CALIFORNIA SALMONID STREAM HABITAT RESTORATION MANUAL

PART XI

RIPARIAN HABITAT RESTORATION

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PART XI. RIPARIAN HABITAT RESTORATION

INTRODUCTION

Natural riparian habitat includes the assortment of native plants that occur adjacent to streams, creeks and rivers. These plants are well adapted to the dynamic and complex environment of streamside zones.

Approximately 95% of the historic riparian habitat has been lost in California, making way for cities, agriculture, mining and other development. The riparian area provides one of the richest habitats for large numbers of fish and wildlife species which depend on it for food and shelter. Many species, including coho and Chinook salmon, steelhead, yellow-billed cuckoo and the red-legged frog, are threatened or endangered in California. Others are rapidly declining.

Most landowners wish to protect their riparian resources while optimizing the value and productivity of their property. These two goals sometimes seem to conflict. An understanding of riparian habitat and stream processes can help landowners conserve riparian resources, and still manage their property productively, and even enhance their property value.

California residents, landowners, land managers, and agencies are increasingly interested in conserving and enhancing watersheds and implementing management practices that are more fish friendly. The riparian corridor is the critical interface between terrestrial and aquatic systems. Increasing numbers of individuals and community groups are involved in habitat conservation and restoration projects in riparian areas. Part XI is intended to encourage and help facilitate the stewardship and restoration of riparian habitat in California watersheds.

In addition to providing basic information about riparian corridors, this Part is intended to assist agencies, landowners, schools and community groups with the planning and implementation of native plant revegetation projects. A plant identification section at the end of Part XI provides detailed descriptions and photographs of plants commonly found along central and north coast California rivers and streams.

STREAM PROCESSES AND RIPARIAN HABITAT

The plant species found in riparian communities differ widely depending upon the character of the watershed and the stream's location within the watershed. The composition of a riparian community is determined by many things, including the reach type, stream slope (gradient), channel confinement, aspect, light availability, water availability, flooding and soil conditions.

For example, at the headwaters of a stream, the gradient is often steep and the riparian vegetation may not vary from the surrounding forest plant community. Further downstream, as the gradient decreases, the riparian corridor begins to differ from the surrounding forest plant community. The riparian canopy is often dominated by trees such as alder, ash, maple, box elder, and oaks, while the surrounding forest may be dominated by conifers. In alluvial areas, sunny openings on gravel bars often provide habitat for species such as mulefat and willow.

Different age classes and species of riparian habitat at different elevations

Streams and their tributaries often cut through broad alluvial valleys. In these alluvial zones, where the substrate is dominated by sand, gravel and silt, the stream freely moves (meanders) back and forth over time, creating and removing riparian habitat naturally. The ability of the stream to move through this meander corridor is what allows the development of diverse riparian forests. Streams in these alluvial areas may have historically included a broad floodplain mature forest with backwater sloughs, oxbow lakes and floodplain wetlands. These diverse habitat features are important for salmonids and other wildlife. Riparian corridors that are wide enough to allow for stream meandering should require little maintenance over the long term. A substantial riparian zone can help to reduce erosion damage to adjacent lands, as well as filter sediment and pollutants. However, due to the high value of agricultural lands as well as the proximity of urban development and other land uses, natural stream movement may not be possible in all managed watersheds.

Russian River meander corridor

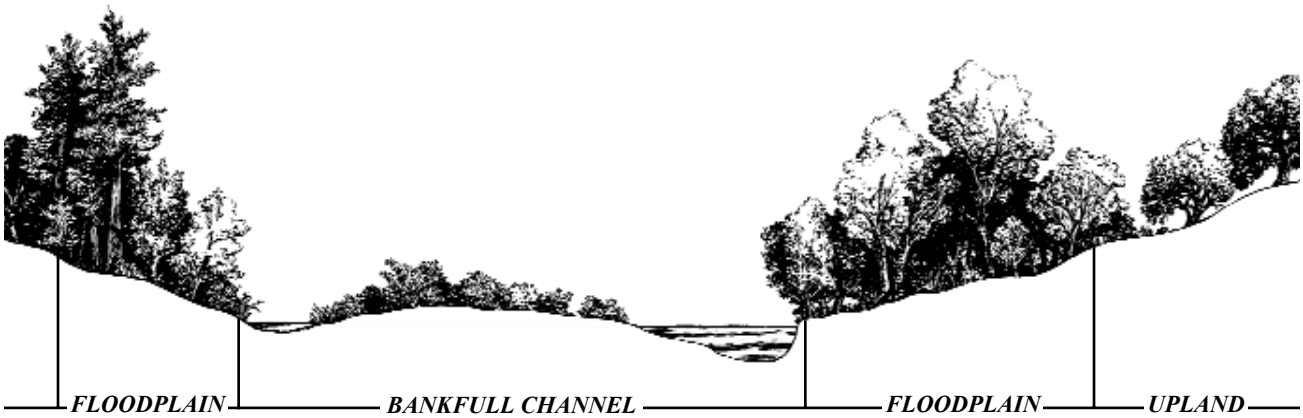
Within the bankfull channel (an area which is regularly flooded), plants are adapted to high levels of flood disturbance during the winter, while tolerating the hot, dry conditions of the gravel bars during the summer. Very few species have the ability to survive in this harsh channel environment; those that do include alder, willow, cottonwood and mulefat. They are called pioneer species, because they colonize recently disturbed sites.

Bankfull channel with small seedlings of pioneer species

The seeds of cottonwood and willow float through the air in the spring just as the water level is beginning to recede. Millions of seeds land on moist gravel bars and germinate there. As the summer progresses, the roots of these tiny seedlings follow the receding water table. Those plants that cannot stay connected to the water table face certain death on the desert-like gravel bar. Those plants that survive the summer drought and winter flood cycle will grow at incredible rates, up to 15 feet per year. As they grow, these pioneer species may begin to trap sediments, and can influence the movement of the stream.

The floodplain is elevated above the bankfull channel and is characterized by many more species than found in the bankfull channel. Floodplain areas support plants that are less adapted to flood scour and do not require as much summer moisture.

Floodplain riparian forests are some of the most important, *and the most impacted*, habitats in California. Intact riparian forests tend to be a dense tangle of large trees in the over-story, and smaller trees, vines, downed wood, and various herbs and fungi in the under-story. The diversity of plants and complexity of habitats in these mature riparian forest zones supports an incredible number of animal species.



Representative cross-section of riparian area

FISH AND WILDLIFE VALUES OF RIPARIAN HABITAT

Salmonids (including coho, Chinook and steelhead) rely on healthy riparian habitat. Riparian trees shade the stream channel, helping to cool the water and retain high levels of dissolved oxygen.

