADS



Harvested rootwads before installation

Root wads are a streambank protection technique that provides immediate riverbank stabilization, protects the toe-of-slope and provides excellent fish habitat, especially for juveniles. They provide toe support for bank revegetation techniques and collect sediment and debris that will enhance bank structure over time. Because of their size, root wads usually require the use of heavy equipment for collection, transport and installation. Consult a streambank revegetation specialist before any streambank revegetation or stabilization technique is utilized in this book.

Identify a collection site and obtain permission to remove trees. Collect root wads from forested areas being cleared for development, or selectively remove from treed area. Do not remove trees from riparian zones. Be careful to avoid damage to other trees and vegetation during collection and clearing of root wads. Larger diameter trees (minimum of 12 inches DBH - diameter breast height) can be pushed over when soils are not frozen, leaving root fans intact. The tree tops should be removed, leaving the trunks (boles) a minimum of 10 feet in length with root fans attached. Optimal root fans are a minimum of 5 to 6 feet in diameter.

Construct during times of dry riverbed or isolate work site to prevent sediment erosion into adjacent water bodies. Determine ordinary high water level for proper placement of root wads and subsequent vegetative layers. It is imperative to tie in project to the existing stabilized streambank at the upstream and downstream ends of the project.

Install root wad by excavating into the riverbank deep enough to accommodate an 8 to 10 foot long tree bole (See *Root Wads Step-by-Step*). Optional header and footer logs may be installed and pinned in place using rebar to help stabilize root wads and the bank. The bole of the root wad is placed into the prepared excavated bank and back-filled with 4-6 inch rock and gravel encased in two layers of biodegradable fabric. The inner layer of fabric is a fine biodegradable mesh (example: Bon Terra's® ENC2, North American Green's C125 BN, or equivalent) and is placed inside the larger mesh fabric (example: Bon Terra's® CF7, North American Green's CCM-700, or equivalent).

The bole is typically embedded at the level of the riverbed, perpendicular to the river, with the fans parallel to the bank. This placement requires that the riverbed be excavated to partially bury the root fan 2 to 3 feet. Root wads should be installed so that the root fans overlap adjacent root wads to provide continuous coverage along the bank area being treated. The fans should be positioned to undulate with the natural bank, providing additional cover for fish. Additional application methods are described in *Applied River Morphology* (Rosgen, 1996). Various revegetation techniques may be applied above ordinary high water level after root wad installation to establish native vegetation on the bank. The adjacent *Step-by-Step* demonstrates brush layering and vegetative mat installations to revegetate the bank above the root wads. To learn more about these methods, please consult the appropriate sections.

Advantages:

- Most stable toe-of-slope protection of techniques mentioned in guide
- Provides fish habitat
- May be used in higher velocity situations
- Helps keep foot traffic off project site

Disadvantages:

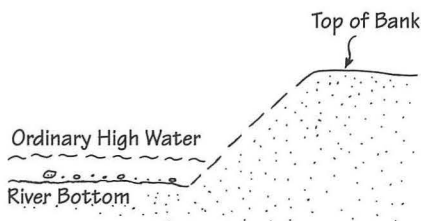
- Root wads limit access to fishery unless grated walkway (gratewalk) and stairs are provided
- Expensive
- Labor intensive
- Heavy equipment required, generally requires contractor



