NRCS
and
Streambank Soil Bioengineering

~

Webinar

~

24 May 2022

Prepared and presented by
Jon Fripp, PE,
NRCS-NDCSMC, Fort Worth, Texas

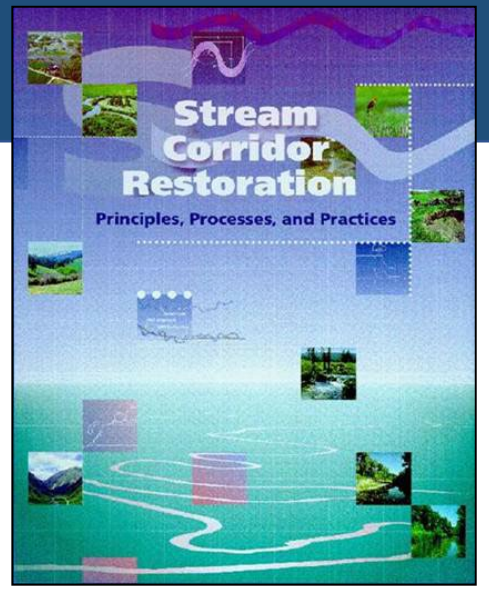
NRCS
Natural Resources Conservation Service

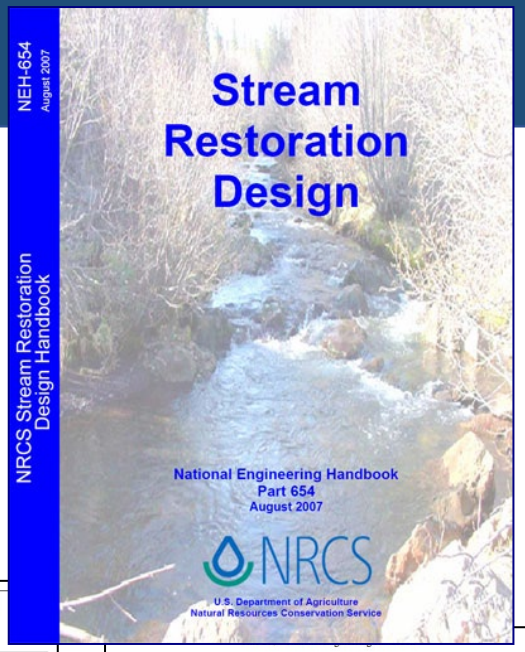
Module Topics

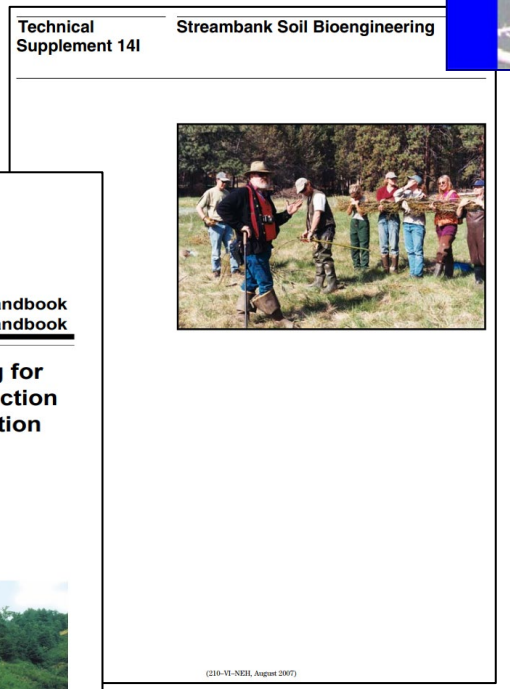
- Streambank Soil Bioengineering Definitions (Ref NEH 653, NEH 654.14) ***What***
- Riparian Zones (Ref NEH 654.14 TS 14I) ***Where***
- Adventitiously Rooting Plants (Ref NEH 654.14 TS 14I)
- Selected Structural and Plant Based Soil Bioengineering Techniques (Ref NEH 654.14 TS 14I, NEH 650.16, NEH 650.18) ***How***

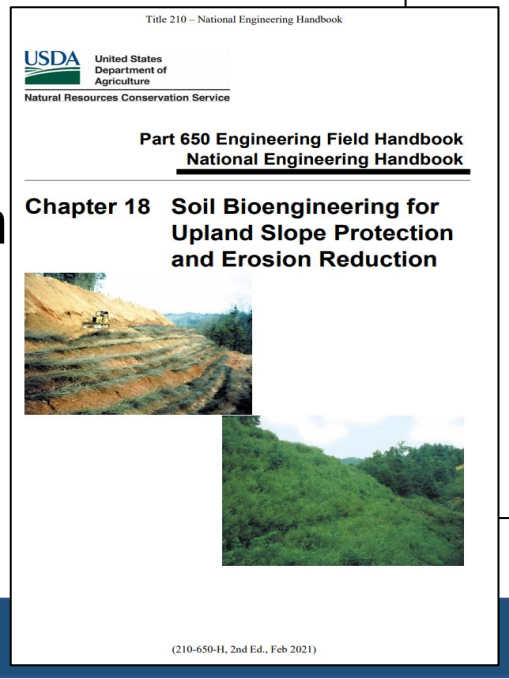
References

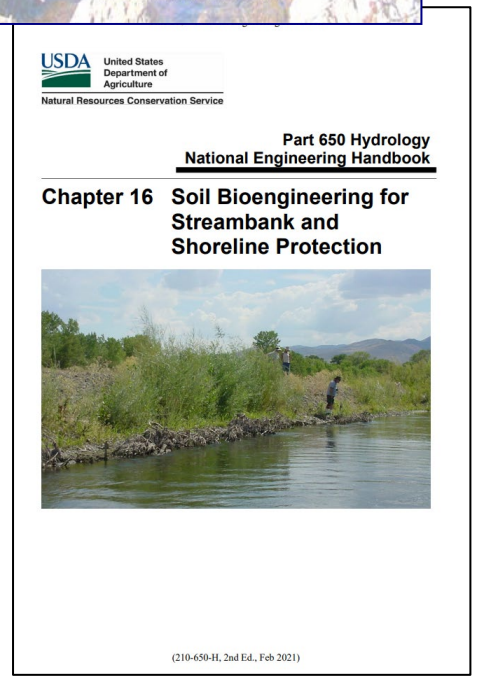
- NEH 653 Stream Corridor Restoration: Principles, Processes, and Practices (1998)
- NEH-654 Stream Restoration Design (2007)
- NEH 654.14 TS 14I Streambank Soil Bioengineering (2007)
- NEH 650.16 Soil Bioengineering for Streambank and Shoreline Protection (2021)
- NEH 650.18 Soil Bioengineering for Upland Slope Protection and Erosion Reduction (2021)





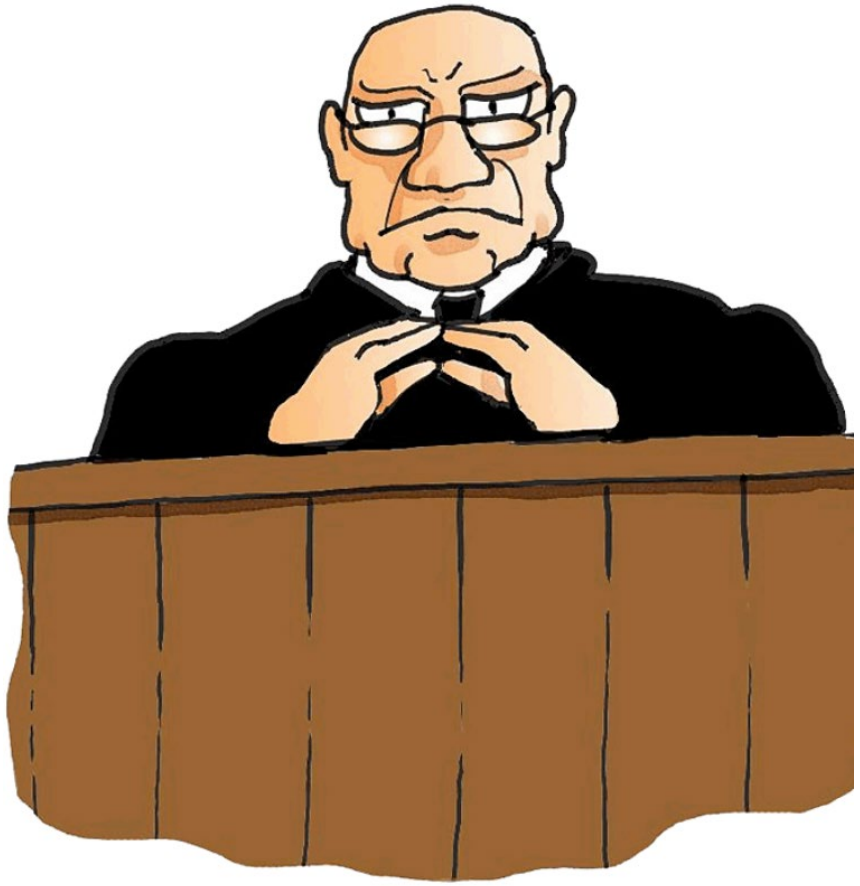






We are not going to talk about…

- Funding and programs
- Regulatory issues
- Permitting issues
- Planning issues



Natural Resources Conservation Service (NRCS)

https://www.nrcs.usda.gov

MISSION:

The NRCS provides leadership in a partnership effort to help people conserve, maintain, and improve our natural resources and environment

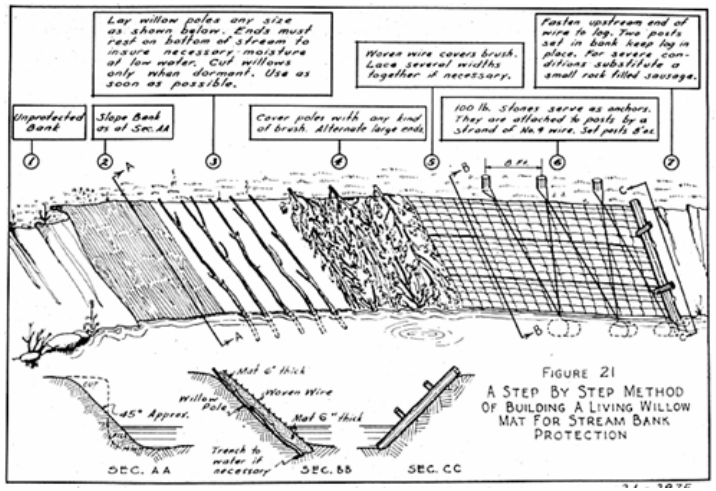
Stream Bank Erosion

- Damage to bridges, roads, houses, agriculture
- Reduce water quality
- Impact the environment

It is a bad thing

Natural Resources Conservation Service *and work in channels*

- NRCS has been involved in channel work since the beginning of the agency
- Average annual EQIP program expenditures* of approximately $21 million on channel and channel related work
- Annual Emergency Watershed Work of approximately $70 million** (FY18) to $200 million (FY22)



* Federal Monies. Seven year (2012-2018) average for Conservation Practice Standards 326, 356, 395, 396, 578, 580, 582, 584. Does not include wetlands, riparian buffers or nutrient work
** FY 2018 Emergency work. Includes hurricane recovery

