CHAPTER 6: WATERWAYS

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THE RIPARIAN ZONE

The riparian zone consists of the area that borders a stream channel and its floodplain, and includes the community of plants and animals living in and next to the water. The native vegetation found in a riparian zone has adapted to the dynamic stream side conditions of winter flooding and dry summers. The riparian zone acts as the transition between the stream and the upper watershed. The zone interacts with the channel and bears strongly on the structure and function of the aquatic ecosystem. The structure and composition of the riparian zone can be affected by the stream type and its active channel, as well as by geologic and topographic features.

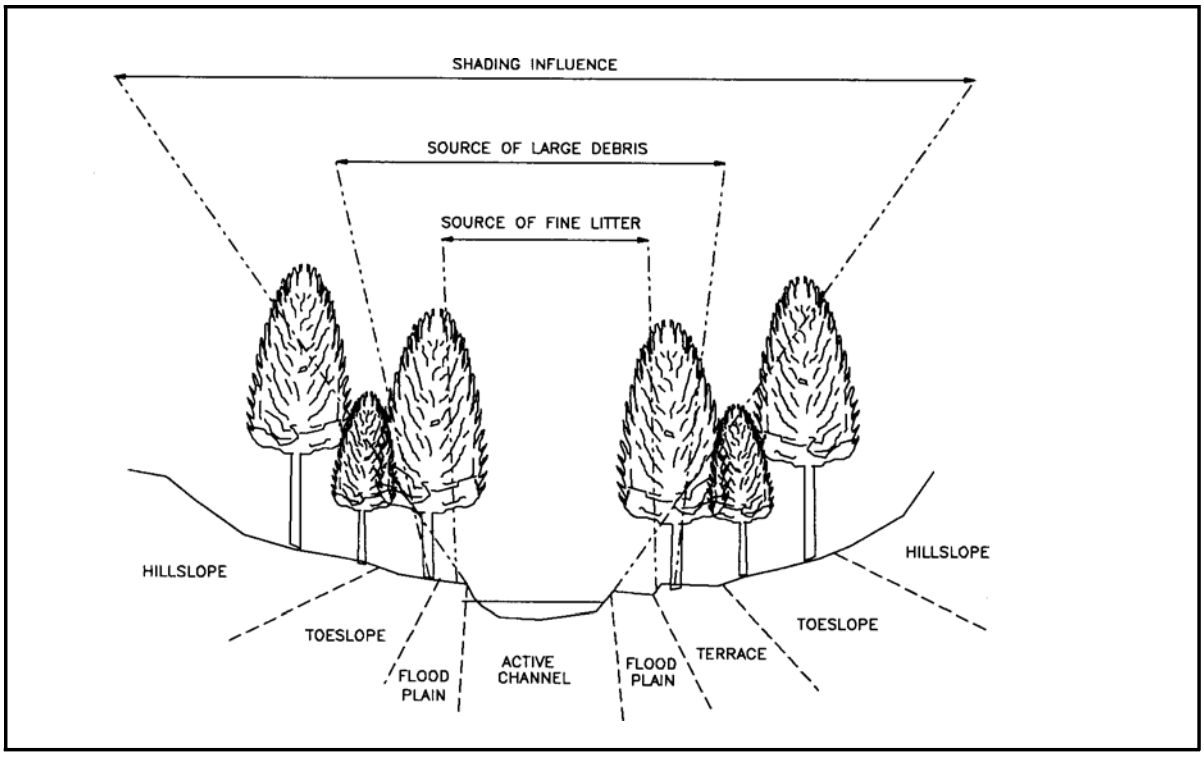


Diagram of functional roles of riparian zones (Lamberti and Gregory, 1989).

THE IMPORTANCE OF RIPARIAN HABITAT TO FISH AND WILDLIFE

Three quarters of amphibians and one-half of reptiles in California are directly dependent upon riparian habitat for their survival. Numerous resident and migratory bird species rely on riparian forests for nesting and food. Terrestrial wildlife species, such as deer, raccoons, bobcats, and mountain lions, use riparian corridors for migration, hunting grounds and shelter. Salmonids (such as coho, chinook, and steelhead) require healthy riparian habitat in equally important ways: riparian trees shade the stream channel, helping to cool the water, an

important factor in the survival of salmonids. Native streamside vegetation provides the leaf litter that is eaten by aquatic insects, which are, in turn, consumed by the fish. Roots of riparian plants provide shelter from predators. When large riparian trees fall into the stream, they provide a source of "large woody debris" to the system – an important structural element in creeks and rivers which helps to form pools and shelter for fish.

RIVER DYNAMICS 101

Vermont River Management Program Fact Sheet, Attached

MANAGING RIPARIAN HABITATS

VEGETATION MANAGEMENT

In some cases, active management of the riparian zone may be required. Landowners who have concerns about Pierce's Disease (for more information, see "Pierce's Disease in Streamside Vineyards", below) may choose to remove certain plants from the riparian areas adjacent to their farming operation. Additionally, invasive plants – such as giant reed, ivy or tamarisk – may need to be removed before they become a significant problem.

"Surgical" removal of native and non-native plants is preferred to the wholesale removal of all riparian habitat. It is recommended that this approach be discussed with your local California Department of Fish and Wildlife representative, as it may require permits. Removal of undesirable plants should be followed with a revegetation program using appropriate native plants (see "Native Plant Revegetation" below).

If herbicide is being used for the control of invasive plants, extra care should be taken to avoid impacts to the aquatic environment, as well as overspray onto native vegetation. Soils in the riparian zone are very porous. The absolute minimum effective amount of herbicide (per the label) should be used, as excess herbicide is likely to be transported through the soils into the stream. Certain herbicides are specially formulated to be less toxic to aquatic organisms and are more appropriate for use in or near aquatic environments. Consultation with your local Agricultural Commissioner's office is recommended.

Riparian trees that fall into the stream play an important role in the aquatic system. They provide structure to the stream environment, helping to form pools as well as habitat for a variety of organisms. "Large woody debris" has been identified by the California Department of Fish and Wildlife as an important factor in the recovery of salmonid populations.

Historically, the approach by many agencies and landowners has been to keep the stream channel "open," by removing any large debris jams. It was believed that these large trees

presented a passage problem for fish. It has since been demonstrated that fish, especially salmonids, are capable of passing over or through most debris jams.

Streamside landowners are understandably concerned about the tendency for large trees to divert the stream towards their banks, causing massive erosion and loss of land. In these cases, large trees are often removed from the system prior to the next flood event. In recent years, there has been a trend towards modification, rather than complete removal of debris jams. This approach allows for the habitat benefits associated with large woody debris, while resolving problems such as fish passage or bank erosion. Contact the California Department of Fish and Wildlife for more information on this topic.

NATURAL REGENERATION

Riparian systems are often capable of rapid natural regeneration after a disturbance event like a flood or other modification to the landscape. The gravel bars and banks in the active channel, provided that there is an upstream source of seeds or plant material, will often revegetate on their own within a year or two. Floodplain areas may take significantly longer and may warrant active revegetation to "jump start" the natural regeneration process.

In areas that are being grazed by cattle or horses, riparian fencing can give the stream enough breathing room to re-create healthy stands of native vegetation. Fencing may be temporary, maintained just long enough to allow native trees and shrubs to re-establish.

If fencing is used to allow for regeneration of riparian habitat, it should be placed to allow for meandering of the stream and the creation of a diversity of habitat stages. Fences placed too close to the stream corridor may be damaged during high flows.

NATIVE PLANT REVEGETATION

Revegetation using native plants is effective for enhancing habitat for numerous fish and wildlife species, as well as reducing upslope erosion and sedimentation to streams. Revegetation may include broadcast seeding of native grass or forbs on hillslopes, in-stream sprigging of dormant willow cuttings to increase cover and reduce bank erosion, installation of plants propagated in a native plants nursery, transplanting of emergent species such as rush, tule or sedge, or direct seeding of native species such as oaks or buckeyes.

A successful revegetation project should include the following considerations:

<u>Revegetation should attempt to replicate the natural system.</u>
In the riparian zone, different species are adapted to distinct microsites, often based on elevation and proximity to the stream. Planning of a riparian revegetation project should take

into account where each species occurs in a natural system. In can be helpful to draw a cross-sectional diagram of your riparian zone, showing where different species occur. This can help you determine planting sites based on elevation above the low flow channel.

Seeds, cuttings or transplants should be collected as close as possible to the project site.
This ensures that only genetically appropriate plants (i.e. those that are adapted to local conditions) will be used on site. Therefore, introduction of plant material from outside of the Russian River watershed is not recommended.

Propagation of plant material in containers needs to begin up to 18 months prior to planned installation.
For example, a particular species may have seed that ripens in July. After treatment of the seed and propagation in the nursery, the plant may not be ready for outplanting until the following fall/winter.

