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HOW TO PLANT WILLOWS AND COTTONWOODS FOR RIPARIAN REHABILITATION

Many riparian areas in the West need rehabilitation. Abuses in the past have caused the destruction of vegetation and accelerated bank and bottom erosion (Kauffman and Krueger 1984; Skovlin 1984; Platts 1981; Thomas and others 1979). Recent emphasis on water quality, aesthetics, wildlife, and fisheries has prompted new interest in methods for revegetating eroding stream channels (Carlson 1992; Carlson et al. 1991). The Interagency Riparian/Wetland Plant Development Project, USDA Natural Resources Conservation Service (SCS) Plant Materials Centers (PMCs), and others are developing new native and introduced varieties of willows and cottonwoods to better meet the needs of riparian rehabilitation. Numerous questions have been asked about rehabilitating riparian zones with willows and cottonwoods. This Technical Note describes a step by step procedure for planting willow and cottonwood cuttings.

Site Considerations

Careful planning before planting is necessary to ensure the solution does not create more problems than those already identified.

* Management (planned grazing system, livestock exclusion, etc.) must be in-place to maintain or improve riparian vegetation. Without proper management, planting efforts could be destroyed (Crouse and Kindschy 1984; Van Haveren and Jackson 1986).

* If native willows or cottonwoods are not found in the vicinity, planting may not be a good option.

* Willow and cottonwood plantings apply only to situations where the rehabilitation time frame is long enough to allow them to become established and stabilize the site. Structures may be more appropriate in emergency situations.

* Unrooted cuttings can be used on sites that range from flat to near vertical slopes. Risk of wash-out and mortality are higher with steeper slopes.

A reconnaissance upstream and downstream from the site selected for revegetation may save time and effort. If there are willows and cottonwoods on adjacent sites, check soil and site conditions and compare them to conditions at the revegetation site. Plantings will be most

successful on sites similar to these stable vegetated areas. Risk of mortality will increase as soil, site, and water column parameters depart from those of the vegetated sites.

There are reasons for vegetation not growing on the disturbed site. Some parameters to inventory in addition to management at the revegetation site include: high streamflow velocities, sharp outside curves, vertical to near vertical or undercut banks, hanging streambanks, mixed stratigraphy of cohesive materials over gravel, and evidence of mass soil slumping. When these parameters are present, revegetation can still be considered, but it is much more difficult because the time period required for stabilization increases, the planting schedule must accelerate, and additional soil losses can be expected.

These conditions indicate structures or bioengineering techniques not covered in this Technical Note need to be included in the planning considerations.

Some data suggests vegetative protection may be adequate if maximum streamflow velocities are less than 8 feet per second. Structural and bioengineering techniques should be considered for velocities greater than 8 feet per second. Woody materials should be considered with velocities less than 8 feet per second. Woody materials in conjunction with herbaceous species should be considered for velocities less than 5 feet per second. Herbaceous materials alone can be used for velocities less than 3 feet per second.

Structures or bioengineering techniques may be needed in situations where the toe of the bank is unstable. In these situations, refer to SCS Engineering Field Handbook, Chapter 16.

Species Selection

During the reconnaissance, identify willow and cottonwood species, soil and site conditions they are growing in, and the moisture regime. If species identification is a problem, at least identify the growth form and conditions where plant is growing. Species identification is important so proper plants can be matched at the revegetation site.

Species have several different growth forms. Willows come in all sizes, from small shrubs to large trees. Some willows sucker profusely while others mature with a large dense basal area. Cottonwood species have narrow to wide crowns and some sucker while others have very shallow root systems. For the most part, small to medium size shrub-type willows and rhizomatous or creeping-type willows are used for planting within the channel banks. These can be planted as live poles or as bundles (fascines). Tree-type willows and cottonwoods are normally selected for the upper bank and floodplain areas.

Mature size and growth form will affect species selection. Large species can partially block or deflect currents. If the mature basal size of the selected species will block more than 10% of the surface width at normal streamflow, another species should be considered.

There are many species of willows that occur naturally in different habitats. Upland willow species are found in relatively dry areas not necessarily associated with seeps, bogs, or high

water. Wetland willows are found growing in standing water or saturated conditions and are adapted to long periods of inundation.

