TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE Portland, Oregon SOIL CONSERVATION SERVICE

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STREAMSIDE REVEGETATION

Stream corridors are major sources of erosion in the Pacific Northwest. People's activities (such as logging, urban development, grazing, cropping, and recreational development) in watersheds have increased surface runoff, removed protective riparian vegetation, and altered flow alignment, often with catastrophic effects. Roughly 10 million tons of sediment come from eroding streambanks each year in Oregon and Washington, much of it caused by people.[1/]

Erosion and Stream Geomorphology

The treatment of streambank erosion, vegetative or otherwise, depends on stream geomorphology and the causes of erosion. Bauer (Palmer 1976) describes four geohydraulic zones for western Washington and Oregon:

1. Boulder zone: located in mountainous terrain, with steep gradients, primarily vertical erosion, narrow channels, and frequent rapids.

2. Floodway zone: braided or shifting stream channels, with alluvial valley floor, moderate gradients, channel islands.

3. Pastoral zone: deep meandering channels, with wide valley floors, natural levees, floodplains, and gradients less than 1 meter/kilometer.

4. Estuarine zone: branching channels in tidal marshes, flat or negative gradients.

Somewhat similar conditions also exist in eastern areas of both states (except for estuarine zones).

Streambank stabilization efforts generally are limited to the pastoral or meandering zones. Some protection can be provided in the floodway or braided channel zones if the stream is allowed room to move. Estuarine zone work consists primarily of tidal zone stabilization or diking and will not be considered in this note.

Streambank erosion can be attributed to: (1) natural processes, (2) upper watershed disturbance, (3) loss of resistant riparian vegetation, and (4) altered alignment of stream flow.

Natural processes are a major cause of erosion in the boulder or floodway zone. Erosion in these areas cannot be treated with vegetation because of stream velocities. Structural measures in these zones also are of questionable value and, therefore, usually not recommended by the Soil Conservation Service.

1/ Extrapolated from a streambank erosion inventory in Oregon (Oregon State Soil and Water Conservation Commission, 1972).

Increased flow from upper watershed disturbance aggravates channel shifting in the floodway zone, and accelerates meandering in the pastoral zone. In many instances, natural vegetation does not provide sufficient resistance to counteract this increased flow. Planted vegetation, therefore, cannot be expected to offer much greater resistance.

Loss of riparian vegetation in the floodway zone has little effect on bank erosion. The effect, however, in the pastoral zone is major. Together with increased flow, depleted riparian vegetation causes tremendous soil erosion. However, revegetation can provide significant resistance to bank scouring in the pastoral zone, because lower velocities permit plant establishment on most of the streambank.

Stream channel alteration (narrowing, straightening, diverting, etc.) also can greatly increase bank erosion if not considered in planning and implementation. Vegetation offers little resistance in downstream responses to improperly designed stream alterations. Erosive forces within a channel alteration generally preclude use of vegetation to stabilize streambanks, except in support of other efforts.

Stream Corridor Management

Revegetation, as well as other treatments, must be consistent with overall management of the stream system. Recently, some landowners have coordinated management of stream corridors. Massive structures are not feasible economically or environmentally for all the thousands of miles of eroding banks (inventoried at 3,800 miles in Oregon; Oregon State Soil and Water Conservation Commission, 1982). Revegetation, therefore, becomes an important part of erosion control efforts that minimize structural treatment. Fish and wildlife, aesthetic, and recreational values in stream corridors require that revegetation be emphasized for treating bank erosion.

Vegetative Design Criteria

Streambank revegetation, as indicated above, is limited to slower-moving reaches with relatively flat gradients (less than 1 meter/kilometer) or in combination with structural measures on somewhat faster streams. In this note, revegetation is the planting of woody shrubs and trees, with appropriate understory cover of grasses and legumes, in the natural stream corridor. Several factors should be considered in the design of vegetative treatments.

