# GUIDELINES FOR HARVESTING AND INSTALLING WILLOW AND COTTONWOOD CUTTINGS

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## *Overview & Purpose*

*This field guide covers basic techniques for selecting, harvesting, storing, and installing willow and cottonwood cuttings. The intent of this field guide is to convey a variety of institutional knowledge and academic research in a way that helps improve your ability to effectively utilize a variety of cuttings for revegetation and bioengineering projects.*

## *Importance of Willows and Cottonwoods in Restoration*

Willows and cottonwoods provide important cover for nesting birds and small mammals, and forage for elk, moose, and other herbivores. Many species of willow grow quickly, providing effective soil stabilization through their large network of woody roots that bind soil particles together. The above-ground biomass of willows and cottonwoods provides floodplain roughness, reducing water velocities and shear stress along stream banks, road embankments, and other erosion-prone areas. Willows have many characteristics that make them resilient to high-velocity flood waters, burial by sediments, long periods of inundation, and heavy browsing by wildlife. Mature cottonwoods, with characteristics similar to willows, add significant structural diversity (i.e., variety of canopy heights) to riparian areas, and are preferred nesting trees for a variety of raptors such as bald eagles (Giordanengo 2017), as compared to exotic trees such as crack willow (*Salix fragilis*). Willows and cottonwoods provide essential shade and organic matter inputs to rivers, both of which are critical to the quality of aquatic habitats. By ensuring correct selection of species, as well as proper storage, handling, timing, and installation, practitioners can improve their chances of a successful restoration project. The methods and tips outlined in the subsequent pages are intended to assist practitioners in making the best possible decisions in projects that involve a variety of willow and cottonwood restoration treatments, including bioengineering treatments.

## *Willow and Cottonwood Biology*

Willows and cottonwoods are deciduous woody plants in the Willow family (Salicaceae), typically occurring in riparian areas (i.e., riverside habitats) and other wetland habitats. Willows are classified in the genus *Salix*, and cottonwoods are in the genus *Populus,* along with aspen and poplars. An important identifying characteristic between willows and cottonwoods is that cottonwood buds are comprised of multiple overlapping (imbricated) scales, imparting a “shingled” appearance. Willow buds are comprised of a single scale, imparting a smooth undivided appearance to the bud. Unlike most other shrubs and trees of North America, willow and cottonwood stems can develop new roots readily from both 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.

### Twig and Bud Terminology

Learning to identify willow twig and bud features, and their role in root and shoot development, aids the practitioner in making sound decisions on selecting, handling, and installing live cuttings. Figure 1 illustrates the typical bud arrangement of a willow twig. Terminal (i.e., apical) buds influence the growth of lower branches through a mechanism known as apical control, where auxins produced by terminal buds are transported to lateral buds (i.e., buds along the stem) and adventitious buds to convey a signal to stay dormant. When the apical bud is removed by a browsing animal or a willow harvester, the hormonal signal 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. For certain species (i.e., sandbar willow, *Salix exigua*), removal of the terminal bud may not be necessary or desirable to achieve project goals. If a tree-like/upright cottonwood is desired, removing the terminal bud(s) is not recommended.

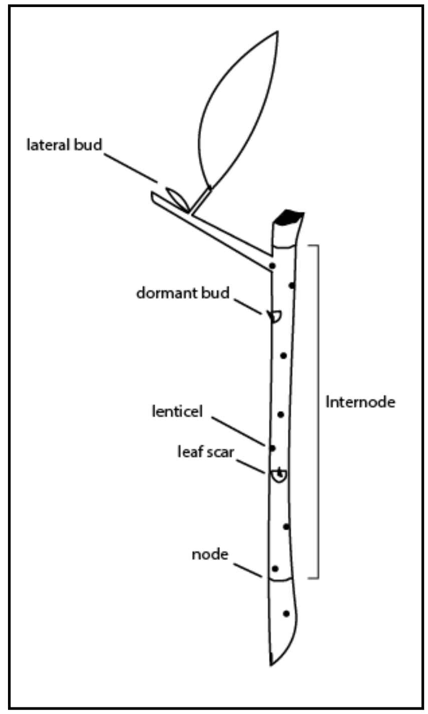


**Figure 1.** Willow twig terminology.

## *SELECTING THE RIGHT MATERIALS: MAKE GOOD CHOICES*

Due in part to the presence of adventitious and dormant buds that have the capacity to form healthy roots and stems under the right environmental conditions, live cuttings (i.e., stakes, whips, or poles) can be effectively used in a wide variety of restoration and bioengineering treatments. Installed properly, and under the right hydrologic conditions, live cuttings can develop adventitious roots (Image 1) and shoots rapidly, forming self-sustaining populations in a matter of years. Survival of these cuttings through the first growing season can exceed 95% of installed cuttings under ideal conditions. However, we recommend three seasons of monitoring before determining the success of any willow restoration project. A variety of decisions can contribute to low survivorship of cuttings, including incorrect species choice for the restoration site, selection of unhealthy willow stems, lack of adequate soil moisture (i.e., insufficient depth of installation), poor timing of installation, and installing willow cuttings in areas unsuitable to short- or long-term willow survival. The following pages provide tips for successful decision making involved in restoration project involving willow and cottonwood species.