Installation of containerized and direct seeded plants should take place in the fall/winter, after several significant rainstorms have resulted in high soil moisture levels.
Plants that are installed at this time have the opportunity to establish a strong root system prior to summer drought.

Broadcast seeding of native grasses and forbs should take place in the fall of each year (usually prior to October 15th) to ensure adequate time for seed germination prior to the rain and cold weather.

In general, planting in the active channel is not recommended.
If there is a severe bank erosion problem, or the system has lost all upstream sources of seeds, some active channel revegetation may be warranted. Because the active channel is subject to regular flooding, installed plants are subject to removal. Willow sprigs, that are adapted to this floodway environment, are an effective, relatively inexpensive way to stabilize a streambank or introduce cover to the stream. Plants installed in the active channel should not have protective hardware, as they are subject to regular flooding.

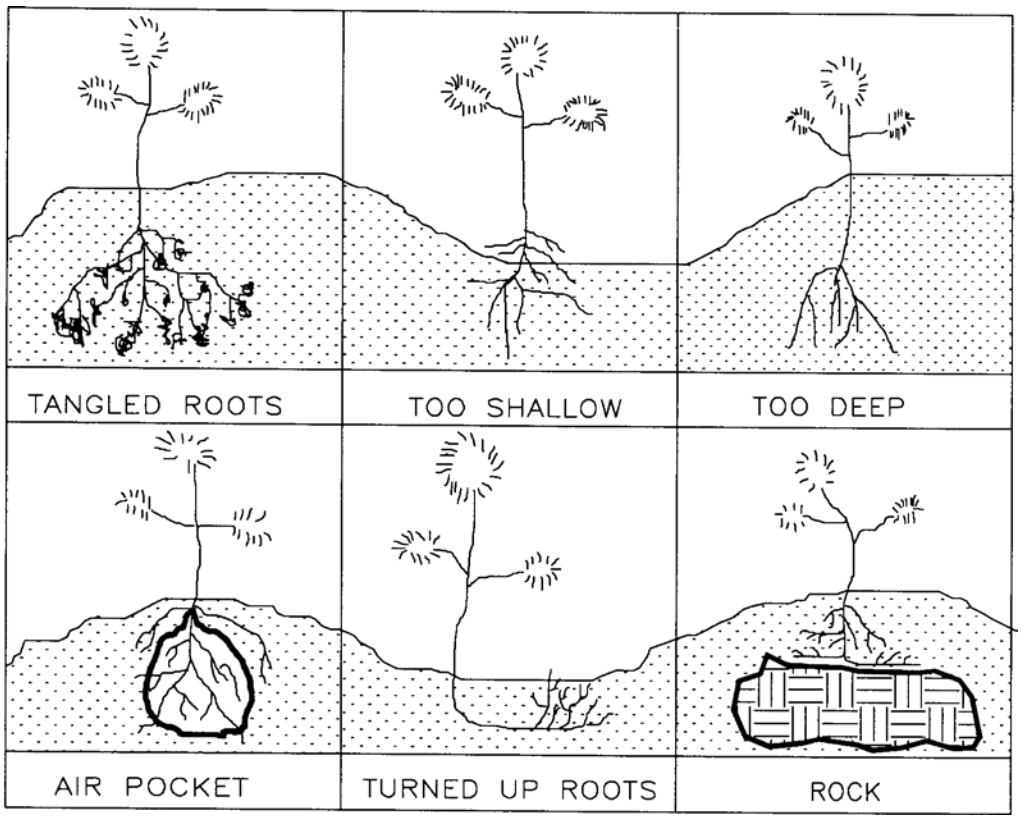
Planting Seedlings

Seedlings can be planted with shovels or western planting tools (also known as hoedads or planting hoes) in most situations. Planting bars may be used if the soil is not too rocky or compacted.

Power augers with carbide-tipped bits are also recommended for planting. Power augers come in two types: one with its own power head, and a second type that attaches to a chain saw power head.

A bucket, waterproof planting bag, or similar container is needed for carrying trees in the field. Use sawdust, peat moss, vermiculite or other moist material around the roots of bare root seedlings to keep them damp at all times. Do not keep seedlings immersed in water since it reduces oxygen and plants may suffocate. In some areas it is necessary to use shade cards or shingles to shelter seedlings. Plastic netting or tubes, spray repellents, or bud caps can be used to protect plants from animal damage.

Seedlings are delicate and must be handled carefully (Figure VII-64). For highest survival, treat trees carefully, and plant them immediately. If planting must be delayed a few days, keep the boxes in a cold, protected place. For containerized seedlings, cut the box down level with the container so that air can circulate between the trees. Keep trees out of rain and wind. To check if trees need water, feel the media at the bottom of the tube. If it is not damp, water the trees, and allow excess water to drain. In cool, damp weather, the biggest threat to seedlings is from mold.



Problems to avoid during tree planting.

Ideal storage conditions for bare root seedlings are a temperature of 33° Fahrenheit and high humidity. If available, refrigerated storage is best. Check packing material around roots to make sure it is moist. If it is drying out, wet thoroughly and allow excess water to drain off. Keep

roots moist, but not the tops. Wet tops can easily become moldy. The biggest threats to bare-root seedlings are dried roots and mold formation; which occurs if the trees become too warm.

Ideal planting days are cool and cloudy, with little or no wind. If possible, avoid planting on warm, windy days. The soil should be moist. Care in planting is more important than speed. Make sure roots never become dry. Planters should only carry about 50 trees at a time. Trees should be carried in a waterproof bag or bucket with plenty of moist material packed around the bare roots to keep them damp. Trees remaining in boxes should be left in boxes and kept in a cool, shady place. Ideally, bare root boxes should be kept refrigerated or packed on ice or snow.

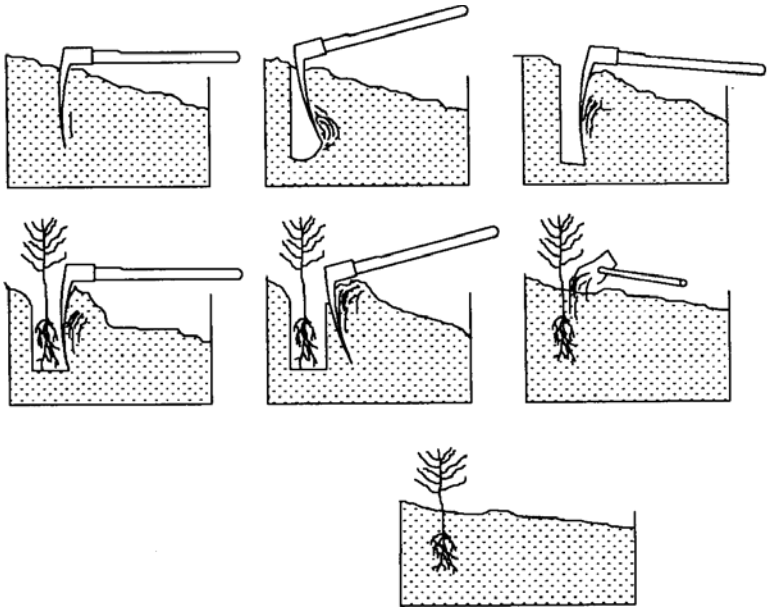
Competition from weeds, grass, brush or other trees can kill or retard growth of seedlings. Choose areas free from this competition, or clear at least a three-square-foot area before planting. Seedlings should not be planted under direct shade of trees, or closer than 6 feet to existing brush, unless lethal temperatures are anticipated.

Clear away loose organic material such as leaves, grasses, etc. from the planting spot to expose mineral soil. If organic matter gets into the planting hole, it can decompose and leave air space. Roots will dry out when they grow into these spaces.