ROOT WADS

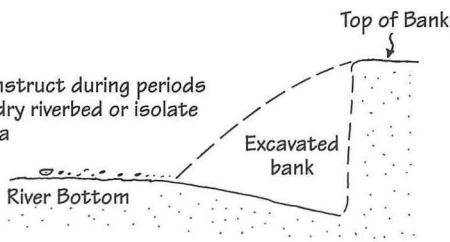
Root Wads Step-by-Step

①



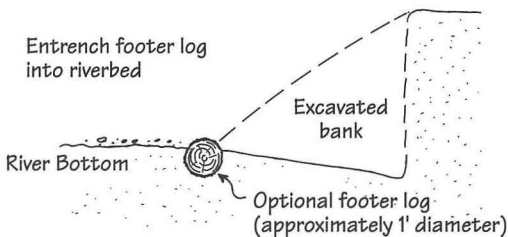
②

Construct during periods of dry riverbed or isolate area



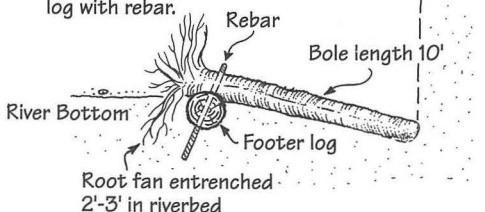
③

Entrench footer log into riverbed



④

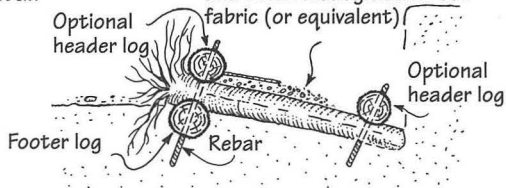
Place root wad; drill through root wad trunk and footer log and pin in place to footer log with rebar.



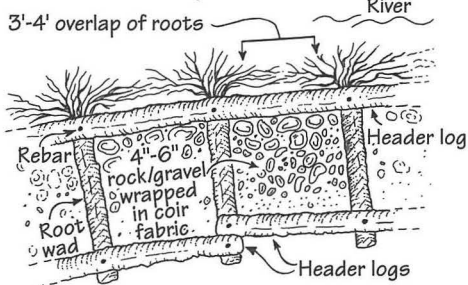
⑤

Pin root wad trunks to header and footer log with rebar.

Fill behind footer log with 4"-6" rock and gravel encased in CF7 and ENC2 biodegradable coir fabric (or equivalent)

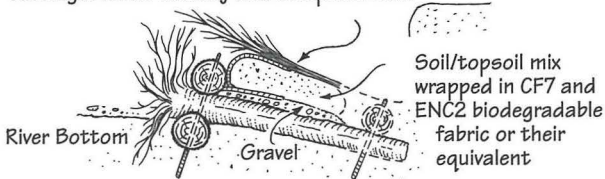


Top View



⑥

Install dormant cuttings 15 stems per linear foot over wrapped soil. Deposit layer of top soil over cuttings. Water liberally and compress soil.



⑦

Repeat step 6 until desired height of bank is reached

Trim willow so 1/4 of total cutting length is above ground.





ROOT WADS



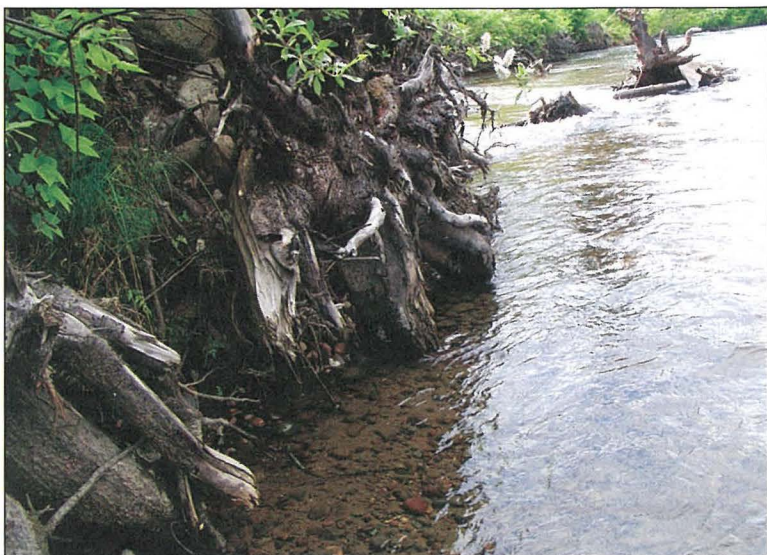
Root wad installation at Pioneer Lodge, Willow Creek



Root wad, rock layer with header log pinning, Pioneer Lodge



Installation of subsequent brush layering/soil wraps above root wads; the picture shows walkway supports installed. Pioneer Lodge, Willow Creek April 10-11, 2001



Root wads at low water levels, Pioneer Lodge



FENCING AND SIGNAGE

Fencing is a protection technique for revegetated areas or to allow natural revegetation to occur. Consideration for fencing includes the ability to protect the revegetation site from further trampling by recreationists, installation of fencing around revegetation project, ability for wildlife to pass by the area without causing themselves harm, and allowing access for visitors, if necessary. Temporary and permanent fencing should be combined with signs to inform the public of the revegetation effort in progress and to keep visitors off of the restored area. Fencing may be combined with elevated, light-penetrating walkways to direct visitors to access and recreational areas. Enforcement of no-trespass areas is crucial if trampling contributed to erosion problem. Limiting access to revegetated areas is imperative to success of projects where vegetation was denuded.

