Riparian Zone Restoration:

Field Requirements and Nursery Opportunities

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ABSTRACT

Riparian corridors can often be classified into 4 distinct zones (toe, bank, overbank, and transitional) wherein specific plants are adapted and should be planted. Nursery managers can grow a variety of species in a multitude of different stock types for planting in those zones. Bioengineering treatments are often necessary to physically stabilize streambanks before plants can be established. Four common bioengineering treatments (brush mattress, wattle, vertical bundle, poles) require specialty plant materials not generally grown in nurseries. Stooling beds of source-identified plants can yield these cuttings for an expanding bioengineering market.

KEY WORDS: Bioengineering, cuttings, revegetation, plant nurseries, streambank, restoration

NOMENCLATURE: USDA NRCS (1999)

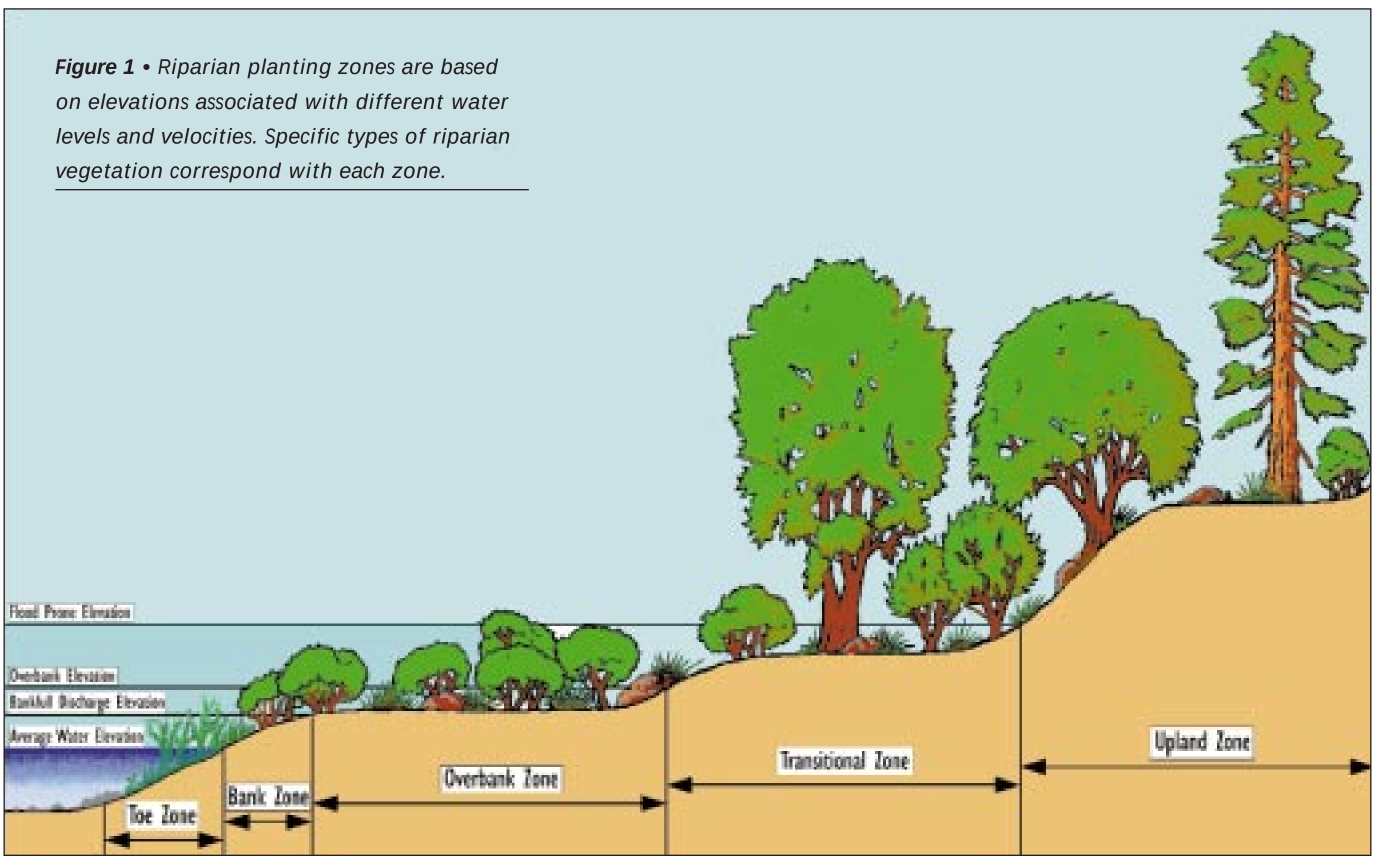


Figure 1 *• Riparian planting zones are based on elevations associated with different water levels and velocities. Specific types of riparian vegetation correspond with each zone.*

Riparian revegetation has received much attention in the past few years. US legislation like the Clean Water Act, water standards like Total Maximum Daily Loads (TMDLs), and ecopolitical issues like the "salmon crisis" (the listing of salmon species as a threatened and endangered species in the Pacific Northwest) have placed new emphasis on restoring riparian function and vegetation to degraded streams. In addition, the importance of treating agricultural wastewater, urban stormwater, mining wastewater, and other polluted water before it enters our rivers and streams will increase demand for restoration. The need to restore western US riparian zones where most woody and herbaceous vegetation has been removed by years of overgrazing is a major policy issue for federal regulatory agencies. Recent large flood events in the Pacific Northwest and the central US, with the resulting damage to private property along the riparian zones, have prompted many agencies to reexamine flood management plans. Planting vegetation along riparian zones to decrease flood peaks has been seen as an alternative to expensive engineered treatments such as concrete, large rock, levies, and dams.