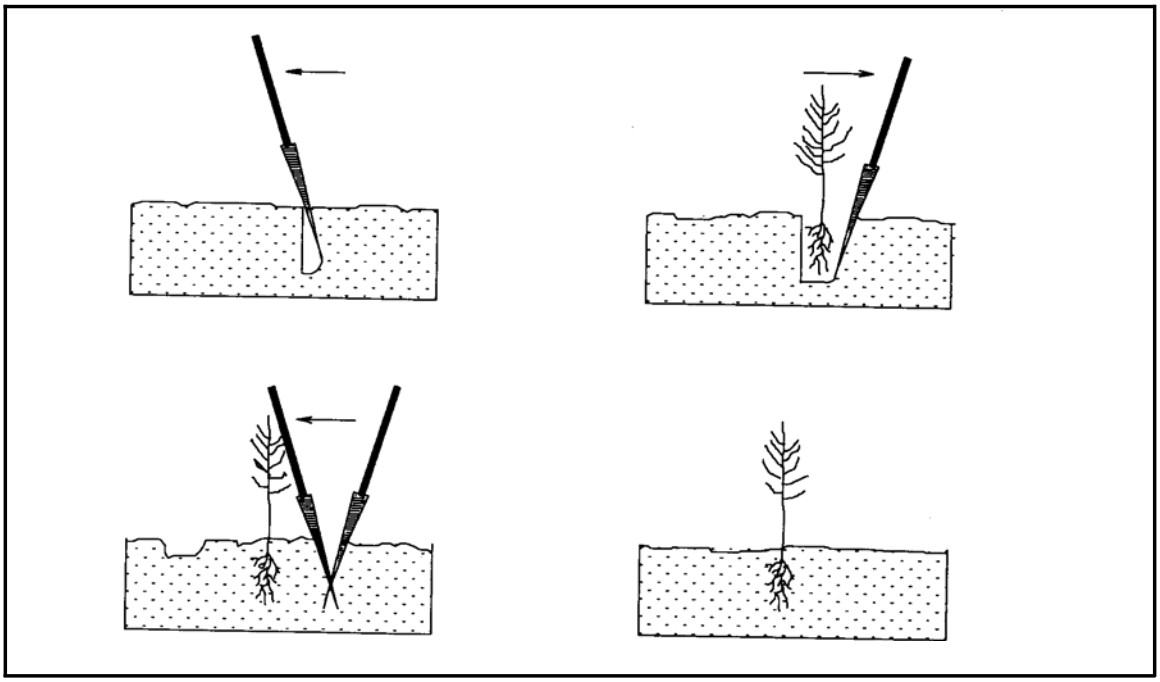
Open up the hole, making sure it is deep enough for the roots to be fully extended (Figure VII-65 and Figure VII-66). Take a tree out of the planting bag or bucket only after the hole is ready. When exposed, fine roots can dry out in as little as 30 seconds. Remember to remove the container before planting a containerized tree. This can be done by cutting container or by pushing up gently on the roots with a stick or broom handle. If roots are curled or bunched up, the tree will not be able to absorb water correctly, will often weaken and die, or may blow down in later life due to poor root structure.

After removing a seedling from the container, hold it in place in the hole, making sure roots are straight, fully extended, and that the seedling is neither too shallow nor too deep. Fill the hole, allowing soil to fall in around the roots. Tamp with hands or with your heel. Fill with more soil, if necessary, and tamp. Tamping is important. If soil is not firmly packed around the roots, air pockets will remain that can dry the roots, and the seedling may be weakly anchored. Addition of fertilizer and plant vitamins at the time of planting is not generally necessary.

Again, care is more important than speed. In regard to spacing, it is better to pick a planting spot shaded by a stump, log or rock, than to strictly follow recommended spacings. During planting of riparian species, care should be taken to ensure that roots have ready access to moist soil.



Steps in tree planting with hoedads. (California Department of Forestry, 1978).



Tree planting. Planting bar method. (California Department of Forestry, 1978).

NATIVE PLANTS TO ENCOURAGE IN YOUR STREAM AREA

The following is a basic list of native plants that can be used to re-vegetate your riparian area. Keep in mind that although the following plants are all suited to the riparian corridor, they each have different growing requirements.

Common Name	Botanical Name
Grasses	
Creeping wildrye	*Leymus triticoides*
Meadow barley	*Hordeum brachyantherum*
'Molate' red fescue	*Festuca rubra 'Molate'*
Sedges	*Carex spp.*
Rushes	*Juncus spp.*
Groundcovers	
Lady fern	*Athyrium felix-femina*
Western sword fern	*Polystichum munitum*
Wood-sorrel	*Oxalis acetosella*
Shrubs & Vines	
Blackberry (native)*	*Rubus ursinus*
Coyote Brush	*Baccharis pilularis*
Currant	*Ribes sanguinem*
Elderberry*	*Sambucus Mexicana*
Hawthorn	*Crataegus douglasii*
Hazelnut	*Corylus cornuta*
Honeysuckle	*Lonicera hispidula*
Rose, California	*Rosa californica*
Snowberry	*Symphoricarpos mollis*
Thimbleberry	*Rubus parviflorus*
Wax myrtle	*Myrica californica*
Trees	
Box Elder	*Acer negundo*
Big Leaf Maple	*Acer macrophyllum*
Bay-laurel (pepperwood)	*Umbellularia californica*
Buckeye	*Aesculus californica*
Coast redwood	*Sequoia sempervirens*
Coffeeberry	*Rhamnus californica*
Coast live oak	*Quercus agrifolia*
Femont cottonwood	*Populus fremontii*
Valley oak	*Quercus lobata*
California black walnut	*Juglans hindsii*
White alder	*Alnus rhombifolia*
Willow (local native)	*Salix spp*
Oregon Ash	*Fraxinus latifolia*

*These plants are also major Pierce's Disease hosts, see below

EROSION CONTROL

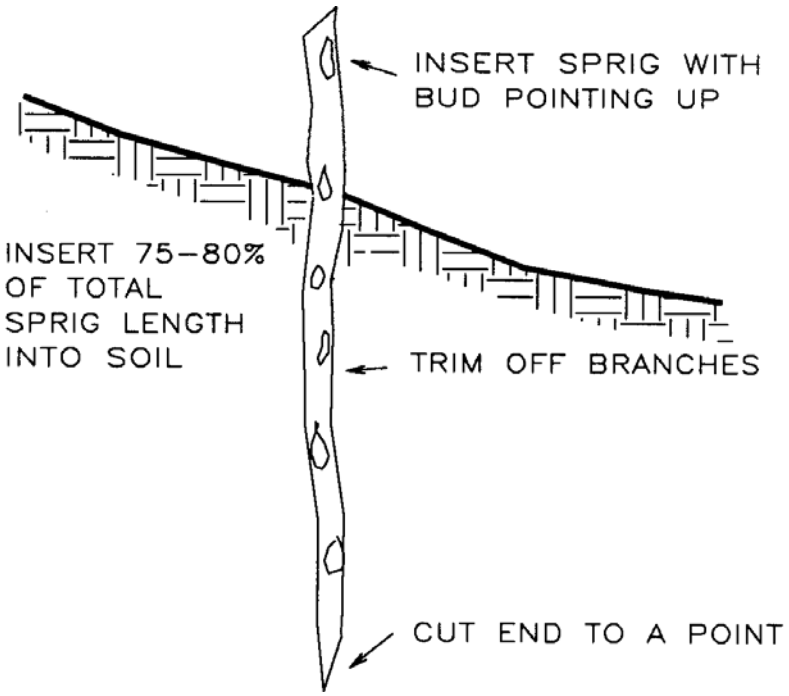
Large flood events may create the need for some sort of erosion control work in the riparian zone to prevent excess siltation into the stream or loss of land. Whenever possible, a vegetative method for reducing erosion is preferable to a structural approach. Structural approaches to streambank erosion (such as rip-rap) tend to fix the stream in one place, preventing the natural movement that creates native habitats. Structural approaches also tend to be much more expensive, require permits, and may damage neighboring properties. Over the long term, structural approaches tend to fail or require excessive maintenance, as was seen on a dramatic scale with the Mississippi River flooding in the 1990's. If a structural approach is unavoidable, native vegetation should be incorporated into the structure. This type of "bio-engineering" will increase the effectiveness of the erosion control method and provide some habitat value as well.

Stream channel erosion control may require permits from various resource agencies. See "Navigating the Permitting Process" in Chapter 1.

BIOENGINEERING

Willow *(Salix)* sprigging can be an effective and inexpensive way to armor active headcuts and eroding gully banks, and to stabilize stream banks where water is flowing parallel with the bank. Willows must be planted in sunny areas where the soil stays moist throughout the dry season. Sprigs should be collected and planted when the willows are dormant. However, sandbar willows do not sprig well and should be avoided; cottonwood is a good alternative to willows. Sprigs should be at least 1/2-inch in diameter and 18 inches long. Sprigs, 2 to 3 inches in diameter and 3 to 4 feet long work best, and should be used in the most actively eroding places. Cuttings should be planted the same day they are cut. If it is not possible, then the entire cutting should be placed in water in a cold area.

Willows respond well to heavy pruning, so they can be collected heavily from a grove. Thin, however, instead of clear-cutting in order to leave cover for resident fauna.



Willow sprigging. (Prunuske, 1987)

Plant the willows with the buds up, after sharpening the basal (bottom) end of the sprig with an axe or pruners right after it is cut from the tree. Sprigs should be driven into the soil 75 to

80 percent of their total length, at a slight angle downstream, to decrease their resistance to water flow. In hard soils an iron bar or a chain saw powered auger can be used to bore planting holes. After placing the cutting in the hole, tamp firmly around the cutting to remove air pockets in the soil. In soft soils, sprigs can be driven in with a wooden mallet or sledge hammer. Cut off the tops of the sprigs if they should split while hammering. Leave only one or two buds exposed.

In large rapidly eroding gullies, or along stream banks, appropriate spacing may be as close as one foot. In more stable gullies typical of relatively small watersheds, the sprigs can be placed 2 feet apart.

Cattle and deer tend to browse heavily on young willow. The revegetated areas may need protection by fencing, wire cones, or heavy netting.

