

PLANT MATERIALS FOR RIPARIAN REVEGETATION

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Abstract

Increased public awareness and concern have prompted new efforts in riparian revegetation using streambank bioengineering techniques. Planting in a riparian zone is very different than planting on upland sites. Riparian planting zones should be used to ensure that the vegetation is planted in the appropriate location so that the planting does not create more problems than was it was designed to treat. The types of plant materials used in riparian revegetation projects include: 1) dormant nonrooted hardwood cuttings which include 3 size classes: propagation cuttings, branched cuttings, and poles; and 2) nursery plants, including bareroot and small and large container stock. Each stock type has its specific purpose, use, and limitations. Many riparian plants are difficult to propagate so propagation protocols are being developed. Streambank bioengineering is relatively new in this country, and requires different types of plant types than nurseries are used to growing. The nursery industry needs to be proactive and pursue this new market for riparian stock by showing potential customers what they can produce and emphasizing native, locally-adapted plants for their area.

Key Words

Restoration, plant nurseries, plant propagation, woody plants, bareroot nursery, container nursery, native species, biodiversity

Riparian revegetation or restoration has received much attention in the past few years. 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) 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 the demand for revegetation efforts. The need to restore overgrazed rangelands in the West where riparian zones have had most of the riparian woody and herbaceous vegetation 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. The need to increase the vegetation along the riparian zones which in turn will decrease flood peaks has been seen as an alternative to expensive engineered treatments such as concrete, large rock, levies and dams.

Streambank bioengineering treatments have many benefits, including:

- reducing streambank erosion by reestablishing the root matrix
- reestablishing the riparian plant community
- improving fish and wildlife habitat
- providing shade on the water to maintain lower water temperatures
- increasing biodiversity of plants and animals
- improving water quality.

Filter strips, constructed wetland systems, and riparian buffer strips have also been used to treat

non-point source pollution before it enters the riparian zone (Schultz 1994).

RIPIARIAN PLANTING ZONES

When planning a riparian revegetation project, it is critical to consider the planting zones and the hydrology for the site. For the stream types commonly treated, there are four planting zones within the riparian corridor, plus the upland zone (Bentrup and Hoag 1998, Biedenbarn and others 1997).

The lowest zone is called the toe zone that extends from the streambed to the average stream water level (Figure 1). The toe zone is subject to the most stress from stream velocities and, because it is underwater for most of the year, it is very difficult to get vegetation established in this zone. It may be possible to plant emergent wetland plant species in some situations.

The bank zone is that portion of the bank from the average water elevation (top of toe zone) to the bankfull discharge elevation. This zone is usually under water for less than 6 months of the

year. It is exposed frequently to erosive stream currents, ice and debris movement, wet-dry cycles, and freeze-thaw cycles. Emergent wetland plants are recommended for planting in this zone where there is low stream energy.

The overbank zone is the area that begins at the top of the bank zone and continues to two-thirds of the flood-prone elevation. This area is typically inundated during the spring runoff and storm events. High debris loads carried by runoff events and ice flows tend to be deposited in this zone. This zone is under water for less than 3 months of the year. Shrubs with flexible stems (for example, willows) and inundation tolerant herbaceous plants are recommended for planting.

The transitional zone goes from the overbank elevation to the flood-prone elevation. It will be inundated for a short period of time during higher flood events. The vegetation will include plants that are adapted to occasional short periods of inundation and drought. Trees such as cottonwoods, birch, tree species of alder, and ash

