# Riparian/Wetland Project Information Series No. 3

**October, 1992**

## USE OF WILLOW AND COTTONWOOD CUTTINGS FOR VEGETATING SHORELINES AND RIPARIAN AREAS

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**ABSTRACT**

The Aberdeen Plant Materials Center in cooperation with the Bureau of Reclamation found the following woody riparian species effective in shoreline protection and revegetation of eroded stream channels: Coyote Willow (*Salix exigua*), Laurel Willow (*Salix pentandra*), Prairie Willow (*Salix humilis*), 'Siouxland' Eastern Cottonwood (*Populus deltoides*), 'Imperial' Carolina Poplar (*Populus canadensis*), and Robust Popular (*Populus robusta*). A small power auger was the most effective planting method on shorelines without rip-rap. "The Stinger", a backhoe attachment, was the most successful method on rock rip-rapped shorelines. Hormones, fungicides, and fertilizer did not necessarily enhance survival and establishment. Long cuttings with large diameters planted into the midsummer water table gave the highest success rate.

**INTRODUCTION**

The Plant Materials Center (PMC) at Aberdeen, Idaho is one of 26 PMCs in the United States run by the USDA, Natural Resources Conservation Service (USDA Soil Conservation Service 1989*a*). Even though we are located in Idaho, our service area includes southern Idaho, southeastern Oregon, the northeastern tip of California, most of Nevada, and Utah. The Aberdeen Plant Materials Center was established in 1939 to assemble, test, and release plant materials for conservation uses; determine techniques for their successful use; provide for their commercial increase; and promote the use of plant materials needed to meet the objectives and priorities of the National Conservation Program (USDA Soil Conservation Service 1989*b*).

The Minidoka Project office of the USDI, Bureau of Reclamation is located in Burley, ID about 80 miles west of Pocatello. Its area of responsibility is the Snake River drainage in southeastern Idaho and western Wyoming. The Minidoka Project operates 8 reservoirs and 2 power plants. It provides full or supplemental irrigation water for about 1.2 million acres. The American Falls Reservoir is the largest reservoir in the system and is the keystone of the Project (USDI Bureau of Reclamation 1981).

The Minidoka Project had previously tested structural and vegetative methods for reducing shoreline erosion around American Falls Reservoir with varied success (USDI Bureau of Reclamation 1992). The vegetative methods indicated great potential in areas with a short fetch (the distance wind can travel unobstructed), so it was decided to expand the testing to areas with more severe conditions. In order to more fully research these methods, the USDI Bureau of Reclamation (USBR) contacted the Aberdeen Plant Materials Center and entered into an agreement with them to develop a vegetative solution to reduce shoreline erosion (USDA Soil Conservation Service 1986).

**PROBLEM**

American Falls Reservoir was built on the Snake River in 1926 to store irrigation water for farmers and ranchers downstream of the dam. The reservoir's capacity is 1,700,000 acre-feet. The elevation of the reservoir is about 4,350 feet. The annual precipitation for this area is 8-10 inches. Idaho Power has a hydroelectric plant downstream of the dam for power generation. The general operation of the reservoir is based on the irrigation needs of the water-right owners below the dam. Drawdown starts in early summer and continues into the fall until the end of the irrigation season, which is usually in October. The water level in the reservoir decreases continuously over the course of the summer according to irrigation water demand downstream. The reservoir is refilled during winter and spring (USDI Bureau of Reclamation 1981).

The main resource problem at American Falls Reservoir is that the majority of the shoreline soils are clay and sand. Much of the shoreline has eroded into 20 to 40 foot vertical cliffs. Wind-driven waves during the spring refill and summer drawdown slam against the vertical cliffs causing massive undercutting and sloughing. In some cases, the shoreline has retreated hundreds of feet with the loss of many acres of valuable farmland. The general rule of thumb has been that 3-5 feet of shoreline is lost each year.

Social, political, and economic reasons have prompted USBR to come up with methods of controlling this erosion. The best structural method to date is to armor the shoreline with geotextile sheet and rock rip-rap. Considering that the reservoir has about 60 miles of shoreline that needs some treatment, the cost of rip-rapping the shoreline at $20-$25 per linear foot is prohibitively expensive (H. Short, personal communication, USBR, Burley, ID, 1992). Additional methods of protecting the eroding shorelines must be found.

