Hedgerows for California Agriculture

A Resource Guide

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1) Increase the knowledge of agricultural professionals about hedgerows as a system component that can help reduce pesticide use, increase on-farm biodiversity and on-farm habitat for beneficial organisms and wildlife, reduce wind and water erosion of soil, beautify the environment, and diversify farm products.

2) Extend the use of hedgerows as conservation and management tools to areas of California where they are not common.

3) Create a hedgerow resource base for farmers and agricultural professionals that can be easily utilized throughout the state.

Cover photo: *Wild rose, toyon, and redbud on Hedgerow Farms, Winters*
Title page photos: *L – Hedgerow in Salinas Valley. R – Seven-year-old hedgerow, Phil Foster Ranches, San Juan Bautista*

Contents

Hedgerow of mixed native shrubs.

Photo: Jack Kenny Clark

Wasp parasitizing pest larva.

Giant Buckwheat with large flowerheads.

Prostrate Coyote Brush.

Hedgerows and Farmscaping

Introduction

Hedgerows, windbreaks, filter strips and other habitat plantings are increasingly being used in modern agricultural systems. Hedgerows have been planted in farming and rural situations for thousands of years. Fields were enclosed as early as the Bronze Age (3000 B.C.–1000 B.C.), and references to hedgerows exist back to 547 A.D. in Great Britain. Ancient hedgerows were used to confine livestock, define property lines, shelter farmland and dwellings from wind, provide food, medicine and fodder (game animals, fruit, nuts, herbs, acorns), and supply structural and fuel

Perennial grass (Creeping Wildrye) next to hedgerow.

wood. The reorganization and industrialization of farmland in Great Britain led to the removal of approximately 200,000 miles of hedgerows between 1947 and 1993, and their reduction continues into the present. However, research into the positive resource qualities of hedgerows for agriculture, wildlife and rural culture has brought attention to their value.

In the 1970s and 1980s the International Tree Crops Institute USA promoted multi-purpose hedgerows, and Bill Crepps and Robert L. Bugg researched hedgerows at the University of California Davis, developing lists of insectary plants. John Anderson began installing multi-species native hedgerows in 1978 at Hedgerow Farms in Winters, California. The Natural Resources Conservation Service (NRCS), Resource Conservation Districts (RCD's), and organizations like CAFF have been active in conservation plantings, and many hedgerows have been planted on farms in California. Windbreaks have been encouraged and used for climate modification and other conservation objectives in the U.S. since the 1930s. Filter strips and grassed waterways are effectively controlling runoff and non-point source pollution from entering waterways.

This resource guide focuses primarily on hedgerows, although there is some overlap, such as with the use of large shrubs or trees to provide windbreak effects, or with the use of grasses and understory plants in hedges to give additional cover and increase control of runoff. Much research is being conducted in many countries into diverse aspects of the functioning of farmscape systems, some of which is summarized in Appendix D of this resource guide.

Definitions

Hedgerows are defined as lines or groups of trees, shrubs, perennial forbs, and grasses that are planted along roadways, fences, field edges or other non-cropped areas. The word "hedge," from the Old English word "hegg," referred to an enclosure or boundary formed by closely growing bushes or by dead plant material.

Windbreaks are barriers usually consisting of trees or shrubs that are used to reduce and redirect wind, resulting in microclimate changes in the sheltered zone.

Filter strips are planted areas that use vegetation to control soil erosion, slow water runoff, and capture and prevent sediments and nutrients from entering waterways.

Farmscaping is the management of vegetation on and around the farm, to include plantings on roadways, field margins, waterways, natural areas and generally non-cropped areas. The term "farmscaping" can cover a wide range of practices, such as grassed waterways, buffers, filter strips and cover crops, as well as hedgerows and windbreaks.

Hedgerows bring diversity to agricultural landscapes.

Benefits of Hedgerows

Hedgerows can have multiple functions: they can serve as habitat for beneficial insects, pollinators and other wildlife; provide erosion protection and weed control; serve as windbreaks; stabilize waterways; reduce non-point source water pollution and groundwater pollution; increase surface water infiltration; buffer pesticide drift, noise, odors and dust; act as living fences and boundary lines; increase biodiversity; and provide an aesthetic resource. Diversity in hedgerow species, especially when using natives, assures a range of attributes, such as multiple kinds of insects and wildlife attracted, positive effects to soil and water resources, and success of individual plants under site-specific climatic and other environmental conditions. These plantings can bring diversity and beauty to the farm, and most growers use plants that they individually like, reporting that they are pleased with the benefits farmscaping brings to their farms.

Insects: Predators, Parasites and Pests

Hedgerows have habitat value for beneficial insects by providing nectar and pollen, alternate hosts and prey, shelter during winter cold and summer heat, wind protection, and nesting sites. Among the beneficial insects attracted to many commonly used hedgerow plants are bigeyed bugs, syrphid flies, lady beetles, minute pirate bugs, green and brown lacewings, parasitic and predatory wasps, tachinid flies and spiders. Some of the many pest insects who fall prey to the above-listed beneficials are aphids, mealy bugs, leaf hoppers, scales, mites, whiteflies, lygus bugs, thrips, squash bugs, stink bugs, codling moths, corn earworms and other caterpillars.

Sweet Alyssum as in-field insectary.

Photo: Jack Kelly Clark

Green Lacewing, a predator of pest insects.