The ability of riparian plants to resist erosive stream flows. Parsons (1964) indicates, "...the principle function of a vegetative lining is to keep fast-moving water and transported coarse materials away from the bank surface... therefore the lengths, number per unit area, and physical qualities of the tops are the most important attributes of the lining." Roots also are important, keeping the plants in place and providing some physical resistance to flow. Certain grasses dissipate energies in grassed waterways where flow does not exceed 2.5meter/second (8 feet/second) for short duration, SCS, 1947. Shrub willows, with high basal stem densities, probably withstand similar velocities and have been shown to be equivalent to a riprap diameter of 15 centimeters (6 inches) (Parson, 1963). In Oregon and Washington, SCS

uses vegetation for bank protection (with structural toe protection, where needed) where average stream velocity through the immediate reach does not exceed 2.5 meters/second. Bend curvature and bank slope are considered for additional constraints on revegetation.

Effective shrub vegetation should have high basal densities, pliable stems, establish quickly, regenerate where damaged, and provide a uniform lining when mature. An ideal shrub lining provides nearly a million pliable stems per hectare within 2 meters of the bank surface 3 years after planting.

A three-year establishment period for woody plants limits the use of vegetative treatments for portions of banks subject to frequent erosive flows. Jetties, riprap linings, or other suitable measures may be needed to control erosion on these lower bank areas and enable vegetative treatment on the rest of the bank.

In some cases, natural revegetation may recolonize the site as rapidly as planted revegetation. Each site should be inventoried for seedling counts and species composition to determine regeneration potential. However, several thousand naturally established alder or cottonwood seedlings per hectare will produce cover inferior to equivalent or greater densities of planted willows, which have a more desirable growth form for erosion control. Natural regeneration should provide the lining required in three years, or be supplemented or replaced with planted vegetation.

To be effective, shrub plantings must provide a lining at least 3 meters (10 feet) wide and preferably wider. The wider the lining, the less vulnerable the streambank is to erosive forces of overland floodwaters returning to the stream channel. A suitable shrubby vegetative "buffer strip" will trap or deflect debris which can cause severe scour on the upper portions or top of inadequately vegetated banks (even though most of the bank is protected by structural means).

To be suitable, an understory cover of grasses and legumes should establish quickly, be somewhat shade-tolerant, and not compete severely with planted woody vegetation.

Site Conditions and Stream Hydraulics. Measurement of flow characteristics within a stream and an inventory of contributing site conditions are essential for successful revegetation. As indicated, revegetation generally is feasible in stream reaches where average stream velocities do not exceed 3 meters/second. However, other factors may lower the effectiveness of vegetation.

Toe stability is essential. Vegetation will not protect the bank surface below the normal waterline (water-vegetation interface), and, indeed, will fail on the upper bank if the base of the bank is not stable. Klingeman (1976) indicates natural erosion control (revegetation without toe protection) is possible on the Willamette River (Oregon) away from sharp changes in flow alignment and locally concentrated flows. Such locations have low gradients and include straight reaches, convex banks (inside curves) or river bends, and concave banks (outside curves) with flat curves (curve radius: stream width ratio of 10-12). Toe stability in such situations also depends significantly on resistance of the soil to erosion. In any case, the toe must be stable, or made stable, prior to revegetating.

Bank slope also affects the performance of vegetation. Klingeman (1976) concludes a 3:1 bank on the Willamette River experiences only moderate velocities whereas a 1½:1 bank encounters high velocities and severe erosion over most of its surface. This is important because revegetation requires establishment periods up to 3 years. As a rule of thumb, vegetation should be planted on 2:1 slopes or flatter, where riprap protects the bottom of the slope, 3:1 slopes or flatter where structures are not needed or jetties are used.

Bank irregularities cause local scour that may lead to greater failure if not treated. This is especially true where toe protection is not installed, or where thick, shrubby linings change rapidly to low density or grassy vegetation.

Compatibility with Structural Treatments. Revegetation treatments often have to be installed in combination with structural measures. Two common structures are riprap and jetties.

Riprap is the placement of rock on the bank surface (usually on a gravel filter) to resist scour, piping, and sloughing of banks. Riprapped areas and upper banks should be seeded to grasses and legumes. However, woody plantings are limited to upper banks except where deposition occurs in the riprap. If riprap is placed too high up the bank (well above the water/vegetation line) shrub plantings may not provide satisfactory fish or wildlife habitat until natural vegetation invades in the rock. Shrub plantings into riprapped areas, where possible, may be desirable to suppress invasion by cottonwoods, alder, or other less desirable species. However, establishment is difficult and may not justify a planting effort. Ideally, riprap should be the minimum required to provide toe protection.