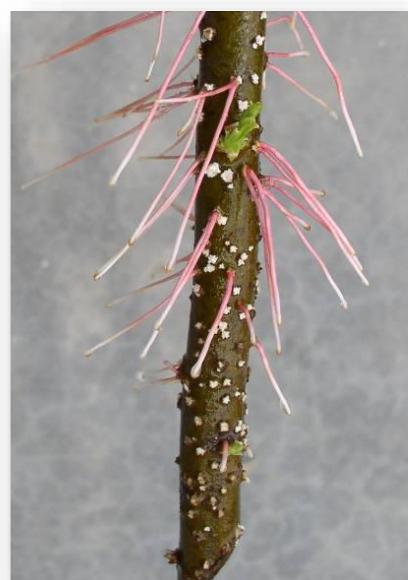

**Image 1.** Roots sprouting from adventitious buds after 13 days of soaking (USDA-NRCS, Aberdeen Plant Materials Center).

## Garbage In = Garbage Out

Even when willows are installed perfectly, the job can fail when cuttings are not properly selected and handled ahead of time. Two simple tips will improve the success of every willow and cottonwood revegetation and bioengineering project:

1) ensure proper *harvest location,* and

2) select only the *healthiest stems*.

**Harvest Location:** Select an ecologically appropriate source population that matches the conditions (i.e., hydrology, landscape position, and elevation) of your restoration site. Avoid sourcing plant materials more than 1,000 feet in elevation above or below your restoration site, or more than 100 miles from the site. Ideally, harvest willows within the same watershed in which the restoration project takes place.


**Healthy Stems:** Always select healthy stems. Ideal cuttings are straight, covered in smooth bark (i.e., not furrowed), free of insect damage such as that caused by oystershell scale (*Lepidosaphes ulmi* in CO), absent fungal damage, exhibit "green" wood in cross-section, have little to no visual damage to bark, and contain abundant healthy buds. Typically, stems more than four years old 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 species occurring in the subalpine.

## HARVEST ETHICALLY -- LEAVE MORE THAN YOU TAKE!

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

- Know before you go! Obtain approval from land owner (public or private) before harvesting. On public lands, a permit is often 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 (e.g., not from just one side of the plant).
- In habitats that support endangered or sensitive species such as Preble's Meadow Jumping Mouse Habitat (<7,400' elevation on the Colorado Front Range of CO), more stringent harvest guidelines should be followed.

## *Harvesting and Preparation*

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

**Select stems** ½ to 1¼ inches in diameter (between the width of your pinky and thumb) for most projects. Some projects may require willow stems up to 2 inches in diameter or cottonwood cuttings up to 6 inches in diameter (e.g., posts) where longer or stronger cuttings are required to reach deep groundwater or penetrate difficult substrates. In such cases, 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 site conditions (i.e., depth to low season ground water). Cuttings can range from 18 inches to over 12 feet long depending on depth to groundwater and height of competing vegetation. In areas where annual flows may impact cuttings, finish height should be 8-12 inches above the ground surface. In areas where competing vegetation forms tall dense cover, finish height should overtop the competing vegetation.

Remove the cutting with a clean diagonal cut at the base of the stem and a horizontal cut at the top. The diagonal surface differentiates the rooting end from the above ground portion, facilitates installation, and increases the surface area in contact with groundwater. The clean horizontal cut at the top reduces incidence of desiccation and pest damage, and facilitates rapid healing of the cut surface.

**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 main stem while trimming the lateral branches. Removing lateral branches assists in bundling, transport, and storage. Removing these branches also aids in maintaining 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.

**Soak cuttings** in water for 10-21 days (depending on species, elevation, and air/water temperatures) to increase the rate and degree of root formation prior to the onset of leaf growth. Cuttings can be soaked in buckets, streams, or ponds containing well-oxygenated water. The lower 50 to 80% of the cutting (Image 2) should be submerged. Ideally, cuttings are soaked long enough such that roots begin to form the day that installation occurs. Research shows significant increase in survival of willows that are pre-soaked prior to planting (Tilley and Hoag 2008).

**Image 2.** Pre-soaking willow cuttings. (courtesy of Dick Voigt)

When leaves appear, heat stress increases, or water tables begin to drop prior to significant root formation, the successful establishment of cuttings can be heavily impaired.