Willow Wall Revetment

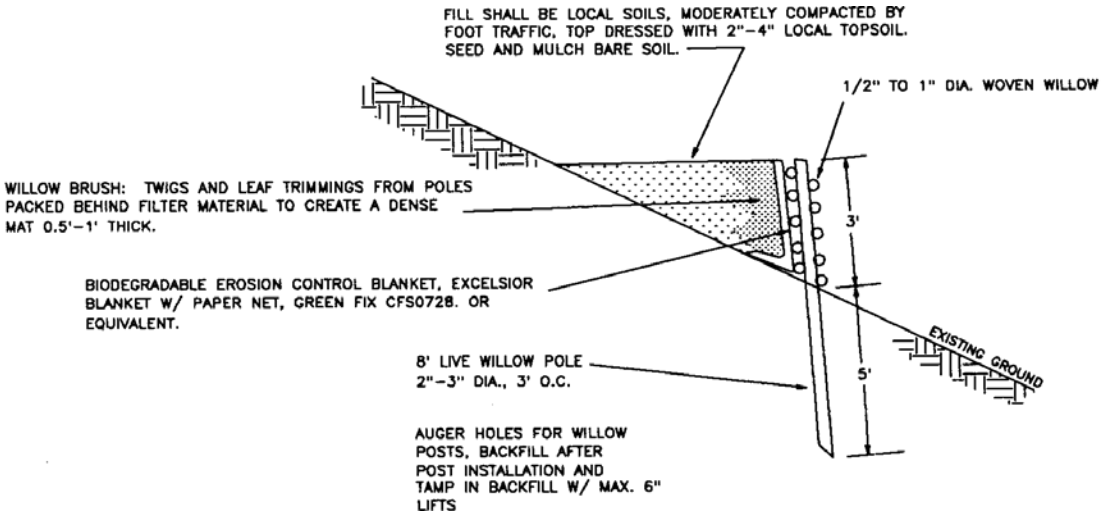
Willow wall revetments can be used for stream bank failures, eroding banks, and bank toe protection. Willow walls restrict sediment yield to a stream and also provide vegetation and canopy. The wall should be constructed along a stream bank at a height that will provide the willows with water during low flow months. If the wall is located upslope from the channel, irrigation may be required during summer months.

1) These walls are built at erosion sites along stream banks. If a rip-rap toe is desired, it should be placed below grade to prevent scouring. If more than one wall is to be constructed up a slope, there should be a three feet space between each successive wall.

2) Planting holes should be bored three feet apart from one end of the site to the other. Hole depth depends on the length of the willow poles being used. For example, an eight feet long willow pole requires a hole five feet deep. The poles should be two - three inches in diameter and as straight as possible. The poles should be set with the tops up and leaned slightly towards the bank at approximately a 15° degree angle to allow for the for the weight of the earth fill to be added later.

3) After the poles have been set and tamped, long, flexible willow branches from 3/4 to 2" in diameter are tightly woven through the standing poles. The woven branches should be packed down as tightly as possible. Both the woven material and the poles should be stripped of all small branches and tops less than two inches in diameter. These can be used later in the back fill brush material.

4) Once the wall is constructed, a backing of biodegradable erosion cloth or netting should be placed against the woven willow pole wall on the bank side. Using smaller tops and green willow branches, create a brush pack approximately one foot wide behind the netting. Backfill the wall with firmly packed down soil. All disturbed soil areas are mulched with litter and seeded. Each end of the wall can be anchored with 3/8" cable and attached to duck bill anchors to add stability.



Willow Wall Revetment (L. Prunuske, 1997)

Brush mattress

Brush mattresses work well for bare eroding streambanks (Figure VII-59). These mattresses protect the stream banks from erosion caused by exposure and scour.

1) The disturbed bank should be sloped and smoothed to ensure that all willows are in contact with the soil. Excavate a toe trench two feet below streambed elevation at the base of the bank for the butt ends of the willow branches.

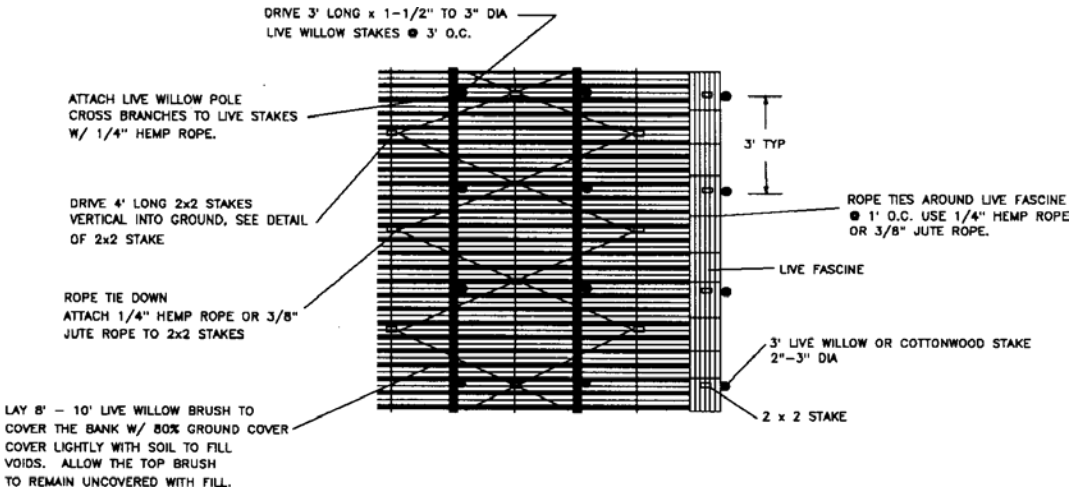
2) Partially drive wood, steel, or live willow stakes in rows on three foot centers along the area of the bank that will be covered by the mattress. After the stakes have been placed, lay live willow branches on the bank with their butt ends in the trench. It is best to use straight branches no shorter than four feet in length and approximately ½ to 1" in diameter.

Place approximately twenty to fifty branches per linear yard, depending on their diameter. If the branches are not long enough to cover the upper bank area, several layers may be used, but it is necessary to lap, or “shingle,” each added layer with the layer below it by at least eighteen inches.

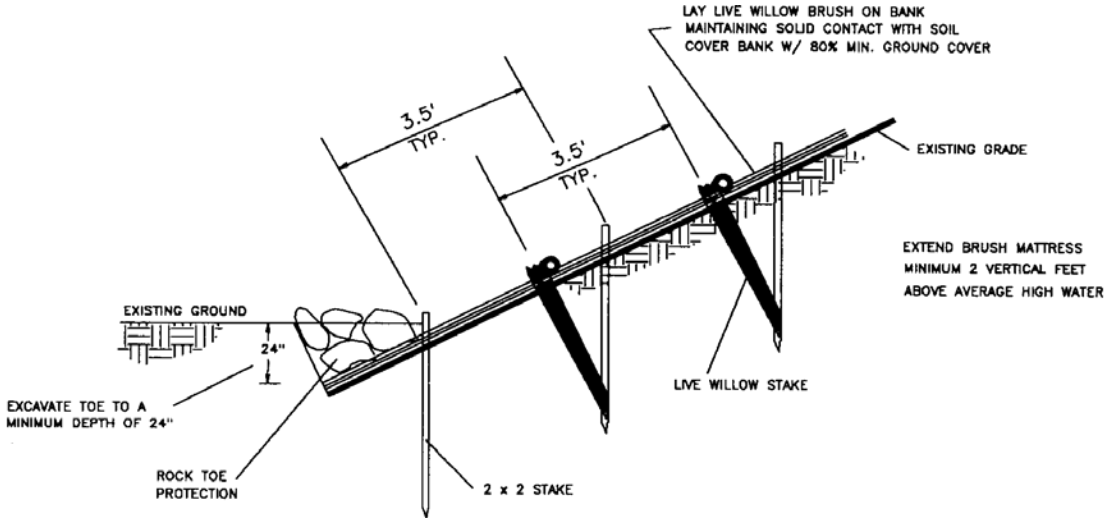
3) Once the bank has been covered with a thick layer of willows, cross branches are placed horizontally over the bottom layer. These branches should be placed against the stakes and then tied to the stakes using wire or string.

4) The stakes are then driven into the bank a minimum of two feet. The deeper the stakes are driven in, the tighter the mattress will be held against the soil of the bank. After completion of the mattress, the trench should be filled with small boulders or rocks to anchor the butt ends of the branches. The entire mattress should be lightly covered with earth or fine streambed material.

Stream channel dimensions, hydraulic factors, available material and other factors may dictate variations to this general design.