Salmonid

Native streamside vegetation provides leaf litter which is eaten by many aquatic insects. These insects are in turn consumed by fish. Roots of riparian plants provide fish with shelter from predators. When large riparian trees fall into the stream, they supply an important structural element in creeks and rivers which helps form pools, sort the substrate, and provide shelter for fish and other aquatic organisms.

Salmonid

Riparian zones along intermittent streams also provide salmonid habitat. Coho salmon and steelhead spawn in the upper reaches of streams and their tributaries while they are flowing in winter. The fry emerge and migrate down to the perennial reaches before the tributaries dry up in summer. These tributaries also serve as important sources of food, spawning gravel, and woody debris that are flushed into the mainstem of a stream during storms. Therefore, alterations to the riparian zones of these seasonal tributaries can have a significant impact on salmonids.

Pacific tree frog (Hyla regilla)

In addition to the important role they play in the salmonid life cycle, riparian areas support an abundance of other wildlife species. Over half of the reptiles and three-fourths of the amphibians in California, including the western pond turtle, red-legged frog and various tree frogs, live in riparian areas. Large numbers of migratory and resident birds rely on streamside habitat. Over one-hundred native species of land mammals are dependent on the riparian zone, including raccoons, ringtails, and river otters. Black-tailed deer utilize riparian zones for fawning.

In an intact riparian corridor, there is a layering effect of plant sizes, shapes and ages that promotes wildlife diversity. A mature riparian forest has a low layer of groundcover, an intermediate layer of shrubs and small trees, and a high canopy of trees and vines. These different layers provide many sites for shelter and food for birds, insects and mammals. In addition, large trees will mature and die, leaving standing snags that provide habitat for cavity nesting birds and other terrestrial wildlife.

Bobcat

Finally, riparian areas act as wildlife corridors, providing important routes for the movement of aquatic species (fish, amphibians, insects), land animals (reptiles and mammals), and birds within a watershed. Stream corridors can be thought of as the circulatory system of the watershed, allowing terrestrial wildlife and fish to migrate up and downstream.

HUMAN VALUES OF RIPARIAN HABITAT

Riparian habitat provides many benefits to streamside landowners. For example, a wide strip of riparian vegetation can offset flood damage to adjacent agricultural lands by acting as a filter for trees and other debris that may wash in during large floods. Riparian vegetation also traps fine sediments and other pollutants contained in terrestrial runoff, thereby preserving instream water quality. Because of their deep roots and dense growth, riparian trees, shrubs, and grasses provide excellent protection against bank erosion, helping to stabilize streambanks.

In addition to assisting with flood protection and erosion control, riparian vegetation may play a role in integrated pest management. Cavity nesting riparian bird species such as kestrels and owls prey on rodents. Other cavity nesting birds such as wrens, tree swallows, oak titmice and bluebirds may help reduce populations of pest insects. Bobcats, coyotes and foxes also use riparian areas to prey on rodents.

Kestrel

Indigenous cultures have relied upon riparian plants for thousands of years, using streamside and wetland plants for basketmaking, as a source of food, and for medicinal purposes.

HUMAN IMPACTS TO RIPARIAN HABITAT

More than 95% of the historic riparian forests in California have been lost due to land use change since European settlement. Logging, urban development, dams, water diversions, gravel mining, and agriculture have all contributed to this loss.

The straightening of creeks for commercial, residential and agricultural activities, and floodplain development, has reduced the width and maturity of the riparian zone, and accordingly changed the river's form through erosional and depositional processes. Dams retain sediment, cut off critical salmonid spawning habitat and may either augment or reduce the natural flow regime. These changes have contributed to the decline of wild salmonids. California rivers once meandered across their forested floodplains, overflowing their banks as a result of winter rains, thus creating a complexity of habitat types. Currently many rivers and creeks have been severely confined, degraded and simplified, resulting in a significant loss of salmonid habitat and biological diversity in general.

Non-Native Invasive Plant Species

Humans have modified riparian areas throughout California in a variety of ways. One of the more serious impacts to native habitats is the introduction of non-native plant and animal species. Invasive plants are a topic of increasing concern for landowners and conservationists. Exotic or non-native plants, such as giant reed (*Arundo donax*) and tamarisk, have spread rapidly and taken over thousands of acres of streamside habitat. These invasive species exclude native vegetation, may increase fire danger and often use large amounts of water, decreasing available resources for fish, wildlife and humans.

Exotic plants usually do not support the same diversity of wildlife found in native riparian forests. If plants such as giant reed or periwinkle dominate the riparian zone, native riparian plants cannot become established. When this happens, the habitat values are often degraded or lost. For example, when an invasive grass such as giant reed becomes established in a riparian area, out-competing native trees such as bay laurel, cottonwood and big leaf maple, the long term consequence is that the large woody debris, shade canopy and leaf litter provided by native species are lost. This results in changes in stream temperature and modification of instream structure and the aquatic food chain. The once complex riparian forest that provided shade, food and structure for salmonids and other species is transformed into a monoculture of grass with very little habitat value. Because riparian species are not especially long lived (20-80 years is typical) invasive species can have extremely negative effects on riparian areas in a relatively short period of time.

Giant reed (Arundo donax)

The following species are common exotic invasive plants found in northern and central California riparian areas, and are pictured in Appendix XI-B:

Common Name	Latin Name	Plant Type
acacia	*Acacia* spp.	tree
cape ivy	*Delairea odorata*	vine
English ivy	*Hedera helix*	vine
eucalyptus	*Eucalyptus* spp.	tree
fennel	*Foeniculum vulgare*	herb
floating primrose	*Ludwigia peploides*	emergent/aquatic
giant reed	*Arundo donax*	grass
Himalayan blackberry	*Rubus discolor*	vine
pampas grass	*Cortaderia selloana*	grass
pepperweed	*Lepidium latifolium*	herb
periwinkle	*Vinca major*	vine
poison hemlock	*Conium maculatum*	herb
tamarisk	*Tamarix* spp.	shrub/tree
teasel	*Dipsacus fullonum*	herb
tree of heaven	*Ailanthus altissima*	tree
yellow star thistle	*Centaurea solstitialis*	herb

Agricultural/Riparian Interface: Pierce's Disease

Pierce's Disease is a fatal disease of grapevines caused by the bacterium *Xylella fastidiosa* which is transmitted by the blue-green sharpshooter insect (*Graphocephela atropunctata*). Certain riparian plants are hosts for the bacteria as well as feeding and breeding hosts for the blue-green sharpshooter. These plants include both native and non-native species and are listed below. In the past, a common practice was to remove all riparian plants adjacent to vineyards in an effort to reduce the incidence of Pierce's Disease. Recent practices have changed to reflect a more surgical approach to removal that only focuses on those plants that are systemic hosts for the bacteria. In systemic host plants, the *Xylella* bacteria spreads systematically throughout the plant after being bitten by the insect. However, in propagative host plants, the bacteria remain at the point of infection and do not spread systemically. Propagative host species are therefore not a high priority for removal. Species such as the invasive, non-native periwinkle (*Vinca major*) are systemic hosts for the bacteria and a breeding/feeding host for the blue-green sharpshooter. These plants are a high priority for removal from an economic perspective, and their removal benefits native riparian habitat as well.