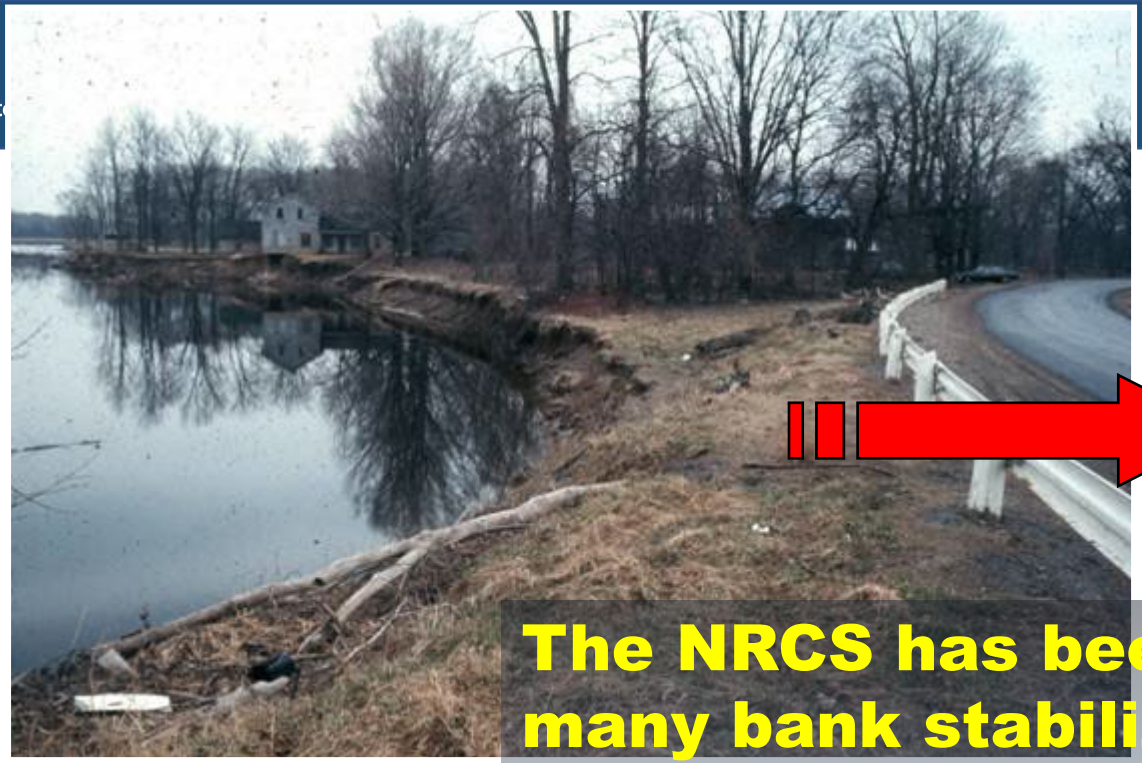


Photo from Don Shanklin

Riprap

The NRCS has been involved in many bank stabilization projects

Soil Bioengineering

Combinations of Hard Bank Protection and Streambank Soil Bioengineering

The NRCS has been involved in many bank stabilization projects

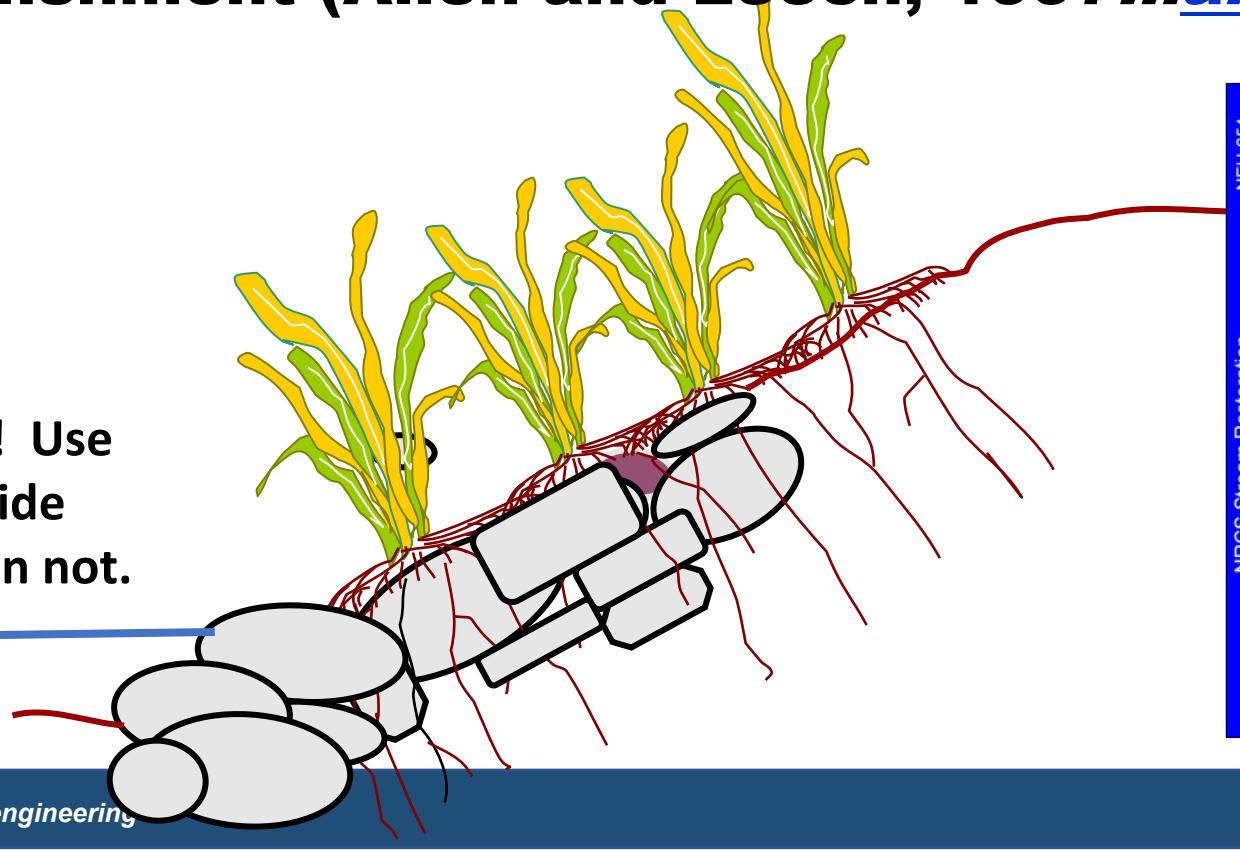
Streambank Soil Bioengineering - Advantages

- Can have higher aesthetic quality than traditional bank protection
- Easier to transition to an end
- Can have some habitat value (aquatic, terrestrial)
- Cost effective
- Self healing - Sustainable
- Indigenous, natural materials
- Installed by landowner/volunteers
- Minimize site disturbance
- Etc..

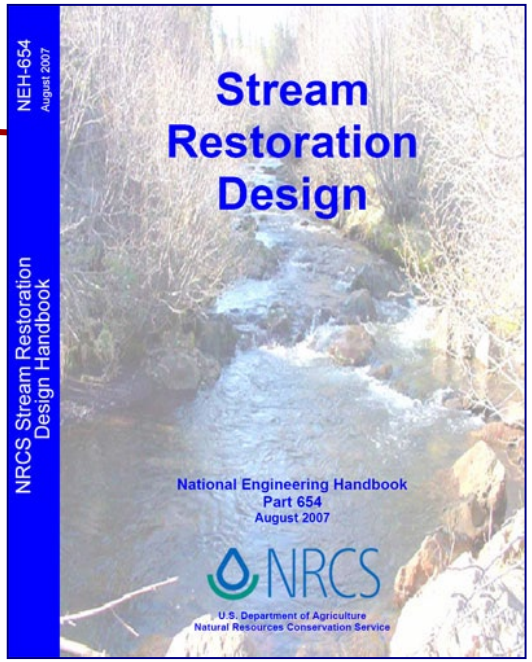
Often used as part of stream restoration projects

Streambank Soil Bioengineering Definition

- **Streambank soil bioengineering is defined as the use of live and dead plant materials in combination with natural and synthetic support materials for slope stabilization, erosion reduction, and vegetative establishment (Allen and Leech, 1997…*and NEH 654.14*)**



Plant roots only go so deep! Use the inert material to provide strength where the plants can not.



Streambank Soil Bioengineering

~~Myth #1: Vegetation is just for aesthetics~~

Streambank soil bioengineering uses plants as a structural component to stabilize and reduce erosion on streambanks rather than just for aesthetics.

- Plants can reduce the erosive potential by decreasing the water velocity along the bank.
- Plants can induce sedimentation.
- Plants can build streambanks.
- Plants can increase the meander radius or decrease it.
- Plants can break-up the side vortices of the stream current.
- Other functions

Streambank Soil Bioengineering

Myth #2: ~~*Inert material is not important*~~

Inert material is often used in combination with the plants to:

- Take pressure off the bank which in turn allows the plants to establish
- Provide permanent strength where plants can't
- Provide temporary strength where the plants can't
- Induce sediment deposition
  - ➢ Provides an improved planting bed for the plants.
  - ➢ Deposits fine soil in areas that have little soil to start with which in turn allows plants to establish where they couldn't before

Concerns…

Bioengineering has various degrees of flexibility.

Does project area allow for movement?

Is area able to sustain plant growth?

- Shade
- Soil compaction
- pH
- Nutrients, etc.

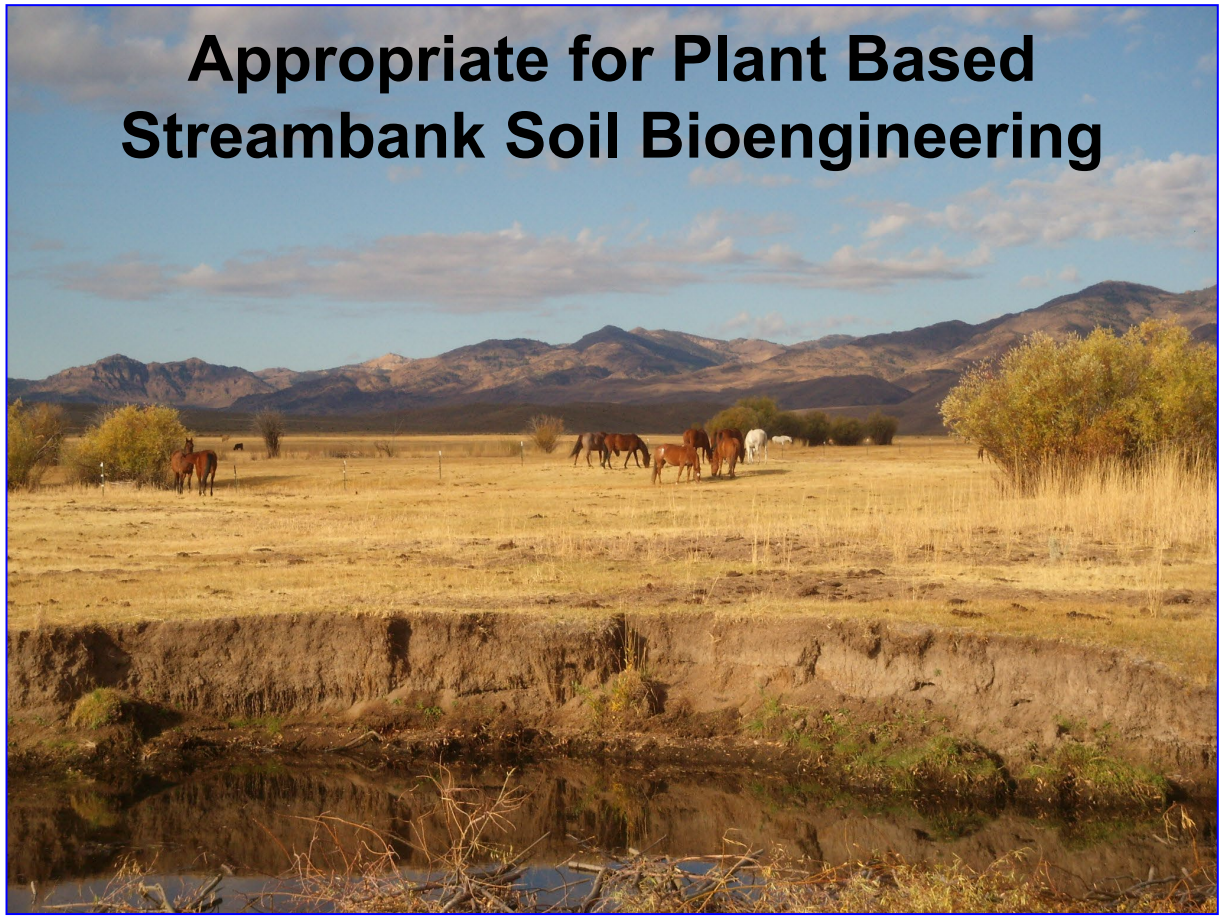
Site dependent

LETS UNPACK THAT FLEXIBILITY CONCERN…

A **Plant Based Streambank Soil Bioengineering** approach does not intend to produce a static bank line. A successful project is a flexible project. The treatments may include inert component s and bank grading, but they fundamentally rely on riparian plants to provide long term strength to the bank. These treatments are applied to sites where the goal is to slow the dynamics of the system to a more natural rate. Additional bank movement after construction of the project is acceptable and expected during high flows. (Riparian/Wetland Project Information Series No. 23 October 2008…***and NEH 650.16, 2020***)

A **Structural Based Streambank Soil Bioengineering** approach is successful when it results in a fairly static bank. The treatments in this category rely on rock, manufactured products, or other inert material to result in a fixed condition. …Treatments such as these are generally applied at high risk sites and areas where additional bank movement is unacceptable. Installed plant material certainly provides aesthetic and habitat benefits to such projects. Plants may also increase strength and shielding to the structure, but the bank line limits are defined fundamentally by the installed structural material. A successful project is a static project.

