Riparian/Wetland Project Information Series No. 9

August, 1995

DESIGN CRITERIA FOR REVEGETATION IN RIPARIAN ZONES OF THE INTERMOUNTAIN AREA

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ABSTRACT

The design criteria for the Soil Conservation Service channel vegetation practice for the Intermountain area consider watershed condition, geomorphology, stream types, community types, stream size, velocity, sinuosity, and bank slope, uniformity, and stratigraphy. Performance standards address benefits to soil stability, fish and wildlife habitat, water quality, and esthetic and recreational value. Specifications are developed for mass, pole, and stump or post plantings. Certain bioengineering practices also are applicable for riparian zones.

INTRODUCTION

The channel vegetation practice (Soil Conservation Service 1977) is a relatively recent addition to the Soil Conservation Service (SCS) National Handbook of Conservation Practices. Although SCS has been actively involved with vegetative treatment in riparian zones since the inception of the agency in the 1930's, it usually was accomplished as an auxiliary treatment within structurally oriented practices, such as open channel, streambank protection, and stream channel stabilization. With increasing concerns, including fish and wildlife habitat, water quality, water conservation, and esthetics in addition to erosion control and water conveyance, SCS consolidated its riparian vegetative technology into the channel vegetation practice in 1977.

The Practice standard definitions for channel vegetation is the establishment and maintenance of vegetation on the banks of open channels, streams, and ditches. The practice imparts several conservation effects: bank stability, increased fish and wildlife habitat index values, filtered surface runoff from adjacent lands, improved watershed hydrologic condition, and increased esthetic and recreational value. Most SCS State Offices have supplemented the national standard with practice design criteria tailored to physiographic regions (examples include Carlson 1979; Soil Conservation Service 1986). Although not excluding herbaceous species, the practice focuses on the use of woody vegetations to achieve the desired effects.

The channel vegetation practice primarily is used for treatment in riparian zones along streams. Streams include those types classified by Rosgen (1985), or the riverine wetland/deepwater systems described by Cowardin and other (1979). The revegetation technology of the practice also applies to transition (riparian) zones along reservoirs and lakes. In contrast, the SCS wetland restoration and development practice (Soil Conservation Service 1989) addresses vegetative treatment within marine, estuarine, lacustrine, and palustrine wetland/deepwater systems.

SCS currently defines riparian zones as natural ecosystems occurring along watercourses or water bodies, occupying the transitional area between terrestrial and aquatic ecosystems. It is evident in the literature that a widely accepted classification system for delineating riparian ecosystems in relation to aquatic and terrestrial ecosystems, and for classifying sites within riparian zones, has not been fully defined (see Brown and other 1979; Driscoll and others 1984; Kovalchik and Chitwood 1990; Minshall and other 1989; Swanson and others 1988). However, despite this, the concept of riparian zones is sufficiently clear to develop sound design criteria for revegetation.

The intent of this paper is to update the design criteria for the SCS channel vegetation practice for riparian zones in the Intermountain area, drawing on recent research findings, resource inventories, and technical reports.

INITIAL DESIGN CONSIDERATION: CONDITION OF THE WATERSHED

Riparian zones inherently are dynamic and very sensitive to changes in management that affect the hydrology of the watershed. Revegetation specialists must be familiar with the condition of upland vegetation and trends in composition and use. If the hydrology of the watershed is affected by overgrazing, excessive logging, major construction, or other activity, and this is visibly evident in the reaction of the stream within the riparian zone, a channel vegetation planting will have a greatly increased chance of failure.

Use historical information, aerial photos, condition of existing riparian zone vegetation, and other aids to assess whether the stream is in equilibrium with the management of the watershed. If not, upland management treatments probably are necessary before it is safe to install the channel vegetation practice.

PRIMARY DESIGN CONSIDERATIONS: GEOMORPHIC VALLEY-FORM, STREAM TYPE, AND COMMUNITY TYPE.

Riparian plantings often fail because they are subjected to hydraulic forces during high stream flow that exceed their capability to withstand, especially during the establishment period. Revegetation specialists should use geomorphic valley-forms described by Minshall and other (1989) for the Great Basin as in initial guide for determining the feasibility of installing the channel vegetation practice. The classes of geomorphic valley-forms are glacial headwaters, glacial valleys, erosional fluvial canyons, depositional fluvial canyons, alluvial valleys, and lacustrine basins. Valley-form classes also are similar to and not inconsistent with the riparian landforms described by Kovalchik and Chitwood (1990) for parts of eastern Oregon.