In 1986, the Aberdeen PMC initiated a research project to study methods of establishing vegetation to protect the shoreline of American Falls Reservoir (USDA Soil Conservation Service 1986). The objectives of the study were: (1) test various plants for their erosion controlling ability along the shorelines (including unprotected stretches and stretches partially or fully protected by structures), (2) improve low cost, high volume planting techniques, (3) ensure low maintenance costs, and (4) maintain or improve wildlife and fish habitat needs, as well as aesthetic values.

The study is composed of two phases. The initial phase began in 1986 and was completed in approximately 2 years. Based on information on cutting size and planting methods developed in this initial phase, the second phase of the study was radically changed. The techniques and species that were developed in the first 2 years of the study were refined and built upon to better handle the wave undercutting and ice problems that plagued the first phase.

## MATERIALS AND METHODS

### Background

Since the 1950's, the Minidoka Project has been testing various methods, both structural and vegetative, to reduce the shoreline erosion on American Falls Reservoir. The first method was to use rock picked off of agricultural fields and pushed over the sides of the cliffs. This method was ineffective because the waves tended to move the small rock and continue to erode the cliffs. They then tried railroad rails pounded into the reservoir bed and old automobile tires piled on the rail to a height of 6-8 feet. The rails and tires were placed about 1-2 feet apart assuming that wave energy would be reduced as it passed through the tires before it hit the banks. This method did not work very well because the wave energy was not significantly reduced. USBR also tried a tire mattress made up of old automobile tires tied together and placed on the shoreline in front of the cliff. They hoped that the tire mattress would reduce wave energy and catch sediment before the waves hit the cliffs. This worked so well that the mattress was totally buried by sediment in a couple of years and the erosion problem started again. After the tire mattress, the USBR used a method called post and wire. This method used railroad rails pounded into the bed, galvanized wire tied to the rails, and rock rip-rap piled between the wire and the cliffs. This method was very successful, but extremely expensive and difficult to repair. Finally, the method currently in use is shaping the upper bank, dropping the soil down to the base of the cliff, dozing a road along the base, laying geotextile (a nonwoven fabric that prevents wave generated energy from washing soil out from under the rock) over the slope, and covering the geotextile with large rock (H. Short, personal communication, USBR, Burley, ID, 1992). (See Attachment 1 for a more detailed description of structural erosion control methods that USBR has used in the past and is currently using.)

The Minidoka Project also tried using Brittle Willow (*Salix fragilis*) for shoreline protection. The Project started planting cuttings in the 1950s. A large bulldozer with 2 ripper teeth drove along the base of the cliffs and short cuttings were placed in the trenches and soil packed around them. The problem with this procedure was that the cuttings were too short. Not only did the wave action tend to destroy the plantings by undercutting, but ice froze around the bases and as the water level in the reservoir continued to rise, it pulled the cuttings out of the ground (USDI Bureau of Reclamation 1973).

This project was designed to expand the USBR's experiments with Brittle Willows and to develop ways to enhance the structural methods that have been used around the reservoir. Initially, the PMC decided to look at different species of willows and cottonwoods in addition to different growth forms.

Many willow and cottonwood species have pre-formed, dormant, root primordia which are initiated in the stems early in their 1st year of growth (Densmore and Zasada 1978; Carlson 1938, 1950; Haissig 1970, 1974). This makes unrooted cuttings collected in the dormant season ideal for testing purposes. It reduces the growing time, pre-planning time, and allows extended time for collection of the planting material.

The Aberdeen PMC has been testing riparian woody species since 1982. A large planting of different windbreak species was established in 1982. It contains, among other things, about 70 different riparian accessions.

A initial evaluation willow planting was established in 1984 at the PMC. It includes about 30 different accessions of willows. These accessions were collected from native stands throughout the Aberdeen PMC service area and from PMCs in North Dakota, Montana, Washington, and Michigan. Evaluation criteria were based on a need for rapid establishment, production of numerous stems, wide range of adaptability, and good regeneration capabilities (USDA Soil Conservation Service 1984). From these two initial trials, 15 different accessions were selected for advanced testing (Table 1).