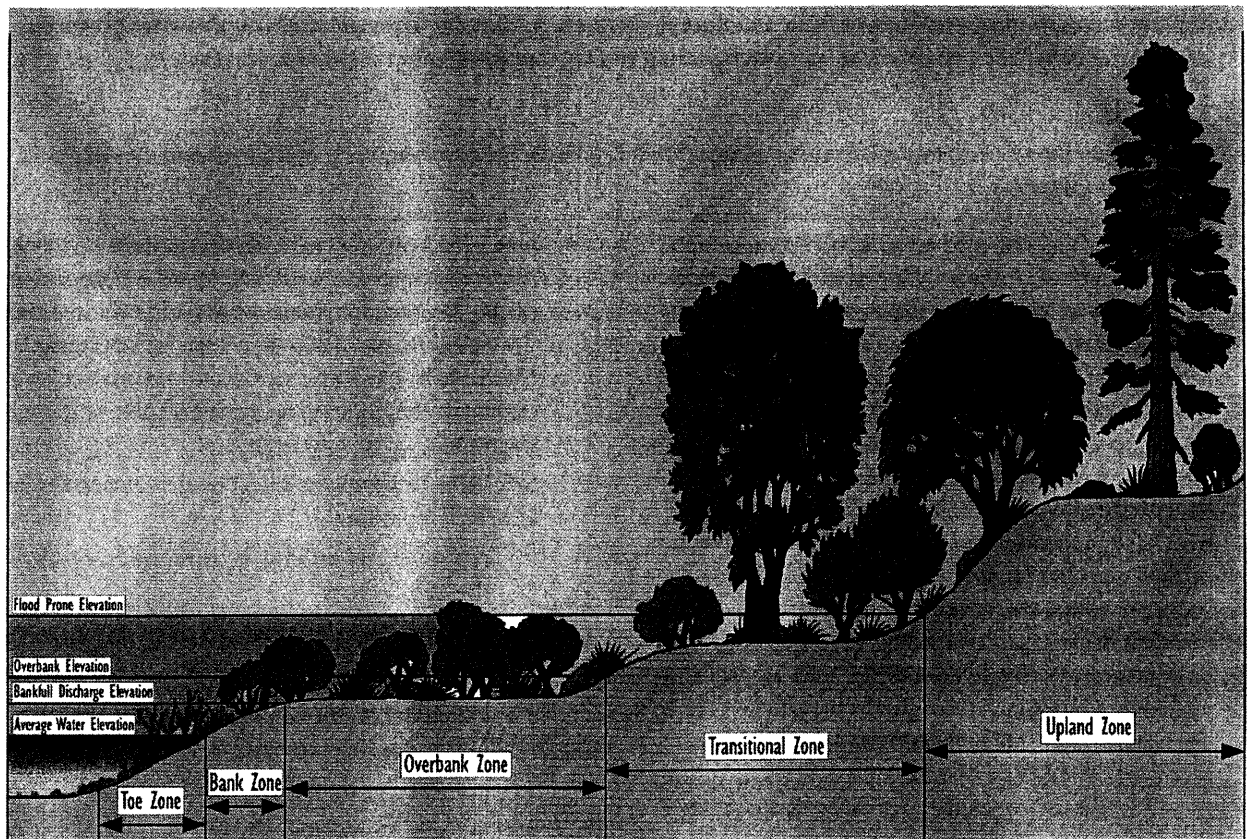


Figure 1. Riparian planting zones are based on elevations associated with different water levels and velocities. Specific types of riparian vegetation correspond with each zone.

are often located in this zone, as well as larger shrub species of willows and other riparian species.

The upland zone is area above the flood-prone zone. Rarely does water ever get this high except in something like a 100-year flood event. Plants are not adapted to prolonged inundation and need to be drought tolerant rather than flood tolerant.

TYPES OF REVEGETATION TREATMENTS

Streambank bioengineering is a treatment used to reestablish woody and herbaceous plant species, stabilize streambanks, and to reestablish or improve riparian buffer zones. The stabilization of streambanks to reduce the amount of total suspended solids entering the riparian zones is receiving new accentuation. The principle behind streambank bioengineering is to use woody and herbaceous roots to increase the strength and structure of the soil (Schiechl and Stern 1994, Biedenbarn and others 1997, Bentrup and Hoag 1998, Grey and Leiser 1982, Grey and Sotir 1996).

There are a wide variety of different treatments used in streambank erosion control. Most of them use dormant nonrooted hardwood cuttings of willow, cottonwood, and red-osier dogwood. For example:

A willow wattle (also called a willow bundle or willow fascine) is a cigar shaped bundle of live nonrooted hardwood cuttings tied together and placed in a shallow trench in the toe zone (Figure 2A). It will provide protection from undercutting when placed correctly at the toe of the slope. If placed in the correct hydrologic zone, the willows will sprout and root. 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. The wattle diameter ranges from 3 to 24 in. (7.6 to 61 cm) and is dependent upon objective and application. Dogwood can also be used for wattles. The amount of nonrooted hardwood cuttings that are needed to build a wattle is dependent upon the diameter of the bundle and length of streambank being treated.