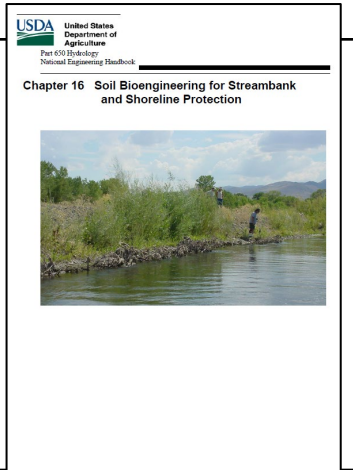
(Riparian/Wetland Project Information Series No. 23 October 2008…***and NEH 650.16, 2020***)


Appropriate for Plant Based
Streambank Soil Bioengineering


Appropriate for Structural
Based Streambank Soil
Bioengineering
Fossil Creek, TX

Treatment Features	Structural Based Streambank Soil Bioengineering	Plant Based Streambank Soil Bioengineering
Bank Line	Determined by designer and defined by placement of the hard material	Approximated by designer and defined over time by natural processes
Dynamism	Low to none. A successful project is relatively static	Moderate. A successful project is as dynamic as a natural, unimpacted reach
Material used	Structural material enhanced with plantings	Living riparian plants. Inert materials may be used to provide temporary stabilization until plants are established
Self healing	Limited. Once structural component fails, the treatment is compromised	Significant. Plant material can be severely impacted yet recover over time
Ecological Benefits	Terrestrial and aquatic benefits provided by plants and placement of inert material	Terrestrial and aquatic benefits provided by plants and the dynamic nature of the resulting project
Typical Applications	Urban or suburban situations where high value infrastructure is adjacent to the waterway	Suburban, rural, or park situations where some movement of the bank line will not endanger life or property
Example treatments	•Rip Rap with live cuttings •Vertical bundles with a rock toe •Log Cribs •Green Gabions •Vegetated Wireface MSE wall •Vegetated geocells •Stone stream barb •Permanent erosion control fabric	•Live cuttings •Vertical bundles •Fascines •Brush Mattress •Brush Revetment •Wattles •Vegetated stream barb •Willow Pole and Clump Planting •Temporary erosion control fabric

This is covered in NEH 650.16 in more detail...



...WHAT IS SPECIAL ABOUT THE VEGETATION...?

Streambank Soil Bioengineering uses Adventitiously Rooting Riparian Plants

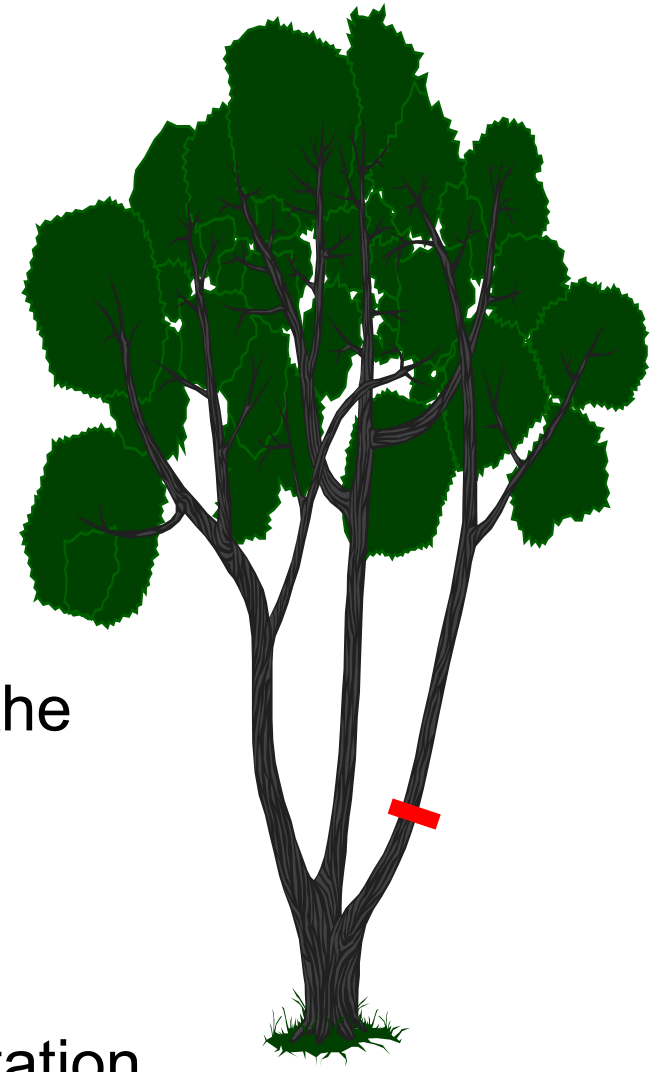
Nevada

North Dakota

Adventitiously rooting = can root from a cutting

How to harvest plants

- ID in summer, harvest when dormant (fall)
- Cuttings should be made from dormant plants.
- Plants must be at least 2 years old.
- Use sharp tools to make clean cuts.
- Nuisance or noxious weeds
- Suitable size and length
- Harvesting of live material shall leave at least one third of the parent plant intact.
- Diameter and length of material will vary depending on soil bioengineering technique used and depth to water table.
- Material should be free of decay, splitting, and insect infestation



Riparian Plants – accustomed to flooding and sediment deposition

Preparation of plant materials

- Paint ends
  - Identify species
  - Reduce drying
- Storage
  - Store cold
  - Store dry (3-4 months)
  - Store in shade on site
- Transport
  - DO NOT allow to dry out
  - Cover if necessary

Preparation of plant materials

Why soak the cuttings?

- Soak in water to hydrate the cutting and to swell the root primordia
- Soaking results in increased shoot and root growth which results in increased drought tolerance and lower mortality

General guidelines on soaking:

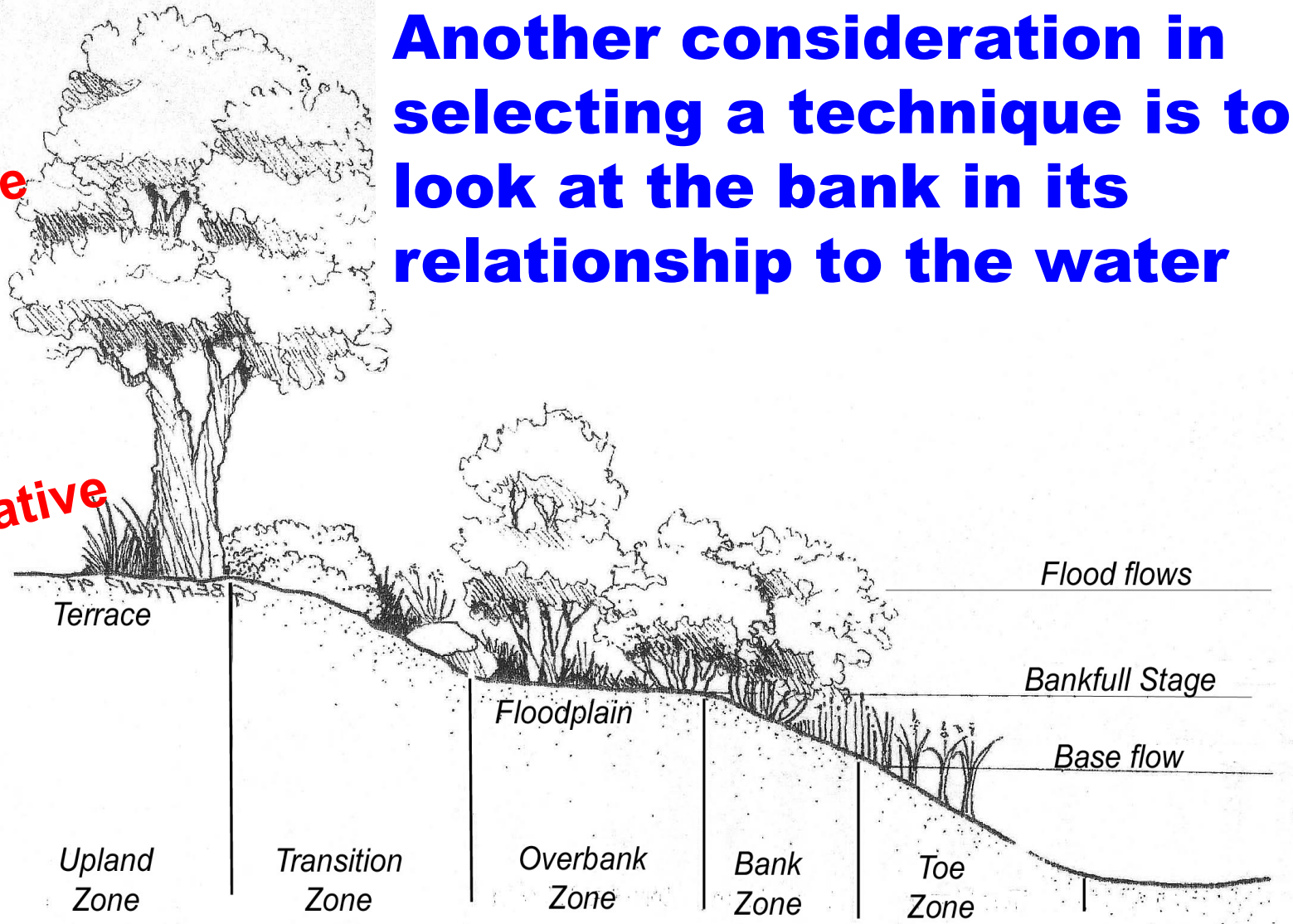
- Soak 10-14 days (24 hours min)
- Soak cut ends or entire cutting
- Soak till bud swell
- DO NOT soak until air roots form (after about 17 days)

Can also install immediately after harvest

Riparian Planting Zones

Another consideration in selecting a technique is to look at the bank in its relationship to the water

Look at what is growing in the bank. We are using the features and attributes of vegetation – therefore soil bioengineering is very dependent on position relative to the stream.



Note: This is a stylized drawing. Zone widths will be different in the REAL world.