Permeable jetties are structures (often rock) which are placed at an angle with the streambank to direct the current away from the bank and encourage deposition. They are especially conducive to reestablishing vegetation from the water/vegetation line up the bank surface. Jetties usually are more compatible with revegetation efforts than riprap.

Fish and Wildlife Habitat. Riparian zones provide unequalled interspersion of food, water, and cover for innumerable fish and wildlife species in Washington. Streambank revegetation treatments should maintain or reclaim this habitat and/or mitigate the loss of habitat following structural treatments. Revegetation should provide a floral diversity common to the immediate natural riparian zone.

Sediment is the most widespread and destructive water pollutant of fish habitat. Bank vegetation not only minimizes erosion but also intercepts sediment from adjoining lands. Bank linings should be as wide as possible to adequately filter the sediment.

Riparian zone width also is crucial to wildlife populations. As a rule of thumb, 50 meters (average of 25 meters on each side of the stream) is a minimum stream corridor width for indigenous wildlife habitat. (Mudd, 1975).

Shading and stream debris are essential components of fish habitat. However, tall leaning trees, fallen trees, and other debris pose erosion hazards and may need to be removed, preferably with hand labor, as part of a revegetation treatment. Revegetation should attempt to replace this loss of habitat. The desire to maintain certain fish or wildlife populations may cause a reassessment of proposed erosion control treatments.

Adapted plants for Oregon. Streambank revegetation involves planting a herbaceous seed mixture on the prepared site followed by a mass planting of woody shrubs. See Interagency Seeding Guide for suitable seed mixtures.

Shrub plantings require willows to provide quick growing erosion-resistant cover. For western Oregon and Washington, Pacific willow *(Salix lasiandra)* and erect willow *(Salix ligulifolia)* may be recommended. It is very common and easily located for sources of cutting stock. It is characterized by long, linear, shiny, green leaves (peach leaf-like). For eastern Oregon and Washington, coyote willow *(Salix exigua)* isrecommended in the Columbia Basin and Plateau and adjoining areas where it is found. It has narrow linear leaves with a gray or silvery appearance and suckers profusely, forming thickets (found normally on sandbars). In mountainous regions, Pacific willow, Scouler willow, or similar species can also be used. In coastal areas Hooker willow can be used.

Several other native shrubs can be used to provide diversity to a streambank treatment.

Western Oregon and Washington	Eastern Oregon and Washington
redosier dogwood *(Cornus stolonifera)*	redosier dogwood
snowberry *(Symporicarpos albus)*	snowberry
wildrose *(Rosa nutkana)*	wildrose
vine maple *(Acer circinatum)*	blue elderberry *(Sambucus caerulea)*
serviceberry *(Amelanchier sp.)*	serviceberry
western hazel *(Corylus cornuta)*	ninebark *(Physocarpus malvaceus)*
douglas spirea *(Spirea douglasii)*	black hawthorn *(Crataegus douglasii)*

These and other species should be planted as rooted stock (preferably at least two years old) because they cannot establish rapidly and compete effectively unless larger, older stock is used.

Cottonwood *(Populus sp.)* alder *(Alnus sp.)*, or other tall, fast-growing species are not recommended for bank plantings because they are prone to topple when mature. These and other trees, if planted, should be set back with a protective shrub lining between the trees and stream.

Methods of Establishment. Herbaceous plants are seeded on streambanks according to normal procedures used for critical area plantings (SCS, 1976). Seeding should be accomplished as soon as site preparation is finished. Sloping should result in a seedbed suitable for planting.

Shrubs should be planted at high densities, preferably 50,000 plants/hectare (20,000/acre). This density results in a spacing of 45 x 45 cm to 90 x 90 cm (18 x 18 inches to 3 x 3 feet). The high planting rate precludes extensive use of potted stock and requires willows as the primary species. Willows are planted as hardwood cuttings (25-45 cm long, 1-2 cm diameter or 12-18 incehs, 3/8-3/4-inch diameter), usually in the spring as native shrubs begin to produce new leaves. Larger cuttings, "whips," 4 feet or greater in length and greater than 1 inch diameter may also be planted. However, they can be planted during the dormant season as early as November. Cuttings are planted perpendicular to the bank surface, preferably leaving no more than 2 shoot buds above ground. Tops of cuttings can be dipped in a white exterior latex paint to prevent moisture loss from the top and indicate which end to plant up.