Brush Mattress Plan View (L. Prunuske, 1997)



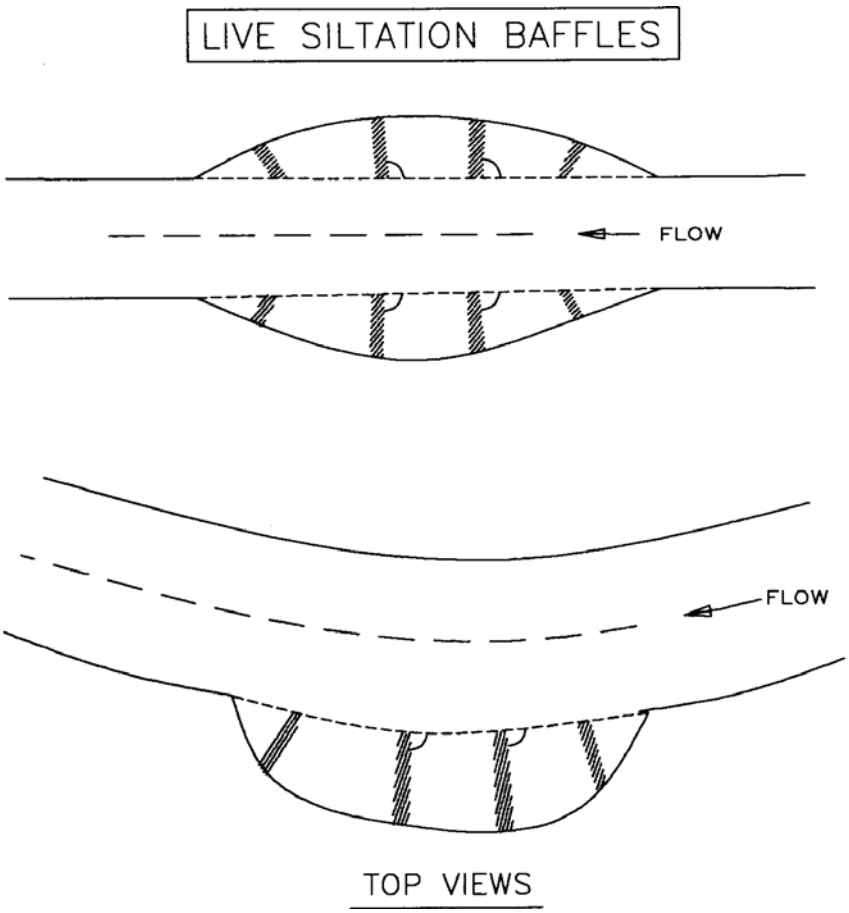
Brush Mattress Cross Section (L. Prunuske, 1997)

Willow Siltation Baffles

Willow siltation baffles are inexpensive structures that can achieve several objectives. Their function is similar to a wing deflector which can be used for bank protection and energy dissipation, as well as for channel constriction. Willow baffles are designed to work in series and pass flow through the structure, sort bedload, dissipate energy, and trap fines.

1) Dig toe trenches perpendicular to the bank approximately 1 ½ - 3' deep. Extend the trenches into the stream channel a short distance. The baffles should be keyed into the bank at least three feet. The excavated material removed from the trench should be placed along the downstream side of the trench. Each successive baffle is installed at different angles. The most

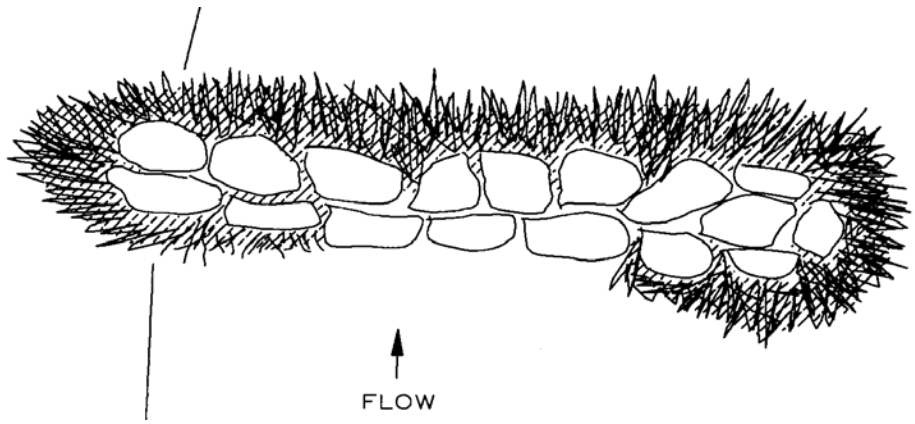
upstream baffle is placed at an acute angle with the bank, and the following baffles are placed at right-angles. The lower baffle is placed at an obtuse angle. The number and length of baffles is dependent on the dimensions of the stream channel and treatment area (Figure VII-61).



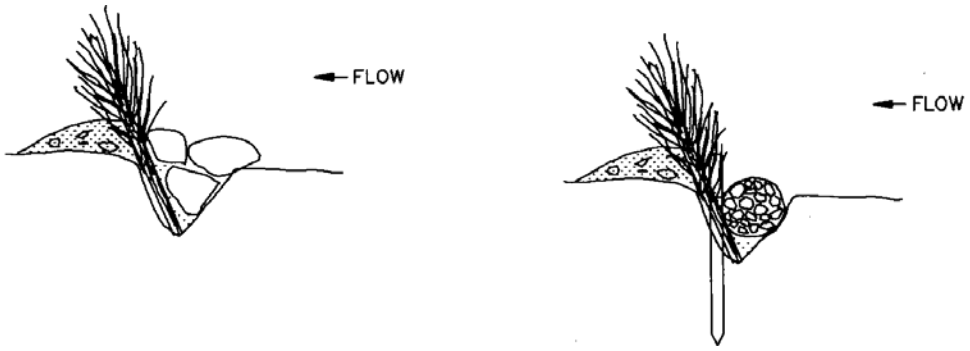
Arrangements of baffles (Schiechtl and Stern, 1996)

2) Willow branches approximately three to six feet long and 1/2" in diameter are placed in the trench pointing downstream. The ends of the baffles that extend into the channel have the willow branches wrapped around, forming an upstream facing "J."

The willows are densely packed with no gaps and form a standing mat. The trench is then back filled with streambed material and small cobble. Some topsoil may be placed at the bottom of the trench to help with root formation. Larger stone is placed on top of the backfill in order to secure the willow branches. The largest rocks available should be placed on the stream channel end of the baffle. Site specifications will be unique to stream channel dimensions, hydraulic factors, and available material and will dictate variations to this general design (Figure VII-63).



Top view of baffles (Schiechtl and Stern, 1996)



Side view of baffles (Schiechtl and Stern, 1996)

INSTREAM HABITAT ENHANCEMENT

Fallen logs, tree stumps and branches provide cover, food and shelter for fish and other aquatic animals, notably young coho salmon and steelhead trout. As a natural component of a well-functioning stream system in our region, woody debris plays an important role in creating the diversity of habitats needed to support fish and other aquatic species throughout their life cycles. Pools form downstream of logs, branches provide shade as well as perches for birds and the insects that feed most aquatic creatures, and large pieces or clusters of woody material trap sediment and spawning gravels.

Some important tips to keep in mind while managing woody material in and surrounding your stream:

- Woody material should be left in the creek whenever possible but in some cases, woody material may need to be modified or removed. Woody material can redirect water to

accelerate bank erosion or dam flow to create potential flood hazards. In an emergency, you have the right to modify or remove the material, but most notify the California Department of Fish and Game (preferably prior to the work) within 2 weeks. In a non-emergency, contact Fish and Game for advice or information on obtaining a permit. You can also contact the Sonoma or Mendocino County Water Agencies or the relevant county planning department if you are concerned about flooding.

- Most fish can swim through or around log clusters. If you know that fish can't swim through a barrier, contact the California Department of Fish and Game.
- Brush, weeds, grass clippings, or other small material should not be thrown into a creek or stored near creek banks to be carried downstream by wind or rain. The brush may create a debris jam downstream on someone else's property or block a culvert, which can cause flooding and erosion or block fish passage.

FISH PASSAGE BARRIERS

A fish barrier is an obstacle that prevents or inhibits the natural migration of salmon, steelhead, and other native fish. These barriers typically include culverts, dams, weirs, and floodgates. Barriers also include natural features such as waterfalls and logjams. Improper placement of structures, such as culverts, can cause water velocities to be too high and water depths to be insufficient. These barriers can also cause behavior changes in fish. Barriers can have a significant impact on native fish by restricting migration during spawning. As fish congregate at barriers, over-crowding increases the likelihood of stress, injury and predation. Barriers also lead to the under-utilization of the habitat isolated by the barriers. Removal of fish barriers will allow fish and other aquatic creatures to fully utilize the stream and swim freely throughout the watershed. Removal of barriers requires permits. Before removing a fish passage barrier, contact the California Department of Fish and Wildlife for technical assistance.

