VEGETATED SLOPE STABILIZATION

Alternative Names: Willow Wattles, Live Bundles, Fascines, Live Staking, Joint Planting, Branch Packing, Brush Layering, and Brush Matting

DESCRIPTION
Vegetated slope stabilization practices use vegetated structures to reinforce sloped soil surfaces by trapping sediment, reducing the velocity of surface runoff, increasing infiltration and facilitating vegetation establishment. Vegetated structures are made up of bound live roots, branches, and cuttings of native woody vegetation that when embedded into the soil can establish roots and grow. Vegetated structures are driven into the soil, placed in shallow trenches, or positioned in rows along the contour of the slope and secured using stakes and/or wire. Vegetated slope stabilization practices require adequate moisture for rooting and sprouting to occur and therefore are often employed along stream banks or in wet areas.

APPLICABILITY
- Appropriate for use on slopes experiencing surface erosion and shallow mass wasting where adequate moisture exists to allow for rooting and sprouting, including:
  - Cut or fill slopes
  - Stream banks and other channels
  - Moist and seep areas
  - Long eroded slopes (where the length can be interrupted by vegetation)
  - Earth embankments
  - Small gullies
- Not applicable on over-steepened slopes, greater than 2:1(run to rise), or cut slopes with shallow soils. Increased infiltration from structures can saturate the subsoil and lead to soil slippage and landslides.
- For over steepened slopes, use in conjunction with other slope stabilization techniques such as riprap and retaining walls. Refer to Sections 4.2-f Retaining Wall and 4.2-g Riprap for more detail.

Advantages
- Structural stabilization of slopes using native materials that sprout roots and grow vegetation.
- Over time materials biodegrade providing organic mulch and nutrients for established vegetation.
- Can be installed by hand.
Disadvantages

- Not always successful in Lake Tahoe Region’s dry climate, especially on south or southwest slopes. Rooting and sprouting will only occur if adequate moisture is available at the time of placement and throughout the first few growing seasons.
- Labor intensive to install.
- Plantings must establish before taking full effect in slowing erosion.
- Excavation to install vegetated structures can disturb the soil and further undermine the slope if installed improperly.
- Vegetated structures can float away if not properly secured along stream banks.

DESIGN CONSIDERATIONS

- Work along or within a stream must be approved by TRPA and other applicable agencies prior to construction.
- Use vegetation that establishes quickly by developing adventitious roots (i.e. cuttings sprout roots and shoots without having a root mass), such as willows, dogwood, and snowberry, especially along stream banks or in wet areas.
INSTALLATION CONSIDERATIONS

General installation guidelines that apply to all vegetated slope stabilization practices discussed in this Handbook are listed below. Following the general guidelines are specific installation considerations for willow wattling, brush layering and matting, and live stake planting.

- Install vegetative structures at the onset of plant dormancy in late autumn or in the early spring. Plants that are dormant are more likely to survive.
- Prepare dormant plant cuttings no more than seven days in advance of placement. Keep cuttings moist at all times by placing them into flowing/oxygenated water. Store in a cool place away from direct sunlight (i.e. under the shade of trees) or refrigerate until needed.
- Retain existing topsoil and woody vegetation for future planting. Refer to Section 4.5-l, for more detail regarding Topsoil Salvage.
- Grade or terrace the slope to reduce possible failure by sliding or slumping. Flatten slopes to reduce potential slumping or undercutting from stormwater flows.
- Work should progress from the bottom of the slope toward the top.

Willow Wattling

Willow wattles are bound bundles of long live branch cuttings placed horizontally along the contour of the slope in trenches. This method is generally considered appropriate for slopes of 2:1 (run to rise) or less.

- Bind together long live branch cuttings approximately 0.5 inches in diameter to form bundles that vary in length from 4 to 8 feet. Alternate the direction of cuttings so approximately one-half of the rootward ends are at each end of the
bundle. Fasten bundles every 18 inches using durable twine or wire and compress to no more than 6 to 8 inches in diameter.

- Space trenches a minimum of 3 feet apart and excavate trenches to contain about two-thirds the diameter of the bundle.

- Overlap bundles a minimum of 12 inches within the trench and secure using wooden stakes every 2 to 3 feet. Size stakes at least 2.5 feet long on cut slopes and 3 feet long on fill slopes. Drive them directly through the bundles until flush with the top and use extra at connections and overlaps.

- Install live stakes on the down slope side of bundles, protruding 2-3 inches above the top of the bundle.

- Backfill trenches with moist soil, ensuring good soil-plant contact in and around the wattles. The tops of wattles should remain slightly visible when installation is complete.