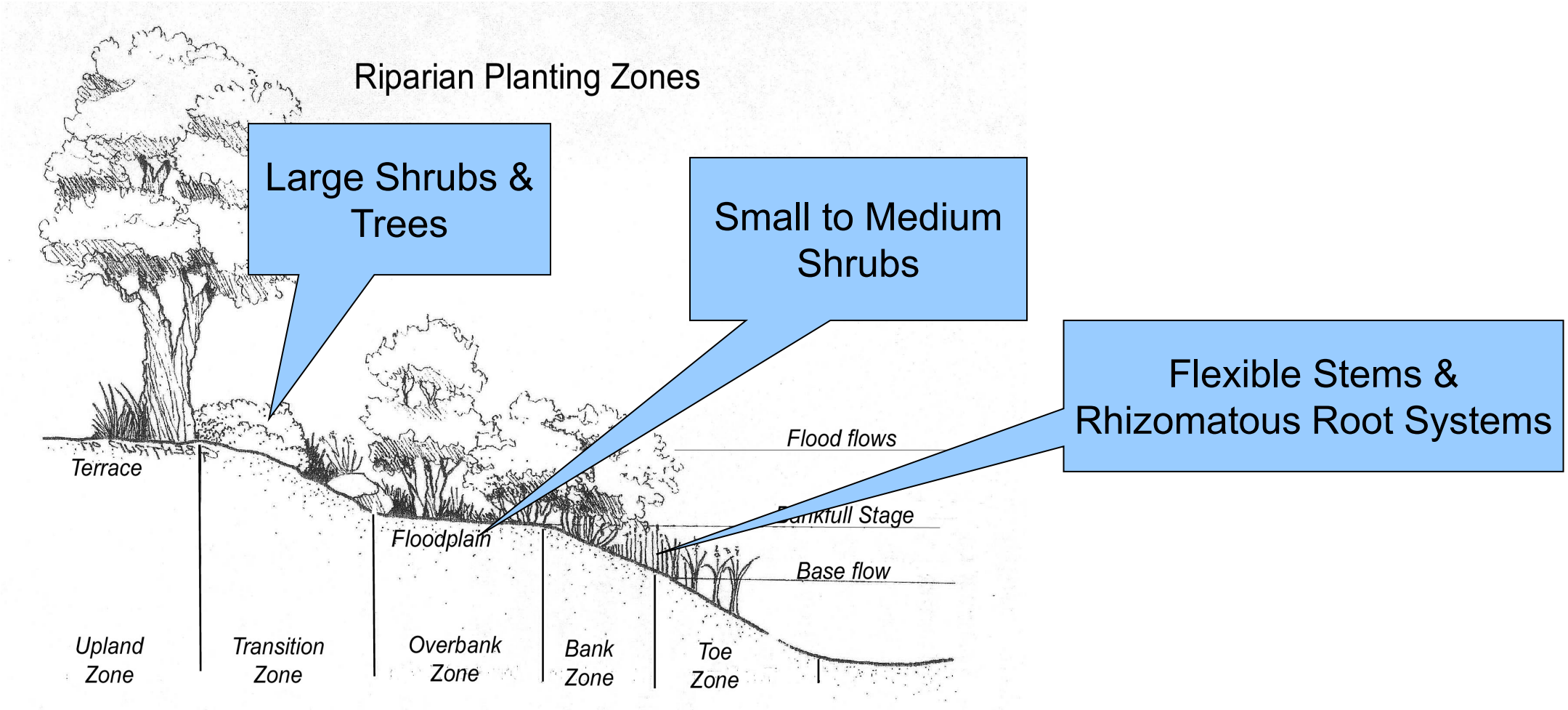
Source: Hoag, et al., 2001. Riparian Planting Zones in the Intermountain West. Information Series #16. NRCS - Plant Material Center, Aberdeen, ID.

The Planting Zones Can Be Identified On Most Stream Channels

BUT

Depends On Flow Regime, Climate, Hydrology and Water Table Elevation

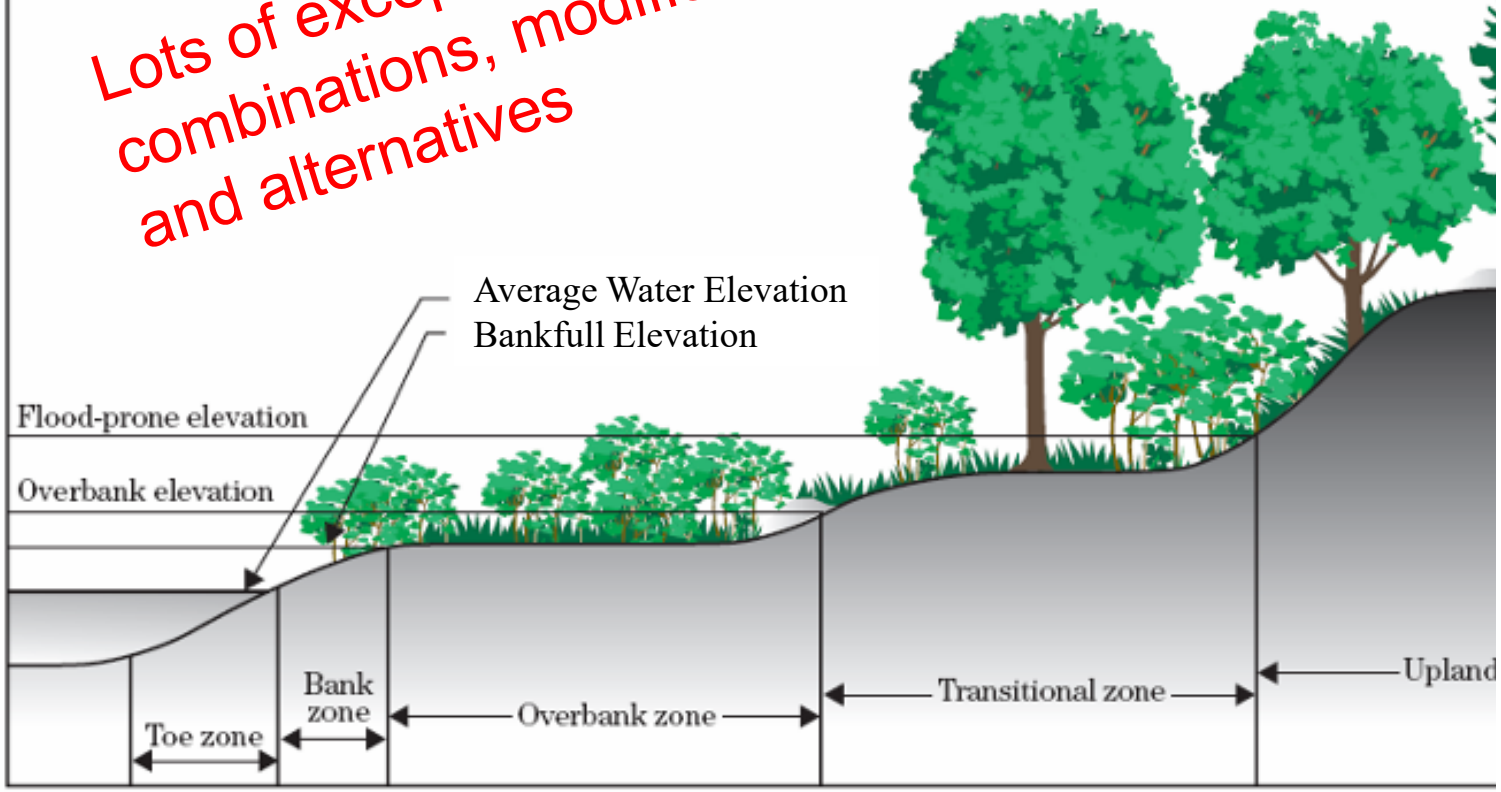
Plants Typically Associated With One Zone Can be Found Other Zones



Source: Hoag, et al., 2001. Riparian Planting Zones in the Intermountain West. Information Series #16. NRCS - Plant Material Center, Aberdeen, ID.

Use the Riparian Zone as a guide to select the stream bank soil bioengineering technique

Lots of exceptions, combinations, modifications, and alternatives



Toe Zone

- **Fascines**
- Coir Log
- Engineered Log Jams (ELJs)
- **Rootwads**
- **Brush/Tree Revetments**
- Brush Box
- Hard Protection
- Lunkers
- Log Cribwalls
- Brush Barbs

Bank Zone

- **Live Poles/cuttings/stakes**
- Brush Layering
- **Brush Mattress**
- Wattle Fence
- **Vertical Bundles**
- **Vegetated Reinforced Soil Slope**
- MSE walls
- Joint Planting

Overbank and Transition

- **Brush Trench**
- Live Clumps
- **Containerized**
- Erosion Control Fabric

Not all techniques are equal

Consider applied stress at design flows

Note that techniques get stronger with time

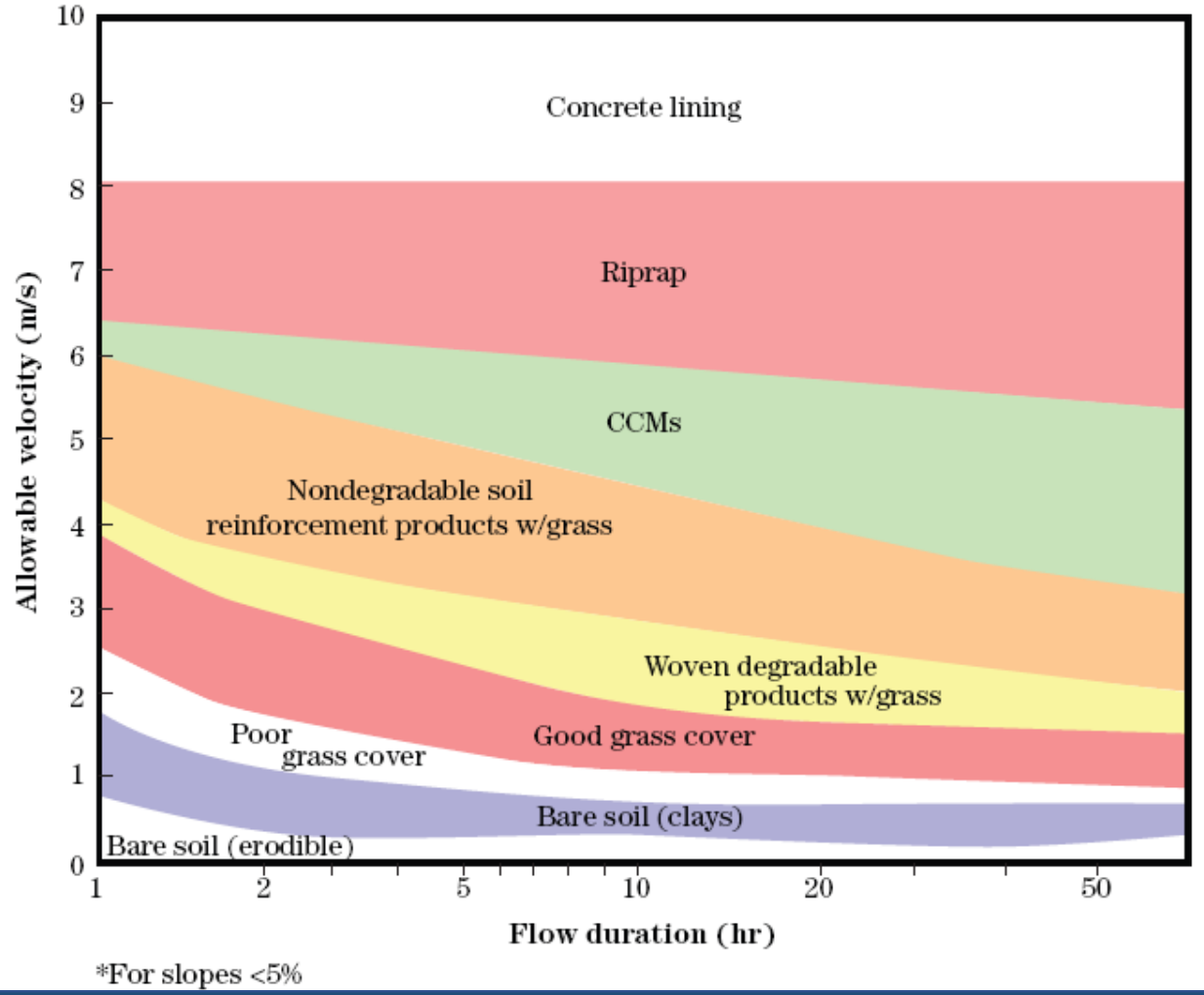
Table TS14I–4 Compiled permissible shear stress levels for streambank soil bioengineering practices