A brush mattress or brush matting (Figure 2B) uses a 4 to 6 inch (10 to 15 cm) thick mat of nonrooted willow cuttings anchored to an eroding streambank. The cut ends of the willows are placed in a trench at the toe of the slope and are anchored by a willow wattle that also protects the toe from undercutting. The willows will sprout

and take root thus stabilizing the streambank with a dense matrix of roots. The sprouts will provide a buffer to move the velocity of the river away from the bank. A brush mattress is used to mainly protect the bank and overbank zones. It will also protect the toe zone when used in conjunction with a willow wattle. A brush mattress will also provide fish habitat, shade, and water quality improvements. The woody plants will provide as much protection to the bank as large angular rock rip-rap after they are established (Schiechl and Stern 1994). A 10 ft (3 m) section of brush mattress takes about one full size pickup bed of willow cuttings (Bentrup and Hoag 1998).

A vertical bundle is similar to a willow wattle except that the bundles are placed in shallow trenches vertically up the slope (Figure 2C). Typically it will protect the toe, bank and overbank zones. Vertical bundles are used in places where the streams are “flashy” (they have high fluctuations in water level) and to establish willows under or through rock rip-rap. When placed vertically up the bank, the cuttings will root into the bank and send sprouts up out of the bank or up through the rock. When placed through rock, the willows will root in the bank under the rip-rap and sprout out over the water. This will provide more rapid shade over the water, better wildlife and fish habitat, and water quality improvements. Dogwood can also be used in this treatment. Vertical bundle diameters should be from 3 to 18 in. (7.6 to 45.7 cm) depending upon the application. The bundle height should be tall enough to extend from about 8 in. (20.3 cm) into the streambed to about 1 foot (0.3 m) above the top of the bank.

Pole plantings (Figure 2D) utilize dormant nonrooted hardwood cuttings that are large diameter branches with all the side branches and the top 2 feet of the stem removed. Most other applications leave the branches and tops on. The cuttings are placed in the ground deep enough to reach the lowest water table of the year and high enough to expose at least 1 to 2 buds. Root primordia will sprout roots when good soil to stem contact is made and exposed sections of the cutting will sprout stems and leaves. Benefits of the pole planting are stability where the plantings are exposed to high stream velocities, the ability to plant in areas where the water table is deeper than

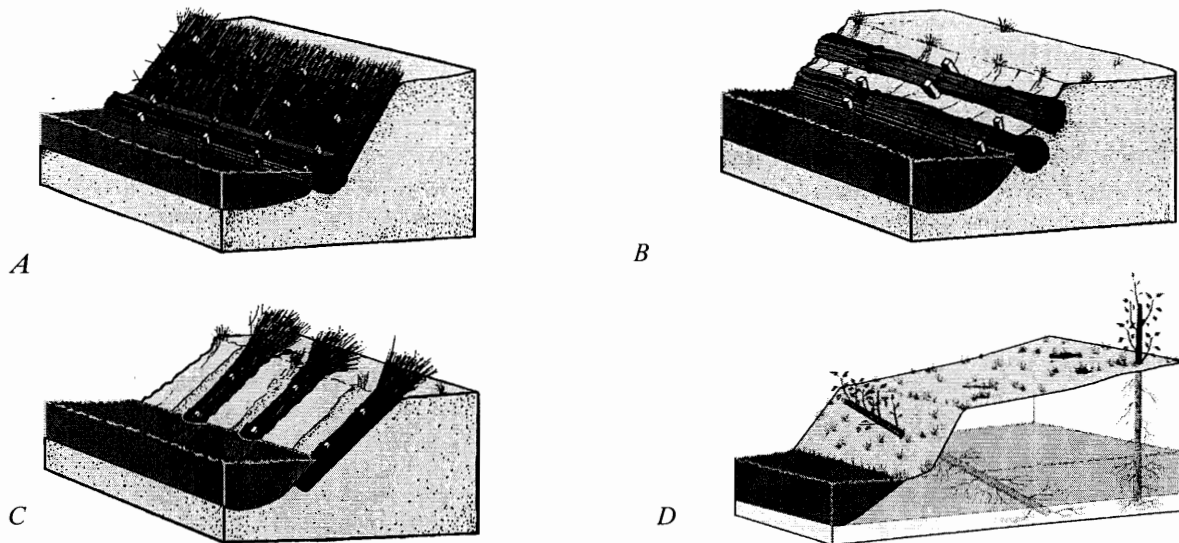


Figure 2A-D. Streambank bioengineering uses nonrooted hardwood cuttings of cottonwood and willows in a variety of treatments: A) brush mattress, B) willow wattle, C) vertical bundle, and D) pole cuttings.

one foot below the surface, and cost where pole plantings are significantly cheaper than bareroot or container stock (Bentrup and Hoag 1998, Carlson 1992, Hoag 1992, Hoag 1993a, and others).