Materials: Fencing may be constructed of wood, metal, plastic material, or rope. Temporary fencing is usually of the plastic and rope variety. Temporary fencing may be used until permanent fencing is installed or until vegetation is well established and the trespass fear deterred. This temporary fencing must be monitored closely for rips and tears in order to determine if it is still providing protection or if it has become a danger to the environment (i.e., caused small animals to get trapped in fencing, break away into the aquatic or terrestrial environment, etc.). Maintenance of the temporary fence is crucial.

Advantages:

- Keeps people off restoration areas
- People management tool directing them to accessible areas
- Protects fish habitat and revegetation areas
- Safety measure to prevent people injuries
- Temporary fencing is inexpensive

Disadvantages:

- Moderately expensive for permanent fencing
- Fencing should be adjustable and parts may need to be seasonally removed, requiring maintenance
- Fence posts may destabilize bank if not installed carefully
- May detract from aesthetic beauty of area
- Fencing usually ineffective without enforcement and sign(s)



FENCING AND SIGNAGE

Signs may be used to announce a streambank revegetation project in progress or the history of a project. They may also be utilized to explain the importance of the riparian area to visitors and educate on fish and wildlife habitat. By sharing the importance of riparian habitat with your visitors, you may help to protect the area from further habitat degradation on-site and throughout the area. Make sure signs are well placed and are established in addition to other protection techniques, such as fencing, enforcement of no-access areas, and/or an elevated light-penetrating walkway.

Materials: Signage may be constructed of wood, metal or plastic material. Many designs are currently available to inform visitors of streambank revegetation projects.

Advantages:

- Fairly inexpensive
- People management tool
- Protects fish habitat and revegetation areas
- Safety measure to prevent people injuries
- Informative aid

Disadvantages:

- Requires posting which may detract from aesthetic beauty of area
- May require maintenance



Educational signage, Centennial Park, Kenai River



ELEVATED WALKWAYS



*USFWS fishwalk and fish cleaning table,
Kenai River*



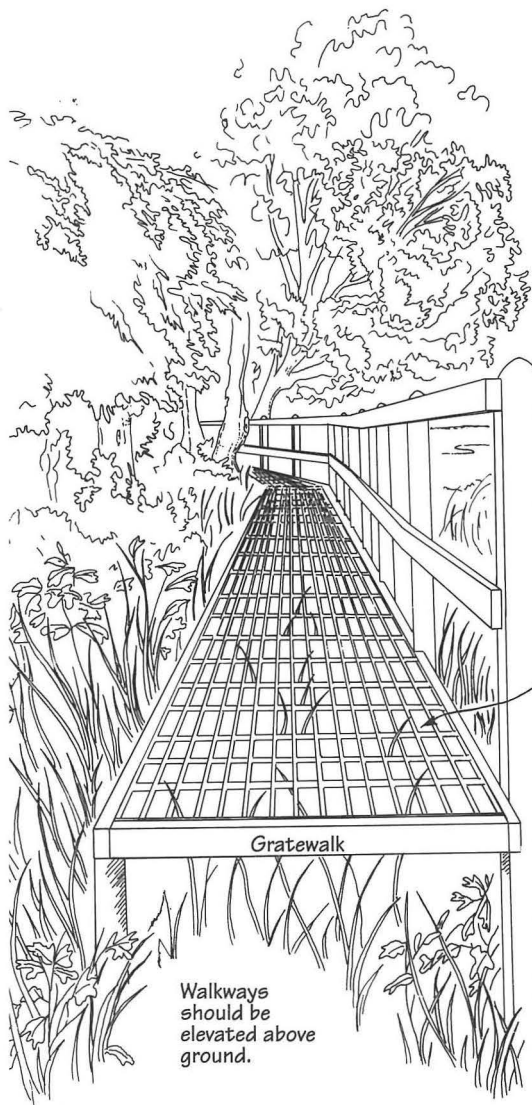
*USFWS angler access gratewalk,
Kenai River*