PIERCE'S DISEASE IN STREAMSIDE VINEYARDS

Note: *the following section is a brief overview of a complex topic. Ongoing research about Pierce's Disease provides new information every few months. For current information about the disease, and management approaches, contact University of California Cooperative Extension at 707-565-2621.*

Pierce's Disease (PD) is a cause for increasing concern among streamside vineyard owners in the Russian River watershed. Certain plants which occur in the riparian zone (both native and non-native) are hosts for the insects which carry PD. Because PD may kill grape vines, it is a serious threat to the viability of streamside vineyards. However, there is equal concern that large scale removal of riparian plants may severely degrade the fish and wildlife values of the riparian zone. A balanced understanding of the disease, as well as the importance of riparian habitat, is essential for an effective and sensitive approach to this problem.

SYMPTOMS OF PIERCE'S DISEASE

Pierce's Disease results in the blockage of the water-conducting system of infected grapevines. As a result, water stress begins in midsummer and increases through the fall. Infected grapevines often die. Leaf symptoms vary among grape varieties and, while all *Vitis vinifera* cultivars are susceptible to Pierce's Disease, varieties are not equally tolerant. While some vines infected during the season appear to recover from Pierce's Disease the first winter following infection, recovery often depends on the variety.

It is important to note that there are other grapevine diseases and nutritional disorders that appear similar to PD. There are many cases where known PD host plants have been found, yet vines were not infected with Pierce's Disease. For assistance in correctly identifying the presence of PD in vineyards, contact UC Cooperative Extension (listed above).

THE ROLE OF THE BLUE-GREEN SHARPSHOOTER

Pierce's Disease is caused by the bacterium *Xylella fastidiosa* and is transmitted by members of the sharpshooter and spittlebug families. The blue-green sharpshooter (*Graphocephala atropunctata*) is the most significant transmitter of this bacterium in the North Coast region. Adult sharpshooters acquire the bacteria by sucking from the xylem fluid, or water vessels, of an infected plant. They transmit the bacteria by moving to another plant and feeding from it, thereby injecting the bacteria into the vessels of that plant. Adult sharpshooters can be differentiated from other sucking insects by the swollen appearances of their faces. This swollen appearance is caused by the bulky muscles in their face which allow them to tap into the water vessels of plants. Sharpshooters require succulent plant tissue or rapidly growing plants as food sources. This kind of plant tissue is provided by non-native invasive herbaceous plants such as periwinkle, non-native invasive woody plants such as Himalayan blackberry, as well as the native California wild grape, where they tend to lay their eggs. Sharpshooters also lay their eggs in weedy irrigation ditches.

It is the over-wintering generation of adult blue-green sharpshooters that causes chronic Pierce's Disease symptoms in grapevines. The over-wintering adults emerge early in the season and feed, and the early-season infections may eventually lead to vine death unlike later-season infections. Eggs laid by these adults emerge into flightless immature insects (nymphs) from late April through July and remain on the same plant where they emerge. Nymphs become adults between late June through August. These adults disperse deeper into the vineyard, away from the riparian area; however, the feeding activity of the summer generations of the blue-green sharpshooter does not usually result in chronic vine infections.

PLANTS THAT MAY HOST PIERCE'S DISEASE

Plant species very in their role as reservoirs of *Xylella fastidiosa* for disease spread. Wild grape, for example, is considered a propagative and systemic host to the bacteria. This means that once a wild grape plant is infected with the bacteria, the bacteria multiply and spread systemically throughout the plant, which becomes a reservoir for the bacteria. The bacteria can then be spread to other plants, including grapevines, by means of the blue-green sharpshooter.

Mugwort, on the other hand, is considered a propagative, non-systemic host to the bacteria. This means that bacteria multiply within mugwort at the site of infection, but do not spread systemically throughout the plant, thereby reducing the chances that the bacteria will be picked up by feeding insects.

The following perennial plants are the major breeding hosts for the blue-green sharpshooter and most are systemic hosts of *Xylella fastidiosa* in Napa, Sonoma, and Mendocino counties:

Non-Native Host Plant List

Common name	Latin name	Type of host
Himalayan blackberry	Rubus discolor	Systemic
periwinkle	Vinca major	Systemic
Wild grape (escaped cultivar or *Vitus californica* hybrid)	Vitis sp.	Systemic

Native Host Plant List

Common name	Latin name	Type of host
California blackberry	Rubus ursinus	Systemic
California grape	Vitis californica	Systemic
mugwort	Artemisia douglasiana	Propagative
Stinging nettle	Urtica dioica	Systemic
mulefat	Baccharis salicifolia	Systemic
Blue elderberry	Sambucus mexicana	Systemic

NRCS BMP FACT SHEETS

GRASSED WATERWAY (412)

Attached.

RIPARIAN HERBACEOUS COVER (390)

Attached.

RIPARIAN FOREST BUFFER (391)

Attached.

River Dynamics 101 - Fact Sheet

River Management Program
Vermont Agency of Natural Resources

Overview

In the discussion of river, or fluvial systems, and the strategies that may be used in the management of fluvial systems, it is important to have a basic understanding of the fundamental principals of how river systems work. This fact sheet will illustrate how sediment moves in the river, and the general response of the fluvial system when changes are imposed on or occur in the watershed, river channel, and the sediment supply.

The Working River

The complex river network that is an integral component of Vermont's landscape is created as water flows from higher to lower elevations. There is an inherent supply of potential energy in the river systems created by the change in elevation between the beginning and ending points of the river or within any discrete stream reach. This potential energy is expressed in a variety of ways as the river moves through and shapes the landscape, developing a complex fluvial network, with a variety of channel and valley forms and associated aquatic and riparian habitats. Excess energy is dissipated in many ways: contact with vegetation along the banks, in turbulence at steps and riffles in the river profiles, in erosion at meander bends, in irregularities, or roughness of the channel bed and banks, and in sediment, ice and debris transport (Kondolf, 2002).

Sediment Production, Transport, and Storage in the Working River

Sediment production is influenced by many factors, including soil type, vegetation type and coverage, land use, climate, and weathering/erosion rates. Once the sediment enters the fluvial system it will be transported and/or stored within the system including the flood plains.

The watershed through which a river flows or drains dictates the sediment types and amount, that will be transported and/or stored. Within the watershed there are locations where sediment is produced, transported,or stored. These zones are often referred to as: source (production), transfer (transport), and response (storage or deposition) (Figure1).

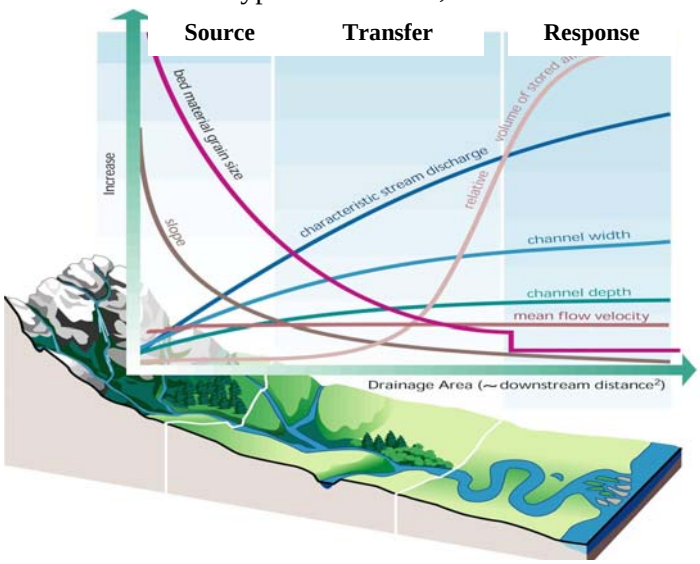


Figure 1 Watershed sediment source, transport and deposition locations. (from the Stream Corridor Restoration Manual, Federal Interagency Stream Restoration Working Group, 1998).

- **Source streams**: Primarily where non-alluvial sediments (colluvial material) enter into the stream system, from landslides and mass wasting failures, and transported with debris during large and infrequent flow events.
- **Transfer streams**: Geomorphically resilient with high sediment transport capacity. These streams are able to convey limited increases in sediment loads and will change little in response to reduction in sediment supply. Generally, the sediment volume supplied to transport reaches is balanced by the sediment exported from the reach.
- **Response streams**: Storage reaches in which significant geomorphic adjustment occurs in response to changes in sediment supply. Zones of transition from transport to response or storage reaches are locations where changes in sediment supply may result in both pronounced and persistent channel instability.

After the sediment enters the fluvial system, the movement of sediment is influenced not only by the zone of the watershed the river is in, but also the local conditions of the river. The sediment transport **capacity** refers to the amount and size of sediment that the river has the ability, or energy to transport. The key components that control the sediment transport capacity, are the **velocity** and depth of the water moving through the channel. Velocity and depth are controlled by the channel slope and dimensions, discharge (volume of flow), and roughness of the channel. Changes in any of these parameters will result in a change in the sediment transport capacity of the river.