TABLE 1

Plants adapted for specific riparian zones in the western US

Scientific Name	***Common Name***	***Riparian Zone***
Schoenoplectus acutus (Muhl. ex Bigelow) A. & D. Löve (Cyperacea). Synonym: *Scirpus acutus* Muhl. ex Bigelow	Hardstem bulrush	Toe
Carex nebrascensis Dewey (Cyperaceae)	Nebraska sedge	Bank
Betula occidentalis Hook. (Betulaceae)	Water birch	Bank, overbank
Salix lemmonii Bebb. (Salicaceae)	Lemmon's willow	Bank, overbank
Cornus sericea L. (Cornaceae)	Redoiser dogwood	Bank, overbank, transitional
Salix amygdaloides Anderss. (Salicaceae)	Peachleaf willow	Bank, overbank, transitional
Alnus incana (L.) Moench spp. *tenuifolia* (Nutt.) Breitung (Betulaceae)	Thinleaf alder	Overbank, transitional
Crataegus douglasii Lindl. (Rosaceae)	Black hawthorn	Overbank, transitional
Sambucus nigra L. spp. *cerulea* (Raf.) R. Bolli (Caprifoliaceae). Synonym: *Sambucus cerulea* Raf.	Blue elderberry	Transitional
Acer negundo L. (Aceraceae)	Box elder	Transitional
Artemisia tridentata Nutt. (Asteraceae)	Big sagebrush	Upland
Salix scouleriana Barratt ex Hook. (Salicaceae)	Scouler's willow	Upland
Pinus ponderosa P. & C. Lawson (Pinaceae)	Ponderosa pine	Upland

Adapted from Bentrup and Hoag (1998).

WHAT IS THE RIPARIAN AREA?

Riparian areas exist where soils are frequently saturated with water and water-loving vegetation is concentrated. They are linear areas along rivers and streams that are occasionally flooded but also occur between aquatic and upland habitats and are adjacent to lakes and reservoirs. Although dominated by water, the outer zones in a riparian area may dry out during periods of low precipitation.

Although regional differences exist, 4 zones comprise the riparian corridor, along with an upland zone immediately adjacent to the riparian area (Figure 1; Biedenharn and others 1997; Bentrup and Hoag 1998). In some cases, individual zones may be small or nonexistent. The lowest elevational zone, the toe zone, extends upward from the streambed to the average stream water level. This zone is subject to the most stress from stream velocities and because it is underwater for most of the year, vegetation is difficult to establish here. In some situations it may be possible to plant emergent wetland plant species in the toe zone.