**Bundle** cuttings in groups of 50 or 100 cuttings per species to facilitate handling and record keeping. **Label** bundles by species name, collection site, collection date, and other pertinent project-specific information.

## *STORING LIVE CUTTINGS*

When possible, avoid storing willows longer than four weeks. When long-term storage is necessary, cuttings should be kept in cold, moist, and dark conditions for up to four months. Research at the Aberdeen Plant Materials Center of Idaho (Tilley and St. John 2012) revealed that cuttings left in cold storage (avg. 36 deg Fahrenheit and 79% relative humidity) for more than four months rapidly loose viability, in part due to desiccation. Cuttings stored in polyethelene bags maintained high survivorship for up to six months in cold storage. However, cuttings in cold storage under high relative humidity are susceptible to mold damage. In the Tilley and St. John (2012) study, storage in polyethelene bags showed greater development of mold and fungus than storage without bags.

Anecdotal evidence from the Colorado State Forest Service Nursery in Fort Collins (Image 3), derived from cold storage of approximately 60,000 willow cuttings (nine species) between 2015 and 2018, indicated that cold storage conditions were adequate to preserve willow cuttings for 4-6 months (depending on the species) when temperatures ranged from 25-30 degrees F, and relative humidity was maintained between 54-55% (Aon, O.D., 2018).

**Image 3.** Willows in Cold Storage at CSFS Nursery, Fort Collins.

In consideration of the data presented above, we recommend cold storage of not more than four months, in dark coolers that maintain between 28 and 32 degrees Fahrenheit, and between 55 and 65% relative humidity.

## *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 groundwater data is extremely helpful; (2) avoid installing cuttings in dense herbaceous wetland communities, as their soils can be anaerobic and can impair survival of 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 it is difficult to install the bottom of the cutting into the low-season groundwater.

**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 relatively unaltered flow regimes, planting willows and cottonwoods just prior to peak discharge is recommended, as long as bud break has not yet occurred. In altered systems, where surface and groundwater elevations are known to drop quickly, early season (i.e., very early spring) planting is recommended.

**The bottom is of upmost 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, 50-75% of the cutting should be below ground.

**Improve root development** by eliminating air pockets (i.e., improve soil-to-stem contact) around the installed cutting. Eliminating air pockets can be as easy as tamping the soil around each cutting using the approach shown in Figure 2.

When installing cottonwood poles (Image 4) or long cuttings into pre-augered holes, add a pancake batter-like slurry of soil and water into the hole after installation, creating good soil-stem contact and eliminating air pockets.

**Pilot holes** allow for easier installation without damaging the cuttings. In soft soils, pilot holes may not be necessary. In harder soils, prepare pilot holes by pounding rebar, circus tent stakes, willow dibble, or similar tools down to the water table. Mechanical devices (e.g., hammer drills, stingers, or augers) can also be used to prepare deeper holes in difficult soils such as cobble.

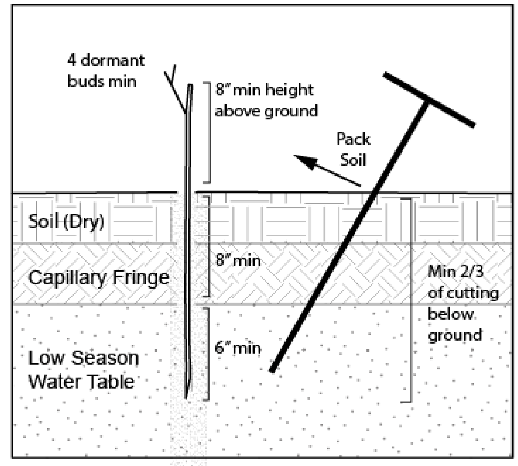


**Figure 2.** Pack soil against the cutting using a diagonal compression. The diagonal angle helps ensure soil is firmed against the stem along its entire length.

**Image 4.** Cottonwood pole in 8' deep pre-augured hole prior to slurry fill.

## *KEY INSTALLATION TIPS*

- Remove the bottom one to two inches of the cutting with a clean diagonal cut to "freshen up" the conductive xylem cells just prior to installation.
- 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 six inches into the estimated low-season groundwater.
- Cut the stem to leave four or more dormant buds above ground. Where scouring flows are expected, leaving just two to three lateral buds above the ground results in a shorter stem, which is less likely to snag on water born debris. Keep cuttings higher above ground where competing vegetation may overshadow the cutting during the growing season.
- Cracked, diseased, or mangled cut ends will increase susceptibility to pest damage and decrease survival rates. If the top of a cutting is damaged from installation, provide a clean diagonal cut just below the damaged surface.

# *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 additional information, refer to the following recommended reading and literature cited.

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