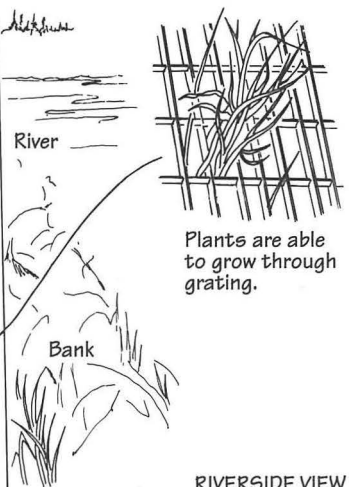
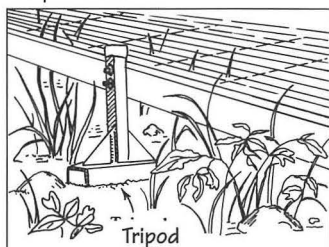
*Vegetation growing through
gratewalk, Kenai River*



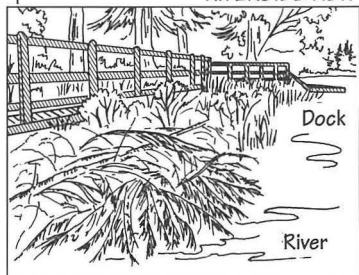
ELEVATED WALKWAYS



Above ground supports are preferred.



RIVERSIDE VIEW





USFWS gratewalk with stairway to river for angler access, Kenai River

Elevated, light-penetrating walkways are a protection technique that provide access while protecting riparian habitat. Walkways should be constructed in a manner that allows riverbank vegetation to grow less unimpeded. Please contact revegetation specialist for site-specific information.



Gratewalk and cabled spruce trees, Kenai River

Materials: Walkways may be constructed using a variety of materials, including expanded and extruded metal, fiberglass, and wood.

Construct walkways to protect the integrity of the existing riverbank. If it is necessary to drive posts into the bank for walkway support, care should be taken to avoid placing posts too close to the edge of the bank to prevent bank destabilization. Walkways can be placed on above ground supports, such as the tripod. Design of walkways should conform to all state, federal and local applicable building codes. Standards for the Kenai Peninsula Borough walkways



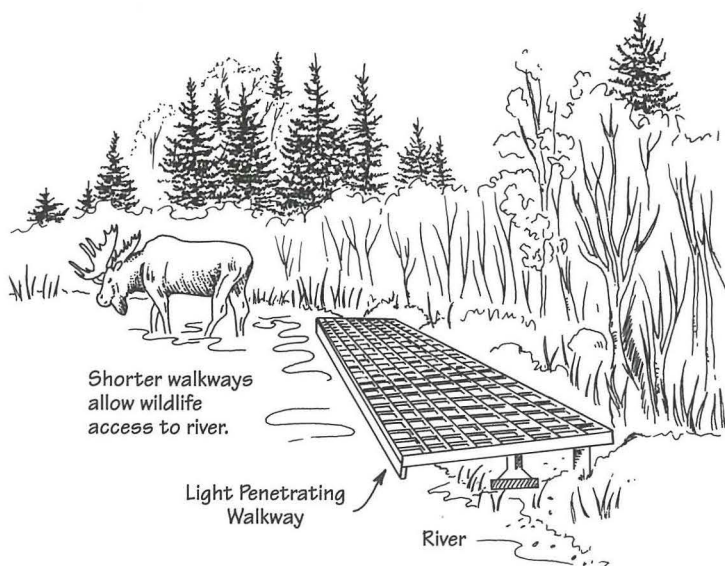
ELEVATED WALKWAYS

within 50 feet of identified waterways are at least 75% light penetrating with 8 inches off the ground or from 25%-75% light penetrating with 18 inches off the ground (Kenai Peninsula Borough Ordinance Chapter 21.18).

- Stairs or ladders can easily be attached to elevated, light-penetrating walkways to provide access into lakes or streams.
- Floating docks can be connected to walkways to provide boating access.
- Walkways can be cantilevered over a river. This will provide good fishing access while protecting riparian habitat.
- Walkway supports should be adjustable to compensate for settling.
- Walkways longer than 50 feet need to have wildlife breaks for safe passage. Avoid handrails when possible to reduce barriers to wildlife movement. If seasonal handrails are installed, remove after each season to reduce animal barriers.