The bank zone extends from the top of the toe zone to the bank-full discharge elevation (Figure 1). This zone is usually under water for less than 6 mo each year, but is frequently exposed to erosive stream currents, ice and debris movement, wet-dry cycles, and freeze-thaw cycles. Emergent wetland plants grow where stream energy is low. From the top of the bank zone to an elevation two-thirds that of the flood-prone elevation is the overbank zone. This area is typically inundated for less than 3 mo each year during spring runoff and storm events. High debris loads are often deposited here. Shrubs with flexible stems (for example, willows [*Salix* spp. L. (Salicaceae)]) and inundation tolerant herbaceous plants grow in this zone.

Above the overbank zone to the top of the flood-prone elevation is the transitional zone (Figure 1). This zone is inundated for short periods of time during major flood events. This zone is where the larger shrub types and trees are found. The vegetation includes plants that are adapted to occasional short periods of inundation and drought. The upland zone occurs above the transitional zone. Water rarely reaches this elevation except during extreme flood events (for example, 100-y floods). Plants in this zone are poorly adapted to prolonged inundation.

PLANT MATERIAL NEEDS WITHIN THE RIPARIAN CORRIDOR

In degraded riparian corridors, plant materials are needed to stabilize streambanks and restore the function of original plant communities. Government employees, consulting engineers, private

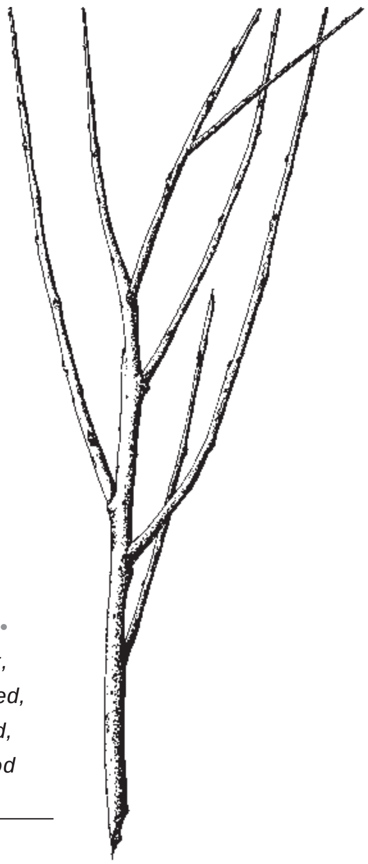


Figure 2 • *Dormant, nonrooted, branched, hardwood cutting.*

organizations, and others need many types of plant materials for riparian restoration. Projects require live plants that have roots, stems, and buds as well as dormant, nonrooted woody cuttings, the later being particularly well-suited for streambank bioengineering. Although a variety of plant stock types are suitable for planting in riparian zones, plants need to be planted in riparian zones based on adaptations of the plant to hydrological and edaphic characteristics of each zone (Table 1). Also, certain plants may need to be planted for other management objectives like diversity or specific habitat improvements. The stock types used in restoration vary by zone, management objective, and to some extent, nursery availability.

Although many people think that large plants can be used for bioengineering, even the largest nursery stock cannot withstand the erosive action of water for the first few years. However, when planted in combination with bioengineered treatments, nursery plants can promote streambank stability, enhance sediment trapping, and mitigate stream energy after their root systems become well established.