Periwinkle (Vinca major)

The following perennial plants are the major breeding hosts for the blue-green sharpshooter and most are systemic hosts of Pierce's Disease in Napa, Sonoma, and Mendocino counties. Removal of these species has been shown to significantly reduce the number of blue-green sharpshooters in riparian areas and adjacent vineyards (The Pierce's Disease/Riparian Habitat Workgroup, 2000):

NON-NATIVE HOST PLANT LIST

Common name	**Latin name**
Himalayan blackberry	*Rubus discolor*
periwinkle	*Vinca major*
wild grape*	*Vitis* sp.

* (escaped cultivar or *Vitis californica* hybrid)

NATIVE HOST PLANT LIST

Common name	**Latin name**
blue elderberry	*Sambucus mexicana*
California blackberry	*Rubus ursinus*
California grape	*Vitis californica*
mugwort	*Artemisia douglasiana*
mulefat	*Baccharis salicifolia*
stinging nettle	*Urtica dioica*

Himalayan blackberry (Rubus discolor)

Mugwort (Artemesia douglasiana)

For more information on the complex topic of Pierce's Disease in north coast streams, visit *www.cnr.berkeley.edu/xylella*, or call your local University of California Cooperative Extension office.

CONSERVATION AND MANAGEMENT OF RIPARIAN HABITAT

Riparian zone in winter with leafless deciduous trees

Many landowners already have intact, healthy riparian corridors on their properties and simply want to preserve these areas in their present state. Others may have riparian areas that are in need of management, due to problems with invasive plants, Pierce's Disease or changes from upstream and downstream land uses. Many landowners are also interested in active restoration of native riparian habitats. The following sections discuss methods for preserving, managing and restoring healthy riparian corridors.

Conserving Riparian Habitat

Healthy riparian corridors require little maintenance over the long term. A stream system that has enough room to move around will sustain a diversity of plant and animal species. Leaving the stream enough elbow room may also protect adjacent land uses from excessive erosion or flood damage.

For those landowners who wish to preserve the integrity of their riparian zones, regular monitoring is recommended. Monitoring can be as simple as walking the stream yearly or seasonally, assessing changes in the stream after a storm or checking for invasive plants or trash that may have been carried in during a flood. More detailed habitat inventory methods are described in Part III of the *California Salmonid Stream Habitat Restoration Manual.*

Conservation of riparian habitat can also be accomplished by placing an easement over the stream corridor. Some conservation easements provide permanent deed guidelines for riparian land uses. Placement of a conservation easement may also provide a tax benefit to the landowner. Some land trust organizations purchase easements from willing sellers.

For more information about conservation easements and land trust organizations, visit the Land Trust Alliance website at *www.lta.org*.

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 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, should be removed before they become a significant problem.

Manual cutting of giant reed biomass

Surgical removal of native and non-native plants along with re-planting of natives is preferred to the wholesale removal of all riparian habitat. While planning for any riparian vegetation project, contact the Department of Fish and Game for technical assistance. Depending on the project, permits may be required from several different local, state or federal agencies. See Part VI for more information on permits.

Riparian forest invaded by periwinkle

The following non-toxic treatments require a significant commitment of time and labor. These treatments need to be based on an understanding of each plant's physiology (i.e., timing of flowering, size and structure of the root system, etc.). For example, a species such as yellow star thistle may be partially controlled by mowing, but the mowing treatment must take place prior to seed development, or it will cause seed dispersal and make the problem worse. Root removal options will vary according to the species. Young tamarisk or tree of heaven seedlings can be pulled using hand tools, but mature plants may require heavy equipment, potentially a cause of excessive disturbance and siltation in the riparian zone. Disturbed areas should be treated to prevent siltation to the stream. Species such as Himalayan blackberry and periwinkle may have extensive root

systems that are difficult to track down and remove. Burning may be accomplished with a backpack torch, but can only take place when there is no threat of wildfire. Tarping is usually implemented after the rainy season has ended. Tarps are then removed prior to the next rainy season. Removal of undesirable plants should be followed with a revegetation program using appropriate native plants which may help to prevent recolonization by other invaders.

There are a variety of non-toxic ways to remove unwanted plant species, and each option should be thoroughly evaluated. Listed below are some non-toxic control options for a variety of invasive non-native plant species. In general, invasive species control will take several years, and will require very careful monitoring and removal of re-growth to ensure success.

Common Name	**Latin Name**	**Removal Options**
acacia	*Acacia* spp.	root removal
cape ivy	*Delairea odorata*	root removal
English ivy	*Hedera helix*	root removal, burning
eucalyptus	*Eucalyptus* spp.	root removal
fennel	*Foeniculum vulgare*	root removal, mowing, burning
giant reed	*Arundo donax*	tarping, hand removal (gravel bars)
Himalayan blackberry	*Rubus discolor*	root removal, burning
pampas grass	*Cortaderia selloana*	root removal
pepperweed	*Lepidium latifolium*	root removal, mowing
periwinkle	*Vinca major*	root removal, tarping
poison hemlock	*Conium maculatum*	root removal, mowing, burning
tamarisk	*Tamarix* spp.	root removal, burning
teasel	*Dipsacus fullonum*	root removal, mowing
tree of heaven	*Ailanthus altissima*	root removal
yellow star thistle	*Centaurea solstitialis*	root removal, mowing, burning

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 air or 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 required by law.

The following websites provide additional information about invasive species and control options:

http://www.caleppc.org (California Exotic Pest Plant Council)
http://www.cdfa.ca.gov/phpps/ipc/noxweedinfo/ (California Department of Food and Agriculture)
http://ceres.ca.gov/tadn/ (Team Arundo del Norte)
http://endeavor.des.ucdavis.edu/weeds/ (CalWeed Database)

Large Woody Debris

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 is an important factor in the recovery of salmonid populations. It is, therefore, desirable to retain a wide riparian corridor with large trees that may be recruited into the stream.