- Use mulch or erosion control blankets to secure disturbed soil and prevent erosion in between rows of willow wattles. Refer to Sections 4.2-j, Bare Soil Protection and 4.5-s, Erosion Control Blanket Systems for more detail.
**Willow Wattle Figure**

PREPARED TRENCH
(EXCAVATE TRENCH 2/3
DIAMETER OF WATTLE,
BACKFILL WITH MOIST SOIL)

LIVE WILLOW WATTLE

LIVE STAKE (PLACE DIRECTLY DOWNSLOPE
OF WATTLE, STAKE SHOULD PROTRUDE 2”-3”
ABOVE BUNDLE)

SLOPE SURFACE

DRIVE STAKES DIRECTLY
THROUGH BUNDLE UNTIL FLUSH

UNDISTURBED SOIL

TIE EVERY 18”
ON CENTER

INSTALL STAKES BETWEEN BUNDLE TIES
SPACED EVERY 2’-3’ ALONG BUNDLE

TAPER WATTLE AT END

BUNDLE DIAMETER
6”-8” (TYP)

BUNDLE CONSISTS OF
LIVE BRANCHES,
VARIOUS LENGTHS

12”-24” LONGER THAN LONGEST BRANCH
(USUALLY 48”-96” LONG)

WILLLOW WATTLE DETAIL

**NOTES:**

1. WATTLE BUNDLES SHALL BE PREPARED FROM LIVING BRANCHES OF WILLOW (SALIX SP.) OR OTHER APPROPRIATE SPECIES. WATTLE MATERIAL CAN BE CUT WITH LOPING SHEARS, CHAIN SAWS, OR POWER BRUSH CUTTING SAW.
2. BUNDLES SHALL BE PREPARED IN ADVANCE OF PLACEMENT AND KEPT COVERED AND WET.
3. BUNDLES SHALL BE LAID IN TRENCHES DUG TO APPROX. 2/3 DIA. OF BUNDLE, WITH ENDS OF BUNDLES OVERLAPPING AT LEAST 12”. BUNDLE OVERLAPS SHALL BE TIED WITH DEAD STAKES THROUGH ENDS OF BOTH BUNDLES.
4. BUNDLES SHALL BE STAKED FIRMLY IN PLACE WITH LIVE AND DEAD STAKES AT LEAST 2.5’ LONG. ALL STAKES SHOULD BE DRIVEN TO A FIRM HOLD, A MIN. OF 18”. LIVE STAKES SHALL BE PLACED DIRECTLY DOWNSLOPE OF WATTLE. AFTER STAKING, BACKFILL EXCAVATED TRENCH WITH MOIST SOIL.

THE TAHOE REGIONAL PLANNING AGENCY (TRPA) SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF ELECTRONIC COPIES OF THIS DETAIL.
Brush Layering and Matting

Brush layering and matting provides slope stability and resistance to soil slumping by inserting branch stems, roots or mulched woody material in a trench or cut slope parallel to the slope contour and backfilling with soil. Stems and roots trap sediment and debris, aid infiltration on dry slopes and uptake moisture on wet slopes. They also sprout and grow, further stabilizing the slope, once vegetation becomes established. This method is more effective than wattles with respect to earth reinforcement and stability.

- Install brush parallel to the slope contour in a trench or cut slope, and backfill with soil excavated from the trench immediately uphill. Brush may need to be secured using stakes and/or wire prior to backfilling.
- Consider use of mulch, temporary seeding, and erosion control blankets between the trenches.
- Avoid slopes steeper than 2:1 (run to rise) and generally limit slope lengths to 20 feet or less.

Live Stakes

Live stakes involve tamping live woody cuttings into the soil at depths close to the water table. This practice creates a living root mat that stabilizes the soil by reinforcing and binding soil particles together and by extracting excess soil moisture. Live stakes help repair small soil slumps caused by excessively wet soil. They are an inexpensive technique and can be used in combination with other slope stabilization methods, such as riprap or erosion control blankets. Refer to Sections 4.2-g, Riprap and 4.5-s, Erosion Control Blanket Systems for more detail.
Live stakes

- Select live stakes that are 0.5 to 1.5 inches in diameter, and approximately two to three feet in length. Install live stakes 2 to 3 feet apart. For easy insertion, cut the rootward end to an angled point, and square the top to drive it into the ground.

- Space stakes along the contour of the slope, with stakes offset relative to adjacent rows to avoid placing stakes above or below each other.

- Establish a pilot hole for each live stake prior to driving it into the ground. Gently tamp stakes approximately 80 percent below the surface and firmly pack with soil after installation. Do not use stakes that split during installation and remove top sections of stakes damaged during installation.

INSPECTION AND MAINTENANCE

- Check vegetated structures annually and after significant storm events for damage, soil slumping, and loose stakes or fasteners. Immediately repair and replace as needed.

- Ensure vegetated structures stay moist to facilitate rooting and sprouting until vegetation becomes established. Irrigation may be needed during the first two years after planting for vegetation establishment.

EFFECTIVENESS CONSIDERATIONS

Many unstable areas can be improved by supplemental plantings that enhance bank stability, increase biodiversity, create wildlife habitat, and improve water quality. One study, Improving the Establishment of Willow Cuttings in Riparian Areas by the USDA Natural Resources Conservation Service, highlights the importance of using indigenous plant materials to the site, proper sizing of cuttings, and pretreatment such as soaking.8

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8 Logar R., Scianna J., 2005, Improving the Establishment of Willow Cuttings in Riparian Areas Forestry Technical Note No. MT-25 for the USDA NRCS