**Table 1**-- Species selected for advanced testing from 2 initial trials at the Aberdeen PMC.

| Accession | Scientific Name | Common name | Source |
|---|---|---|---|
| 9005049 | *Salix pentandra* | Laurel Willow | Michigan |
| 9047349 | *Salix vitellini* | Golden Willow | North Dakota |
| 9044859 | *Salix alba* | White Willow | North Dakota |
| 9053849 | *Salix fragilis* | Brittle Willow | Idaho |
| 9020059 | *Salix drummondiana* | Drummond Willow | Washington |
| 9020121 | *Salix lemonii* | Lemon Willow | Washington |
| 9020100 | *Salix rigida* var. *mackenziana* | Mackenzie Willow | Washington |
| 303584 | *Salix humulis* | Prairie Willow | North Dakota |
| 9026075 | *Salix exigua* | Sandbar Willow | Montana |
| 9020099 | *Salix exigua* | Sandbar Willow | Washington |
| 9044861 | *Salix exigua* | Sandbar Willow | Idaho |
| 9031690 | *Populus robusta* | Robust Poplar | North Dakota |
| 9031688 | *Populus deltoides* | 'Souixland' Cottonwood | North Dakota |
| 432347 | *Populus* x *canadensis* (*deltoides* x *nigra)* | 'Imperial' Carolina Poplar | Michigan |
| 9005050 | *Salix purpurea nana* | Dwarf Blue Artic Willow | Michigan |

**Site**

American Falls Reservoir is an extremely harsh site because of three major limiting factors. The first major limiting factor at the reservoir is the soil. It is mainly clays and silty clays intermixed with layers of sand. It is very compacted and has almost no organic matter or soil nutrients (USDA Soil Conservation Service 1981). This makes root penetration very difficult. In addition, as the soils dry out during drawdown, the sand, shattered clay, and silts fill the planting holes as fast as the drill instrument is removed.

Another major limiting factor is the lack of natural vegetation. Few species are available at the reservoir to establish, spread, and protect the shoreline. These species are normally found only in protected areas that have water seepage from springs or irrigation water that drains underground from the fields above the reservoir.

The last major limiting factor is the drawdown of the water stored in the reservoir. From the start of the irrigation season in mid-April to the end of the irrigation season in late October, the water in the reservoir is drawn down to as low as 10 percent (or less) of its capacity. This means that willows planted along the shore in the spring are 1,000 feet or more from water by the end of the irrigation season. After the irrigation season, the reservoir begins to refill, and the last 10 vertical feet of the reservoir normally fills by March or April. This means that willows planted at the base of the shoreline are inundated just before they break bud and may stay inundated until June or July.

American Falls Reservoir lies generally southwest to northeast. Prevailing winds are from the southwest and are most active in the early spring. Test plots were established on five different beaches around the reservoir. Of the five beaches, three beaches are unprotected and face east, west, and south. The unprotected beaches are bounded by vertical cliffs at the high-water line, and fairly uniform slopes drop away from the cliffs at 3 to 5 percent. The other two beaches have existing structures, such as rail and wire, rail and tire, rock rip-rap, and tire mattresses. The PMC planted willows in front of these structures to slow the wave energy down before they hit the structures. These structures generally extend 40 to 60 feet out from the cliffs. One beach faces east and the other faces west.

**Test Design**

The test plots were set up in replicated randomized complete blocks. Initially, each block contained all of the accessions in a test and extended out from the cliff at three different inundation levels. At each inundation level, treatments were randomized. Each combination of inundation level, accession, and treatment was replicated three times. The accessions were planted with five members spaced 1 foot apart in a "W" arrangement. This allowed not only an adaptation test, but was also thought to provide the best protection possible for the shoreline. As the survivability of the different accessions became established, the "W" arrangement was supplemented by various other arrangements based on the individual growth types of the accessions. For all succeeding tests, accessions were planted in five groups of four individuals randomly arranged in the various segments of the block.

Generally, we tried to use the natural growing habits of the willows when designing the layout of the tests. Creeping-type willows with their flexible stems and extensive root systems were planted furthest out so that they would decrease wave energy as the wave passed through them. Creeping-type willows also tend to bend with the current, act as a slide for debris coming downstream and accumulate sediment (Carlson 1979; Parsons 1963; Platts and Rinne 1985). Shrub-type willows with shorter stature and somewhat flexible stems and tree-type willows with large roots and trunks provide obstacles to ice, logs, and other debris. In addition, when they fall over they provide a mechanism that controls channel gradient and stability (Heede 1977; Sedell et al. 1982). All three willow types were planted in association with each other in a way that wave energy would be reduced as it passed through each successive type before it impacted the cliff or structure (Hoag 1992).

**Test Methods**

Initially, to improve low-cost, efficient, successful planting techniques, five different factors were examined. They were: (1) planting methods, (2) cutting diameter, (3) cutting length, (4) planting depth, and (5) planting supplements. To test these factors, five different accessions were used that grew on different areas of the reservoir as native or naturalized species, or are species widely used and well adapted to the area. In subsequent years, after establishing which factors improved willow establishment, stored versus fresh cuttings and additional species were examined.