Practice	Permissible shear stress (lb/ft²)*	Permissible velocity (ft/s)*
Live poles (Depends on the length of the poles and nature of the soil)	Initial: 0.5 to 2 Established: 2 to 5+	Initial: 1 to 2.5 Established: 3 to 10
Live poles in woven coir TRM (Depends on installation and anchoring of coir)	Initial: 2 to 2.5 Established: 3 to 5+	Initial: 3 to 5 Established: 3 to 10
Live poles in riprap (joint planting) (Depends on riprap stability)	Initial: 3+ Established: 6 to 8+	Initial: 5 to 10+ Established: 12+
Live brush sills with rock (Depends on riprap stability)	Initial: 3+ Established: 6+	Initial: 5 to 10+ Established: 12+
Brush mattress (Depends on soil conditions and anchoring)	Initial: 0.4 to 4.2 Established: 2.8 to 8+	Initial: 3 to 4 Established: 10+
Live fascine (Very dependent on anchoring)	Initial: 1.2 to 3.1 Established: 1.4 to 3+	Initial: 5 to 8 Established: 8 to 10+
Brush layer/branch packing (Depends on soil conditions)	Initial: 0.2 to 1 Established: 2.9 to 6+	Initial: 2 to 4 Established: 10+
Live cribwall (Depends on nature of the fill (rock or earth), compaction and anchoring)	Initial: 2 to 4+ Established: 5 to 6+	Initial: 3 to 6 Established: 10 to 12
Vegetated reinforced soil slopes (VRSS) (Depends on soil conditions and anchoring)	Initial: 3 to 5 Established: 7+	Initial: 4 to 9 Established: 10+
Grass turf—bermudagrass, excellent stand (Depends on vegetation type and condition)	Established: 3.2	Established: 3 to 8
Live brush wattle fence (Depends on soil conditions and depth of stakes)	Initial: 0.2 to 2 Established: 1.0 to 5+	Initial: 1 to 2.5 Established: 3 to 10
Vertical bundles (Depends on bank conditions, anchoring, and vegetation)	Initial: 1.2 to 3 Established: 1.4 to 3+	Initial: 5 to 8 Established: 6 to 10+

* (USDA NRCS 1996b; Hoag and Fripp 2002; Fischenich 2001; Gerstgrasser 1999; Nunnally and Sotir 1997; Gray and Sotir 1996; Schiechtl and Stern 1994; USACE 1997; Florineth 1982; Schoklitsch 1937)

The designer should consider modifying recommendations based on site specific conditions such as *duration of flow*, soils, temperature, debris and ice load in the stream, plant species, as well as channel shape and planform

Figure 8–25 **Limiting Velocities and Duration**

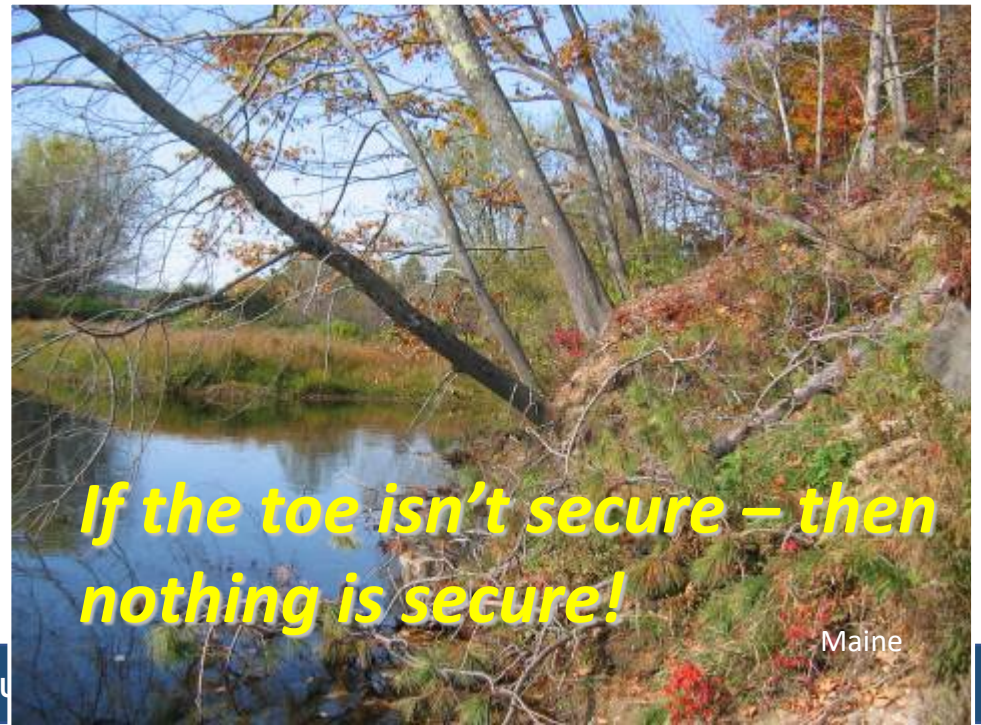


*For slopes <5%

TOE ZONE

- Elevation zone between the bed and the average water elevation.
- Zone of highest stress

Often inert material is used in this area



Top three

1. **Protect the toe**
2. **Protect the toe**
3. **Protect the toe**

-Rob Armstrong

Often rock is used at the toe…


Maryland

Rock toe and vegetation

San Antonio, TX

Brush layer and willow cuttings placed behind rock

Fascines

(Plant Based Streambank Soil Bioengineering)

Long, cigar shaped bundles of live material anchored to bank

- Only at toe zone if used on a shallow stream
- Surface erosion
- Prevention of rill/gully formation
- Traps sediment
- Reduces slope steepness
- Protects against very shallow slides (<12 inch)
- Fascines can also be used as drains to collected runoff

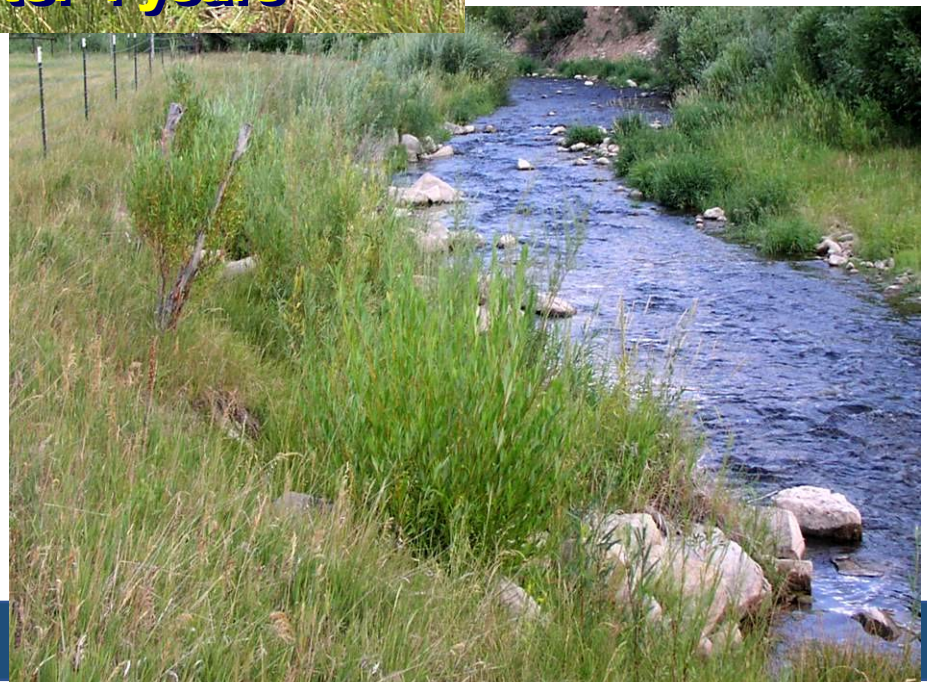
Fascines - Installation

- Trench at toe of bank (2/3rds diameter of fascine)
- Secure with stake through the bundle every 2 to 4 feet
- Wash in loose soil to get good soil to stem contact

Be sure there is good soil to stem contact


Before


After 4 years



BRUSH OR TREE REVETMENT

(Plant Based Streambank Soil Bioengineering)

A continuous line of dead, woody material placed along the toe of the bank

Brush or Tree Revetments

- Provides physical protection
- Reduces the stream velocity
- Causes sediment to drop out and deposit around the branches.
- Builds up the streambank and develops substrate for planting


Sept 2003 - August 2016

Design Considerations

- What material is going to be used to create the revetment
- Stability of the stream system
- Sediment and debris load in stream.
- How is live material going to be established
  - Volunteer? Plantings?
- Upstream key in
- Bed key in
- Anchoring


Idaho


Nevada

Brush or Tree Revetments

Hard wood for toe protection

Live clumps and flexible wood for toe protection

Rootwads

(Structural Based Streambank Soil Bioengineering)

- Large logs along bank with root mass projecting into the flow
- Often as a continuous line
- Been used in a variety of areas

- Stream bank stability enhancement
- Habitat restoration
- Shade and edge cover
- Terrestrial habitat

Design Considerations

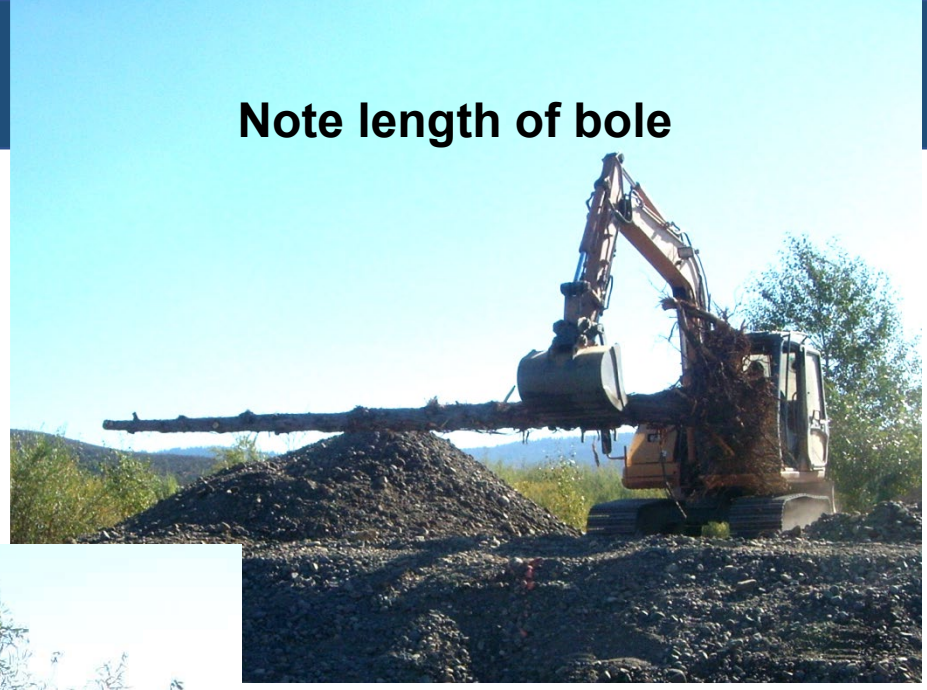
- Stability of the stream system
- Forces
- Drift load in stream
- Anchoring

