

FIELD GUIDE FOR HARVESTING AND INSTALLING WILLOW AND COTTONWOOD CUTTINGS

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INTRODUCTION AND PURPOSE

This field guide covers basic techniques for selecting, harvesting, storing, and installing willow and cottonwood cuttings for restoration projects. It also provides a basic understanding of the biology of Salicaceae, the family that includes all willow and cottonwood species. Knowledge of Salicaceae biology informs plant selection, harvest, storage and installation techniques. These techniques, in turn, play a key role in the success of a diversity of restoration projects, from live staking to advanced bioengineering structures.

IMPORTANCE OF WILLOWS AND COTTONWOODS IN RESTORATION

In arid regions of the Rocky Mountains, willows and cottonwoods provide important wildlife cover for nesting birds and small mammals, and forage for elk, moose, and other herbivores. Willows and other riparian vegetation provide effective soil stabilization through the large web of underground roots that bind soil particles together. The above-ground biomass of riparian vegetation slows water velocities and therefore aids in reducing shear stress along stream banks, road embankments, and other erosion-prone areas. Willows have a number of characteristics that make them resilient to high-velocity flood waters, burial by sediments, long periods of inundation, high winds, and heavy browsing by wildlife. Cottonwoods provide similar benefits, as well as providing structural diversity (i.e., variety of canopy heights) in a riparian habitat. Furthermore, willows and cottonwoods provide essential shade and organic matter inputs to rivers, both of which are critical to the quality of aquatic habitats. Such riparian vegetation also facilitates nutrient uptake of effluents such as nitrates and phosphates.

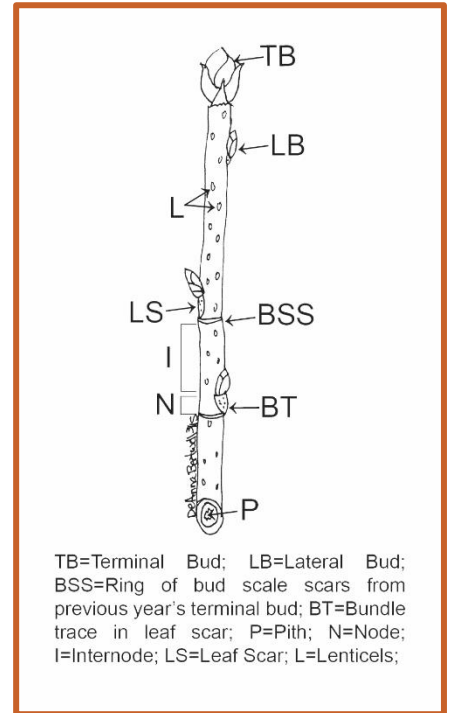
BIOLOGY, BEAVERS, AND BENEFITS

Willows and cottonwoods are deciduous woody plants in the Willow Family (Salicaceae) that typically occur in mesic sites such as riparian areas (i.e., riverside habitats) and other wetland habitats. Willows are classified in the genus *Salix*, and cottonwoods are in the genus *Populus*. Both willows and cottonwoods have an important feature in their biology that make them excellent candidates for use in ecological restoration.

Willow and cottonwood stems can develop new roots readily from dormant buds and adventitious buds (i.e., buds that develop in an “atypical” place rather than at the branch tip or in leaf axils) when in contact with water or moist soil. This strategy is helpful in habitats where beaver routinely cut and haul willows to construct dams and lodges. Should a stem break loose and flow down river, or become dislodged by a flood, the stems root readily in the muddy riverbanks. And so in the course of riparian restoration we find ourselves following in the footsteps of the beaver. However, incorrect selection of species, as well as improper storage, handling, timing, and installation techniques, can produce widely varying results. This guide provides tips and information to help you improve your chances of success in a riparian restoration project.

APICAL CONTROL IN SHRUBS

All woody plants, including willows and cottonwoods, produce a mix of hormones including auxins, cytokinins, ethylene, and gibberellins. Hormones are substances that are produced in small amounts and influence the growth, development, and differentiation of cells and tissues. The specific ratio and timing of hormone release has strong control over plant growth. One example of this is known as *apical control*, where the top branches of a plant (i.e., apical or terminal buds) have an influence over the lower branches. Apical control occurs widely among willows and cottonwoods, where auxins produced by terminal buds are transported to lateral buds (i.e., buds along the stem below the terminal bud) and adventitious buds to convey a signal to “stay dormant.” When the apical bud is removed by a browsing animal or severed by a willow harvester, the hormonal signal from auxin is interrupted, which stimulates the growth of lateral and adventitious buds. In heavily browsed areas, it is the removal of the terminal buds that causes a bushy appearance in both willow and cottonwood stands. Under some conditions, however, and for certain species (e.g., sandbar willow, *Salix exigua*), removal of the terminal bud may not be necessary or desirable to achieve project goals. If a tree-like willow is desired, removing the terminal bud(s) is not recommended.