**Planting Methods**-- Seven treatments were tested: Direct insertion by hand, direct insertion by pounding with a small sledgehammer onto a special shock-absorbing cover, a 1.5-inch-diameter hand auger, and 1-inch-diameter planting bar. In subsequent years, a 3-inch-diameter, two-person power auger, a 3-inch-diameter, towable one-person power auger, and "The Stinger" ("The Stinger" is a new attachment for a backhoe for planting in rock rip-rap) were tested. The compacted nature of the clay soils meant an aggressive method was needed to get the cuttings into the ground.

**Cutting Diameter**-- Cutting diameter varied greatly by species. Six classes of diameters were established: 0.125-0.25, 0.25-0.5, 0.5-0.75, 0.75-1.0 inch, 1.0-1.5 inches, and greater than 1.5 inches. All diameter classes were represented by all the accessions tested except the Dwarf Blue Arctic and the Sandbar Willows, which rarely get bigger than 0.25-0.5 inches. In subsequent years, "dormant stump" plantings were made where the cutting diameters ranged from 2 to 8 inches in diameter.

**Cutting Length**- Cutting length varied greatly by species and source. The majority of the first plantings were 18 inches long. Specific tests were made of 1-foot, 2-foot, and 3-foot lengths. Generally, only about 6 to 10 inches of the cutting protruded from the soil after planting. Subsequent years' tests were made of 8 to 12 foot lengths. The extended length was to ensure the stem tops protruded above the high waterline.

**Planting Depth**-- Planting depth varied with the planting method. The cuttings were placed so that at least one to three buds were above ground level. Generally, where possible, two-thirds of the cutting was placed into the ground. Direct insertion by hand was the shallowest method, about 3 to 6 inches, with a few cuttings going as deep as 8 to 10 inches. The hand auger and planting bar generally put the cuttings down approximately 12 inches. The power augers put the cuttings down to a depth of 24 to 34 inches depending on the compacted soil layers. With an extension, the one-person towable auger could go deeper than 36 inches. "The Stinger" can punch holes through large rock rip-rap as deep as 7 feet.

**Planting Supplements**--Planting supplements were examined to see if they would enhance survival and rapid establishment which would in turn decrease the total cost per plant. About 50 gm of Ozmacote 19-6-12 time-release fertilizer was placed 3 inches below the cutting in a hand-augured hole and covered with a layer of soil. Two treatments, fertilizer and no fertilizer, were applied to each of four different accessions. Four treatments: rooting hormone, fungicide, rooting hormone and fungicide, and no treatment, were also tested. The rooting hormone was 0.1 percent Indole-3-Butyric acid. The fungicide was 4.0 percent Thiram. They were applied as dry powder dips or as liquid dips just prior to planting according to the manufacturer's recommendations. In addition, soaking the stored cuttings for 24 to 48 hours in tap water versus planting dry cuttings was tested.

**Adaptation Trial**--Over 14 different accessions from Washington, Oregon, Montana, Utah, Idaho, North Dakota, and Michigan were tested to examine their range of adaptability. These cuttings were arranged in rows that contained 10 cuttings of a single accession with each accession randomly replicated three times along the beach. The cuttings were planted in rows at a 45-degree angle to the cliff. The rows were 2 feet apart and the cuttings were 3 feet apart within the row.

**Stored versus Fresh Cuttings**--Large-diameter cuttings were harvested from dormant plants in late winter. The cuttings were then placed in a walk-in cooler that was set at 24-32 degrees F. The cutting date was documented. Large-diameter fresh cuttings were harvested 20 hours prior to planting. Both stored and fresh cuttings were harvested from the same parent plant. All cuttings were 1.5 inches or larger. All cuttings were planted 26 to 34 inches deep. After planting, 2 to 6 feet of the stem protruded above the ground.

## RESULTS AND DISCUSSION

Initially, of the first four planting methods that were tested, direct insertion by hand was the most successful. It was followed closely by the hand auger and the planting bar. The direct insertion by pounding tended to shatter the tops of the cutting, even though a special metal pipe cover with a piece of rubber belting was placed in the top to absorb some of the force generated by the sledgehammer. This method was used only once and was discontinued.

Close contact between the surface of the cutting and soil was identified as a critical element to cutting establishment. Removal of extra soil from the hole, led to problems with air pockets and lightly compacted soil when backfilled after planting the cutting. The better the soil is packed around the stem or the closer the hole diameter is to the stem diameter, the better the establishment success.