TYPES OF PLANT MATERIALS USED IN STREAM REVEGETATION

There are two different categories of plant materials used in riparian revegetation: 1) dormant, nonrooted hardwood cuttings used in bioengineering applications and 2) live plants used for a variety of other purposes. 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 structures, nursery plants can promote streambank stability after their root systems become well established.

DORMANT NONROOTED HARDWOOD CUTTINGS

The plant materials that are most widely-used in bioengineering treatments are dormant nonrooted hardwood cuttings that are used in bundles, fascines, and other bioengineering structures (Figure 2A-D). Cuttings are preferred because of their availability, ease of harvest, ease of planting, and their ability to root. Willow, cottonwood, and

red-osier dogwood are the most common species used because of their ease of rooting and planting as well as tolerance to saturated soils and even periodic inundation. Few other riparian woody plants easily root from hardwood cuttings and so must be propagated by seed. A list of suitable species for streambank bioengineering is provided in the National Engineering Manual, Chapter 16, and the USDA NRCS Aberdeen Plant Materials Center Technical Note 32, and others. Both of these publications can be obtained from your local NRCS field office.

Woody stems or large branches should be collected from donor plants near the project area during the winter dormant season. Collections should be made from as many different plants as possible to promote biodiversity. After collection, the cuttings can either be stored for future planting or transported to the planting site. At the planting site they are soaked in water for 1 to 7 days prior to use (Hoag 1993b).

For revegetation projects that will require a large amount of plant material over several years, cuttings from **donor** plants can be 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. Single mother plants can also be established in large containers. Besides the convenience, cuttings collected at the nursery often perform better than wild collections. For example, over 90% of narrowleaf cottonwood (*Populus angustifolia*) cuttings collected from stooling beds rooted whereas wild cuttings had only 62 to 85% rooting success (Dreesen and Harrington 1999).

Three size classes of cuttings are used in riparian bioengineering structures: propagation cuttings, branched cuttings, and poles (Table 1).

Propagation cuttings—These cuttings are relatively small (Table 1) and are used only in nursery propagation. Dormant hardwood cuttings are most commonly used although softwood cuttings from tips of actively growing plants are necessary to propagate some species (Dumroese and others 1997). Although propagation cuttings can be collected from donor plants near the project site, it is more efficient to establish stooling beds or mother plants at a nursery. Another option is serial propagation where cuttings can be harvested from the current year's crop.

Stem cuttings have an inherent polarity and will always produce shoots at the distal end (nearest the bud) and roots at the proximal end (nearest the main stem or root system). To distinguish between the top and bottom of hardwood cuttings, the bottoms are cut at an angle, which not only ensures that the cuttings are planted right side up but makes them easier to stick into containers or nursery beds (Hartmann and others 1997). In nursery stooling beds, willow and poplar are collected as long cuttings or whips that are then cut into the proper length. If collected by hand, the basal cut is typically made just below a node where roots form more readily. When large numbers of cuttings have to be made, then bundles of whips are cut with a band saw. Bundles of cuttings are then secured with a rubber band and stored under refrigeration at 32 to 40 °F (0 to 4.5 °C) to keep them dormant until they are planted (Landis and others 1999). Cultural procedures for growing propagation cuttings in either bareroot beds or containers are discussed in the Nursery Plants section.

Branched cuttings—This class includes branches and stems that are relatively large (Table

1). Branched cuttings can be collected near the project site or from stooling beds in a nursery. If the project area is far from the nursery, the large volume of plant material needed may make it more practical to collect on-site. Branched cuttings often have the tops and flowering parts cut off before they can be used for some of the bioengineering treatments. They differ from propagation cuttings and poles in that side branches are left in place during processing (Carlson and others 1992, Bentrup and Hoag 1998).

Branched cuttings are very effective for streambank erosion control when collectively used in brush mattresses, fascines, and vertical bundles (Figure 2A-C). Branched cuttings can be collected from native cottonwood or willow stands, and limited harvesting does not permanently harm the stands because these species readily resprout. In fact, harvesting can actually help to rejuvenate decadent stands. Up to 20% deadwood can be included with branched cuttings in bioengineering applications. The deadwood provides structural rigidity to the bioengineering treatments. Although branched cuttings typically have lower establishment rates than propagation cuttings, bioengineering structures made with branched cuttings are essential to initial stream stabilization.