Historically, the approach by many agencies and landowners has been to keep the stream channel clean and open, by removing any log debris accumulation. It was believed that these large trees presented a passage problem for fish. It has since been recognized that fish, especially salmonids, are capable of passing over or through most debris accumulation. Substantial retention of sediment above debris accumulation may indicate a potential fish passage problem. Streams with large woody debris provide good quality salmon habitat.

Large woody debris creates pool habitat

Large woody debris provides structure to the stream environment

Streamside landowners are understandably concerned that large fallen trees may 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 of large debris accumulation, rather than complete removal. An example of this might include pruning tree limbs and allowing the trunk to remain in the stream. This approach allows for the habitat benefits associated with large woody debris, while resolving problems such as fish passage. Contact the California Department of Fish and Game for more information on this topic. See Part VII on barrier modification and log structures for habitat enhancement.

RESTORATION OF NATIVE RIPARIAN HABITATS

Natural Regeneration and Exclusionary Fencing

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

Stream floodplain being grazed by livestock

In areas that are being grazed by livestock or are heavily impacted by other native grazing herbivores, exclusionary fencing can give the streambank enough protection 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 (ten years is often adequate).

If fencing is used to allow for the regeneration of riparian habitat, it should be set back far enough to allow the stream to meander and create a diversity of habitat. Fences placed too close to the stream corridor may be damaged during high flows, wasting time and money.

Exclusionary fencing along stream headwaters

Fencing design, including type of wire, gauge and spacing must be specific to the types of animals you are attempting to exclude. Many fencing supply stores have this information and can help you with construction specifics. Alternative water sources for livestock should be devloped to keep them out of the stream channel. If conditions require that livestock access the stream for pasturing or crossing between pastures, use specialized floating fences (which span the channel) to limit such access. When funding restoration projects, the Department of Fish and Game requires a riparian management plan to be developed and signed by the landowner. For more detailed information on exclusionary fencing, see Part VII.

Erosion Control

Large flood events may create the need for 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 such as bioengineering is preferable to a structural approach such as riprap. Structural approaches to stream bank erosion such as riprap tend to fix the stream in one place, exclude riparian vegetation, and prevent the natural movement that creates diverse habitats. Structural approaches are often more expensive, require permits, and may damage neighboring properties. Over the long term, structural approaches tend to fail or require excessive maintenance. If a structural approach is unavoidable, native vegetation should be incorporated into the structure. Bioengineering will increase the effectiveness of the erosion control method and provide some habitat value as well. See Part VII for descriptions of bioengineering.

Installation of erosion control

Planning and Implementing a Successful Revegetation Project

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
- instream 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
- direct seeding of native species such as oaks or buckeyes.

The landowner, project personnel, or watershed organization should become acquainted with the stream processes and natural habitat of the area to create a plan that works within the local riparian ecosystem. While planning for any riparian vegetation project, contact the Department of Fish and Game or the Natural Resources Conservation Service for technical assistance. Depending on the project, permits may be required from several different local, state or federal agencies.

Tree shelter installation

Creating and implementing a revegetation project can be a complex process, taking four to six months for design and approval, and several additional months for implementation. In some cases, involving a consultant or watershed group with expertise in the process can save time and be more cost effective. See Part VI for more information on permits.

Riparian Revegetation Project Planning

A successful revegetation project will:

- establish a diversity of native plant types and plant species in the riparian area
- provide fish and wildlife habitat
- reduce erosion
- require minimal annual management.

Revegetation should attempt to replicate the natural system.

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 the natural system. It can be helpful to draw a cross-sectional diagram of the riparian zone showing where different species occur. This can help determine planting sites based on elevation above the bankfull channel.

Diverse riparian and upland habitat

In general, container planting in the bankfull channel is not recommended.

If there is a severe bank erosion problem, or the system has lost all upstream sources of seed, some active channel revegetation may be warranted. Since the bankfull channel is subject to regular flooding, installed plants are likely to wash out prior to establishing a root system. Willows, whether as sprigs, a willow mattress or willow wall, are adapted to this flood prone environment, and can be an effective, relatively inexpensive way to stabilize a streambank or introduce cover to the stream. Plants installed in the bankfull channel should not have protective hardware, as it will likely be lost to flooding.

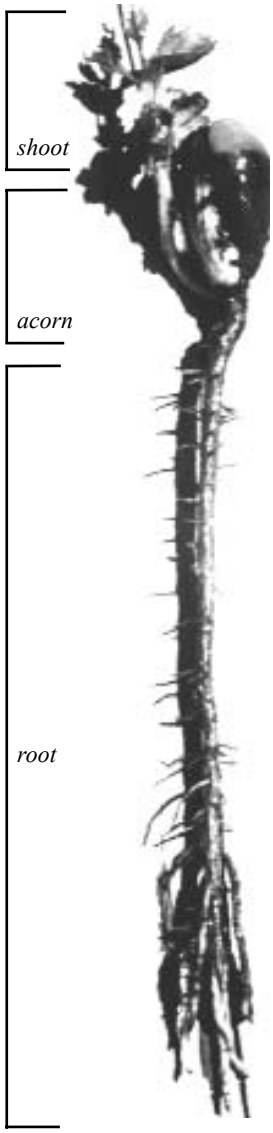
Seeds, cuttings or transplants should be collected as close as possible to the project site.

Local collection of plant material ensures that only genetically appropriate plants (i.e., those that are adapted to local conditions) will be used on site. Introduction of plant material from outside of the project watershed is not recommended. The use of local plant material usually results in higher survival rates.

Valley oak (Quercus lobata) an important native seed

Sources for Native Plant Material

Appropriate, site specific native plants are one of the most important aspects of a successful riparian restoration project. Project planning may need to begin up to 18 months in advance to obtain those species that must be grown in containers. 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. This is often the most important phase of planning a successful restoration project. If you are not in a position to grow the plants yourself, it is a good idea to order plants from a local native plants nursery as soon as you have selected a restoration site.



Bare-root stock can also be used instead of container stock. However, bare-root stock is often difficult to locate because few nurseries produce it. Spacing of plants depends on the species, the goals of the project, desired densities, and many other factors. General spacing recommendations are included in Table XI-1, page XI-26.

Nurseries specializing in California native plants do things differently than typical landscape nurseries. California native plant nurseries usually custom collect site specific material for particular restoration projects, or at minimum, they track where the plant material was collected. This ensures that you can purchase plant material suitable for your project site.

The California Native Plant Society website, *http://www.cnps.org/links/grow links.htm* includes a variety of resources about California flora, including a list of native plant nurseries.