The first four planting methods rarely placed the cuttings deeper than 12 to 14 inches. Excellent sprouting success was obtained the first summer with these methods. However, by the following summer, after a normal windy spring and abundant wave action, most of the cuttings had either been ripped out of the soil entirely or the soil was washed away from the roots down to about 8-10 inches. It was apparent that the cuttings had grown a good root system over the initial summer growing season with some of the roots measuring over 26 feet long. However, for cuttings to survive on the reservoir, it was apparent they were going to have to be planted much deeper.

The Aberdeen Plant Materials Center and other PMCs in the West have been researching species of willows and cottonwoods, planting supplements, and planting techniques for many years (Briggs and Munda 1992; Carlson 1992; Fenchel et al. 1988; Hoag 1991; Hoag et al. 1991). Through this research, the PMCs have determined that large unrooted cuttings of willows and cottonwoods, when planted with good stem to soil contact, will root and sprout quite readily. Cuttings from 1 to 8 inches in diameter and 4 to 15 feet in length have been tested with excellent establishment success (Briggs and Munda 1992; Carlson et al. 1991; Fenchel et al. 1988; Hoag 1991).

Sprouting success was significantly increased when the cuttings were larger than 0.5 inches in diameter. In subsequent years, it became apparent that cuttings no less than 1 inch and preferably larger than 1.5 inches in diameter produced the best sprouting and establishment success. "Dormant stumps" were also used with a diameter of 3 to 8 inches. "Dormant stumps" appear to have a much better supply of stored energy than the smaller diameters, so they can survive a longer sprouting period. They can also withstand much greater wave velocities than can the smaller diameters (Carlson et al. 1991; Hoag et al. 1992; USDA Soil Conservation Service 1983) .

The 18 inch length of the initial cuttings were determined to be too small after the first 2 years. This was because: (1) they could not be planted deep enough to keep the waves from washing them out, (2) they could not be planted deep enough to reach the mid-summer water table, and (3) the cuttings would be totally inundated during initial bud break, not to mention late spring and early summer growing periods.

After determining that larger cuttings would increase the establishment success, power augers were tested. It was clear that the other methods, even though they were fast and efficient, were not going to get the cuttings deep enough to allow them to survive on American Falls Reservoir. Tractor-mounted power augers or any other vehicle-mounted equipment could not be used at the reservoir because of the soils. If the soils were the least bit wet, any heavy piece of equipment would mire down in a very short period of time. Handheld power augers, in the size necessary to get through some of the hardpan areas, were too large and cumbersome to efficiently plant large numbers of cuttings with a reasonably sized planting crew. The towable auger was an attempt to increase the number of cuttings that could be planted over long distances and with a reasonably sized crew. Both power augers had establishment rates that were equal to the hand augers.

"The Stinger" was designed and built specifically for rock rip-rap. Rock rip-rap is a popular method for protecting shorelines and streambanks. Woody vegetation has been planted in rock rip-rap in the past, but the methods have concentrated on planting the cuttings first and dumping rock on top of them or planting through the rock rip-rap with a steel bar or water jet (Schultze and Wilcox 1985). Neither of these methods are very efficient nor have achieved great success. "The Stinger", however, builds upon these methods and utilizes the power of a backhoe to plant much bigger diameter and much longer cuttings than was possible before. "The Stinger" can plant cuttings right through rock rip-rap with minimumal effort to better stabilize the rock, allow the cutting to be above the ice layer, and to improve the aesthetics of the rip-rap.

"The Stinger" can plant 3-6 inch diameter and 4 foot or longer willow and cottonwood cuttings directly into rock rip-rap.  This tool was built to fit on the end of a backhoe arm in place of the bucket.  The shaft is a cold roll round steel bar 8 feet long.  The total length for punching holes is 7 feet.  The business end of the bar is 4 inches in diameter, pointed and hardfaced with electric welding rod.  The mainframe that attaches to the backhoe was manufactured from 3/4 inch steel plate and allows the bar to move back and forth.  This movement will allow a hole to be punched almost perpendicular, if it were required, into a vertical bank.

"The Stinger" was designed to be heavy enough to punch down through the large rock rip-rap and into the soil underneath. Generally, the soil underneath is moist to wet when the willow and cottonwood cuttings are being planted. Once  "The Singer" goes through the rock, there is not much resistance from the soil.

Cutting lengths of 8 to 12 feet had excellent establishment success because of two factors.  First, the cuttings could be planted 32 to 84 inches deep, and second, they extended 3 to 5 feet above the high water.