If spreading of planted species is considered a problem, selection might include only male clones. Both willows and cottonwoods have male and female plants. Selecting male plants will reduce spreading from seeds.

More shade will be produced with tall and/or wide canopy species. This may be important to water temperatures and fish habitat. Concentrate tree species on the southerly side of stream to achieve the most shade over the widest area.

Stem flexibility is important for species at waterline to mid-bank on streams with high velocities, debris loads, and ice flows (Parsons 1963; Platts and Rinne 1985). Species with deep or rhizomatous root systems might be better suited to streams with severe ice flows (Platts and Rinne 1985).

Livestock and wildlife can adversely impact the riparian zone. Some plant species such as willow, cottonwood, golden current, waterbirch, chokecherry, dogwood, serviceberry, mockorange and silver buffaloberry are fairly palatable. It may be advantageous to plant unpalatable species, like Hawthorne, on the mid-bank to top bank and floodplain areas rather than more palatable species. Other less palatable species include: woods rose, skunkbush sumac, Douglas spirea, and common snowberry.

Grazing can also reduce reproduction of young plants, particularly those that reproduce by seed. Species selection of strong suckering or rhizomatous species may be an advantage. Improper grazing management can adversely impact even these species. A grazing management plan is needed whenever planting riparian areas that are grazed.

Aesthetics can usually be improved by selecting more than one species to provide differences in size, shape, color, and texture. More than 1 species or clone also increases resistance to pests and diseases, in addition to increasing diversity for wildlife. However, the species planted at the waterline should be a single species for the full length of any one reach so that varying sizes and shapes do not cause the force of water to move behind that planted line.

Most species of willow and cottonwood have good fire tolerance and resprout well after fire. Many cottonwoods are more susceptible to fire as they mature. Both are also very well adapted to high density plantings one would plant to achieve a barrier effect.

There may be times when native species will not meet the landowners objectives. Introduced species can be considered in the revegetation plan. Refer to the Idaho Tree Planting Handbook for plant characteristics.

Species Distribution or Planting Design

A planting design should be developed to show where each species is to be planted on the site. The entire problem section should be planted, not just parts of a reach or curve. This will reduce the chance of water eroding behind the planting.

Each species grows in specific ecological zones along the stream channel and flood plain (Carlson et al. 1992). For example, rhizomatous willows are often found and usually should be planted on inside curves (gravel, silt and sand bars) of a stream channel. Inside curves or point bars undergo less erosion from moving water, but have a longer inundation period. Rhizomatous willows are rarely found on sharp outside curves.

Shrubby species are normally planted on outside curves of a stream channel as a continuous barrier. Outside curves incur more erosion from streamflow, but have a shorter inundation period. Plant the entire reach with the same species. Taller shrubby species may also be planted mid-bank to upper bank and on the floodplain for diversity and additional stabilization or as a buffer zone.

Plant tree species up the bank from the shrubby species or on top of the bank. The shrubby species provide protection for the tree species when planted in this manner.

The reconnaissance survey will help identify these relationships. See "Spacing" section to help in planting design and to help determine numbers of plants or cuttings needed.

Type of Planting Stock

Cuttings, whips, plugs, conetainers, bare-root, potted, clumps, and paper-sleeved planting stock are all viable alternatives (Carlson et al. 1992; Dirr and Heuser 1987; Platts et al. 1987).

General advantages of nursery stock include: good potential root development, good carbohydrate reserves, few pest problems, readily available for many species, and no money and labor is needed from the buyer to collect the stock.

Disadvantages of nursery stock include: more expensive than hardwood cuttings collected near the revegetation site, short root systems can wash out easily, short root system may not reach moist soil during the growing season, and roots of grasses and weeds are in the same zone competing for moisture and nutrients.

Stem cuttings can be divided into softwood, semi-hardwood (greenwood), and hardwood categories. Hardwood stem cuttings can also be divided into deciduous, narrowleaf evergreen, and broadleaf evergreen (Dirr and Heuser 1987). This Technical Note will concentrate on deciduous hardwood cuttings from moderate age stem materials. Deciduous hardwood cuttings of willow and cottonwood species are generally recommended over other types of cuttings because of the high concentration of pre-formed, dormant root primordia located throughout the length of the stems (Densmore and Zasada 1978; Carlson 1938, 1950; Haissig 1970, 1974).