BIOENGINEERED TREATMENTS

The use of bioengineered treatments in riparian restoration is a relatively new procedure in the US. Bioengineered treatments are mostly comprised of dormant, nonrooted, hardwood cuttings (Figure 2). Willows are the most commonly used species, but other easy-to-root species like cottonwood (*Populus* spp. L. [Salicaceae]) and redoiser dogwood (*Cornus sericea* L. [Cornaceae]) are suitable if planted in the appropriate zone. Often cuttings are organized into bundles and placed at particular locations within the riparian zone to physically stabilize streambanks, and as cuttings sprout and grow, the roots increase soil strength and structure (Grey and Leiser 1982; Schiechtl and Stern 1994; Grey and Sotir 1996; Biedenharn and others 1997; Bentrup and Hoag 1998). Benefits of streambank bioengineering include: 1) reducing streambank erosion by reestablishing the root matrix; 2) reestablishing the riparian plant community; 3) improving fish and wildlife habitat; 4) providing shade on the water to maintain lower water temperatures; 5) increasing biodiversity; and 6) improving water quality. Bioengineering treatments include, but are not limited to, brush mattresses, wattles, poles, and vertical bundles.

Brush Mattress

A brush mattress or brush matting (Figure 3a) uses a 10- to 15-cm (4- to 6-in) mat of cuttings anchored to an eroding streambank. The basal ends of the cuttings are placed in a trench at the toe of the slope and are anchored by a wattle (described below) that also protects the toe from undercutting. A 3-m (10-ft) section of brush mattress takes about one full size pickup bed of cuttings (Bentrup and Hoag 1998). The cuttings will sprout; the resulting foliage in addition to the woody stems provides a buffer to shift stream velocity away from the bank and the dense matrix of roots stabilizes the streambank. A brush mattress is used to mainly protect the bank and overbank zones. After sprouting, plants from the brush mattress provide fish habitat, shade, and improve water quality. Plants established from a brush mattress will protect the bank as well as large angular rock riprap (Schiechtl and Stern 1994).

Wattle or Fascine

A wattle (also called a bundle or fascine) is a cigar shaped bundle of cuttings tied together and placed in a shallow trench in the toe zone (Figure 3b). The amount of cuttings that are needed to build a wattle depends on bundle diameter and streambank length. Shorter cuttings can be overlapped to make wattles longer. Wattles prevent water from undercutting the bank when placed correctly at the toe of the slope. A wattle can also be used to break up slope length and decrease erosion caused by overland flow, high rainfall, or spring thawing of ground frost, although in such locations the cuttings may not grow into plants. Wattle diameters range from 8 to 60 cm (3 to 24 in) and are dependent upon objectives and applications.

Vertical Bundle

A vertical bundle is similar to a wattle except that bundles are placed in vertical shallow trenches (Figure 3c). The key to this treatment is ensuring the butts are into the low watertable and the tops are not covered. Vertical bundles typically are used to establish woody plants in the toe, bank, and overbank zones. Vertical bundles are used when streams are "flashy" (high and rapid fluctuations in water level), soils are rocky and difficult to plant, and to establish plants in conjunction with rock riprap. In this position, cuttings will root and produce shoots above the bank or riprap, providing shade over the water, better wildlife and fish habitat, and water quality improvements. Vertical bundle diameters range from 8 to 46 cm (3 to 18 in) depending upon the application. Each cutting should extend from about 20 cm (8 in) into the streambed to about 30 cm (1 ft) above the top of the bank.

Pole Cuttings

Many riparian restoration projects fail because high water velocities rip plants out before they have a chance to establish an extensive root system, or they die when soils dry out later in the season (Hoag 1993b). Pole cuttings (Figure 3d) are large diameter main stems that have all side branches and the top 30 to 60 cm (1 to 2 ft) removed. Poles are a bioengineering treatment that are planted in the bank, overbank, and transitional zones. Poles generally are at least 1 m (3 ft) long and are placed vertically in the ground (or at a 45 degree angle out over the water) deep enough to reach either the lowest water table of the year or extend below the roots of competing vegetation and high enough to expose at least 1 to 2 buds above the height of surrounding competing vegetation. Platts and others (1987) speculated that cutting performance is poor when competing shade suppresses shoot growth. Benefits of pole plantings include: 1) stability of the cuttings when exposed to high stream velocities; 2) an ability to plant in areas where the water table is deeper than 30 cm (1 ft) below the surface; and 3) lower costs than traditional bareroot or container nursery stock (Carlson 1992; Hoag 1992, 1993; Bentrup and Hoag 1998).