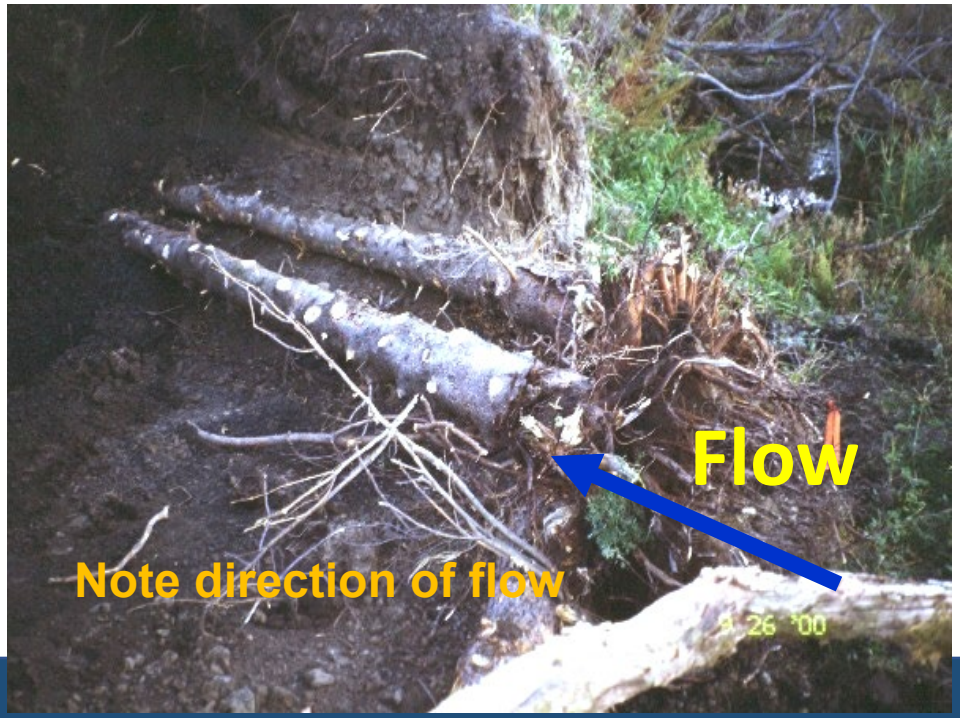
- Backwater affects
- Safety
- Tolerance for risk

Root mass should be touching the bottom and should be tucked behind the adjacent root wads.

Note vegetation in key

Note length of bole

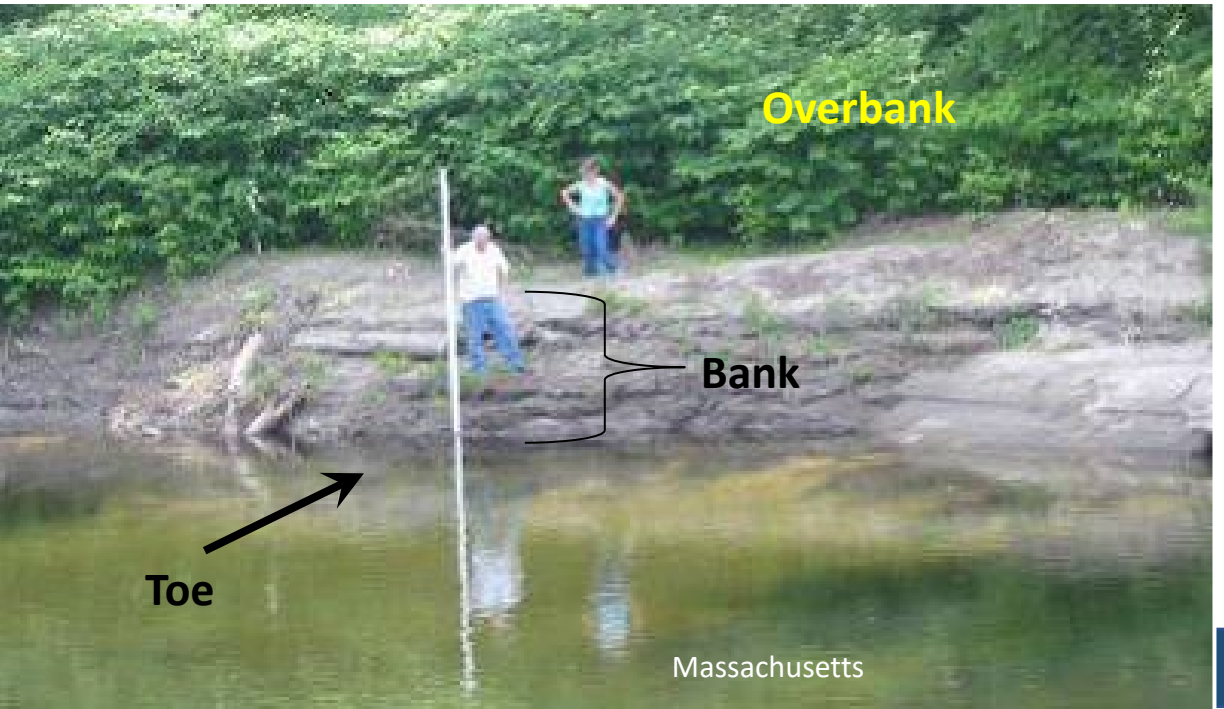


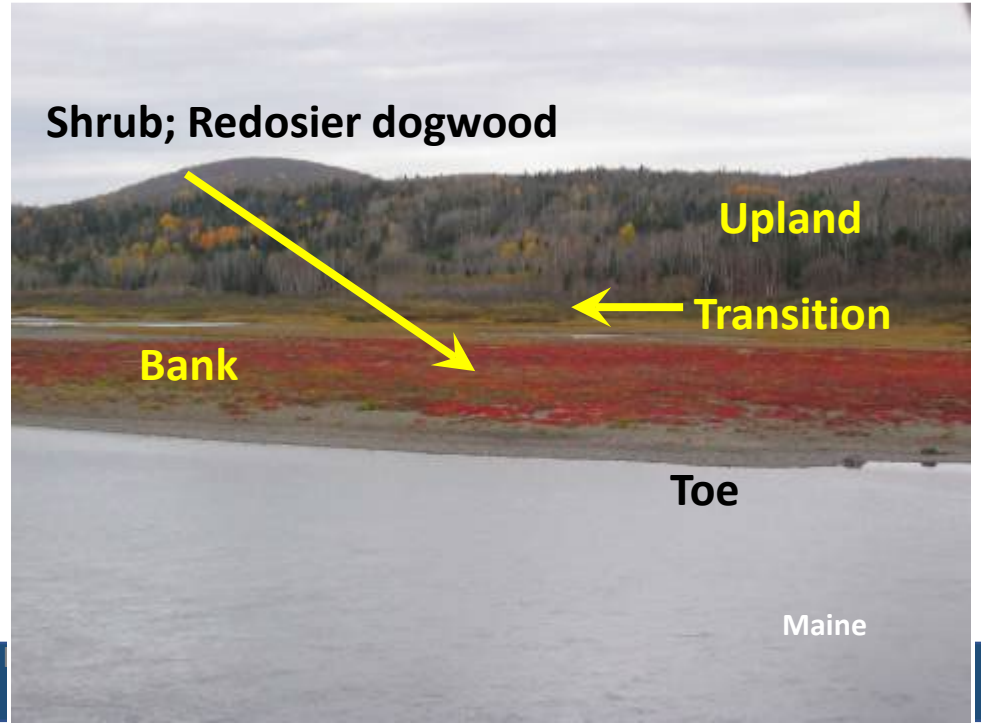


BANK ZONE

Often where we see the erosion

- That portion of the bank from the average water elevation to the bankfull discharge elevation.
- Shrubby willows, baccaras and/or dogwoods are often successful woody species for this zone.





Live Cuttings, Live Stakes, Live Poles – *Dormant Unrooted Cuttings*

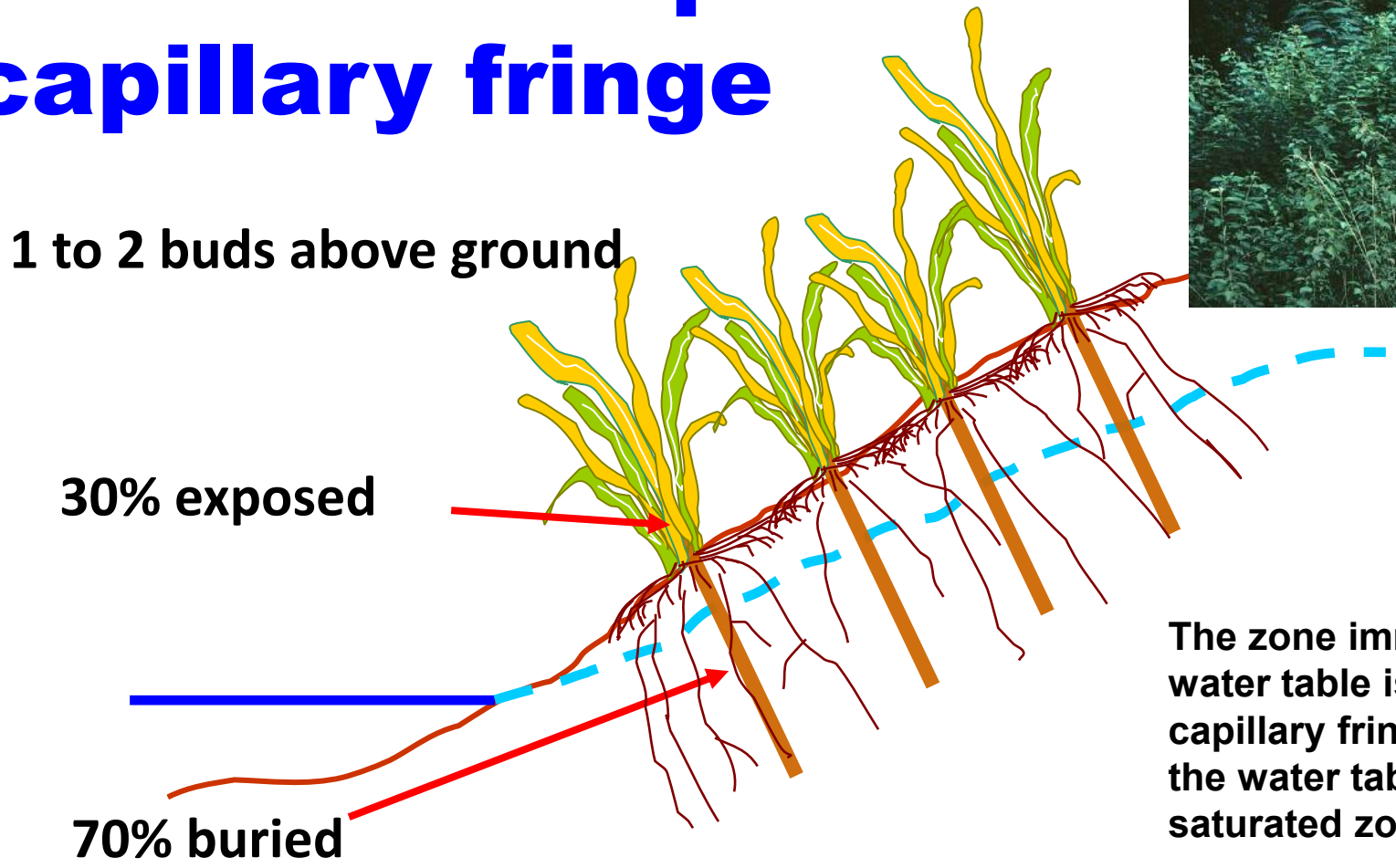
(Plant Based Streambank Soil Bioengineering)