Gratewalk with stair to river bed for fishing access, Kenai River





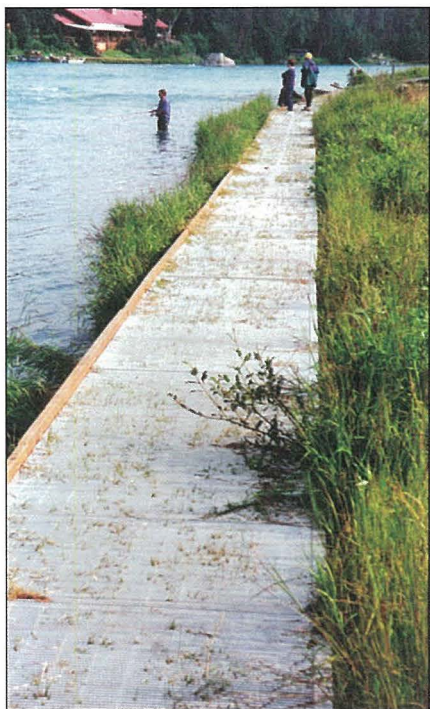
Angler access gratewalk, Slikok Creek Recreation Site, Kenai River

Advantages:

- Keeps people off vegetation, allowing native vegetation to grow
- Provides access and directs people to recreational sites
- Protects investment, stream-bank and restoration work
- Prevents trampling and erosion of vegetation
- Protects fish and wildlife habitat

Disadvantages:

- Moderately expensive
- Maintenance is required
- Certain portions may need to be seasonally removed
- Drilling pipe for walkways may be difficult and risks destabilizing banks, may require heavy machinery
- Aesthetics, not natural structure



City of Soldotna Rotary Park angler walkway, Kenai River

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Riparian or Wetland Restoration Funding/Technical Resources

Federal Financial Assistance

"Funding for Habitat Restoration Projects: A Citizen's Guide" Fiscal Year 2003
<http://www.estuaries.org/objects/FFGFY2003FullFinalv2.pdf>

Environmental Protection Agency

Clean Water State Revolving Fund

<http://www.epa.gov/owm/cwfinance/index.htm>

Five Star Restoration Program

<http://www.epa.gov/owow/wetlands/restore/5star>

Nonpoint Source Implementation Grants (319 Program)

<http://www.epa.gov/owow/NPS/>

Follow link to funding opportunities

United States Department of Agriculture

Forest Service

Taking Wing

<http://www.fs.fed.us/biology/wildlife/takingwing/index.html>

Farm Service Agency

Conservation Reserve Enhancement Program

<http://www.fsa.usda.gov/pas/publications/facts/pubfacts.htm>

<http://www.fsa.usda.gov/dafp/cepd/crep.htm>

Natural Resources Conservation Service

Conservational Technical Assistance

<http://www.nrcs.usda.gov/programs/cta/index.html>

Emergency Watershed Protection Program

<http://www.nrcs.usda.gov/programs/ewp/index.html>

Environmental Quality Incentives Program

<http://www.nrcs.usda.gov/programs/eqip/>

Watershed Protection and Flood Prevention

<http://www.nrcs.usda.gov/programs/watershed/>

Wetlands Reserve Program

<http://www.nrcs.usda.gov/programs/wrp/>

Wildlife Habitat Incentive Program

<http://www.nrcs.usda.gov/programs/whip/>

Department of the Interior

U.S. Fish and Wildlife Service Alaska Grants

<http://alaska.fws.gov/grants/index.htm>

National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service

NOAA Community-based Restoration Program

http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/index.html

Department of the Defense

U.S. Army Corps of Engineers Civil Works Directorate

Planning Assistance to States Program, Section 22 of the Water Resources Development Act

Beneficial Uses of Dredged Material, Section 204 of the Water Resources Development Act

Aquatic Ecosystem Restoration, Section 206 of the Water Resources Development Act

Section 1135 of WRDA 1986, Modifications of Corps Projects to Improve the Quality of Fish and Wildlife Habitat

Flood Mitigation and Riverine Restoration (Challenge 21)

See the link below for Sections 206 and 1135 information:

<http://www.poa.usace.army.mil/en/cw/index.htm>

Alaska Department of Fish and Game

Kenai River Watershed Cost Share Program

<http://www.sf.adfg.state.ak.us/SARR/restoration/restor.cfm>

Alaska Department of Environmental Conservation

Alaska's Clean Water Actions Grant Solicitation

<http://www.dec.state.ak.us/water/acwa/acwa%20grant/>

Other Funding Source Documents

“Catalog of Federal Domestic Assistance.” Published annually by General Services Administration.