Poles—Many riparian revegetation projects fail because high water velocities rip the plants out before they have a chance to establish an extensive root system, or they die when soils dry out later in the summer and fall. Pole plantings provide a means to overcome both of these problems (Table 1). The basic idea is to plant long cuttings of dormant willow and cottonwood (Figure 2D) to a sufficient depth that they will stay in the water table throughout the year. These species have dormant root primordia underneath their bark so that roots will sprout along the entire buried section and the poles will establish quickly after outplanting. The other benefit is that these large diameter pole cuttings will remain anchored during floods (Hoag 1993b).

Because of the large size of the plant material, mother plants can be established in the nursery to produce poles. Carlson (1992) concluded that establishing and managing "orchards" for producing poles should be a top priority for forest and conservation nurseries. Much of the research in this area has been done in the Southwestern

US. At the Los Lunas Plant Materials Center in New Mexico, pole cuttings are grown in production blocks that yield large poles after 3 growing seasons (Dreesen and Harrington 1999). 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.

As with other types of woody, nonrooted hardwood cuttings, poles are harvested during the winter dormant season with loppers, handsaws, brush cutters (with smaller diameter species), and chain saws. A large number can be harvested in a relatively short time with an experienced well-trained crew and transported to the planting site. Poles are prepared by removing the side branches and tops, packing them into bundles, and then shipping them to the customer. Prior to planting, post cuttings are soaked for 1 to 7 days to allow the root primordia to swell to the point they are ready to emerge from the bark. Once the roots emerge, it is much harder to plant the cutting because the roots are so tender that they are easily scraped off when planting them.

Poles can be planted in holes slightly larger than their diameter. This significantly increases the potential number of planting methods that can be used. Chainsaw augers, bucket augers, dibble bars, planting bars, and a tractor-mounted piece of equipment called the Stinger have all been used to plant poles (Hoag 1993c). Poles that fail to grow can be easily replaced by pulling them out of the hole and shoving a replacement back into the same hole with minimal effort.

NURSERY PLANTS

Container or bareroot plants add diversity to the riparian revegetation area by ensuring the establishment of species that do not root readily from woody cuttings. Many people just assume that all willows or cottonwoods will root easily and so stick hardwood cuttings directly into the streambank. Although many of these cuttings will sprout shoots initially, some will tend to dieback later in the season due to poor root egress or pathogenic cankers.

Propagation method—The choice of propagation method is important and both the biology of the species and the objectives of the revegetation project must be considered. Many keystone riparian trees and shrubs including cottonwood and willow can be produced vegetatively, but some species or ecotypes are recalcitrant. For example, standard hardwood cuttings of Scouler willow do not root well, even in the nursery, and so this species must be propagated by other means (Dumroese and others 1997).

If it is possible to propagate a plant either by seed or vegetatively, then the amount of genetic variability that is desired in the crop must be considered. Sexual reproduction results in a mixture of genetic characteristics in the offspring, so each plant will appear slightly different from its parents and each other (Figure 3). Because maintenance of genetic diversity is so important in ecosystem management, seed propagation is encouraged whenever possible because it is easier to capture and preserve biodiversity with seeds

Table 1. Types of cuttings used in riparian revegetation.

Type of Cutting	Diameter	Length	Type of Wood	Pre-Rooted	Use
Propagation	0.2 to 0.8 in. (0.5 to 2 cm)	4 to 10 in. (10 to 25 cm)	Softwood or Hardwood	Yes	Live plants: Grown in bareroot beds or containers at nurseries
Branched	0.5 to 2 in. (1.3 to 5.1 cm)	4 to 15 feet (1.2 to 4.6 m)	Hardwood	No	Bioengineering: brush mattresses, fascines, vertical bundles at the project site
Pole	0.75 to 8 in. (1.9 to 20.3 cm)	3 to 12 feet (0.9 to 3.6 m)	Hardwood	No	Bioengineering: individual placement at the project site

than with vegetative propagation. When harvesting seeds or cuttings, collections should be made 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. Nursery plants are traditionally divided into 2 major stock types: container and bareroot.

Bareroot stock—Bareroot nursery stock is grown in soil either from direct sowing, transplanting smaller bareroot or container plants, or rooting propagation cuttings. Because of the higher cost of establishment and longer production times, bareroot seedlings are less commonly used for riparian revegetation. However, bareroot plants are usually less expensive to produce, handle and transport than large container stock.