Pole cuttings (large diameter unrooted stems) are recommended for most plantings from water line to mid-bank. Pole cuttings of willows and cottonwoods are also recommended on upper-banks and floodplains where the water table is relatively deep. Pole cuttings usually provide the only means to reach this moisture and establish a high concentration of roots for that portion of the stem within the moist zone.

Pole cuttings have the additional advantage of being relatively inexpensive. They are easy to harvest and store. They are also much easier to plant. High mortality can occasionally occur, but this is somewhat offset by lower costs, ability to rapidly plant large numbers, and ease of replanting the following year.

Generally, whips (less than 3/8 inch diameter) are not recommended because energy reserves in the stem are limited and they are more susceptible to cytospora canker, a fungus causing twig dieback (Biggs et al. 1983; Briggs 1991).

Plugs, conetainers, bare-root, potted, and paper-sleeve planting stock are best when used:

* on mid-bank to upper-bank or floodplain where long periods of inundation or water erosion is minimized.

* where adequate moisture is available -- i.e. natural precipitation is adequate for species selected or plants are irrigated.

* where there is no competing vegetation or a 30" diameter area around plant is scalped of competing vegetation at planting time.

* where plants have a low risk of physically being pulled or eroded out due to shallow rooting systems during the establishment period.

Source of Cuttings from Commercial Stock

Willows and cottonwoods have been used extensively for riparian rehabilitation because they are easily established from cuttings. Cuttings can often be obtained from commercial nurseries or from native stands located near rehabilitation sites. When buying cuttings from commercial sources, released varieties of adapted species should always be specified.

PMCs and Projects conduct extensive research and testing with native willows and cottonwoods collected from service area states having similar climate, soils, and topography. Once a willow or cottonwood meets the testing criteria, it is released to the public. Commercial nurseries and growers then propagate the species on a much larger scale for sale. The released variety name is the key to getting a plant adapted to conditions similar to where it was tested. All named varieties have documentation that describes growth characteristics, performance, and selection criteria. This ensures they are the same stock as originally tested.

Plugs, conetainers, bare-root, potted, and paper-sleeved nursery stock purchased through nurseries should be rooted from local materials. This could be from a local ecotype or the same

watershed, but should not be from more than 200 miles east or west or 100 miles north or south or more than 2000 feet elevation difference from planting site. Ask the nursery where the stock came from. See Idaho Tree Planting Handbook for more information.

Source of Cuttings from Native Stands

Native willow and cottonwood stands located near the rehabilitation site are another source of cuttings. Native stands of willow and cottonwood usually have or have had insect and disease infestations which can stress the plants in the potential "mother" stand. Low water years and long periods of drought may also stress the plants. This stress means that the stem cuttings may not have peak energy reserves. Low energy reserves translate into lower establishment success.

When planning the number of cuttings to harvest, take these stress indicators into account. Always obtain permission to harvest from the landowner, private or public, before starting to cut.

Timing of Harvest

Establishment success is significantly increased if cuttings are taken from live, dormant willows either in late fall, winter, or very early spring before the buds start to break. Densmore and Zasada (1978) found that spring collections survived better than fall collections. However, studies in Idaho have found no such differences (Hoag 1991; Hoag et al. 1991; Hoag et al. 1992). See "Storage" section for procedures when harvesting well before the projected planting date.

Cutting Diameter

Cuttings should generally be 3/4 inch diameter or larger depending upon the species (Briggs and Munda 1992; Hoag 1991; Hoag et al. 1991; Hoag et al. 1992; Fenchel et al. 1988). Rhizomatous or spreading willow stems will rarely get much bigger than 3/4 inches in diameter. Tree-type willows can be several inches in diameter. Larger diameter cuttings have more energy and stored reserves than smaller diameter cuttings. Highest survival rates are obtained using cuttings 2 to 3 inches in diameter. Cuttings as large as 8 inches have been tested with excellent success (Carlson et al. 1991; Hoag et al. 1992). However, the larger the cutting diameter, the longer the cutting should be, and the deeper the hole should be to support it. The deciding factor for selecting the cutting diameter is the planting method you will use (see Planting Methods). Larger diameter and longer cuttings will be needed for more severely eroding sites and where the water table is deeper. When planting into rock riprap, cuttings should be larger than 3 inches, preferably 4-5 inches. They will not bend or break when pushed between the rocks in the riprap.