<http://purl.access.gpo.gov/GPO/LPS1729>, (202) 708-5126.

“Catalog of Federal Funding Sources for Watershed Protection” (1999), 2nd Edition EPA Watershed Academy, Office of Water, Publication No. EPA 841-B-99-003. Searchable database at:

<http://cfpub.epa.gov/fedfund>

National Center for the Environmental Publications and Information (NCEPI), (800) 490-9198.

“Environmental Grantmaking Foundations.” Published annually by Resources for Global Sustainability, Inc.

<http://www.environmentalgrants.com>, (800) 724-1858

“Restore America’s Estuaries.” (Source of publications)

<http://www.estuaries.org/policyandfunding.php>

“A Guidebook of Financial Tools” (1999). EPA Environmental Financial Advisory Board. <http://www.epa.gov/efinpage/guidbkpdf.htm>

or e-mail: mcprouty.timothy@epa.gov

“State and Local Government Guide to Environmental Program Funding Alternatives” (1994). EPA document #EPA 841/K-94/001, Office of Water.

Permitting Links

Army Corps of Engineers, Alaska District, Regulatory Branch, Department of Army Clean Water Act (404) Permit

<http://www.poa.usace.army.mil/reg/>

Alaska Department of Natural Resources, Office of Habitat Management and Permitting, Title 41 Permit Information

<http://www.dnr.state.ak.us/habitat/title41.cfm>

Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation. <http://www.dnr.state.ak.us/parks/index.htm>

Environmental Protection Agency, NPDES Stormwater Program

<http://cfpub.epa.gov/npdes/stormwater/swphases.cfm>

Alaska Department of Fish and Game, Special Areas Program

<http://www.sf.adfg.state.ak.us/SARR/SpecialAreas/SpecialAreas.cfm>

Contact your local Borough, Municipality or village to determine if additional permits are required.

Materials and Price List

Item:	Price:
Coir log (12" diameter, 20' length)	\$125-\$165
Biodegradable fabric, C125 BM (ENC2 Equiv.)	\$122
6.67' X 108'	
Biodegradable fabric, coir mat 700 (CF7 Equiv.)	\$264
2 m X 50 m	
Galvanized stainless steel cable	
3/16" 250' spool	\$110
Galvanized stainless steel cable	
1/8" 250' spool	\$86
Duck bill earth anchor (size 68)	\$8-\$10
Felt leaf willow (per stem)	~\$1.50
Native seed*	Variable
3/16" cable ferrule	\$0.42
1/8" cable ferrule	\$0.28
Cable cutter	\$20
Rebar (1/2 inch diameter X 20')	\$5
Sledge hammer, 16 lbs.	\$30
Soil (pit run truckload)	\$100
Topsoil (truckload)	\$150
Gravel/rock (truckload)	\$150
By-pass lopper, 27"	\$20
Hand by-pass pruner	\$7-\$22
Swaging tool	\$25
Bow rake	\$5
Shovel	\$5-\$22
Extended handle drain spade	\$13-\$20
Biodegradable twine	
Spruce tree - installed by the foot	\$13-\$50, Contractor
Root wad - installed by the foot	\$175-\$300, Contractor
Elevated light-penetrating walkway (4' wide)	Contractor
Installed by the foot	
For aluminum (on Kenai)	\$100-\$160
For steel (on Kenai)	\$95-\$250

*See ADNR website: http://www.dnr.state.ak.us/ag/ag_pmc.htm

Please note that these prices were quoted for 2004 and will change. These are only estimates to be used for initial project preparation. Varying prices will result from consultation with stores and contractors, depending on date, locality, and conditions.

Contacts

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Spawning sockeye salmon. Grouse Creek, Alaska. Note naturally vegetated bank