Seedlings—Few riparian plants are grown as bareroot seedlings because often the seeds are

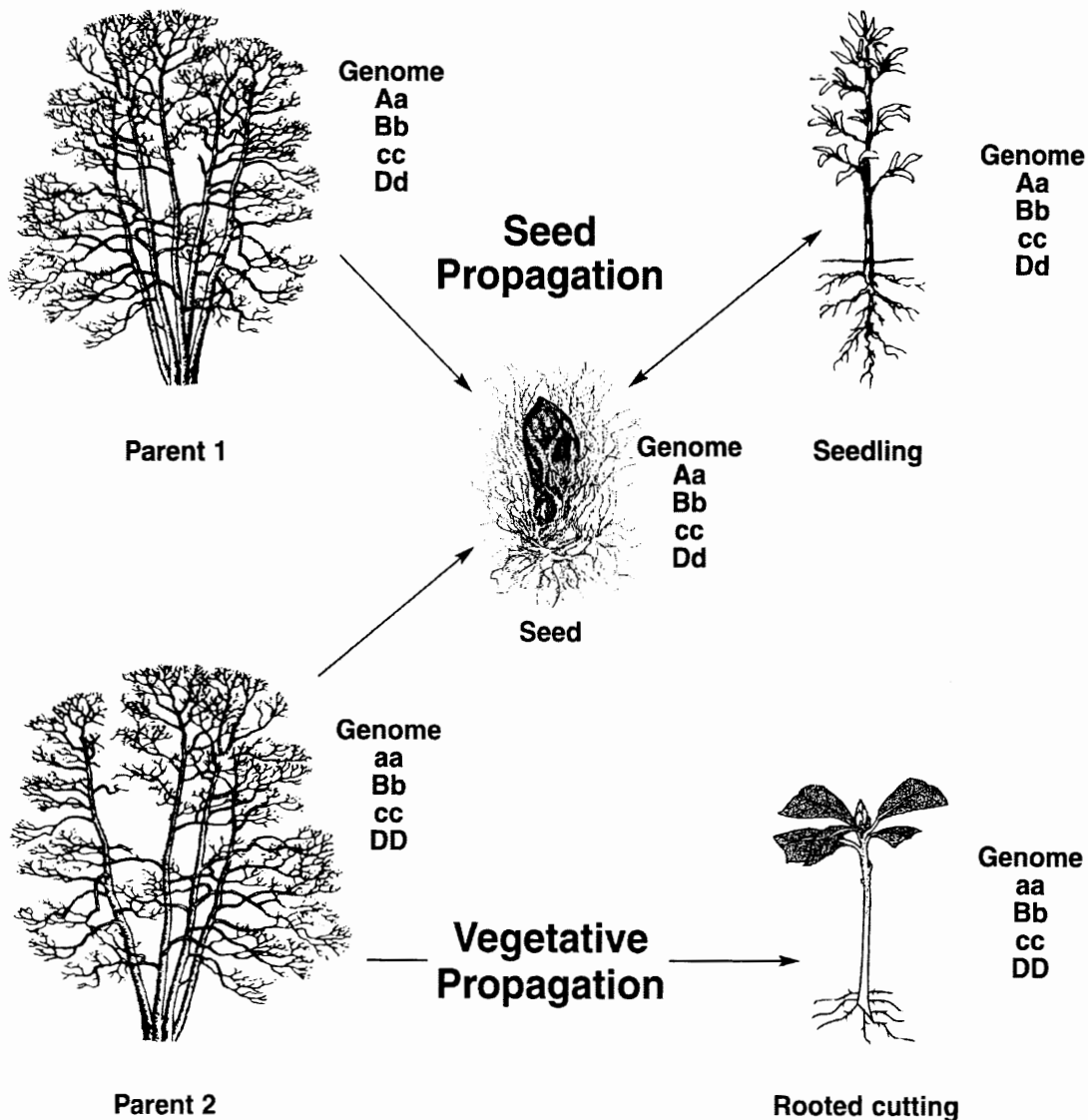


Figure 3. Plants propagated from seed look different from their parents and each other because they contain a mixture of the genetic characteristics of the 2-parent plants. Vegetative propagation, on the other hand, produces exact duplicates of the parents.

difficult to handle or they have complicated dormancy. For example, cottonwoods and willows have very small seeds that are short lived and they are covered with fine hairs that resist water imbibition making them difficult to propagate in bareroot seedbeds. Some nurseries do produce bareroot seedlings of riparian trees such as ash and oaks, and other species could be grown if the markets existed.