Because of the large size of the plant material necessary for pole cuttings, mother plants should be established in the nursery for efficient production of suitable material. Carlson (1992) concluded that establishing and managing "orchards" for producing poles should be a top priority for forest and conservation nurseries. Dreesen and Harrington (1999) provide step-by-step instructions for establishing cottonwood cuttings at the Los Lunas Plant Materials Center in New Mexico and harvesting large poles 3 y later. Another possibility that is being tried at the J Herbert Stone Nursery in Oregon is to convert existing willow stooling beds over to pole production. Since willows under cultivation reach sexual maturity rapidly (in as little as 4 y [Dreesen 2000]), savvy growers may be able to collect a few seed harvests prior to harvesting pole cuttings.

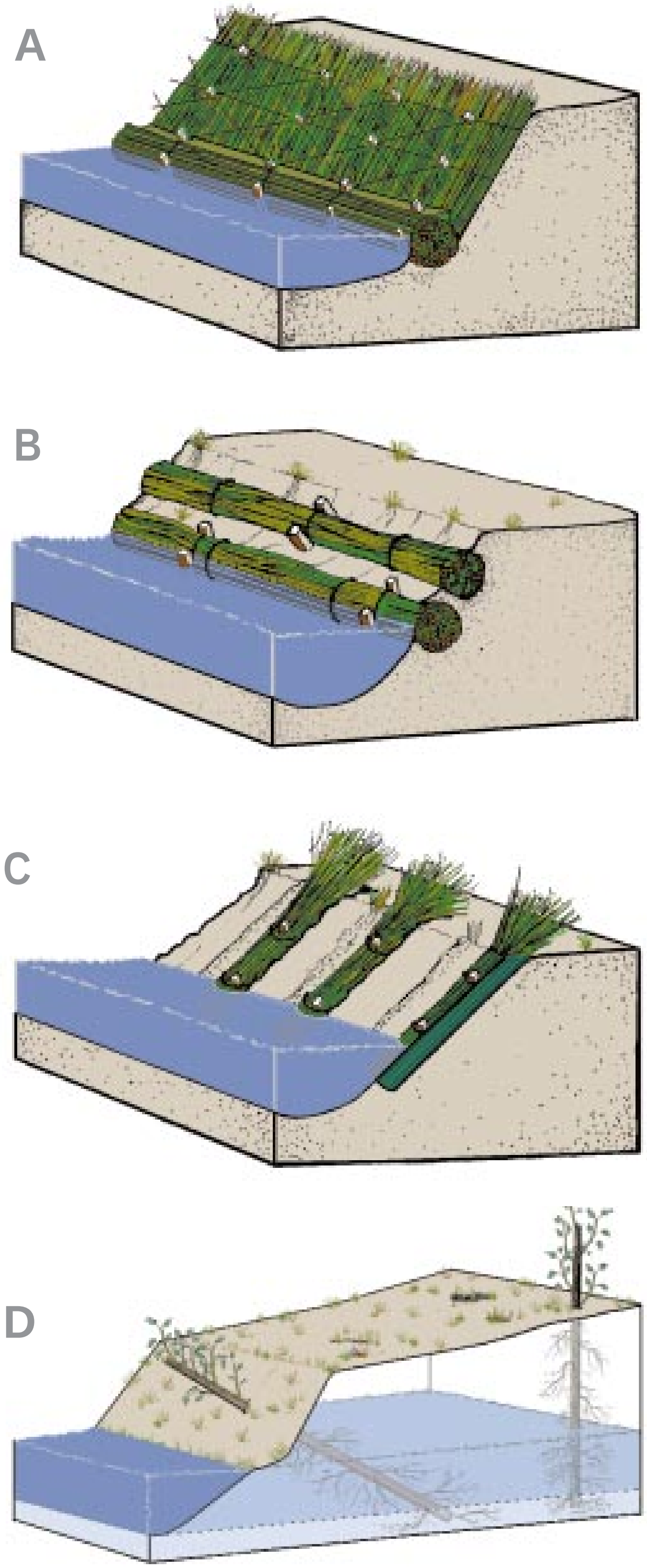
NURSERY OPPORTUNITIES FOR PRODUCTION OF PLANT MATERIALS

Nursery managers are adept at growing plants for a variety of conservation and restoration activities. Riparian species can be produced from seeds or vegetatively. Plants can be grown as bareroot, bareroot transplants, container, balled and burlapped, and Plug+One stock (Buis 2000). Plant sizes can vary from very small to that requiring truck-mounted spades. The particular stock types needed for sites depends on the local hydrologic and edaphic characteristics; fortunately, nursery managers can now grow plants in a seemingly endless variety of stock types to meet a myriad of restoration objectives and site characteristics. However, because of the relative newness of bioengineering in the US, nursery managers may be missing an opportunity to produce non-traditional plant materials, specifically cuttings and poles.

Cuttings for Bioengineering

Most bioengineering treatments require dormant, nonrooted, branched, hardwood cuttings. For restoration projects that will require a large amount of plant material over several years, cuttings from on-site donor plants can be

Figure 3 • Streambank bioengineering uses dormant nonrooted hardwood cuttings in a variety of treatments: A) brush mattress; B) wattle; C) vertical bundle; and D) pole plantings.



brought back to a nursery for multiplication. This is particularly useful for remote projects, such as high elevations, where field collections would be difficult. Mother plants are established in nurseries to provide a source of cuttings. Stooling beds are hedge-like rows of mother plants that are established in bareroot nurseries or in the vacant field next to a container nursery. Single mother plants can also be established in large containers. If a nursery requires propagation cuttings for producing stock as well as branched cuttings for bioengineering treatments, selective harvesting of cuttings may allow both to be collected from the same mother plants. Because maintenance of genetic diversity is so important in ecosystem management, cuttings should be collected from as many individual plants as possible to maximize genetic diversity. Guinon (1993) provides an excellent discussion of all the factors involved in preserving biodiversity when collecting seeds or cuttings, and suggests a general guideline of 50 to 100 donor plants.