Cutting Length

Cutting length is largely determined by the depth to the mid-summer water table and erosive force of stream at the planting site (Briggs and Munda 1992; Fenchel et al. 1988; Hoag 1991; Hoag et al. 1991; Hoag et al. 1992). Plantings can occur at the water line, up the bank, and on top of bank in relatively dry soil, as long as cuttings are long enough to reach into the mid-summer water table. Make sure:

* Several inches of cutting are in the mid-summer water table.

* 3-4 buds are above the ground.

* no less than 1/2 the total length is in the ground.

* If long periods of inundation exceeding 30 days are likely, cuttings should be long enough to extend 6-12 inches above the expected high water line.

* If weeds are a problem, the cutting should extend above herbaceous growth in summer to receive adequate light and below weed root mass to minimize competition (Hoag et al. 1991; Platts et al. 1987).

When planting for bank stabilization, the cutting should extend 2-3 feet above ground so as it leafs out, it can provide immediate bank erosion protection. The cutting should be planted as much as 3-5 feet into the ground if it is not this deep, moving water can erode around cutting and rip it out of the ground. Tests have shown that even with establishing root systems as long as 15-28 feet, the erosive power of a stream can rip a short cutting out of the ground (Hoag 1991; Hoag et al. 1991; Hoag et al. 1992).

Harvest of Cuttings

Once cutting size and source location has been determined, the actual cutting process can begin. Lopping shears, pruning shears, a small wood saw, brush cutters, or a chain saw can be used to harvest cuttings. Size of the cuttings will determine what you use to cut them.

* Make clean cuts. Ensure all equipment is sharp.

* Use live wood at least 1 year old or older. However, very old wood should not be used (Briggs and Munda 1992; Fenchel et al. 1988). Chmelar (1974) indicated that larger and older wood is required to propagate species that are difficult to root. The best wood is 4-5 years old and smooth barked not deeply furrowed.

* Avoid suckers, current year's growth, because they lack the stored energy reserves necessary to consistently sprout when planted.

* No more than 1/3 of any one individual plant should be removed. In the case of rhizomatous species, no more than 40% of the plant should be removed.

* Select branches which will not impair the source willows health and appearance.

* When harvesting from native stands, make sure the stand will not be denuded or destroyed by your cutting activity.

* Consider removing cuttings from inside the crown area rather than the more visually obvious exterior area. Try to spread your harvesting activity throughout the stand.

* Cut the apical bud plus several inches off cutting before planting it. The apical bud (bud at tip of branch) draws too much energy from stored reserves, reducing chance of survival. The upper part of the stem also has the flowering parts (Kay and Chadde 1992). By cutting it off, energy is redirected to the root and branch primordia in the lower part of stem.

* Trim off all side branches so cutting is one single stem.

* A processing alternative is to cut the top of cutting with a horizontal cut and bottom of cutting with a 45° cut. This allows quick recognition of cutting top (see Sealing Harvested Cuttings).

* Care should be taken to select materials free of splitting, disease, and insect damage.

Sealing Harvested Cuttings

One of the most important steps in this process is the identification of **TOP** of cutting. If cutting is planted upside down, significant mortality will occur. To identify which end is the top of cutting, look at the leaf scar and emerging buds. Buds emerging from leaf scar always point up. Another key is the stem. It is usually a smaller diameter near top of cutting, but this is not always obvious. The leaf scars are the most reliable key.

When the top of cutting has been identified, you should seal it. Dipping the TOP 1-2 inches of cutting into a 50-50 mix of light colored latex paint and water, prevents excessive transpiration of water from cutting. This also reduces the possibility of diseases entering the open top of the cutting after it has been planted. In many cases, cuttings sprouted the first year, but died the second year from disease or desiccation over the hot summer months. Perhaps the best reason for painting the top of cuttings is it helps inexperienced planting crews plant cuttings properly, with the top up! It also helps locate the cuttings more easily for subsequent planting evaluations. This technique is inexpensive, easy, and effective.