- Induces deposition
- Lowers velocities
- Mechanically pins the stream bank
- Often used with other techniques

Gum Springs, MD

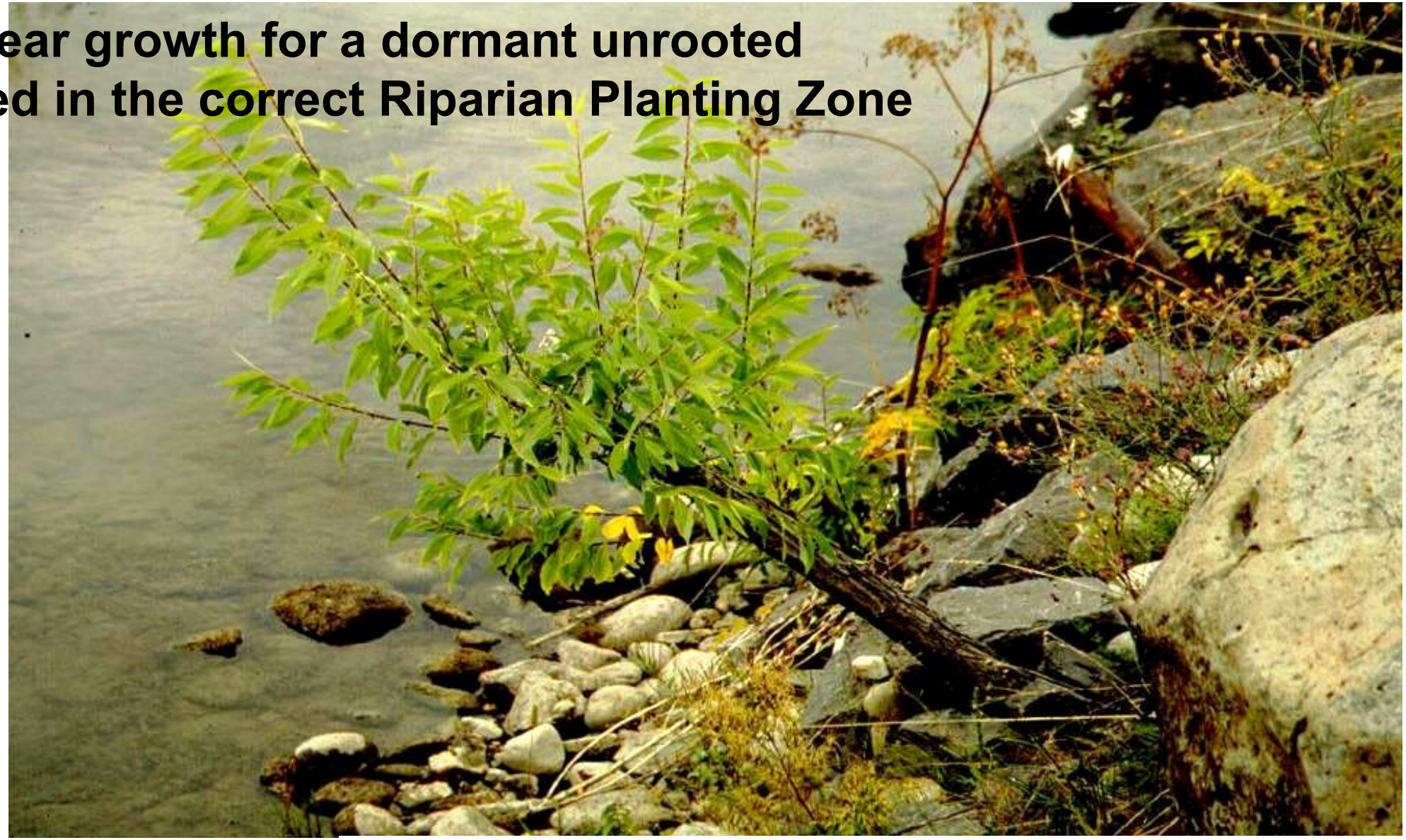
Santa Maria, CA

Be sure live stakes/poles reach capillary fringe



The zone immediately above the water table is known as the capillary fringe. The zone below the water table is known as the saturated zone.

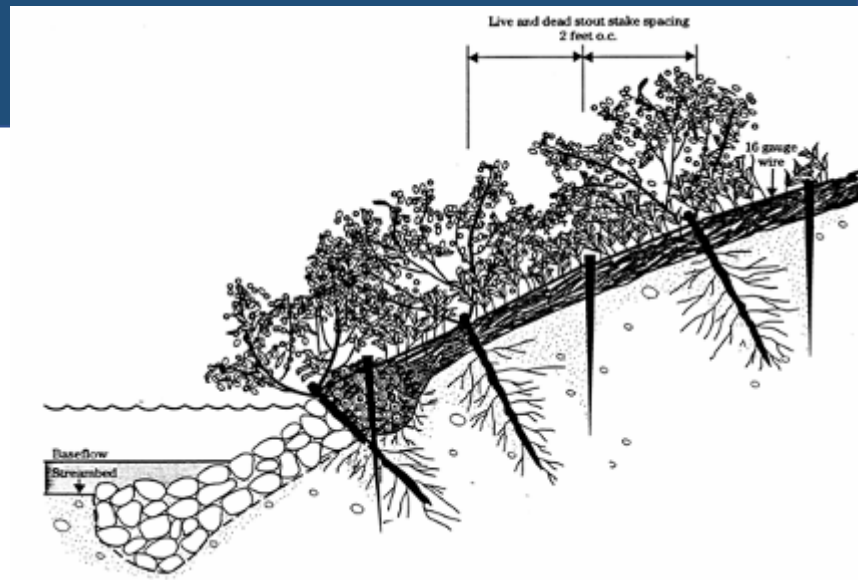
Typical one year growth for a dormant unrooted cutting planted in the correct Riparian Planting Zone



Adventitiously rooting = can root from a cutting

Brush Mattress

(Plant Based Streambank Soil Bioengineering)



- Typically for stream banks
- Rapid immediate protection
- Traps sediment
- Labor intensive

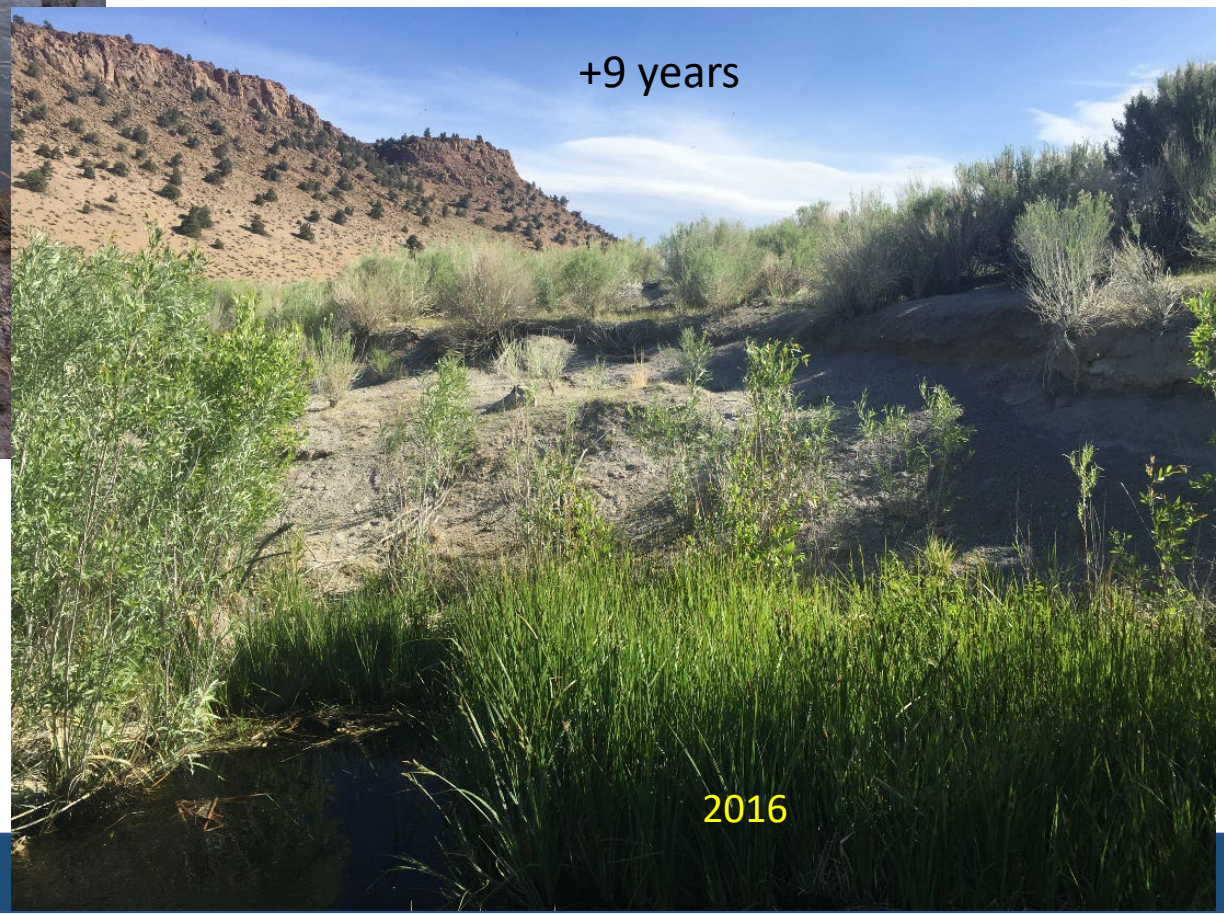
- Slope
- Trench at base
- Place branches
- Secure with short lengths of wire/string
- Typically, the string/wire is in a diamond pattern

Vertical Bundles

A vertical bundle is a bundle of willows that lay vertically up the bank so the bottoms are in the bed and the tops are 8-12 in above the top of the bank.

- Assemble cuttings into a bundle 3” to 1’ in diameter. All butts down and all tops up.
- Hold tightly and tie tightly about every 2 ft
- Don’t tie the top 1/4 of the bundle
- Dig a trench that is about 2/3 of bundle diameter, and down into the stream bed to about 6 inch below low water
- Place Stake perpendicular to bank and through the bundle
- Cover bottom ½ - 2/3s of bundle with soil and wash in

NOTE: Key to success is good soil to stem contact!!