The specific characteristics of the sediment **load** is another key factor influencing channel form and process. The load is the total amount of sediment being transported. There are 3 types of sediment load in the river: dissolved, suspended, and bed load. The dissolved load is made up of the solutes that are generally derived from chemical weathering of bedrock and soils. Fine sands, clay, and silt are typically transported as suspended load. The suspended load is held aloft in the water column by turbulence. The bed load is made up of sands, gravel, cobbles, and boulders. Bed load is transported by rolling, sliding, and bouncing along the bed of the channel (Allan, 1995). While dissolved and suspended load are important components of the total sediment load; in most river systems, the bed load is what influences the channel morphology and stability (Kondolf, 2002).

By comparing the sediment transport capacity with the sediment load, some general assumptions can be made as to whether a river will erode more sediment, deposit extra sediment, or be in balance with the amount of erosion and deposition happening. For example:

- If the capacity is greater than the load, erosion would be expected. {capacity > load = erosion}. This is due to the river having the excess energy needed to transport more sediment than is currently being transported.
- If the capacity is less than the load, deposition would be expected {capacity < load = deposition}. The amount of excess energy needed to move the extra sediment is not available in the system, so the sediment is deposited in the channel.
- If the capacity equals the load, no net change in erosion and deposition would be expected. {capacity = load = no net erosion/deposition}. River systems, or reaches ,are considered **in equilibrium** when there is a balance between the amount of sediment load being supplied to the system and the capacity of the system to carry that sediment load (Field, 2002).

Another way to view this concept is to use Lane's Diagram (Figure 2). Lane's balance diagram demonstrates how the channel may respond to a change in various parameters, such as sediment load, channel geometry, channel slope, erosion resistance, and discharges (hydrologic load). For example, by increasing the amount of sediment load the scale will tip toward aggradation (sediment deposition); to bring the scale back in balance a change in either the channel geometry, slope and/or hydrologic load would be needed. There are natural fluctuations in the balance of any of these inputs; such as flood events, valley wall slope failures increasing sediment loads, beaver dams or debris jams causing changes in channel geometry, etc. Human caused changes in this balance are also occurring in the watershed, along the floodplains, and in the channel. The degree and type of adjustment will depend on whether it is a source, transfer or response reach, the sediment transport capacity, and the type and magnitude of change that was introduced to the system.

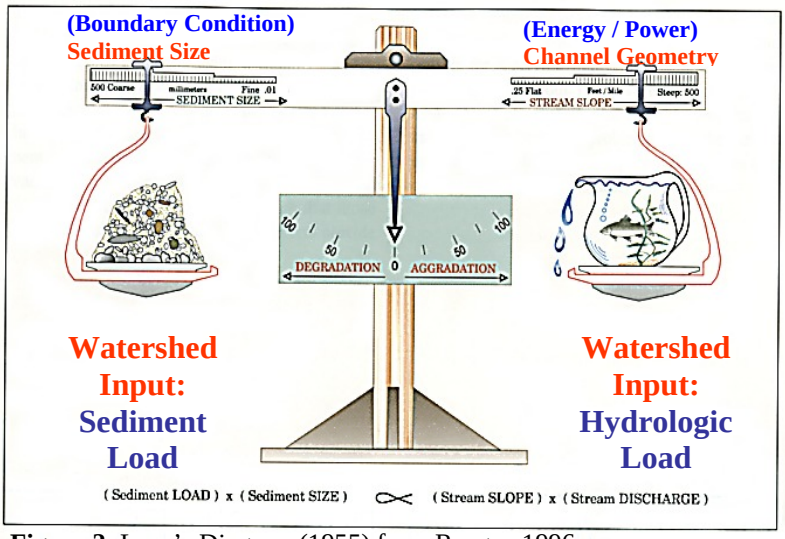


Figure 2: Lane's Diagram (1955) from Rosgen 1996

Types of Channel Adjustments in the Working River

When the balance of sediment load, hydrologic load, and/or channel geometry and slope is changed there is often a response, or adjustment of the fluvial system as it attempts to re-establish the equilibrium condition. Of the types of rivers typically seen in Vermont, the process of adjustment is predictable. Schumm's Channel Evolution Model (1984) in Figure 3 illustrates the most commonly encountered channel adjustment or response sequence in Vermont. The channel evolution model is helpful in demonstrating the response of the river to climate driven or human imposed changes within its watershed, floodplain, and within the channel itself. It is also valuable in demonstrating that rivers are not static systems; rivers will respond and adjust as the input variables to the system are changed.

Stage II Incision, downcutting, and degradation are all words used to describe the process whereby the stream bed becomes lower in elevation relative to its flood plain through erosion, or scour, of bed material, channel management activities such as dredging or straightening, or flood plain filling or encroachment. Some streams incise so deeply they become entrenched streams (losing access to their floodplains altogether). Channel incision may occur when there has been a significant increase in flows, a significant decrease in sediment supply, a significant increase in slope due to a reduction of channel sinuosity or loss of floodplain access. Active incision is energized by high flow events or triggered by a significant reduction in the channel bed (boundary) resistance.

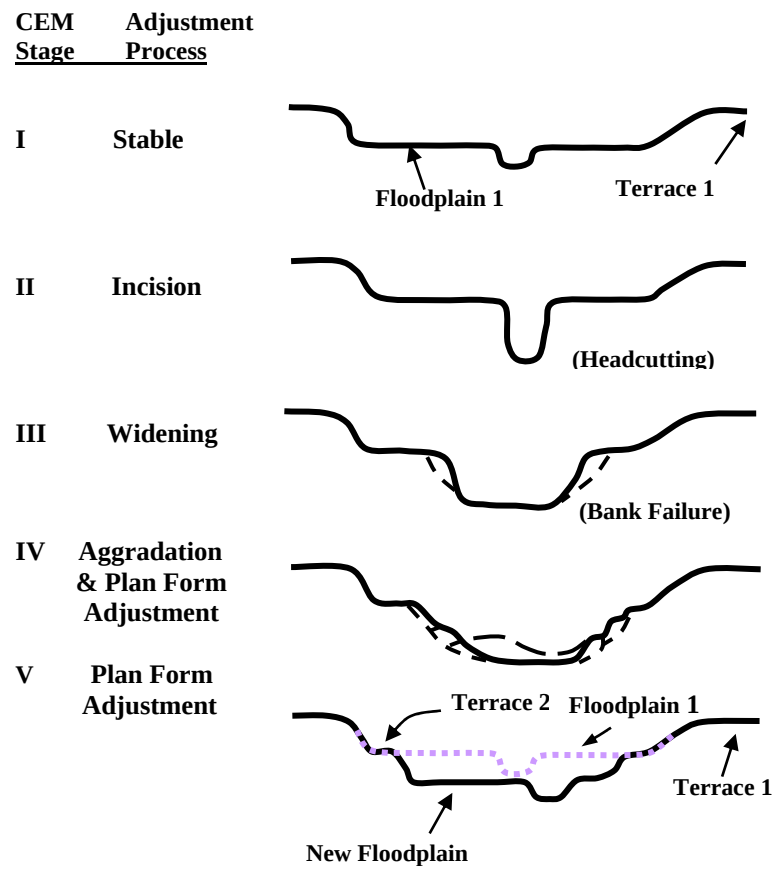


Figure 3: Five Stages of Channel Evolution (CEM) (Schumm, 1984), the channel condition and adjustment often observed during each stage

Stage III Widening usually follows the channel degradation process. The containment of higher flows within an incised channel increases available energy and typically leads to erosion of one or both banks. Alternating stages of widening and aggradation occur as the stream forms a new floodplain at a lower elevation. An over-widened channel is also an outcome of the sediment aggradation process (Stage IV). When the stream becomes incapable of transporting its sediment load, sediments collect on the stream bed, forming mid-channel or point bars that concentrate flows against the banks, and lead to a wider channel. In situations where bed scour resistance is significantly greater than bank erosion resistance, the channel response to an increase in flows, decrease in sediment supply, or channel straightening, may skip over Stage II incision, or express incision only to a minor or inconsequential degree.

Stage IV Aggradation is a term used to describe the raising of the bed elevation through an accumulation of sediment. Channel aggradation may occur when there has been a significant decrease in flows, a significant increase in sediment supply, or a significant decrease in slope due to meander elongation or downstream hydraulic constrictions, such as bridges and culverts. Depending on upstream processes and the boundary conditions of the reach, channel widening may occur in association with channel aggradation.

The **Planform** is the channel shape as seen from the air. Planform change can be the result of a straightened course imposed on the river through different channel management activities, or a channel response to other adjustment processes such as aggradation and widening. When a river changes planform and cuts a new channel, a change in channel slope usually results, sometimes initiating another channel evolution process. This evolution process will start with degradation if the channel slope is increased, or with aggradation if the slope is decreased.

When a stream is in adjustment, it is evolving toward equilibrium or working to reestablish balance with its watershed inputs (VT Stream Geomorphic Assessment Phase 3 Handbook, 2004). Using the fundamental relationship offered by Lane (Figure 2) an understanding may be gained as to how different land uses, management activities, or natural events (i.e. floods) "tip the balance." The time required for a stream to adjust to a given disturbance is difficult to predict owing to the fact that they are influenced by boundary conditions, climate, and history or persistence of disturbance (Center for Watershed Protection, 1999b) but can take decades or centuries.

