Deep-planting methods that require minimal or no irrigation to establish riparian trees and shrubs in the Southwest

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During the past 20 years, the Los Lunas Plant Materials Center (LLPMC), USDA Natural Resources Conservation Service, has developed deep-planting techniques that require minimal or no follow-up irrigation to establish woody vegetation on disturbed riparian sites in the arid and semiarid Southwest. The use of these techniques results in minimal maintenance and high survival rates, which will reduce ultimate revegetation costs. Invasive exotic woody species, primarily saltcedar (Tamarix sp. L.) and Russian olive (Elaeagnus angustifolia L.), have been controlled on floodplain tracts totaling more than 13,750 ha (34,000 ac) along New Mexico’s major rivers during the past five years by mechanical extraction or herbicide application (New Mexico Department of Agriculture 2005). Principal motives for these efforts include conserving groundwater, reducing wildfire potential, restoring wildlife habitat, and providing grazing or other beneficial uses. The alteration of surface and groundwater hydrology by flood control structures and flow regulation has encouraged the spread of invasive woody species (Stromberg et al. 2007) and has resulted in relatively deep water tables on many sites. The lack of overbank flood events on these rivers has perturbed normal ecosystem function and prevented the natural recruitment of native species comprising the gallery forest and its understory vegetation. The establishment of planted obligate riparian woody plants (i.e., phreatophytic overstory trees and understory shrubs) requires either prolonged irrigation until the transplants’ root systems can extend into the permanent unsaturated soil moisture above the water table (i.e., the capillary fringe) or deep-planting techniques that allow immediate root contact or rapid root extension into this moisture supply.

PLANTING DORMANT POLE CUTTINGS

The LLPMC began investigating deep-planting methods over two decades ago to improve establishment of cottonwood (Populus deltoides Bartr. ex Marsh. and P. fremontii S. Wats) and Goodding's willow (Salix gooddingii Ball) dormant pole cuttings (LLPMC 2006a). Traditional pole cuttings are harvested from plantation-grown young stems of tree-type cottonwood or willow species and used to establish the overstory structure of riparian forests (figure 1). The key survival advantages of using pole cuttings are the water uptake through the stump end set in groundwater and the proliferation of adventitious roots in the capillary fringe. To maximize survival, 3- to 4-year-old, large-diameter, dormant, vigorous pole cuttings are harvested, trimmed of all lower branches, kept hydrated, and planted in early winter to early spring. The depth of the planting hole must be sufficient for the stump end of the pole to be immersed in groundwater throughout the growing season; the hole depth and the desired aboveground height of the planted pole will determine the length of pole. An example of woody riparian species established using dormant pole cuttings is illustrated before revegetation (figure 2) and six years later (figure 3).

Site characteristics can significantly reduce the survival and growth rates of pole cuttings:

- Excessive depth or extreme seasonal fluctuation of groundwater can result in water stress.
- Excessive salinity can inhibit rooting and growth.
- Fine-textured soils can restrict aeration at depth and diminish root development.
- Cold soils of high elevation sites can delay root growth until soil temperatures moderate, which often results in cutting mortality.
- Wet-meadow environments that are characterized by shallow depth to

Figure 1
Cottonwood (Populus deltoides) pole plantation with one-year-old stems in right foreground, two-year-old stems in left foreground, and stems ready for pole harvest in background and far right.
groundwater and organic-rich anaerobic soils lack sufficient aeration for rooting and subsequent survival.

Monitoring of groundwater depth and fluctuation as well as determining soil salinity and texture are highly recommended prior to planting (LLPMC 2006b). Maintenance requirements for pole plantings need to be considered in the planning stage including protection from domestic or wild browsers (especially beavers) and controlling infestations of defoliating insects such as cottonwood leaf beetle.

**PLANTING DORMANT WHIP CUTTINGS**

Dormant whip cuttings (typically less than 2.5 cm [1 in] diameter and 2.4 m [8 ft] long) can be planted on streambanks prone to erosion during high-flow events; the dense, woody cover will armor the banks, and prolific root systems will help to stabilize the streambank soils (LLPMC 2007a). Those woody species that root easily from dormant cuttings are good candidates for streambank stabilization and include thicket forming coyote willow (*Salix exigua* Nutt.) and redosier dogwood (*Cornus sericea* L.) as well as multi-stem shrub willows such as bluestem (*S. irrorata* Anderss.), park (*S. monticola* Bebb), Bebb (*S. bebbiana* Sarg.), and arroyo (*S. lasiolepis* Benth.). As with pole plantings, the key to successful establishment is to place the base of the dormant whip cutting into the water table to ensure the cutting is well hydrated while it forms adventitious roots that extend into the capillary fringe. Another crucial factor is that the dormant whip cutting is planted deep (i.e., several feet) into the alluvium to resist extraction by flood flows. Whip cuttings of most willow species have inherent flexibility, which makes them well adapted for enduring flood events.