The one of the major problems with the American Falls Reservoir plantings was ice.  In a normal year, USBR endeavors to hold off on filling the last 10 vertical feet of the reservoir because of the thick ice sheet that forms on the surface.  When the ice does form, it freezes around the trunks of the trees and shrubs established along the shoreline and will actually pull them out of the ground.  In addition to freezing around the stems, willows planted in front of structures encountered severe damage along the stems from ice chunks that were floating on the surface after breakup.  The wind-driven waves would smash the ice against the willows, which could not give enough because they were planted too close to the structures (Hoag 1991; Hoag et al. 1991).

In the planting supplement trial, we could find no clear-cut advantage to using fertilizer, rooting hormones, or fungicides when the cuttings were part of a high-volume, high-intensity shoreline or riparian planting program.  Untreated cuttings had as high or higher establishment success when compared to those that were treated.

Data on soaking are not clear-cut in our studies.  However, when one reviews the literature with its numerous references to the benefits of soaking, it should be encouraged as a standard practice (Briggs and Munda 1992; Fenchel et al. 1988; Hansen, E.A. and Phipps 1983; Platts et al. 1987; Peterson and Phipps 1976).

In the stored versus fresh trial, we found no significant difference between cuttings that were harvested in the dormant season and stored in a cooler until summer, and fresh cuttings that were harvested the day before the plantings.  However, long term trends appear to suggest that fresh cuttings are not as tolerant of adverse conditions, such as, hot temperatures, short water, insect infestations, etc.  The storage option provides more flexibility with harvesting, site preparation, and planting than the fresh cut option.  Cuttings can be stored for extended periods of time without much decrease in sprouting success (Cram and Lindquist 1982; Platts et al. 1987).

**PLANTING RECOMMENDATIONS**

Based on our research at American Falls Reservoir, ID and Trout Creek, NV the following recommendations for planting cuttings of willows or cottonwoods are suggested:

1) **Cutting Diameter--**

a) Diameter is species dependent. Some species, such as, Coyote Willow (*Salix exigua*), rarely get larger than 1 inch in diameter while some cottonwood species easily reach 12+ inches.
b) Larger diameter is better. Cuttings should be at least 1-inch or greater in diameter, preferably 3-4 inches.

2) **Cutting Length--**

a) Below Ground--The cutting should be long enough to reach the mid-summer water table. This is to ensure the cuttings have ample water to sprout and begin establishment. It should also be long enough to extend below the competing herbaceous vegetation root mass.
b) Above Ground--The cutting should be long enough to extend above the high water during spring runoff or peak irrigation surges in order to intersect wave action. It should also be long enough so that it will not be shaded by surrounding above ground vegetation. Another consideration is inundation. Most willows and some cottonwoods can withstand months of inundation. By making the cutting long enough to extend above the high water mark, the chances of the cuttings dying from drowning will decrease.

3) **Cutting Treatment--**

a) After harvesting the cutting, cut off the apical bud so that energy will be re-routed to the lateral buds for more efficient root and stem sprouting.

b) Cut off all side branches from the cutting flush with the cutting stem. This makes it easier to plant and saves on stored energy reserves.

c) After the cutting has been divided into appropriate sections, the top should be sealed by dipping into white latex paint, paraffin, or sealing wax. Only 1-2 inches of the top should be sealed. The paint is generally cheaper because it can be a 50-50 mix of latex paint and water. This process decreases desiccation and ensures that the top is planted up rather than in the ground if you are using an inexperienced crew.

d) If the cuttings are harvested before the planting date, the cuttings should be stored in a cool (24-32°F), dark place and kept moist by wrapping them in wet burlap or peat.

e) Before planting the cuttings, they should be soaked in water for 1 to 14 days. This initiates the preformed dormant root primordia growth and starts the cutting out with a high moisture level.

4) **Planting Depth--**

a) Holes should be deep enough to reach the mid-summer water table. As general rule of thumb, 2/3s of the cutting should be planted in the ground and at least 2-3 buds should be above ground. The hole should be deep enough to meet these requirements.

5) **Planting Method--**

a) The planting method or instrument should be selected based on accessibility to the planting site.

b) Its ability to dig the planting hole deep enough at the selected site (see Planting Depth).

c) Its ability to dig a hole that will allow good soil to stem contact without excess digging and backfilling. Good soil to stem contact is one of the most important rules that should be followed.