Common container sizes found in native plants nurseries are listed below:

Container Name	Size	Uses
6” and 8” supercell	1 1/8” x 6” 1 1/8” x 8”	Best for plants with fibrous root systems
deepots	2 1/2” x 10”	Good for trees and shrubs
treepot	4” x 14”	Generally used for trees
treebands	2 1/2” x 5”	Good for trees and shrubs

Native plants nurseries also use unique containers like treepots, deepots or supercells (shown to the left) to develop an optimum root-to-shoot ratio (see example photo, above right). This approach provides plants with a well established root system prior to outplanting at the revegetation site.

Emergent Transplant Installation

Plants such as rushes, sedges and tules are commonly called emergent plants, because they are often associated with creeks, wetlands and lakes, where they emerge from the water. They may reproduce from seed or from the spreading of underground rhizomes. This vegetative form of reproduction makes emergent species ideal candidates for transplantation into revegetation sites. These species are widely adapted to a range of environments, including high velocity bankfull channels, slow moving backwaters, seeps on hillslopes, and stable, relatively dry floodplains. It is important to identify the species to use and transplant them in an appropriate location. There are also some non-native species of emergents that should not be transplanted into riparian zones. Care should be taken to sensitively harvest these plants so the existing population is not seriously degraded. It is a good idea to take several small clumps from a variety of larger clumps, leaving the majority of each population intact to ensure genetic diversity.

Collecting emergent vegetation

Emergent vegetation, rhizomes exposed

Steps required to transplant emergent species:

- In the winter or early spring, carefully harvest rhizomes and the above-ground portions of the plant with a mattox, sharp trowel or shovel. Make sure one to several intact rhizomes remain for each transplant.
- Store the collected plant in a cool moist location until time for transplanting. Ideally, plants should be stored in moist soil, and should be transplanted as soon as feasible after collection.
- Dig a hole for the transplant that is large enough to accommodate the extended rhizome without bending or breaking it. Place dirt around the rhizome, pack it down, and water it in thoroughly to close any air holes around the rhizome.
- Trim back the above ground portions of the plant in order to stimulate rhizome growth.

Installation of emergent vegetation

Dormant Willow or Cottonwood Sprig Installation

Willows and cottonwoods are in the willow family (*Salicaceae*) and are generally adapted to bankfull channel environments. Species in this family form specialized roots along their stems, allowing for vegetative reproduction in riparian corridors. This feature makes them good candidates for installation as sprigs or dormant cuttings. In general, willows need significant amounts of light and a year-round source of moisture. They are good candidates for revegetation as long as their root zone remains moist during the summer. Because of their ability to withstand flood flows, they are often a good choice for bank stabilization projects in bankfull channel areas. There are many varieties of willow and cottonwood in California. Some (such as the curly willow and Lombardy poplar) are not native and should never be planted in riparian areas. They may not supply the same habitat values as the native plants, and may hybridize with them. Cuttings should be harvested from a variety of parent plants in order to avoid out-planting genetically identical material. These techniques result in a more successful project, will ensure genetic diversity, and do the least damage to the collection site.

Sharp, clean loppers produce high quality sprigs and cuttings

Typical dimensions for willow and cottonwood sprigs

Steps required to install dormant willow and cottonwood cuttings:

- Harvest cuttings during the winter months when plants are dormant (usually December-January). Although willows and cottonwoods will grow from cuttings at other times of the year, dormant cuttings are more resistant to disease, have higher survival rates, and do not require irrigation if planted in the appropriate location. Sprigs may be harvested using sharp, clean loppers, hand shears, or a chainsaw. The cuttings

Store cuttings in a moist environment

may be collected at a range of sizes (i.e., ½ inch to 4 inches diameter and up to 8 feet long). It is important to select material that has not become too woody, and that has several viable buds along the stem.

- Cuttings may be used immediately, stored on-site in the stream, or stored off-site in a bucket of cool water. Ideally, material should be harvested and installed the same day.

- Sprigs should be installed with buds pointing up, with approximately ¾ of the cutting in the soil, and ¼ exposed. Holes may be dug with a pick, with a piece of rebar, with an auger, or a backhoe (for large material). In areas with soft soil, you may avoid digging a hole by cutting the bottom at an angle and pounding it into the ground with a small sledge hammer. If the top is damaged by the hammer, cut off the top of the sprig to allow for clean healing or place a driving shield over the top to drive in the sprig.

Auger used for planting holes

Small sledge hammer for installing sprig

Clean, sharp loppers cut off damaged top of sprig

Container Plant Installation with Shelters
Container plants need to be ordered or propagated months in advance and may be grown by a native plants nursery or an individual practitioner (see page XI-16). Although the installation of container plant material requires more up-front planning than sprigging, emergent transplants and direct seeding, it also allows for the installation of a more diverse plant palette. Some projects use a two-phased approach, with cuttings, emergents and direct seeded species installed the first year, followed by installation of container plants the second year.

Steps required for installing container plants with shelters:

- Plants should be installed during the winter. Plants that will not be irrigated should be planted from December through February, after rains have thoroughly saturated the ground. Plants that will be drip irrigated can be installed at other times during the year. Because of the dangers of planting on the bank of a stream during high flow periods, when stream banks are slippery and the current swift, it may be best to delay some projects until conditions are safe.

- When installing plants, dig holes to twice the depth of the root-ball of the plant to be installed, crumbling any large soil clumps. Partially refill the hole, firmly tamping the soil to create a firm base for the new plant. Place the plant so the top of the root-ball is slightly above finish grade, to allow for future settling. Fill the hole and tamp firmly to remove any air pockets. Irrigate immediately, ensuring the water soaks deeply, unless the ground is already saturated.

Remove weeds from the planting area

Dig the planting hole twice the depth of the root ball

Water the plant immediately, ensuring that the water soaks deeply. If planting in low moisture conditions, plants should be watered during the planting process and therafter until rains begin.

- Where damage from domestic animals and wildlife is a concern, consider protecting plants with shelters (except those that will be in flood-scoured areas). Shelters should be firmly staked and tied so they will remain upright. There are a variety of shelters available, ranging from chicken wire enclosures (screen and collar, shown in photo at bottom) to plastic tubes (a.k.a., *supertubes*, shown in photo at right). All of these methods have proven successful, if they are maintained and weeds are controlled. Shelters should be removed as soon as the plants begin to outgrow them (3-5 years is typical for riparian plants).

- Weeds should be carefully controlled in revegetation areas before and after installation. Plants can become lost in the weeds, increasing maintenance costs and reducing project success. Mow tall weeds before installation, and consider using weed mats (3-foot-diameter sheets of specially designed woven or perforated plastic) around each new plant.