The LLPMC’s typical method of augering holes to plant dormant whip cuttings is to use a spline-drive rotary hammer with a 2.5-cm (1-in) diameter bit that is 0.91-m (36-in) long (figure 4). The 0.76-m (30-in) deep holes have sufficient diameter to accept most whip cuttings and depth to allow the whips to withstand flood flows. If the soil contains dense cobble or has a rip-rap cover, a long, sharpened rod (referred to as a stinger) attached to a backhoe or excavator arm can punch holes of ample...
A waterjet stinger can also be employed to excavate planting holes with water pressure (Hoag et al. 2001). Another good method for planting whip cuttings is to use a large diameter auger to reach the water table and place several whips in each hole to produce a clump of plants.

**PLANTING TALL-POT CONTAINERIZED STOCK**

The establishment of many important woody riparian species, particularly understory shrubs, has not been generally successful using pole or whip cuttings. As a result, about 10 years ago the LLPMC began producing riparian understory transplants in 10-cm (4-in) diameter and 76-cm (30-in) deep pots (what we call tall pots, figure 5) as a means to allow rapid root extension into the capillary fringe and to minimize irrigation requirements (LLPMC 2007b). An example of the tall-pot planting method is presented in figure 6. Success rates of 90% or higher were achieved in many situations where the lower portion of the root ball was placed in contact with the capillary fringe. If the top of the capillary fringe was just below the rootball, a few irrigations using embedded watering tubes placed in the planting hole provided deep soil moisture (this methodology has also been called deep pipe irrigation [Bainbridge 2006]) and allowed rapid root extension into the capillary fringe (figure 7).

**DEEP-PLANTING OF LONG-STEM CONTAINERIZED STOCK**

In the last several years, the LLPMC has attempted to revegetate riparian sites that have fairly deep water tables where the bottom of a 76-cm (30-in) root ball is still quite distant from the capillary fringe. Some initial trials with deep burial of tall-pot stock in holes up to 2-m (6.6-ft) deep showed positive results using transplants with stem heights on the order of 1.8 m (6 ft) and with total plant heights of roughly 2.6 m (8.5 ft). This approach violates several basic horticultural tenets, which consider the burial of the root crown and the use of transplants with large shoot-to-root ratios as detrimental transplanting practices.

Figure 5
Dormant long-stem New Mexico olive in a 1-gal tree pot (left) and a 30-in tall pot (right). Note yard stick between pots for scale.
Initial species planted using this technique included New Mexico olive (Forestiera pubescens Nutt.), desert false indigo (Amorpha fruticosa L.), and Emory's baccharis (Baccharis emoryi A. Gray) and exhibited impressive shoot growth, indicating rapid root extension into the capillary fringe. Sample plants were excavated after one and two growing seasons; the development of adventitious roots in shallow soil horizons was quite evident (figure 8). The success of these deep-planting techniques seems reasonable considering that riparian species should be adapted to burial by sediments deposited by flood events, a common occurrence in properly functioning riparian systems.

As soon as it became apparent that deep-planting of long-stem stock held promise for high survival and growth rates on sites with deeper water tables, the LLPMC tested the same procedure with long-stem stock grown in 1-gal (3.79-L) tree pots (container size 10 cm × 10 cm × 36 cm deep [4 in × 4 in × 14 in deep]) (figure 5). Advantages of producing long-stem
Other species of the cottonwood floodplain forests that are amenable to long-stem deep plantings include golden currant (Ribes aureum Pursh), screwbean mesquite (Prosopis pubescens Benth.), and skunkbush sumac (Rhus trilobata Nutt.). We have recently tried this technique with tree species including netleaf hackberry ( Celtis laevigata Willd. var. reticulata [Torr.] L. Benson) and boxelder (Acer negundo L.) with excellent survival. Several important riparian shrub species including four-wing saltbush (Atriplex canescens [Pursh] Nutt.) and Torrey wolfberry (Lycium torreyi Gray) have growth forms not amenable to long-stem production in tree pots but can be grown successfully in tall pots.

After the initial long-stem deep-planting trials were installed, we became aware of restoration research from Australia that has taken a similar approach called “long-stem tube stock” (Hicks n.d., 2006). These articles acknowledge the long-stem approach runs counter to conventional horticultural recommendations regarding burial of the root crown and establishment of plants with long stems in small containers. Their method uses small container sizes, 5 cm \( \times \) 13 cm (2 in \( \times \) 5 in) forestry tubes, and attempts to produce stock with stem heights of 0.9 to 1.2 m (3 to 4 ft). Much of their deep planting has been in riparian environments, but they also have used this stock type for arid region plantings in highly saline surface soils as well as sand dune restoration.

CONCLUSIONS

The deep planting of pole cuttings, whip cuttings, tall pots, and long-stem stock can preclude or drastically reduce the need to apply irrigation water to establish riparian shrubs and trees. The cost savings of minimal or no irrigation and high percentages of transplant survival will, in most situations, far outweigh the added expense of the planting stock and deep planting methods. Deep-planted stock should persist for the long term, and some species will spread vegetatively. However, if natural recruitment is not reinstated as a result of overbank flooding from a river or overland flooding from tributary drainages, the eventual seedling regeneration of these riparian species is not expected.

REFERENCES