6) **Planting Supplements--**

a) In high-volume, high-intensity planting programs, the use of the following supplements do not necessarily increase the establishment success to a point where they will repay the extra effort and cost associated with them.
- fertilizer
- rooting hormone
- fungicide

## REFERENCES

Briggs, J.A. and B. Munda. 1992. Collection, evaluation, selection, and production of cottonwood poles for riparian area improvement. Final Report to the US Fish & Wildlife Service. USDA-SCS, Tucson Plant Materials Center, Tucson, AZ. 32 pages.

Carlson, J.R. 1979. Streamside vegetation. USDA Soil Conservation Service Technical Note PM-12, Spokane, WA, January, 1979. 9 p.

Carlson, J.R. 1992. Selection, production and use of riparian plant materials for the western United States. In: Proceedings--Intermountain Forest Nursery Association. USDA Forest Service Gen. Tech. Rep. RM-211. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO. pp 55-67.

Carlson, J.R.., G.L. Conaway , J.L. Gibbs , and J.C. Hoag. 1991. Design criteria for revegetation in riparian zones or the intermountain area. In: Proceedings--Symposium on Ecology and Management of Riparian Shrub Communities. USDA Forest Service Gen. Tech. Rep. RM-65. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. pp 163-166. pp 163-166.

Carlson, M.C. 1938. The formation of nodal adventitious roots in *Salix cordata*. American Journal of Botany 25: pp 721-725.

Carlson, M.C. 1950. Nodal adventitious roots in willow stems of different ages. American Journal of Botany 37: pp 555-561.

Cram, W.H. and C.H. Lindquist 1982. Refrigerated storage for hardwood cuttings of willow and poplar. Tree Planter's Notes 33 (4): pp 3-5.

Densmore, R. and J.C. Zasada. 1978. Rooting potential of Alaskan willow cuttings. Canadian Journal of Forest Research 8: pp 477-479.

Fenchel, G., W. Oaks, and E. Swenson. 1988. Selecting desirable woody vegetation for environmental mitigation and controlling wind erosion and undesirable plants in the Rio Grande and Pecos River valleys of New Mexico. Five year interim report (1983-87). Los Lunas, NM: USDA-SCS Los Lunas Plant Materials Center. 49 pp.

Haissig, B.W. 1970. Preformed adventitious root initiation in brittle willows grown in controlled environment. Canadian Journal of Botany 48: pp 2309-2312.

Haissig, B.W. 1974. Origins of adventitious roots. New Zealand Journal of Forest Science 4(2): 299-310.

Hansen, E.A. and H.M. Phipps. 1983. Effects of soil moisture tension and preplant treatment on early growth of hybrid *Populus* hardwood cuttings. Canadian Journal of Forest Research 13: pp 458-464.

Heede, D.B.H. 1977. Case study of a watershed rehabilitation project. Alkali Creek, CO. USDA Forest Service Res. Pap. RM-189. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Hoag, J.C., G.L. Young, and J.L. Gibbs. 1991. Planting techniques for vegetating riparian areas from the Aberdeen Plant Materials Center. Paper presented at The 45th Annual Meeting of the Society for Range Management, Spokane, WA. 6 pp.

Hoag, J.C. 1992. Planting Techniques from the Aberdeen, ID, Plant Materials Center for vegetating shorelines and riparian areas. In: Proceedings--Symposium on Ecology and Management of Riparian Shrub Communities. USDA Forest Service Gen. Tech. Rep. RM-65. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. pp 163-166.

Parsons, P.A. 1963. Vegetative control of streambank erosion. In: Proceedings of the Federal Interagency Sedimentation Conference. Misc. Publ. 970. USDA Agricultural Research Service (Science and Education Administration), Washington, D.C. pp 130-136.

Peterson, L.A. and H.M. Phipps. 1976. Water soaking pre-treatment improves rooting and early survival of hardwood cuttings of some populus clones. Tree Planter's Notes 27 (1): 12, 22 pp.

Platts, W.S. and J.N. Rinne. 1985. Riparian and stream enhancement management and research in the Rocky Mountains. North American J. Fish Manage. 5: 115-125.

Platts, W.S., C. Armour, G.D. Booth, and others. 1987. Methods for evaluating riparian habitats with applications to management. USDA Forest Service Gen. Tech. Rep. INT-221. Intermountain Research Station, Ogden, UT. 177 p.

Schultze, R.E. and G.I. Wilcox. 1985. Emergency measures for streambank stabilization: an evaluation. Paper presented at North American Riparian Conference, Tucson, AZ, April, 1985. 3 p.