Installation of supertube on newly planted native seedling

Installation of weed mat

Installation of screen and collar protective hardware

Direct Seed Installation

Several riparian species are good candidates for direct seeding. These include large seeded species such as buckeye, native California black walnut, California bay laurel and the native oaks. Large seeds provide these species with a reserve of nutrients that can sustain them during the early phases of seedling development. Although some other seed producing species can be direct seeded under ideal conditions (including weed free environments with good soil moisture), it is generally not a successful technique. Additionally, many seeds are adapted to very specific conditions prior to germination, and may require treatment such as cold stratification or seed coat scarification. In order to ensure genetic diversity and maximize project success, seeds should be collected from several source plants.

Buckeye seed with developing root

Steps required for direct seeding:

- Collect the buckeye, bay, walnut or oak seeds when ripe (fall or winter, depending on the species). Ideally, seeds should be collected from the trees, rather than the ground in order to reduce damage from insects and bacteria. Seeds should come off easily. Check each seed for large numbers of insect holes or mechanical damage, and discard those that appear diseased or feel lighter than the others.
- Store seeds in a cool place until ready for out-planting. If seeds will be stored for more than a few days, they should be placed in plastic bags with perlite and refrigerated.
- Plant seeds in the winter, when soil moisture has reached a depth of 10 inches or more. Dig a shallow hole at each planting location, and cover seeds with one to two inches of soil. If seeds have begun to germinate, care should be taken to protect the tender new root. For buckeye, only one seed should be required, whereas for the other species you will want to install three to five seeds per planting spot. Once they have germinated, you can select the strongest seedling and clip the others with shears.
- If you choose to protect seedlings from deer browse, the techniques described on the following pages may be used.

Careful placement of buckeye seed

Cover seed with 1-2 inches of soil

Project Maintenance

Maintenance of native plant revegetation projects is critical to project success, and often requires an equal or greater expenditure of labor and resources than the installation phase. Maintenance usually includes weeding, watering and general monitoring.

Important maintenance tasks include:

- Regular hand weeding around individual plants during the height of growing season in spring and early summer, as well as one final weeding in the fall. In some cases, where tall weedy species like mustard, hemlock or fennel are present, the whole site may require mowing or mechanical weeding in order to ensure site access and reduce excess shading.

- Soil moisture should be checked on a regular basis during the first two to three growing seasons and plants evaluated for drought stress. The watering regime (whether hand irrigation or a drip system) should be scheduled according to plant needs, rather than an arbitrary schedule. Irrigation should include the minimum amount necessary to keep the plants healthy so they do not become dependent upon additional water. If the plants are appropriate to the location, and installed correctly at the right time of year, they should not require irrigation past year three. Watering should taper off as the plants mature.

- General monitoring should take place at each maintenance visit. Each plant should be checked for signs of disease, rodent or insect browse, and drought stress. Damaged plants should be replaced when possible. Encroachment by invasive species should also be monitored, and these species controlled before they take over the revegetation site.

Mechanical weeding of project site

Hand watering of individual plant

REGULATORY AGENCIES AND REQUIREMENTS

(excerpted from The Pierce's Disease/Riparian Habitat Workgroup, 2000
Riparian Vegetation Management for Pierce's Disease in North Coast California Vineyards)

Several federal, state, and local agencies have regulatory authority over work done in the riparian corridor and may need to be contacted for a revegetation project. It is the landowner's responsibility to be familiar with these agencies and notify them when a project is planned.

Different agencies may have jurisdiction over a project, depending on the character or extent of the project. Most revegetation projects will involve only the removal of specific non-native plants, and replanting of native plants. Such simple revegetation projects will require the least regulatory agency input. The one agency that will certainly require notification, even for a simple revegetation project, is the California Department of Fish and Game. In addition, the Regional Water Quality Control Board may need notification if the project would result in soil erosion, and/or runoff of pesticides into the stream (due to removal of a vegetative buffer).

Some revegetation projects may have a streambank stabilization component. If the stabilization involves re-contouring of the streambed and banks, the United States Army Corps of Engineers and NOAA Fisheries may need notification, in addition to the two agencies mentioned above. Streambank stabilization projects that use bio-technical approaches, such as live vegetation baffles and revetments, will have fewer negative impacts to natural resources and may need less regulatory agency involvement than projects with standard engineering and riprap. The use of standard engineering and riprap is generally discouraged in areas that contain threatened and endangered species, such as salmon and steelhead, because of the negative effects on habitat.

Formal agency notification typically involves completing a form that describes the project, often with a project design map and written description, and paying a fee. Talking to agency representatives about the project before this formal notification can save a significant amount of time. Most agencies encourage informal consultation in the early stages of project planning. The concerns of each party can be addressed, and potential roadblocks eliminated or reduced. In some cases, one agency may pass your project on for review by other agencies, but do not assume this will happen. The landowner and project manager is always responsible for informing all agencies. Many of these agencies charge fees to process the applications and permits. Call each agency for information and a current fee schedule.

Riparian revegetation project, Russian River watershed

Become familiar with the regulatory agencies described below. Even better, get to know the agency staff that work in your area and find out what their interests are, before designing your project (refer to Part VI, Project Planning and Organization).

Activity	**Agency to Contact**
Native plant revegetation	California Department of Fish and Game
Native plant bio-engineering	California Department of Fish and Game
Streambank stabilization (riprap, other structures)	United States Army Corps of Engineers California Department of Fish and Game
Earth moving & placement of fill	United State Army Corps of Engineers California Department of Fish and Game Regional Water Quality Control Board County Permit and Resource Management Dept. County Planning Department Natural Resources Conservation Service
Herbicide application	Agricultural Commissioners Office Regional Water Quality Control Board
Vegetation removal (native or non-native)	California Department of Fish and Game

Riparian corridor expansion project

Herbicide application

Table XI-1. Native Plants for Revegetation: Planting Location, Container Type and Spacing

The following plants are common in central and north coast watersheds and are recommended for use in riparian revegetation projects. Before choosing plants for a revegetation project, survey your area to determine the appropriate species, or consult with a native plant specialist. This table provides information about the typical location of riparian species, the revegetation approach (e.g., container, direct seed, dormant sprig or transplant) and general spacing suggestions.