Potted or rooted shrub stock is planted using conventional procedures used in landscaping and reforestation efforts. Potted stock should be used for floral diversity, only. However, natural succession on a planted streambank will eventually provide a diverse bank cover.

Maintenance and Protection of Vegetation. All plantings must be allowed to establish and control erosion as specified. This may require fencing to restrict grazing, human use, or other potential damage to the vegetation.

As with other treatments, spot failures should be promptly repaired. Left unrepaired can lead to substantial failure of the vegetative lining.

Mature trees in danger of toppling should be cut a few inches from the ground. Usually such trees (cottonwood, alder) sprout profusely after cutting and provide excellent bank cover for several years before becoming mature again.

Installing Revegetation Treatments

A few simple steps are required to plan and install streamside revegetation. First, the proposed treatment should be compatible with the management plan (if developed) for the stream corridor. In the absence of a guiding overall approach, the probable impact on the stream system should be appraised. In fact, Washington and Oregon require environmental assessments of fish and wildlife resources prior to obtaining the necessary permits to work in stream corridors. Ensuing steps include the following:

Inventory site conditions. SCS has developed design criteria for erosion control treatments in stream corridors (Soil Conservation Service, 1986). Site investigations crucial to designing vegetative treatments include the following: (1) obtain cross-sectional area, gradient, and other hydraulic data to determine potential average stream velocities or other measure of the erosive force of water upon the bank to be treated. SCS

design velocities are based on a bank full condition. Point bar vegetation and final bank slope should be considered in determining cross-sectional area, (2) obtain soil particle size distribution to determine bare bank resistance to erosion and the kind and magnitude of toe (and lower bank) protection needed to establish vegetation, (3) inventory existing adjacent shrubs and trees to select appropriate species to plant.

Determine feasibility of vegetation. If average stream velocities do not exceed 2.5 meters/second (10 feet/second), vegetation should be considered on the bank to be treated. Stream radius-stream width ratios should not be less than 6, the toe must be stable, and the bank slope no steeper than 2:1. If these parameters are exceeded, structures should be specified to establish and support vegetation.

Develop streamside revegetation specifications. Vegetative plans should be incorporated in a total treatment plan (including structural measures). Specification items for revegetation include:

I. Site Preparation: Remove bank irregularities that may cause local scour. Shape bank as needed to obtain the desired slope and planting surface.

II. Grass-Legume Seeding. Broadcast the appropriate seed mixture over the site followed by covering with soil and/or suitable mulch. Fertilize lightly to avoid excessive competition with subsequent shrub planting (unless site is extremely infertile).

III. Shrub Planting: Plant willow cuttings and rooted shrubs at a ratio of 20 cuttings or more per rooted shrub. Rooted stock may be planted in clumps interspersed throughout the site.

IV. Protective fencing: As needed, install permanent or temporary fencing suitable to prevent grazing or other encroachment on the planted area.

V. Width of Vegetative Treatment: Planting, alone or in combination with sufficient existing bushy vegetation, shall provide a "buffer strip" at least 3 meters (10 feet) wide.

Contract the job. Discounting bank shaping, revegetation generally costs less than 1/10 of equivalent protection offered by riprap. Commercial nurseries and landscaping firms, as well as service groups and individual landowners, are potential bidders for revegetation contracts.

Summary

1. Several thousand miles of eroding banks in the Pacific Northwest preclude massive structural treatments as major means of erosion control. Revegetation must be a major part of any solution. Revegetation costs generally do not exceed 1/10 the cost of equivalent riprap coverage.

2. In geomorphological zones where most erosion is natural, revegetation (as well as structural treatment) is tenuous at best. Erosion control treatments are best suited to meandering zones where human activity is often a major cause of erosion.

3. Revegetation success depends on fitting treatment to hydraulic conditions of the stream and stream corridor management considerations including agricultural and urban development, fish and wildlife habitat, aesthetics, and recreation.

4. Revegetation specifications are developed based on an inventory of stream hydraulics and other site conditions and a design criteria that considers adapted plants and their erosion control characteristics, the hydraulic limitations of revegetation, desired fish and wildlife habitat, and suitable methods of installation and maintenance.