The six geomorphic valley-forms can be correlated to the stream types described by Rosgen (1985) and to vegetation community types described by Youngblood and others (1985), Padgett and others (1990), and inferred from Brunsfeld and Johnson (1985). In doing so, alluvial valleys are subdivided into a mid-and-low elevation phase, and braided stream channels are dealt with separately.

GLACIAL HEADWATERS AND VALLEYS

These two geomorphic classes are combined and include palustrine wetlands in glacial basins high in organic matter, and broad U-shaped valleys containing rivulets and small streams.

Stream Characteristics-Small, low-order streams, probably Rosgen C-type; highly permeable substrate provides underground reservoir, which minimizes flooding during high precipitation and runoff; low velocity, often meandering.

Vegetation-Primarily wetland species (*Carex, Eleocharis, Juncus*), with levees and hummocks supporting low-growing willows *Salix planifolia, S. wolfii.*

Revegetation Potential-Stream should be allowed to move within confines of broad valley in most situations; revegetation should focus on restoration of unnaturally disturbed sites, using native willows on levees and hummocks.

EROSIONAL FLUVIAL CANYONS

Stream Characteristics-High-gradient, high-velocity, highly confined, down-cutting, low- to mid-order streams in V-shaped canyons; corresponds to Rosgen A stream types.

Vegetation-Narrow band of riparian vegetation along stream with primarily deep-rooted species; community types include dominants river alder (*Alnus incana*), water birch (*Betula occidentalis*), and aspen (*Populus tremuloides*); associated species are native Booth and Geyer willows (*Salix boothii, S. geyeriana*), chokecherry (*Prunus virginiana*), serviceberry (*Amelanchier* spp.), dogwood (*Cornus* spp.), mockorange (*Philadephus* spp.), and other forest shrub understory species.

Revegetation Potential-Relatively low due to high flow velocities; plantings usually will have little impact other than esthetic, unless most of the canyon vegetation, including riparian, has been destroyed; planting must be made in protected areas behind boulders and along small backwaters; bioengineering techniques, such as wattling and fascines, may be employed to control canyon slope sloughing into stream.

DEPOSITIONAL FLUVIAL CANYONS

Stream Characteristics-Moderate to high gradient and velocity, moderately to highly confined, low- to mid- order streams in V-shaped canyons, where deposition has occurred with the formation of a small flood plain; canyon walls confine stream, restricting meandering; corresponds to Rosgen B stream types; flow regimes are characterized by high disparity between maximum and minimum discharges, resulting in scoured floodplains or incised channels.

Vegetation-Stream terraces support relatively deep-rooted river alder, water, aspen, or cottonwood (*Populus trichocarpa, P. angustifolia, P. fremontii*); dogwood, serviceberry, and chokecherry are common shrub components; Geyer and Booth willow are the most common willows, but also prevalent are whiplash willow (*S. lasiandra* ssp. *caudata*), sandbar willow (*S. exigua* ssp. *melanopsis*), and Drummond willow (*S. drummondiana*).

Revegetation Potential-Relatively low due to high flow velocities and floodplain scouring; effects of revegetation are low unless the riparian zone and adjacent uplands have been drastically disturbed; plantings usually are limited to supplementing structures built on the floodplain, such as bridges; plantings must be made in protected areas; bioengineering techniques, such as live cribwalls, may be successful.

BRAIDED STREAM CHANNELS

Stream Characteristics-Moderate gradient and velocity, unconfined braided channel form; often located where fluvial canyons empty into broad valleys and deposit coarse sediments; these zones are naturally highly erodible; corresponds to Rosgen D stream types.

Vegetation-Gravel bars and secondary channels may support cottonwood, sandbar willow, and other species that establish on freshly deposited sediment.

Revegetation Potential-Poor to fair; plantings are vulnerable to channel shifting; stream should be allowed to move as needed; consider establishing, protecting, and maintaining parent trees and shrubs as seed sources if large areas are denuded.