COMMON NAME	LATIN NAME	PLANTING LOCATION	REVEGETATION APPROACH	SPACING feet-on-center	PAGE
BROADLEAF TREES					
Big Leaf Maple	*Acer macrophyllum*	floodplain	container	8 – 10’	A-1
Black Cottonwood	*Populus balsamifera* ssp. *trichocarpa*	channel	container, sprig	8 – 10’ 2 – 6’	A-2
Box Elder	*Acer negundo* var. *californicum*	floodplain	container	8 – 10’	A-3
California Bay Laurel	*Umbellularia californica*	floodplain	container	8 – 10’	A-4
California Buckeye	*Aesculus californica*	floodplain	container, direct seed	8 – 10’	A-5
Coast Live Oak	*Quercus agrifolia*	floodplain	container, direct seed	8 – 10’	A-6
Fremont Cottonwood	*Populus fremontii* ssp. *fremontii*	floodplain, channel	container, sprig	8 – 10’ 2 – 6’	A-7
Mountain Dogwood	*Cornus nuttallii*	channel	container	8 – 10’	A-8
No. CA Black Walnut	*Juglans californica* var. *hindsii*	floodplain	container	8 – 10’	A-9
Oregon Ash	*Fraxinus latifolia*	floodplain, channel	container	8 – 10’	A-10
Oregon Oak	*Quercus garryana* var. *garryana*	floodplain	container, direct seed	8 – 10’	A-11
Red Alder	*Alnus rubra*	floodplain, channel	container	8 – 10’	A-12
Sycamore	*Platanus racemosa*	floodplain	container	8 – 10’	A-13
Valley Oak	*Quercus lobata*	floodplain	container, direct seed	8 – 10’	A-14
Water Birch	*Betula occidentalis*	channel	container	8 – 10’	A-15
White Alder	*Alnus rhombifolia*	channel	container	8 – 10’	A-16
Willow	*Salix* spp.	channel, floodplain	container, sprig	8 – 10’ 2 – 6’	A-17
CONIFEROUS TREES					
California Nutmeg	*Torreya californica*	floodplain	container	8 – 10’	A-18
Coast Redwood	*Sequoia sempervirens*	floodplain	container	8 – 10’	A-19
Douglas Fir	*Pseudotsuga menzieii*	floodplain	container	8 – 10’	A-20
Pacific Yew	*Taxus brevifolia*	floodplain	container	8 – 10’	A-21
Western Hemlock	*Tsuga heterophylla*	floodplain	container	8 – 10’	A-22
SHRUBS AND SMALL TREES					
Blue Elderberry	*Sambucus mexicana*	floodplain	container	8 – 10’	A-23
California Blackberry	*Rubus ursinus*	floodplain	container	4 – 6’	A-24
California Hazelnut	*Corylus cornuta* var. *californica*	floodplain	container	4 – 6’	A-25
California Wild Rose	*Rosa californica*	floodplain	container	4 – 6’	A-26
Cascara	*Rhamnus purshiana*	floodplain	container	4 – 6’	A-27
Coffeeberry	*Rhamnus californica*	floodplain	container	4 – 6’	A-28

COMMON NAME	LATIN NAME	PLANTING LOCATION	REVEGETATION APPROACH	SPACING feet-on-center	PAGE
SHRUBS AND SMALL TREES					
Coltsfoot	*Petasites frigidus*	floodplain	container	4 – 6’	A-29
Creambush	*Holodiscus discolor*	floodplain	container	4 – 6’	A-30
Elk Clover	*Aralia californica*	floodplain	container	4 – 6’	A-31
Hawthorn	*Crataegus douglasii*	floodplain	container	4 – 6’	A-32
Mulefat	*Baccharis salicifolia*	floodplain	container	4 – 6’	A-33
Ninebark	*Physocarpus capitatus*	floodplain	container	4 – 6’	A-34
Osoberry	*Oemleria cerasiformis*	channel	container	4 – 6’	A-35
Pacific Wax Myrtle	*Myrica californica*	floodplain	container	4 – 6’	A-36
Red Elderberry	*Sambucus racemosa*	floodplain	container	8 – 10’	A-37
Red Flowering Currant	*Ribes sanguineum*	floodplain	container	4 – 6’	A-38
Red Twig Dogwood	*Cornus glabrata*	floodplain	container	4 – 6’	A-39
Salmonberry	*Rubus spectabilis*	floodplain	container	4 – 6’	A-40
Snowberry	*Symphoricarpos albus*	floodplain	container	4 – 6’	A-41
Spiraea	*Spiraea douglasii*	floodplain	container	4 – 6’	A-42
Stink Currant	*Ribes bracteosum*	floodplain	container	4 – 6’	A-43
Stream Dogwood	*Cornus sericea*	channel	container	4 – 6’	A-44
Thimbleberry	*Rubus parviflorus*	channel	container	4 – 6’	A-45
Toyon	*Heteromeles arbutifolia*	floodplain	container	4 – 6’	A-46
Twinberry	*Lonicera involucrata*	floodplain	container	4 – 6’	A-47
Vine Maple	*Acer circinatum*	floodplain	container	4 – 6’	A-48
Western Azalea	*Rhododendron occidentale*	floodplain	container	4 – 6’	A-49
Western Spicebush	*Calycanthus occidentalis*	floodplain	container	4 – 6’	A-50
Wild Mock Orange	*Philadelphus lewisii*	floodplain	container	4 – 6’	A-51
VINES					
California Wild Grape	*Vitis californica*	floodplain	container	4 – 6’	A-52
Dutchman's Pipevine	*Aristolochia californica*	floodplain	container	4 – 6’	A-53
Honeysuckle	*Lonicera hispidula* var. *vacillans*	floodplain	container	4 – 6’	A-54
Manroot	*Marah fabaceus*	floodplain	container	4 – 6’	A-55
Poison Oak	*Toxicodendron diversilobum*	floodplain	container	4 – 6’	A-56
Virgin’s Bower	*Clematis lasiantha*	floodplain	container	4 – 6’	A-57
EMERGENT AND HERBACEOUS PLANTS					
Bulrush	*Scirpus acutus* var. *occidentalis*	channel	container, transplant	1 – 2’	A-58
Cattail	*Typha latifolia*	channel	container, transplant	1 – 2’	A-59
Creeping Wild Rye	*Leymus triticoides*	floodplain	container, transplant	1 – 2’	A-60
Horsetail	*Equisetum* spp.	floodplain, channel	container, transplant	1 – 2’	A-61
Indian Rhubarb	*Darmera peltata*	channel	container, transplant	1 – 2’	A-62
Mugwort	*Artemesia douglasii*	floodplain, channel	container, transplant	1 – 2’	A-63
Rush	*Juncus* spp.	floodplain, channel	container, transplant	1 – 2’	A-64
Sedge	*Carex* spp.	floodplain, channel	container, transplant	1 – 2’	A-65
Spike rush	*Eleocharis* spp.	channel	container, transplant	1 – 2’	A-66
Stinging Nettle	*Urtica dioica*	floodplain, channel	container, transplant	1 – 2’	A-67

GLOSSARY

Achene: Dry, one-seeded fruit that often looks like a seed. Produced in a one-chambered ovary. Does not open to release the seed.