Rooted cuttings—Several riparian species are routinely propagated from short hardwood cuttings, especially cottonwoods and willows. Because they root easily and require less cultural attention than seedlings, rooted cuttings of these species grow rapidly and shippable plants can easily be produced in 1 season. In southern California, large black willow (*S. goodingii*) plants (> 6 ft or 1.8 m) are produced from hardwood cuttings in 1 year (Evans 1992). Planting and cultural techniques for propagating poplars and willows are provided by Morgenson (1992).

Bareroot transplants—Transplants are seedlings that have been harvested from their seedbeds or containers and then replanted in another location for additional growth. Traditionally, most transplants were bareroot seedlings grown for 1 or 2 years, replanted into a transplant bed, and then allowed to grow for another year or two. Transplanting small container seedlings into a bareroot nursery for an additional year or two of growth produces this stock type, also called a plug transplant. “Plug+1s” are an economical way to grow large stock types for riparian revegetation projects. In the last few years, container-to-container transplants are becoming more popular.

Container stock—Container plants can be produced by sowing seed or sticking propagation cuttings into containers and then growing them for 6 months to 1 year in a greenhouse or open compound. Container plants are preferred for riparian revegetation projects because they are quick to produce, easy to handle, and often have better outplanting performance on tough sites than bareroot stock. For riparian projects, container stock can be divided into 2 categories: small and large. We usually recommend as large a plant as possible because, other things being equal, large plants have more expansive and aggressive roots systems and can better withstand water erosion. Smaller container plants also cannot handle the water fluctuations as well as the larger

sized stock. Of course, other considerations such as cost per plant and handling on the outplanting site will also affect the choice of stock type.

Small Containers (“Plugs”)—Woody shrubs, grasses and wetland plants are often grown in small containers (volumes less than 15 in³ or 245 cm³). Plugs are used in bioengineering designs when the water is too deep or persistent to get woody plants established in other ways. For example, plugs are preferred over direct seeding because seeds of many herbaceous riparian plants need 3 things to germinate: water, heat, and light. The light requirement means that seeds must be sown on the surface and, as soon as water is released back into the site, the seeds float. Once this happens, the wind will concentrate them at the shoreline and prevent good plant distribution. Because of the light and heat germination requirement, few riparian herbaceous plant seeds will germinate in deep standing water. Transplanting wild plants (“wildlings”) is sometimes used but small volume containers have been shown to have higher establishment rates and to spread faster and further (Hoag 1994).

Riparian herbaceous plant plugs also promote the trapping of sediments that will rebuild the streambank and will also increase the natural establishment of woody plant species. The fine root hairs of grasses or wetland plants, when combined with the larger deeper roots of woody plants, help bind the soil particles together and reduce streambank erosion. Sedges (*Carex* sp.), spikerush (*Eleocharis* sp.), bulrush (*Scirpus* sp.) and rushes (*Juncus* sp.) are used extensively in riparian and wetland revegetation because of their aggressive root systems. Manning and Padgett (1989) demonstrated that Nebraska sedge (*Carex nebrascensis*) had 112 feet of roots per cubic foot of soil (1205 m/m³) in the top 4 in. (10.2 cm) of the soil profile. They also found that its root system extended as much as 6 feet (1.8 m) deep in some areas, which is significantly better than typical grass species found in the same area.

Large containers—We define large containers as ranging in volume from 15 in³ (245 cm³) to 5 gallons (18.9 l). Large stock types are becoming more popular in riparian revegetation because they handle the changing water table and erosive effects of floods better than smaller plants. Large container plants are used extensively in the overbank and transitional zones (Figure 1) to

produce immediate shade on the water, and allow sedimentation on the floodplain. Large plants have faster growth rates and, when they die and fall over, they provide large woody debris in the stream to create fish habitat. This is particularly critical for salmon revegetation efforts where many plant species have been eliminated by logging or grazing. In the Pacific Northwest, species grown for the overbank and transitional zones include conifer evergreens like spruce, hemlock, western redcedar, and other broadleaf trees like ash, hackberry, and some of the tree-type willows that can not be planted in the channel itself. In addition to improving the physical structure of the riparian zone, large container stock increases biodiversity and provides quick food and habitat for a wide variety of wildlife. For example, large stock types were used to produce “instant habitat” for the Least Bells’ Vireo (*Vireo bellii*), an endangered bird in a Southern California riparian community (Evans 1992).