Rivers are a metaphor for "change." Every fluvial system changes in time. **Sensitivity** refers to the likelihood that a stream reach will respond to a watershed or local disturbance. The exercise of assigning a sensitivity rating to a stream is done in the context that some streams, due to their setting and location within the watershed, are more likely to be in an episodic, rapid, and/or measurable state of change or adjustment. A stream's inherent sensitivity may be heightened when human activities alter the setting characteristics that influence a stream's natural adjustment rate including: boundary conditions; sediment and flow regimes; and the degree of confinement within the valley. Streams that are currently in adjustment, especially degradation or aggradation, may be acutely sensitive.

The Dynamic River

Knowing that rivers are a dynamic system and are sensitive to change (Figure 4), the types of management strategies considered for the watershed and the river must evaluate the short and long term effect(s) of that management strategy on the fluvial system. The geomorphic condition of the stream can be used as both an indicator and predictor of watershed function and health. Applying the science provides tools to manage fluvial conflicts between river processes and human investments by recognizing streams as a continuous system, rather than a collection of unrelated problem sites.

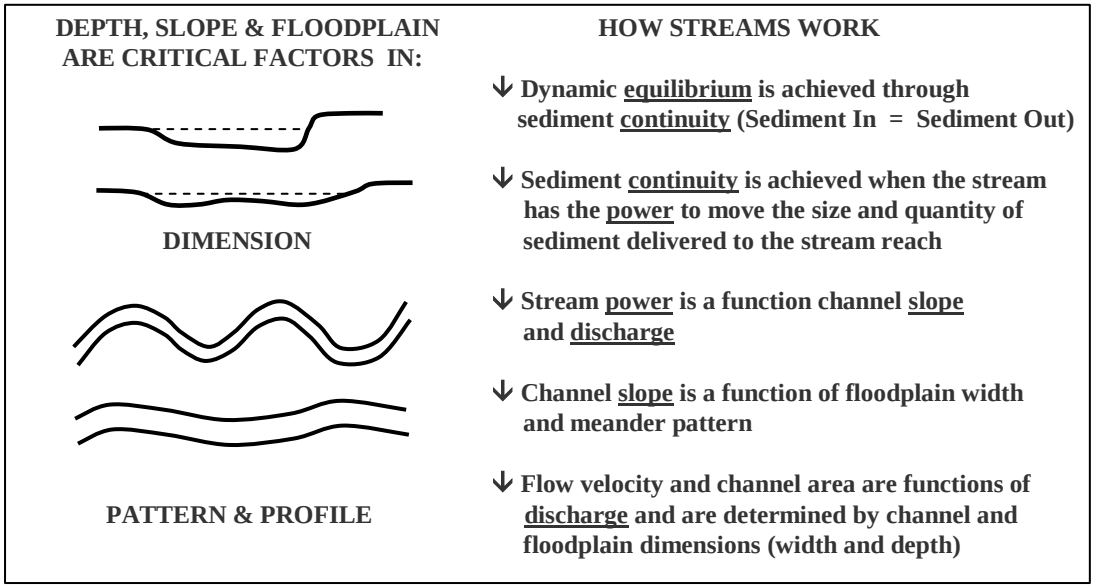


Figure 4. "How Streams Work" to achieve sediment continuity and dynamic equilibrium.

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Best Management Farming Practices for Water Quality Protection

Grassed Waterway (412) Fact Sheet

BMP: Protect ditches and banks from concentrated flow from runoff; divert water to a stable outlet; and/or establish vegetation to filter sediment from a slope.

NRCS Practice Standard: Grassed Waterway (412)

Grassed waterways are natural or constructed channels, typically broad and shallow in shape, that are planted and continuously maintained with low-growing grassy cover to convey storm water runoff.

Grassed Waterway (NRCS Conservation Practice Code 412)

Definition: A shaped or graded channel that is established with suitable vegetation to carry surface water at a non-erosive velocity to a stable outlet. Grassed waterways are used to control gullying or soil erosion from concentrated water flow, where storm water runoff can be conveyed at velocities less than five feet per second.

Purpose

- Provide a more natural, lower velocity alternative to other means of storm water conveyance.
- To convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding.
- To reduce gully erosion.
- To protect/improve water quality.
- To maintain or enhance watershed function and value.
- May enhance wildlife habitat.

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

CONSIDER THIS:

Where grading is used to construct waterways, establish an effective sod, preferably comprised of permanent grasses, applying mulch and irrigation prior to the beginning of the fall rainy season. Establish vegetation before allowing water to flow in the waterway.

Use mulch, anchoring, a nurse crop, rock, hay-bale dikes, filter fences, or runoff diversions as necessary to protect the vegetation until established.

Where conditions warrant additional erosion protection, stone-lined channel bottoms, or periodic rock checks finished at channel-bottom grade may be used.

Select species that have the capacity to achieve adequate density, stiffness and vigor within an appropriate time frame to stabilize the site sufficiently.

When applying straw mulch apply at 1500 lbs/acre at planting, distributed uniformly over seeded area within 48 hours after seeding. Anchor straw using hand tools, rollers, crimpers, disks or similar equipment.

After establishment maintain dense vegetation, reseeding and irrigating when necessary.

Control undesirable weed species; mow after rainy season.

Inspect and repair after storm events, reseed disturbed areas.

Do not use fertilizer when using for water quality.

Best Management Farming Practices for Water Quality Protection

Riparian Herbaceous Cover (390)

BMP: Protect ditches and banks from concentrated flow and runoff. Detain or filter eroded sediment leaving the operation. Protect creeks, streams and rivers from sediment.

NRCS Practice Standard: Riparian Herbaceous Cover (390)

Developing and managing zones of buffer vegetation between farmed and non-farmed seasonal or perennial aquatic areas (streams, creeks, rivers, ponds or lakes). Herbaceous buffers consists of grasses and grass-like plants and forbs that can tolerate intermittant inundation. Helps stabilize stream banks and shorelines.

Riparian Herbaceous Cover (NRCS Conservation Practice Code 390)

Definition: Grasses, sedges, rushes, ferns, legumes and forbs tolerant of intermittent flooding or saturated soils, established or managed as the dominant vegetation in the transitional zone between upland and aquatic habitats.

Purposes:

- Provide or improve food and cover for fish and wildlife
- Improve and maintain water quality
- Reduce erosion and improve stability to stream banks and shorelines
- Dissipate stream energy and trap sediment
- Enhance stream bank protection as part of stream bank soil bioengineering practices.

Consider this:

Establish riparian buffers by October 15 and maintain.

Make certain channel and stream bank stability is adequate to support this practice.

Select plants that are adapted to site and hydrologic conditions and provide diversity preferred by fish and wildlife. Plants must be able to endure saturation and inundation.

Select native species that provide a deep binding root mass to strengthen stream bank and shoreline.

Select species that have stiff stems and high stem density near the ground surface.

If mowing is necessary it should occur outside of the nesting season.

Control concentrated flow erosion in the up gradient area prior to establishment of the riparian herbaceous cover.

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

Best Management Farming Practices for Water Quality Protection

Riparian Forest Buffer (391)

BMP: Protect ditches and banks from concentrated flow and runoff. Detain or filter eroded sediment leaving the operation. Protect creeks, streams and rivers from sediment.

NRCS Practice Standard: Riparian Forest Buffer (391)

A riparian forest buffer is an area of trees and shrubs located adjacent to streams, lakes, ponds, or wetlands. The vegetation extends outward from the water body for a specified distance necessary to provide a minimum level of proection and/or enhancement.

Riparian Forest Buffer (NRCS Conservation Practice Code 391)

Definition: An area predominantly trees and/or shrubs located adjacent to watercourses or water bodies.

Purposes:

- Create shade to lower or maintain water temperatures to improve habitat for aquatic organisms.
- Create or improve riparian habitat
- Reduce excess amounts of sediment, organic materials, nutrients and pesticides in surface runoff.
- Reduce pesticide drift entering the water body.
- Enhance stream bank protection as part of stream bank soil bioengineering practices.
- Restore riparian plant communities.
- Increase carbon storage in plant biomass and soils.

Consider this:

Head cuts and stream bank erosion should be assessed and treated appropriately before establishing the riparian forest buffer.

Make certain channel and stream bank stability is adequate to support this practice.

Select trees and shrubs that are adapted to site and hydrologic conditions and provide diversity preferred by fish and wildlife.

Select native species adapted to area.

Tree and shrub species which may be alternate host to undesirable pests should be avoided.

Specification for each installation shall be based on a thorough field investigation of each site.

Minimum width shall be at least 35 feet measured horizontally on a line perpendicular to the water body beginning at the normal water line, bank-full elevation, or the top of the bank as determined locally.

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.asp