Sedell, J.R., F.H. Everest, and F.J. Swanson. 1982. Fish habitat and streamside management past and present. In: Proceedings of Society of American Foresters annual meeting. Society of American Foresters, Bethesda, MD. pp. 244-255.

USDA Soil Conservation Service. 1981. Soil Survey of Power County Area, Idaho. USDA Natural Resources Conservation Service, Boise, ID. 278 p.

USDA Soil Conservation Service. 1983. Dormant stock planting for Channel stabilization. USDA Soil Conservation Service Tech Note BN-22, Phoenix, AZ. December, 1983. 15 p.

USDA Soil Conservation Service. 1984. 1984 Willow (*Salix*) Initial Evaluation Project Plan. Aberdeen PMC. September, 1984. Unpubl. 5 p.

USDA Soil Conservation Service. 1986*a*. American Falls Reservoir Shoreline Protection Project cooperative agreement between USDA SCS, Aberdeen PMC and USBR, Minidoka Project, Burley, ID. Unpubl. 4 p.

USDA Soil Conservation Service. 1986*b*. American Falls Reservoir Shoreline Protection Project Plan. Aberdeen PMC. October, 1986. Unpubl. 5 p.

USDA Soil Conservation Service. 1989*a*. Plant Materials Centers: Finding vegetative solutions to conservation problems. USDA Natural Resources Conservation Service Plant Materials Program Public Information Publication, Washington, D.C. October, 1989. 56 p.

USDA Soil Conservation Service. 1989*b*. History of the Aberdeen Plant Materials Center. USDA Soil Conservation Service Public Information Publication, Boise, ID. June, 1989. 29 p.

USDI Bureau of Reclamation. 1981. Water Power Resources Service (Bureau of Reclamation) Project Data. USDI Bureau of Reclamation, Engineering and Research Center, Denver, CO. pp 639-648.

USDI Bureau of Reclamation. 1992. American Falls Reservoir erosion report. USDI Bureau of Reclamation, Minidoka Project, Burley, ID. Unpubl. 2 p.

USDI Bureau of Reclamation. 1973. USDI Bureau of Reclamation, Project History, Minidoka, ID. USDI Bureau of Reclamation, Minidoka Project, Burley, ID. Volume 67: pp 27-31.

***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 Dept., and Idaho Power Co.***

## ATTACHMENT 1

### USDI BUREAU OF RECLAMATION

**American Falls Reservoir Erosion Control Measures**

The post and wire protection that was installed at 2 locations on American Falls Reservoir was in response to the public's request for an erosion control method that would utilize small rocks that were picked out of agricultural fields adjacent to the reservoir. Initial construction costs were about equal to rock rip-rap. As time goes on, the durability of the wire is questionable as stress points have failed and repair is difficult. In addition, rounded rock is required verses angular rock normally used in rip-rap. The conclusion after using this method, is that it is not durable or flexible enough to use on large scale.

The post and tire protection was also tried on 2 different points around the reservoir. One site was a jetty structure and the other was place in front of the reservoir cliffs to try and prevent mass slumping of the cliffs. The jetty site has worked well by piling up the sands and silts behind it and providing protection to a section of shoreline behind it. The other site has slowed erosion rates, but not stopped it. This site has now been rip-rapped behind the post and tire section. The post and tire method allowed too much wave energy between the tires so cliff erosion continued only on a smaller scale. Another problem was that the tires had to be continually replaced because the old ones would disappear into the clay base. This method has been discontinued.

The present method in use is rock rip-rap with geotextile sheet underneath. This method is installed in August and September when the reservoir is at least 12-15 feet below high water. The construction is started with a longboom excavator that slopes the clifftop back to remove any under cut material and to provide fill at the base of the cliff for a building pad. Then a large dozer builds a pad wide enough to accommodate 10 wheel dump trucks, usually about 10-12 feet. The slope on the pad is smoothed and compacted by a small dozer. The top of the pad is 4 feet above the highwater mark which allows sufficient freeboard for most storms. A key trench (3'x 3') is dug with a small excavator. The key trench allows additional protection against undercutting. Next, a nonwoven geotextile material (ARMCO 1120 or equivalent) is laid on the slope in place of gravel. The geotextile is 60% cheaper than gravel. Finally, rock rip-rap is end-dumped onto the fabric and pushed as necessary with a small cat to get a layer of 2 to 4 feet. The rock around American Falls Reservoir is difficult to find because the lake area is lacustrine in nature with basalt flows that surface in specific areas. Quarries have been found on the west side of the lake where well graded material from 6 inches to 5 feet plus is blasted out of the basalt flows.