Propagation protocols—The propagation of riparian plants is a relatively new phenomenon and so reliable information on how to germinate seeds or root cuttings is often hard to find. For this reason, the U.S. Forest Service has started collecting comprehensive “recipes” on how to propagate native plants. A typical protocol starts with target seedling specifications and then discusses seed and/or vegetative propagation information, ending with the season of outplanting. Protocols should also include a crop production schedule that gives a visual calendar of the propagation process (Landis and others 1999). Propagation protocols for a wide variety of native plants are being developed and uploaded in the Native Plant Network:

<http://www.nativeplantnetwork.org>

Other propagation information is also available. The Nursery Technology Cooperative at Oregon State University recently published *Propagation of Pacific Northwest Native Plants* (Rose and others 1998), which contains information on riparian trees, shrubs, and other plants. The National Proceedings of the Forest and Conservation Nursery Associations are a good source of propagation information (for example, Dumroese and others 1997) as is the Combined Proceedings of the International Plant Propagation Society.

New nursery managers, in particular, are going to need some basic cultural information before

starting to plan for a potential crop. The indirect experience gained by talking to other growers, although time-consuming, is valuable. Many private nurseries do not want to share their propagation secrets for obvious reasons, but government nurseries are excellent sources of technical information, as most consider technology transfer to be part of their mandate. The J. Herbert Stone nursery of the USDA-Forest Service has propagation information on bareroot cuttings of willows and cottonwoods and small and large container riparian plants.

The USDA-NRCS Plant Materials Centers are also a good source of information. For example, the Interagency Riparian/Wetland Plant Development Project at the in Aberdeen, ID PMC has documented efficient seed germination protocols for 6 different species of wetland plants. These protocols have increased the efficiency and reduced the cost of propagating riparian plants (Hoag 1994; Hoag and Sellers 1994).

IMPACTS ON NURSERIES

Even though streambank bioengineering is relatively new in this country and has not been totally accepted by the engineering profession, it is gaining in popularity and reputation. Many regulatory agencies are requiring plants be part of any structural work that is done in the riparian zone. Much research has been done on ways to improve on establishment techniques for woody plants in conjunction with rock structures. In many cases, it has been demonstrated that the vegetation can improve the rock structure, reduce the maintenance requirements, increase the long-term strength, and provide benefits like aesthetics, wildlife habitat, and water quality improvements.

The nursery trade must understand that streambank projects are requiring different types of plant material stock than what they have been used to providing. There is a large market developing for dormant nonrooted hardwood cuttings of willows, cottonwoods, and dogwoods that are large diameter, vigorous, healthy, and relatively free of insect and disease damage. Mother plants that are planted in a controlled environment such as a nursery can provide an easy and economical source of cuttings for many years. The idea that cuttings can be grown, cut, bundled and delivered to the planting site is becoming more widespread. Both large and small container

stock of native woody and herbaceous plants are needed in large numbers not only for riparian revegetation projects, but also for constructed wetland systems that are being used to cleanup agricultural wastewater.

Nurseries will need lead time to begin growing these native ecotype stock types. In many cases, the nurseries are able to contract the actual collection of seeds and cuttings from a revegetation site, take the seeds and cuttings back to the nursery, grow the plants according to the exact specifications of the buyer, and deliver the plants to the planting site. Some nurseries are contracting to plant the plants after they have grown them.

Although cost has been a major restriction in the past, the Endangered Species Act and other legislation will require the use of native ecotypes in a variety of stock sizes. The timing of this new market is being pushed rapidly to the forefront of many agencies' priorities and the nursery trade must respond or it will be left behind. Nurseries must expand out of their traditional markets and into the realm of seed and cutting collection, custom propagation, and planting.

CONCLUSIONS AND RECOMMENDATIONS

1. Pursue new markets. Time is critical as markets for native riparian plant material are developing rapidly. Therefore, nurseries must be aggressive and seek out new customers to introduce their products and services. Attend meetings of potential customers and use new marketing techniques like establishing a website on the internet.
2. Practice "Show and Tell." Many customers have no understanding of nursery procedures or potential so be sure to show potential customers what you can produce—both species and stock types. Invite potential customers to an open house at your nursery to show what types of plant materials you can produce. Showing is always better than telling, so try to grow some typical riparian plants or establish stooling beds or mother plants ahead of time.
3. 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. Explain the importance of using native plant material that is collected at their project area and adapted to the local environment. When growing sample plants, make sure that you have the proper sources for a specific project.

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