MID-ELEVATION CONFINED ALLUVIAL VALLEYS

Stream Characteristics-Low gradient and velocity; meandering pattern; small-to medium-sized, low-to mid-order streams, usually moderately confined; 5,000-7,000 feet elevation in north, higher moving south; corresponds to Rosgen C stream types.

Vegetation-Booth and Geyer willow dominate most communities on soils too waterlogged for deeper rooted alder, birch, and cottonwood; deeper rooted species may occur on small terraces where access to aerated water is available.

Revegetation Potential-High, using Booth and Geyer willow as primary species; river alder, water birch, and cottonwood may be planted where site conditions permit.

LOW-ELEVATION UNCONFINED ALLUVIAL VALLEYS

Stream Characteristics-Low gradient and velocity, highly sinuous, slight to no confinement; corresponds to Rosgen C stream types; sediments are much finer, but substantial water may percolate into the valley groundwater reservoir; evaporation also is significant in large, hot, arid Great Basin valleys; streamflow may be greatly reduced as it proceeds to lacustrine basins.

Vegetation-Black cottonwood (north and west), narrow-leaf cottonwood (east), and Fremont cottonwood (south), are very common depending on location within the Great Basin; usually associated with coyote willow (*Salix exigua* var. *exigua*) and yellow willow (*S. lutea*); for smaller streams, these two willows may be the dominant woody vegetation on soils too waterlogged for cottonwood.

Revegetation Potential-High, using native cottonwood or willow; a typical planting along medium to large streams includes willows established at the waterline and cottonwoods with understory shrubs on the upper bank and low terraces.

LACUSTRINE BASINS

Stream Characteristics-Slow-moving, often ephemeral streamflow; often saline-alkaline soil conditions; may terminate into saline lake, dry lake bed, or playa.

Vegetation-May include cottonwood and willow if in a freshwater environment, or salt-tolerant species such as saltcedar (*Tamarix* spp.) or introduced Russian olive (*Elaeagnus angustifolia*); intermittent streams may support saltbushes (*Atriplex* spp.), greasewoods (*Sarcobatus* spp.), or rabbitbrushes (*Chrysothamnus* spp.).

Revegetation Potential-High, where not excessively saline-alkaline, using native species.

ADDITIONAL DESIGN CONSIDERATIONS

In general, low-to mid-order meandering streams are more suitable for revegetation than larger streams, which can be more likely to have catastrophic flooding events with localized highly erosive flow velocities. For small streams, the ratio of revegetation biomass to volume of flow is greater and more favorable for stability purposes. For larger streams, the point of greatest erosive force often lies below the low waterline on the outside of meanders, making plantings vulnerable to undercutting unless the toe is stabilized structurally. Large streams also are more susceptible to ice flows, which can scour and denude a vegetated streambank. On the other hand, larger streams often are dammed for flood control and irrigation, which tends to reduce spring peak flows and produce long-duration moderate flows during the summer.

STREAMFLOW VELOCITY

Where woody revegetation is subject to direct attack during high-water events, average stream velocity for mid-to-large streams should not exceed 5 feet per second for extended durations. A fully revegetated streambank can withstand flows up to 8 feet per second for relatively short duration. There is very little published information on the relationship of the stability of woody bank linings to flow velocity. Parsons (1963) evaluated streambank willow plantings in the Northeastern United States and equated a fully developed stand of densely stemmed purple-osier willow (*S. purpurea*) to a blanket of 6-inch angular riprap. Other than this useful information, the criteria given here are inferred primarily from field experience and from research on the hydraulic resistance of grassed waterways (Temple and others 1987).

Average stream velocity through the reach to be treated should be computed using data obtained from at least three representative cross-sections (usually above, below, and midpoint; or point bar, outside curve, next point bar on meandering streams). Stream gradients are below 1 percent, with greatest success when approaching and less than 0.1 percent.

STREAMBANK SLOPE AND UNIFORMITY

Vegetative performance is affected by bank slope. For example, a 3:1 bank on a large stream will experience only moderate velocities, but a 1.5:1 bank (natural repose) will be subject to high velocities and significantly more erosion (Klingeman and Bradley 1976). Therefore, streambanks to be treated should be 3:1 or flatter, except for those between jetties, which may be 2:1 or flatter.

Bank irregularities cause local scour, which often leads to greater failure. Examples are uneven bank surfaces, abrupt changes in density and form of riparian vegetation, trapped debris, and changes in soil type. Each must be considered for its effect on the energy of the stream. Insofar as possible, a streambank on mid-to large-sized streams subject to upper flow velocity limits should be made as uniform as possible before planting.