Branched cuttings often have the tops and flowering parts removed either before or after they are used for some bioengineering treatments, but side branches are left in place during processing (Carlson and others 1992; Bentrup and Hoag 1998). Branched cuttings typically have lower establishment rates than propagation cuttings. However, such rates are acceptable in bioengineered treatments because dead material still serves a function and the high density of propagules results in acceptable plant density even at low establishment rates.

Since cuttings can be collected during winter or very early spring that are usual nursery "slow times," nursery production of cuttings may allow nurseries to expand their market base. During collec-

An additional resource for information on streambank bioengineering can be found in Bentrup and Hoag (1998). More information on woody plant species and what zones they should be planted can be found in Ogle and Hoag (2000). Additional information on riparian planting zones and where different species should be planted can be found in Hoag (2000). A comprehensive guide to roadside bioengineering, along with a additional references to general bioengineering, is provided by Lewis (2000).

tion, cuttings could be immediately processed into the bioengineering treatments required for field use as part of the contract service. Bundles of cuttings should be stored under refrigeration at 0 to 4.5 °C (32 to 40 °F) to keep them dormant until they are planted (Landis and others 1999; Hoag 1993b).

RECOMMENDATIONS FOR NURSERY MANAGERS

Pursue new markets. Time is critical as markets for native riparian plant material are developing rapidly. Nurseries must be aggressive and introduce their products and services to new customers. Attend meetings of potential customers and use new marketing techniques like establishing a website on the Internet.

Practice "Show and Tell." Many customers lack understanding of nursery procedures or potential so nursery managers must show potential customers what can be produced—both species and stock types. Showing is always better than telling, so nursery managers should grow some typical riparian plants or establish stooling beds or mother plants ahead of time.

Emphasize "source identified" and "locally adapted." Many project managers, especially engineers and even other biologists, do not understand that revegetation projects have different objectives than other types of plantings. Nursery managers must explain the importance of using native plant material that is collected at or near the project area and adapted to the local environment.

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