USING LIVE CUTTINGS FOR RESTORATION

Thanks to the nature of willow biology, and especially to the presence of adventitious and dormant buds that form roots when wet, live cuttings (poles, stakes, or whips) can be used in a variety of restoration practices. When installed properly and under the right environmental and moisture conditions, live cuttings can develop roots and above-ground shoots rapidly. Survival of these cuttings through the first growing season can range between 45% and 90% of installed cuttings. However, subsequent survival can be highly variable, and three seasons of monitoring is recommended before claiming success or admitting defeat for any willow restoration project. Lack of adequate soil moisture, poor timing, incorrect species choice, prolonged inundation, and improper selection of willow stems are important factors associated with poor survivorship of cuttings.

Careful attention to harvesting healthy stems, proper stem diameter and age, groundwater hydrology, depth of installation, and good soil-to-stem contact all contribute to successful restoration projects.



Roots sprouting from adventitious buds after 13 days of soaking. USDA-NRCS, Aberdeen Plant Materials Center

SELECTING THE RIGHT MATERIALS: GARBAGE IN = GARBAGE OUT

The best willow installation job often fails when the cuttings are not properly selected and stored ahead of time. These simple rules will improve the success of every willow and cottonwood project and help to protect the resource.

Harvest Location: Select a source population as close to your project site as feasible, preferably within the same drainage. Harvest species that occur in the same site conditions (e.g., hydrology, landscape position, elevation) as the conditions of your restoration site. Avoid sourcing plant materials more than 1,000 feet in elevation above or below your restoration site.



Healthy Stems: Always select healthy stems (i.e., “green” wood in cross-section) that are: relatively straight, covered in smooth bark (i.e., not furrowed or damaged), and free of insects, disease, or fungal damage. For most willow and cottonwood species, stems older than four years of age produce fewer adventitious buds and are lower in vigor than younger stems. This is especially true for species such as peachleaf willow (*Salix amygdaloides*), Bebb’s willow (*S. Bebbiana*), and many alpine and subalpine species.

HARVEST ETHICALLY -- LEAVE MORE THAN YOU TAKE!

Follow ethical harvest guidelines to conserve health of the donor stand:

- Know before you go! Obtain approval from land owner (public or private) before harvesting. In some cases a permit may be required.
- Remove no more than 20% of the branches from any single willow.
- Never remove more than 30% of the overall canopy cover from any willow stand.
- Harvest stems evenly through the stand (e.g., not from one side of the plant only).
- In Preble’s Meadow Jumping Mouse Habitat (<7,400’ elevation on the Colorado Front Range), and in other sensitive wildlife habitats, more stringent harvest guidelines should be followed.

HARVESTING AND PREPARATION

Tools: Lopping shears, hand by-pass pruners, small wood saws or brush cutters, twine, labels, buckets, trash cans.

HARVESTING & STORING

Harvest cuttings during the dormant season (i.e., between fall dormancy/leaf abscission and spring bud break):

Select stems ½ to 1¼ inches (between pinky and thumb width) in diameter for most projects. Some projects may require willow stems up to 3 inches in diameter or cottonwoods up to 6 inches in diameter (e.g., posts) where longer or stronger cuttings are required to reach deep groundwater. In this case, cuttings may need to be installed into the soil via pounding, hammer drills, water stingers, augers, or other means.

Cut stems to length, as determined by specific project needs (e.g., depth to late-summer water table, severity of erosion and flood damage). Cuttings can range from 18 inches to 12 feet long depending on depth to groundwater and height of competing vegetation. Remove the cutting with a clean diagonal cut at the base of the stem. The diagonal surface differentiates the rooting end from the above ground portion, and facilitates installation.

Leave the terminal buds and a few upper branches intact until installation. Remove all but the top few lateral (i.e., side) branches by clipping them as close to the stem as possible. Use caution to avoid damaging the stem while trimming the lateral branches. Removing lateral branches assists in transport and storage, helps maintain an appropriate root-to-shoot ratio, and reduces transpiration losses prior to root establishment. Logistically, a trimmed willow cutting is easier to install down a narrow pilot hole.