STREAMBANK STRATIGRAPHY

The stability of a streambank also depends on the layers of deposited materials through which the stream has incised. Fine-textured bank soil may be quite resistant to stream tractive forces or seepage pressure, but erosion of an underlying gravel layer may cause undercutting and collapse of the entire bank. Vegetative treatment may need to be supplemented with structural measures for complex situations.

REVEGETATION PERFORMANCE CRITERIA

Conservation effects of the channel vegetation practice can be measured or estimated for the various resources it impacts.

SOIL STABILITY

Vegetative bank protection is provided by: (1) above-ground stems diffuse erosive tractive force of water against the bank surface, and (2) the root mass, when exposed, provides and "armored" blanket resistant to erosion. No visible sign of bank erosion or bank sloughing should be evident. Stem densities are high enough to preclude passage by livestock, and with difficulty, by humans.

WILDLIFE HABITAT

Riparian zones provide more diverse food, water, and cover for wildlife than most other ecosystems. Streambank plantings can maintain or reclaim habitat where competing land uses tend to reduce plant diversity and density along streams. Plantings should be as diverse in composition as the major components of the target plant community type.

Mudd (1975) found that optimum wildlife habitat value in eastern Washington along the Touchet River was realized when riparian zones were approximately 150 feet wide. This width is recommended for medium-to-large streams in the Intermountain area for plantings focused on wildlife habitat. Where possible, determine habitat suitability indices (U.S. Fish and Wildlife Service 1980) for target wildlife species to assess benefit of riparian plantings.

FISH HABITAT

Analyze benefit to fish habitat by using comprehensive procedures recommended by Platts and others (1987) to evaluate shading and other fish habitat factors in the stream reach that has been revegetated. Use fish models to determine habitat suitability indices for target species.

It should be recognized that bank stability recommendations, which emphasize reduction of stream irregularities, may conflict with fish habitat recommendations, which encourage bank undercuts and diverse microenvironments within the stream. In general, a channel vegetation practice should not reduce habitat for target fish species, and with few exceptions, should increase its value.

WATER QUALITY

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. Riparian vegetation should be as wide as possible to adequately filter the sediment, with a recommended minimum width of 20 feet for this purpose, preferably wider. These buffer strips also should contain sufficient herbaceous understory plants and litter for adequate ground cover at the bank surface.

TYPES OF CHANNEL VEGETATION PLANTINGS

High-density mass plantings utilize hardwood cuttings or whips, bareroot seedlings or rooted cuttings, and container transplants planted 1 to 3 feet apart. This type of planting often is employed on bank slopes between jetties, slopes above riprap placed to the low-water mark, and on graded, set-back banks along low-velocity streams.

The intent is to maximize stem densities on the bank. As plant material usually is small, favorable planting conditions, including good moisture and slight to no weed competition, are required for success.

POLE PLANTINGS

Dormant poles, ranging to 20 feet in length of easily rooting species, such as cottonwoods, are used in more difficult conditions. Poles are used to reach water tables to ensure rooting, provide enough aboveground height to escape shading by weeds and browsing by large animals, and to resist burial by bank sloughing. Pole plantings are less likely to wash out due to greater structural attributes.

STUMP OR POST PLANTINGS

These are similar to pole plantings, except that larger diameter plant material is used, and lengths usually range from 6 to 10 feet. The best species are tree willows. Structural properties are emphasized, using "piling" or "breakwater" concepts. Larger stumps have thick bark, which resists wind, sun, and sand abrasion. Stumps also are planted into the water table to ensure rooting. On small streams, shrub willows may be used for smaller scale stump plantings, and are especially useful in incised channels where bank sloughing is prevalent.

BIOENGINEERED VEGETATIVE STRUCTURES

These may include willow wattles, fascines, and live cribwalls, among other techniques (Gray and Leiser 1982). Design criteria and specifications for these practices are under development as a supplement to the SCS Engineering Field Manual.

CHANNEL VEGETATION PRACTICE SPECIFICATIONS

Exposed streambanks to be planted must be shaped to recommended uniformity and slope, and the toe of the bank must be stable. If possible, the upper end of the planting should be within a stable reach of the stream. For mass plantings, remove existing weeds and as much of the weed seed source in the topsoil as possible by grading or tillage. Surface water from adjacent uplands must be diverted or conveyed through the planting area in a nonerosive manner.