Storage

The preferred timing for harvesting willow and cottonwood cuttings is when they are dormant. To minimize storage time, harvest cuttings in early spring and plant immediately there after. If this is not possible, cuttings can be harvested in late fall or winter and stored in a large cooler at 24-32°F until just before planting. Cuttings can be stored for several months in a cooler (Platts et al. 1987). Whether cuttings are kept in a cooler, root cellar, garage, or shop floor, make sure the storage area is dark, moist, and cool at all times. If cuttings are stored at higher temperatures, a fungicide should be applied to prevent damage caused by pathogens or saprophytes (personal communication, D. Darris, Corvallis PMC manger, 1993)

Cold storage in a moist potting medium or moist peat can stimulate callus formation of cuttings and speed rooting once planted. For large numbers of cuttings, this is usually impractical and costly.

Treatment of Cuttings

In Interagency Riparian/Wetland Plant Development Project tests, fertilization, treatment with rooting hormone, or treatment with a fungicide did not significantly affect the rooting of willow and cottonwood pole cuttings (Hoag 1991; Hoag et al. 1991; Hoag et al. 1992; Fenchel et al. 1988; Ogle 1990). Many willows and cottonwoods are very easy to root without special treatment. These treatments increase cost, labor requirements, and time necessary to plant without significantly increasing survival.

Pre-plant Soaking of Cuttings

Prior to planting, all cuttings should be soaked for a minimum of 24 hours, whether they are stored or harvested and immediately planted (Hoag 1991; Hoag et al. 1991; Hoag et al. 1992). Some research recommends soaking the cuttings for as much as 10-14 days (Briggs and Munda 1992; Fenchel et al. 1988). The main criteria is that cuttings should be removed from water prior to root emergence from the bark. This normally takes 7 to 9 days (Peterson and Phipps 1976). Soaking is important because it initiates root growth processes within the inner layer of bark in willows and cottonwoods.

Only the bottom 1/3 of the cutting need be placed in water. However, soaking the entire cutting is not detrimental (avoid soaking latex painted top if possible). Soaking can be accomplished in a garbage can, irrigation ditch, stream, pond, lake, or other body of water that is deep enough as long as the cuttings are protected from sun and wind exposure during soaking process. Soaking significantly increases the survival rate of the cuttings (Briggs and Munda 1992; Fenchel et al. 1988; Hoag 1991; Hoag et al. 1991; Hoag et al. 1992; Peterson and Phipps 1976).

Spacing Considerations

Plant the cuttings about 1-3 feet apart for shrubby types and about 6-12 feet apart for tree-types. In areas where you expect erosion, plant shrubby types 1-1.5 feet apart to better protect the banks. Exact spacing between tree-types further up the bank and shrubby types below should be based on crown characteristics and height. General ideas on spacing can be found in the Idaho Tree Planting Handbook. However, crowding cuttings a little will not stress them because they will not lack water and will provide better protection to the bank.

When to Plant

Willow and cottonwood cuttings have been successfully planted from early spring to late fall.

* Preferably, cuttings should be planted in early spring after spring runoff occurs in streams or after high water drops to typical levels on reservoirs, ponds, or lakes.

* Rooted stock should be planted in early spring after frost has left soil. See Idaho Tree Planting Handbook for additional information. Avoid planting cuttings or rooted stock in heat of summer because of the stress it places on them.

* When planting multiple sites along a stream, sites may need to be planted in different years.

* A successful planting on an inside meander could force water to the outside curve before planting on outside curve is fully established, thus increasing risk of failure.

* Rhizomatous species often are planted on inside curves and once established can spread rapidly.

* Consideration should be given to planting outside curves first and allowing time for establishment. Delay planting inside curve until two or three years later. The inside curve is often not eroding and will begin to heal without planting.

Planting Methods and Planting

Cuttings:

Tractor-mounted posthole diggers, one- or two-person posthole diggers, soil augers, planting bars, shovels, soil probes, or simply pushing the cutting into moist soil have all been used successfully to plant willow and cottonwood cuttings. When selecting the appropriate planting method, you should keep several things in mind.

* It is essential to have good contact between cutting and soil for roots to sprout. Air pockets around the cutting will kill the roots.

* Avoid damaging buds when inserting the cutting into the hole.

* Additional soil may be needed to get good soil to stem contact. Preference should be given to native soil nearby to encourage mycorrhizal formation and/or nodule formation by nitrogen-fixing organisms.