Bundle cuttings in groups of 50 or 100 by species. Keep bundles cool, moist, and shaded during transportation and on-site storage.

Prior to planting, **soak cuttings** in water for 7-14 days to increase the rate and degree of adventitious root formation. Cuttings can be soaked in buckets, streams, or ponds with well-oxygenated water. Roughly 50 to 80% of the length of the cutting should be in contact with water while soaking. Plants should be weighted down when soaked in a horizontal position. Research shows significant increase in survival for willows that are pre-soaked prior to planting (Tilley and Hoag 2008).

CAUTION – Dangerous Stowaways!

Avoid soaking cuttings in water bodies that may harbor aquatic nuisance species such as New Zealand mudsnail, Eurasian milfoil, chytrid fungus, and other pests that are exotic and known to negatively impact native species. To be safe, soak your cuttings in buckets of tap water or in water from your restoration site.

Pre-soaking willow cuttings.
(USDA-NRCS, Aberdeen Plant Materials Center)

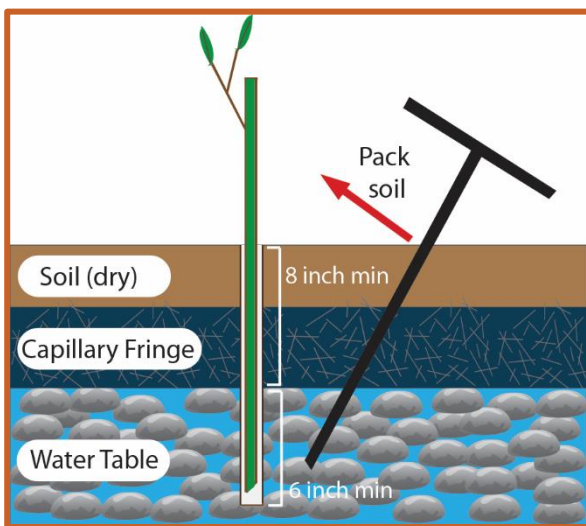


Tools: planting bars (dibbles), rebar, rubber mallet/mini sledge, post-hole diggers, electric hammer-drills, soil augers, power stingers, shovels, buckets, lopping shears.

INSTALLING LIVE CUTTINGS

Location location location. It's as true with willow and cottonwood plantings as it is in real estate: location matters! While a full site analysis and planting location plan is beyond the scope of this field guide, some tips include: (1) previous knowledge of soil moisture, hydrographs, and/or groundwater monitoring well data is extremely helpful; (2) avoid installing cuttings in dense herbaceous wetland communities, as such soils can be anaerobic and difficult for survivorship of fresh adventitious roots; (3) avoid installing cuttings too close to the stream edge, especially in unconsolidated soils, as it is likely the eroding streambank will result in the loss of your planted materials prior to establishment; (4) avoid installing willows too far away from the water, such that the bottom of the cutting and the adjacent buds are not in contact with the low/dry-season groundwater – unless utilizing artificial irrigation.

Optimal time for willow and cottonwood planting varies by region, plant community, and local hydrologic (i.e., stream and groundwater hydrology) regime. Typically, cuttings are installed after spring thaw but before bud break, or in fall after leaves change color and/or drop. If planting in fall, be sure to install cuttings deep enough (i.e., at least 2 feet) to avoid being dislodged from the ground by winter freeze-thaw cycles. In river systems with fairly unaltered flow regimes, planting willows and cottonwoods after peak discharge (i.e., during the receding limb of the hydrograph) is recommended, as long as the timing in that location is prior to bud break. In altered systems, where surface and groundwater elevations are known to drop quickly, early season (i.e., very early spring) planting is recommended.



Pilot holes allow for easier installation without damaging the cuttings. In soft soils, pilot holes may not be necessary. Prepare pilot holes by pounding in rebar or other appropriate tools. Mechanical devices (e.g., stingers or augers) can also be used to prepare deeper holes in difficult soils.

The bottom is of top importance. The bottom 6-8 inches of the cutting should be installed below the expected dry-season water table. **NOTE: Sufficient depth of installation is the most difficult task for any laborer.** Generally, 50-80% of the cutting should be below ground.

TIP: many cuttings are not installed deep enough to reach the low-season groundwater. To adequately address this, ensure that the pilot hole reaches a depth of at least 6 inches into the estimated low-season groundwater.