Water must not be deflected against the bank during the establishment period, so instream debris management may be advisable.

PLANT MATERIAL

Use species native to the indigenous community type. Commercially grown nursery stock is higher quality and results in higher establishment rates. Native stand sources may be decadent, with inadequate carbohydrate reserves for good survival, and not extensive enough for large projects.

Hardwood cuttings should be a minimum of 18 inches long and 0.5-inch bottom diameter; whips 3 to 6 feet long, and minimum 0.75-inch diameter; poles 8 to 20 feet long, and 1.5 to 5 inches to diameter; and stumps 4 to 10 feet long, and 2 to 8 inches in diameter. Butt ends of larger dormant stock should be cut at a 45-degree angle, and the growing end cut flat and treated with tree paint or other suitable sealant. Stump bark should be scored with a sharp object to encourage rooting.

Bareroot or container transplants should comply with common nursery quality standards.

PLANTING CONFIGURATION

Visualize the mature planting and whether it will deflect flows and provide other desired benefits. Plantings should provide a minimum-width bank lining of 20 feet. Mass and pole plantings should be a minimum of two parallel rows wide in staggered or diamond pattern, with no breaks or gaps in the planting. Stump plantings may be planted in a single, unbroken row at the base or below the toe of the bank.

Mass planting spacings range from 1.5 to 3 feet; pole and stump plantings 2 to 6 feet, depending on size of the plant material. Spacings may be somewhat wider on the upper bank.

PLANTING METHODS

All dormant cuttings, whips, poles, or stumps must be planted to the summer water table depth, if necessary using augers to drill sufficiently deep holes to reach moisture. Bareroot or container plants may be planted at or just above the waterline, or on upper banks if weed competition is slight and moisture adequate. Comply with standard woody transplanting procedures (see Platts and other 1987).

Where bank sloughing is a potential problem, minimize burial by planting at an angle nearly perpendicular to the natural angle of repose.

Consider installing the practice in stages, particularly if both sides of the stream are being planted. Plant outside curves first, and plant remaining sites, if needed, after the initial plantings establish.

PLANTING DATES

In plant-hardiness zones 6 and below (average annual minimum temperatures below °F), install plantings in the early spring in March to mid-April; in zones 7 and above, from November to early March.

WEED CONTROL

Expect many weeds the first year as riparian zones contribute a wide variety of wind-and waterborne seed, mostly undesirable (often noxious) introduced weeds, to a newly planted bank. A typical erosion control seeding may provide severe competition to woody plantings and may encourage rodent populations, which may girdle woody plants. Consider mulching with gravel or bark around woody plantings in lieu of seeding groundcovers. Bank areas not planted to woody plants should be seeded to reduce safe sites for weed invasion.

GRAZING OR BROWSING MANAGEMENT

Plantings require 3 years of unimpeded growth to fully establish. Provide protection from browsing by large animals as necessary.

MAINTENANCE

Replant any failed portion of the practice during establishment and succeeding years. If stability is the primary objective, consider periodic pruning to maintain or increase stem densities. Riparian zones are dynamic, so expect changes in stream course, plant composition, and structure. Continuous monitoring is recommended.

TECHNOLOGY NEEDS

To strengthen the design criteria for the channel vegetation practice in the future, the following actions are recommended:

1. Develop a consensus among resource agencies and groups on a hierarchical riparian site classification, which will enable individual riparian sites to be rated for suitability for revegetation.

2. Conduct further research into the relationship between performance of bank vegetation and the hydraulic properties of the stream.

3. Conduct research on the compatibility of herbaceous groundcovers with woody plants in riparian plantings.

4. Develop monitoring procedures and a data/knowledge base that capture the long-term performance of channel vegetation plantings made throughout the Intermountain area.

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The Interagency Riparian/Wetland Plant Development Project is sponsored and funded by: USDA Natural Resources Conservation Service (Idaho & Utah), USDI Bureau of Land Management, USDI Bureau of Reclamation, US Fish and Wildlife Service, US Forest Service, Idaho Fish and Game, Idaho Transportation Department, and Idaho Power Co.