Allelopathic: Plant produces and releases a toxic substance that results in suppressed growth in other plant species.

Alternate: Describes growth pattern in which new structures develop singularly along axis. For leaves, only one leaf is produced per node so leaves appear to have "alternated" the side of the stem from which they grew (see opposite).

Annual: Plant completes entire life cycle, from germination to seed production and death, in one year or growing cycle (see biannual, perennial).

Asexual: Reproduction by a single individual using a process that is not sexual and does not involve the union of individual cells and the reassortment of genetic characteristics.

Biennial: Plant completes entire life cycle, from germination to seed production and death, in two years or growing cycles. Usually flowers are produced only during the second cycle (see annual, perennial).

Bisexual: Flowers have both female and male fertile reproductive structures (see unisexual, dioecious, monoecious).

Bract: A leaf-like or scale-like structure associated with and usually directly under a flower or cone.

Capsule: Dry, pod-like fruit with fused or partially fused chambers. When ripe, the fruit splits to release multiple seeds.

Catkin: An unbranched inflorescence of closely attached flowers. Flower petals and sepals are inconspicuous or absent but bracts can be showy. Flowers are all the same sex on each catkin.

Compound: Composed of two or more parts or repeating a structural pattern.

Deciduous: Leaves fall off naturally at the end of each growing season and re-grow after a period of leaf-less dormancy (see evergreen).

Dioecious: Male and female flowers produced on separate plants. Each plant produces either male or female unisexual flowers (see monoecious and bisexual).

Elliptic (al): Shaped like a flattened circle, widest at center and tapering almost equally at both ends.

Evergreen: Leaves remain green and on the plant throughout the year, and do not shed en-mass at the end of the growing season (see deciduous).

Gall: An abnormal outgrowth in plant tissue caused by certain parasitic insects, fungi, bacteria, or mechanical injury.

Inflorescence: A cluster of flowers and associated structures such as bracts, petioles and stems (does not include full sized foliage leaves).

Lanceolate: Lance shaped, width widest along lower half and tapers to a point at the tip.

Monoecious: Plant produces both male and female unisexual flowers (see dioecious and bisexual).

Oblong: Longer than wide, with almost parallel sides and rounded corners at each end.

Opposite: Describes a growth pattern in which new structures develop directly across from one another. In leaves, two leaves will grow per node on opposite sides of the stem (see alternate).

Ovate: Egg shaped, widest below middle, tip round or pointed.

Palmate: Radiating from a common point, similar to fingers from the palm of a hand.

Perennial: Plants live more than two years or growing cycles. For this text, description applies to plants that are non-woody above ground and also describes species that lose all above ground structures during dormancy and re-grow from roots (see annual, biannual).

Petiole: Slender stem that supports the leaf, i.e. the leaf stalk.

Pistil: Female reproductive structure of the flower. At the base is the ovary with one or more ascending stalk-like structures (styles) supporting the pollen receiving structure, the stigma (see stamen).

Sepal: Outer most structure of the flower. Similar to petals but usually green.

Stamen: Male reproductive structure of the flower. A stalk like structure (filament) with a pollen-producing anther at the tip (see pistil).

Stigma: Pollen receiving structure of the pistil. Usually located near the flower center, elevated above the ovary. The stigma is often sticky or hairy and sometimes lobed.

Terminal: At the end or tip of a structure.

Unisexual: Flowers that have either male or female fertile reproductive structures but not both (see bisexual, dioecious, monoecious).

BIBLIOGRAPHY

Recommended publications for further information on riparian habitat and restoration:

Best, Catherine, J.T. Howell, Walter and Irja Knight, and Mary Wells. 1996. *A Flora of Sonoma County*. California Native Plant Society Press, Sacramento, California.

Burridge, Betty. 1995. *Sonoma County Breeding Bird Atlas - Detailed maps and accounts for our nesting birds*.

Circuit Rider Productions, Inc. 1989. *Acorn to Oak: A Guide to Planting and Establishing Native Oaks,* Circuit Rider Productions, Inc., 9619 Old Redwood Highway, Windsor, California 95492.

Circuit Rider Productions, Inc. 1999. *The Cavity Nesting Bird Education and Enhancement Project.* Circuit Rider Productions, Inc., 9619 Old Redwood Highway, Windsor, California 95492.

Chestnut, V.K. 1974. *Plants Used by the Indians of Mendocino County, California.* Mendocino County Historical Society, Publication Headquarters, 243 West Bush Street, Fort Bragg, California, 95437.

Faber, Phyllis M. and Robert F. Holland. 1982. *Common Riparian Plants of California: A Field Guide for the Layman*. Pickleweed Press, 212 Del Casa, Mill Valley, California, 94941.

Goodrich, Jennie, Claudia Lawson, Vana Lawson and Parrish Lawson. 1980. *Kashaya Pomo Plants.* Heyday Books, Berkeley, California.

Hickman, James C., ed. 1993. *The Jepson Manual: Higher Plants of California*. University of California Press, Berkeley and Los Angeles, California.

Marcus, Laurel and Dennis Jackson. 1998. *Watershed Stewardship - Creating a Watershed Atlas and Monitoring Program.* Sotoyome Resource Conservation District, Santa Rosa, California.

Martin, Alexander C., Herbert S. Zim and L. Nelson Arnold. 1961. *American Wildlife & Plants: A Guide to Wildlife Food Habits.* Dover Publications, Inc., 180 Varick Street, New York, New York, 10014.

McMinn, Howard E. 1974. *An Illustrated Manual of California Shrubs.* University of California Press, Berkeley and Los Angeles, California.

Ornduff, Robert. 1974. *Introduction to California Plant Life.* University of California Plant Life. University of California Press, Berkeley and Los Angeles, California.

Schmidt, Marjorie G. 1980. *Growing California Native Plants.* University of California Press, Berkeley, California 94720.

Smith, Gladys L. and Clare R. Wheeler. 1992. *A Flora of the Vascular Plants of Mendocino County, California.* The University of San Francisco, San Francisco, California.

The Pierce's Disease/Riparian Habitat Workgroup, 2000. *Riparian Vegetation Management for Pierce's Disease in North Coast California Vineyards.* Circuit Rider Productions, Inc., 9619 Old Redwood Highway, Windsor, California 95492.

Warner, Richard E. and Kathleen M. Hendrix. 1984. *California Riparian Systems - Ecology, Conservation, and Productive Management*. University of California Press, Berkeley and Los Angeles, California.