* Carefully tamp the soil around the cutting firmly several times as you fill the hole.

* The planting depth will determine the planting method. Deeper holes will be easier with a power auger or a soil auger.

* Experimentation with planting methods before starting will ensure the right equipment has been selected. This would also be a good time to train the planting crew on use of equipment, safety and planting techniques.

Clump Planting:

Clump plantings can be used in areas where heavy runoff occurs or where the water column directly impacts the vertical banks (personal communication, D. Ogle, Idaho-Utah Plant Materials Specialist, 1993). These areas are difficult to plant and establish with traditional methods.

* The basic procedure is to locate clumps of willows that are accessible to a backhoe.

* The backhoe digs up a clump of willows, travels back to the planting site, and places the willow clump in a predetermined location by pushing out a hole as it deposits the clump.

* Generally, clumps are placed close together along the entire problem section of stream to keep water from cutting around the planting. Pulling or pushing soil from the streambank above willow clumps and packing it behind clumps will improve establishment success and assist in bank shaping.

* Root bunches (sod) of rhizomatous grass species can be placed behind the willow clumps to speed up recovery time of the near vertical banks. Some minor bank shaping will improve establishment of the herbaceous material. Grass species can also be seeded by hand.

* Planting should be done following high water flows in the spring to reduce chance of ripping clumps out before the roots start to spread.

* Temporary protection, such as steel posts with woven wire, sunlight degradable netting, etc., may be necessary to hold willow clumps in place until they are well established which can take 2-3 years. Usually, this is only necessary in areas were high velocities impact the bank.

Other Planting Stock:

See the Idaho Tree Planting Handbook for information on planting nursery stock.

Permits

The landowner is responsible for all permits prior to any planting. The completed plan should be copied as needed and provided to landowner for submission to the state Department of Water Resources and/or US Army Corps of Engineers. Each state has specific permitting requirements and landowner is responsible for locating appropriate agency. Normally any work done in a stream channel requires notification and approval by these agencies and the issuance of permits before starting any work.

Management and Maintenance

Preserve or initiate management that will keep, maintain, and improve the planting and other riparian vegetation. Proper management is necessary to maintain healthy, competitive plants that function for the intended objectives. This is as important as the planting itself to ensure rehabilitation of the riparian area. Some maintenance will be needed on site for several years after planting. Vegetation should be evaluated and monitored annually. Some replanting will be needed in succeeding years. If you don't replant the first or second year, your continuous barrier could be jeopardized. Once water gets behind the willow line you have planted, it is extremely difficult to repair the damage.

Monitoring of the site is necessary so any in-stream dead organic material (i.e. old logs, dead root masses, branches, etc.) can be removed before stream flow is deflected or gravel bars form. It is much easier to prevent this kind of damage than it is to repair it. As willows age and start to develop their growth patterns, some will probably need to be trimmed or cut to stimulate smaller and denser growth. Subsequent trimming should be done in the dormant season so willows will not be slowed during the growing season. During the establishment period, leave standing dead branches in the clump plantings to reduce stream flow velocities, thus protecting the establishing clumps.

If livestock use the area, a grazing plan should be developed. Little to no grazing should occur during the establishment period. This can take 2-5 years depending on growing conditions. Larger planting stock may be more resistant to grazing pressure, but should be monitored closely to avoid serious damage.

Temporary fencing may be necessary to control livestock and wildlife use of the plantings during the establishment period. Permanent fencing is an option to prevent grazing by livestock and/or wildlife. Consideration should be given to the creation of "riparian pastures", i.e. grazing units that include riparian zones and flood plains as a majority of the pasture. These riparian pastures often include high maintenance fences as a result of heavy grazing pressure from both livestock and wildlife. Water gaps for livestock should be planned at inside curves. These areas have reduced erosion potential, are generally gravelly, and can be planted to a rhizomatous willow that will resprout easily. Access to water gaps can also be protected with gravel or concrete pads if heavy trampling problems arise or if water access at inside curves is not possible.

Finally it is critical to protect streamsides and plantings from continuous use during long winter feeding periods. Feed grounds should be located away from streamside areas. If this is not possible, the area should be fenced and water gaps provided so direct access to riparian corridor is controlled.

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