INSTALLING LIVE CUTTINGS (CONTINUED)

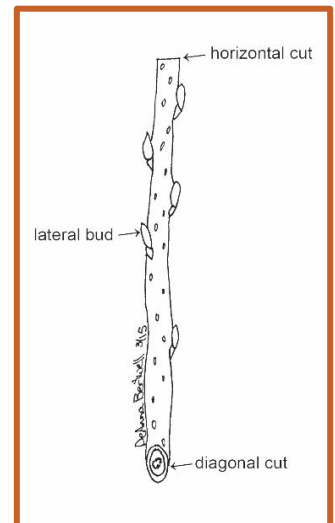
Backfill around cuttings to ensure good soil-to-stem contact (i.e., without air pockets). When installing cottonwood posts or cuttings into pre-augered holes, add a pancake batter-like slurry of soil and water into the hole, allowing sediment to displace any air pockets as water leaches into underlying soil.

NOTE: Willow and cottonwood roots cannot survive in dry air! Tamp your soil around the cuttings to eliminate air pockets.



IMPORTANT INSTALLATION TIPS

- Remove the bottom 1-2 inches of the cutting with a clean diagonal cut to “freshen up” the conductive xylem cells prior to installation.
- Be sure upward-facing tips of lateral buds point sky-ward and the diagonally cut end, usually the thicker end of the cutting, is inserted into the ground.
- Cut the top of the stem to leave 1-3 feet remaining above ground, so competing plants do not overshadow the cutting during the growing season, or high water does not completely overtop them.
- Cracked, diseased, or mangled cut ends will increase susceptibility to pest damage, decreasing survival rates. If cuttings are damaged from installation, provide a clean diagonal cut just below the damaged surface.
- A minimum of two lateral buds (preferably 3 or more) should be present on portion of stem remaining above the ground.



SOFTWOOD CUTTINGS

Softwood cuttings are comprised of the current year's growth. For many non-salicaceae species, softwood cuttings can be used in a nursery setting to propagate container stock. To improve success, follow these tips:

- Perform the snap test (i.e., audible snap when bent between fingers) to determine if softwood is in an appropriate stage for harvesting.
- Include 6-8 inches of softwood and 6 inches of hardwood with your cutting.
- Place entire cutting in water immediately.
- Remove all but top 3-6 leaves (before harvesting).
- Transport cuttings safely to propagation facility within four hours of harvesting (sooner the better).

CLUSTER PLANTING

To improve chance of establishment per planting site, install multiple cuttings in a single larger hole (cluster planting, Hoag 2009). Typically, 3 cuttings per hole is sufficient. This is a useful technique in cobble-dominated substrate such as along river banks.

GLOSSARY

Adventitious Buds/Roots: buds or roots that develop in an “atypical” place rather than at the branch tip or in leaf axils.

Apical Dominance: The phenomenon whereby the main central stem of a plant grows more strongly and readily than the lateral or side stems.

Bioengineering: Also referred to as “biotechnical slope protection,” this is the integration of living woody and herbaceous materials along with organic and inorganic materials to increase the strength and structure of soil.

Buffer: A vegetated area of grass, shrubs, or trees designed to capture and filter runoff from surrounding land uses.

Canopy: The overhead branches and leaves of vegetation.

Capillary Fringe: The distance water is wicked upwards above the water table by capillary action in the soil.

Coir: A woven mat of coconut fibers used for various soil erosion control applications; Biodegrades after a period of a few years.

Fascine: A long bundle of brushwood or cuttings that is typically installed near the toe of the slope, and is used to stabilize stream banks and other slopes.

Leaf Abscission: The process by which a plant sheds some of its parts, such as leaves, spent flowers, secondary twigs, seeds, and ripe fruits.

Live Cuttings: Leafless stem cuttings of woody plant species.

Pilot Hole: A pre-drilled or augered hole in the soil substrate created in advance before installing a live cutting.

Riparian Area: An ecosystem situated between aquatic and upland environments and is characterized by greater soil moisture than adjacent upland areas. Riparian areas are periodically influenced by flooding.

Root-to-Shoot Ratio: The dry weight of root biomass divided by the dry weight of shoot biomass. A plant that has a greater biomass of leaves and stems, compared to the biomass of its roots, would have a low root-to-shoot ratio. A low root-to-shoot ratio is considered an unhealthy condition for many plants.

Stinger: A tool used to create holes to use for planting cuttings from woody species.

Wattle: A sausage-like bundle of plant cuttings used to stabilize stream banks and other slopes.

Xylem: A compound tissue found in vascular plants used to transport water and some nutrients up from its roots to its stem, leaves, and buds.

RECOMMENDED READING AND LITERATURE CITED

For advanced techniques and additional detail, refer to the following recommended reading and literature cited.

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