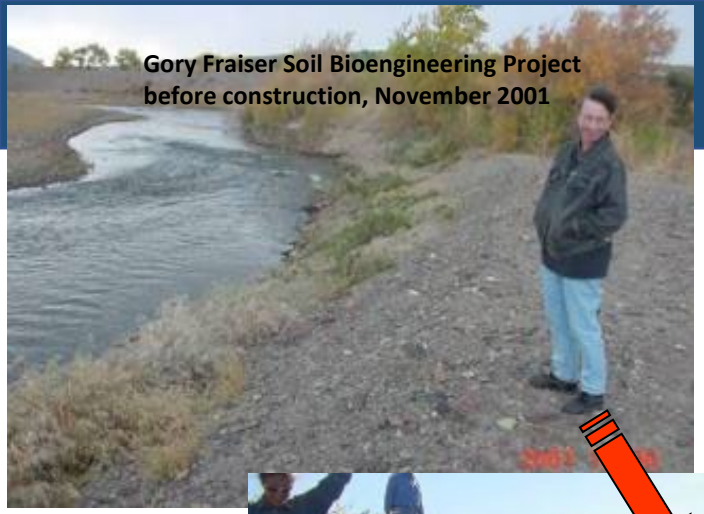

+9 years
2016

Vertical Bundles behind rock rip-rap

Vertical Bundles placed against bank and tock pulled up to cover them and the bank

California

Vertical bundles, live stakes, and tree revetment


Gory Fraiser Soil Bioengineering Project before construction, November 2001

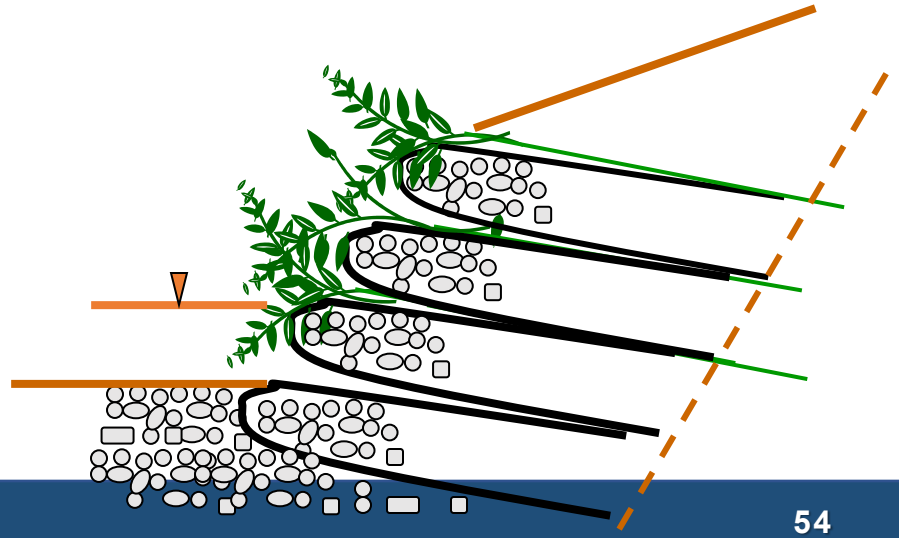

August 2003.

Vegetated Geogrid

Also called brush layering with soil wrap and Vegetated Reinforced Soil Slope

Similar to branch packing except that natural or synthetic geotextile materials are wrapped around each soil lift between the layers of live branch materials. (NRCS Chpt 16)

- Used above and below bankfull
- Constructed during low water
- Can be time consuming to construct
- Functions immediately
- Can be used on steep slopes.
- Not a retaining wall unless other work is done



Wrap fabric around the soil for a minimum of 3 ft and secure.

Can be used on larger bank projects

Deerfield Massachusetts

A Streambank soil bioengineering project is not as strong initially as it is once vegetation is firmly established. But is it strong enough initially?

Massachusetts

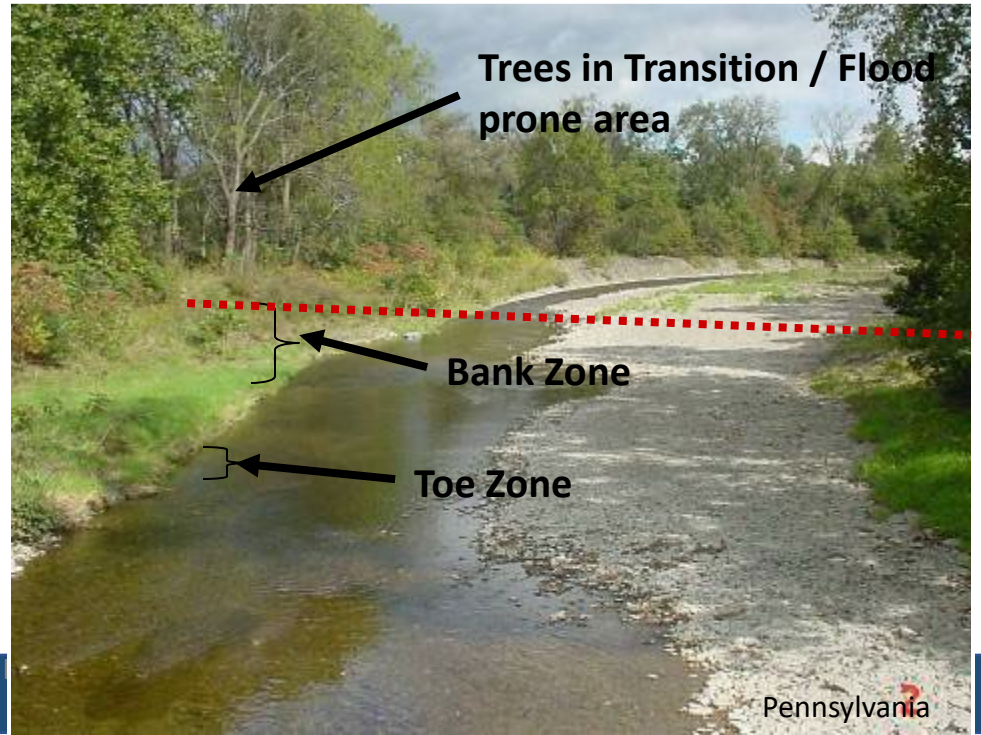
Note: consider project performance both long term and immediately after construction

OVERBANK ZONE

- Zone is broad between bankfull stage and overbank elevation.
- Plants in this zone should be inundation tolerant.
- Shrubby plants with flexible stems are often found here
- Alder, birch, cottonwoods, sycamores, willows, and mesquite can also occur in the overbank

TRANSITION ZONE

- This zone is where the riparian plant species transition to upland species.
- This zone is where the TREE SPECIES are usually found.



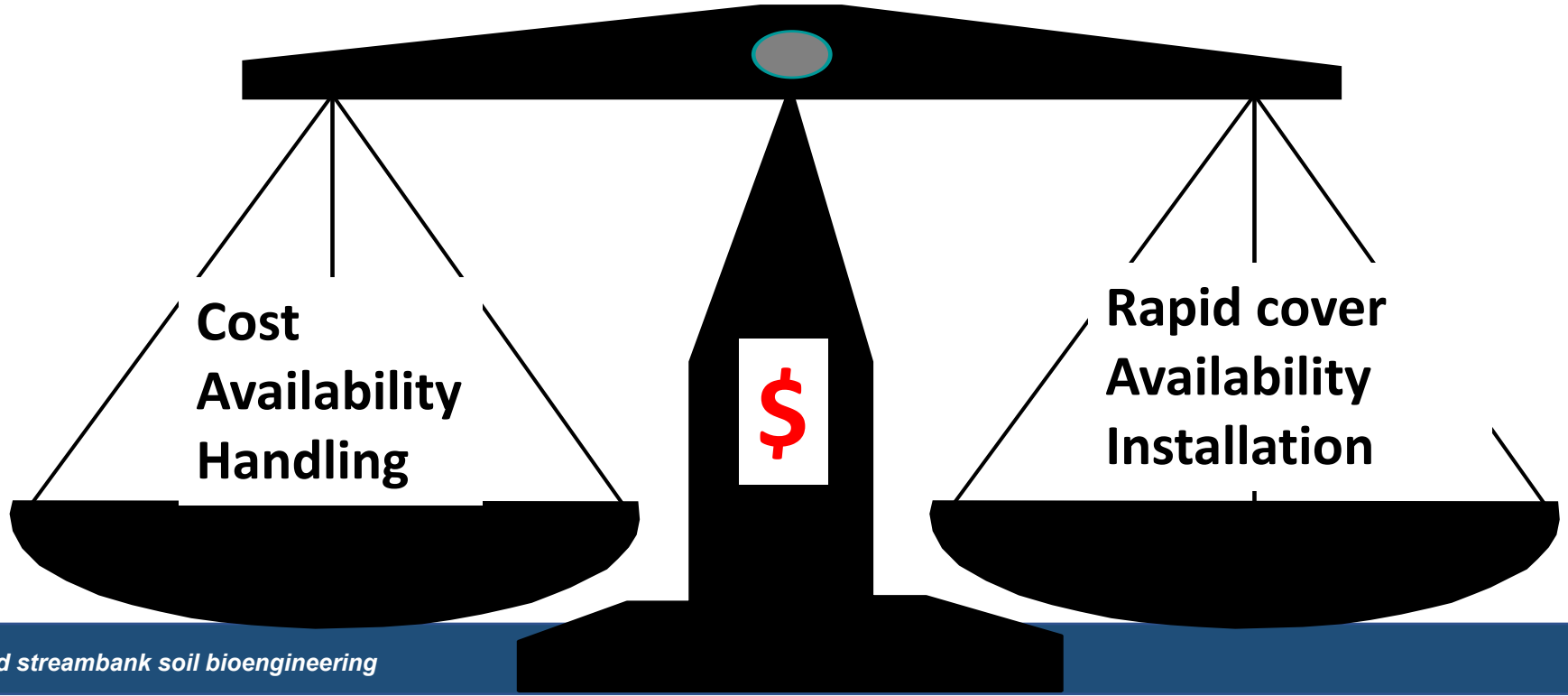
Containerized Planting Stock

Vegetate work areas
Parks, Riparian, Corridor

Cost Issues

- Purchase
- Inspection
- Warranty

cuttings < bare root < container



CLUMP PLANTING

--Willows

- Rapid Stabilization
- Labor Intensive
- High success rate
- Bank and overbank zone

Clump Planting

- Installation

Digging live willows including the above ground biomass and as much of the root system as will fit in the bucket.

Clump Planting

- Installation

Excavate hole to water table

Root collar below ground

Backfill and water

Streambank Soil Bioengineering
Many Different Types of Practices

Toe Zone
- Fascines
- Rootwads
- Brush/Tree Revetments
- Brush Box
- Deflectors
- Vanes
- Stream barbs
- Engineered Log Jams (ELJs)
- Hard Protection
- Coir logs
- Lunkers
- Log Cribwalls
- Brush Barbs

Bank Zone
- Live Poles/cuttings/stakes
- Brush Mattress
- Vertical Bundles
- Vegetated Reinforced Soil Slope
- Brush Layering
- Wattle Fence
- Brush Layering
- MSE walls
- Joint Planting

Overbank and Transition
- Live Clumps
- Containerized
- Erosion Control Fabric
- Brush Trench
- etc.

All are basically some variation of the installation of a cutting or a mattress/bundle installation.

Regardless of practice, the *keys to success* are:

- **Good soil to stem contact**
- **Vegetation installed so it can get water – right zone**
- **Acceptable flexibility**

Caution:

- Natural channels in this environment can be expected to move and suffer bank erosion during large storms.
- Even with an established system, periodic bank erosion will occur. That is the nature of rivers.
- Soil bioengineering treatments will not be as static as a traditional engineered bank stabilization project.
- The soil bioengineering treatments are often not an immediate fix. The growth and development of the riparian buffer is crucial.
- These treatments rely on deposition of sediment and woody material from the streamflow and the ensuing establishment of vegetation.
- If a moderate storm occurs before vegetation is established and firmly anchors the deposited material, there is a high potential for significant additional bank erosion.

- **An interdisciplinary team approach is always recommended. Additional information should be obtained from engineers, hydrologists, soil scientists, biologists, plant people, and other professionals.**
- **This workshop does not address water quality monitoring, regulatory, and permit requirements.**
- **NOTE: Always obtain ALL required permits before beginning any construction (USACE 404, State permit, etc).**

Consider taking more Classes and Workshops

- Streambank Soil Bioengineering (***one week class, hands on field and classroom***)
- Streambank Stabilization and River Structures
- Stream Corridor Restoration
- Fluvial Geomorphology 1-day short course
- SVAP II (Stream Visual Assessment Protocol)
- Low Tech Process Based Restoration
- Riparian Ecology Restoration and Management
- Basic and Advanced HECRAS (HECRAS for NRCS, An Introduction to Water Surface Profile Modeling)

Questions?