While some research has been done worldwide on insect relations with specific plants, much more is needed to test the effectiveness of hedgerows in providing pest control in various agricultural situations. A technique known as interplanting for luring beneficial insects into crop production areas is also being researched. Examples of this interplanting include the planting of alfalfa or sweet alyssum strips within fields, and the planting of individual annual insectary plants, such as dill, coriander and toothpick ammi, among crops. Care should be taken with the use of these annuals, however, since some, such as sweet alyssum and toothpick ammi, can become invasive and problematic weeds.

Many hedgerow plants have large flower heads with multiple flowers, to provide plentiful pollen and nectar as well as wide landing pads for the beneficials. Buckwheat and yarrow are

Known Pollen and Nectar Sources for Beneficial Insects

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Willow spp.	■	■	■	■	■							
Ceanothus spp.		■	■	■	■	■	■	■				
Yarrow			■	■	■	■	■					
Elderberry			■	■	■	■	■	■	■			
Coffeeberry				■	■	■	■					
Hollyleaf Cherry				■	■							
Toyon					■	■	■					
Buckwheat spp.					■	■	■	■	■	■	■	■
Deergrass					■	■	■	■	■			
Saltbush, Fourwing					■	■	■	■				
Milkweed					■	■	■	■	■	■		
Goldenrod							■	■	■	■	■	
Coyote Brush	■							■	■	■	■	■

examples of plants with this type of floral structure. Planting several types of shrubs can provide a year-round flowering sequence. For example, ceanothus blooms from February through August; buckwheat, toyon and yarrow flower in the summer; and coyote brush blooms from August through January. With such an array of flowering plants, a 12-month supply of pollen and nectar is available. Pest control with beneficial insects can be more effective when managers evaluate the flowering times of certain species as they relate to the insects using those species, and determine when additional food is needed for the beneficials of interest.

Flowering hedgerows provide nectar and pollen as well as cover and habitat for insects.

Besides being used as pollen and nectar sources, plants can be visited by beneficial insects to find insect hosts or prey, to secure cover, to feed on plant sap or to use vegetation as oviposition sites for reproduction. Habitat plantings provide both nectar and pollen sources and natural enemy/plant associations.

Photo: Jack Kelly Clark

Syrphid fly, a pollinator and predatory insect.

Pollinator Plants

Flowering plants attract many kinds of insects including pollinators, which are economically important for farmers. Bees, butterflies, flies, beetles and others pollinate 75 percent of food

crops. Including plants in hedgerows that provide habitat for pollinators has the potential for increasing the effectiveness of pollination on nearby fields and can build up a reservoir of insects that work for the farm. Hedgerows serve as protection for sensitive insects from pesticide drift and also provide potential nest sites for native bees. Most bees travel less than 500 yards from their nests, so the creation of habitat can attract and keep bees near the crop.

Erosion Protection and Runoff Control

Hedgerows and other farmscape plantings, such as filter strips, can help control erosion and water runoff and will reduce the amount of nutrients, pesticides and sediments that are flowing from agricultural land to waterways. Plantings of shrubs and grasses can slow runoff, increase surface water infiltration by improving soil structure around the root zone, arrest sediment movement, assist with infiltration and assimilation of plant nutrients, and cool water on small watercourses by shading.

Erosion ditch before revegetation.

Same area with grasses and yarrow.

Regional Water Quality Control Boards in California are requiring farmers to meet new water quality regulations. In the Central Valley and Central Coast regions, all irrigated agricultural operations with runoff containing sediments and nutrients have to apply for a Waiver of Waste Discharge Requirements. As part of the waiver, farmers must meet certain water quality conditions, some of which can be met with vegetated plantings that help filter and reduce water runoff. More information on the agricultural waiver process is on local Regional Water Quality Control Board Web sites, which can be located on the State Water Resources Control Board Web site www.swrcb.ca.gov/regions.html.

Perennial grasses along roadway in Salinas Valley.

Weed Replacement

Hedgerows and other vegetative plantings can effectively replace invasive annuals in non-cropped areas. Over time, as the plantings develop in size and root structure, perennials outcompete annual weeds for light, water, air and soil. Any planting requires management of unwanted weedy growth, and attention to weed control in farmscape plantings is required, particularly during establishment. The replacement of unsightly and costly weedy areas with multi-

functional perennial vegetation can help achieve this farm management goal.

Coast redwood, incense cedar, soapbark tree and giant sequoia as windbreak in San Juan Bautista.

Windbreaks

Hedgerows can modify winds with plants of various heights. Windbreaks help control wind erosion, reduce the drying effects of wind on soil and plants, help protect young seedlings and crops, provide increased yields, and shelter buildings and living areas. Windbreaks also offer valuable cover and nesting sites for birds and other wildlife. Tall, medium-tall, dense, and low-growing evergreen trees can be used singly, together, or in combination with shrubs.

Historical use of tree species for windbreaks has included: blue gum (*Eucalyptus globulus*), athel (*Tamarix aphylla*), Arizona cypress (*Cupressus glabra*), Monterey cypress (*Cupressus macrocarpa*), Monterey pine (*Pinus radiata*), beefwood (*Casuarina spp.*) and Lombardy poplar (*Populus nigra* 'Italica'). Windbreaks of blue gum have been used in the Salinas Valley since the late 1880s, as documented by John Steinbeck in East of Eden. Blue gum, however, can be extremely invasive, displacing the diversity of native habitat and having negative characteristics for California wildlife, such as diminishing breeding sites for ground- and shrub-nesting songbirds.

Some windbreaks use native trees such as coast redwood, incense cedar and giant sequoia. Other non-native evergreen trees, such as pepper tree, strawberry tree, myoporum, evergreen euonymous and soapbark tree also make effective components of windbreaks. More information on windbreak designs can be found at local NRCS offices and on the NRCS Web site.

Economic Returns

The inclusion of plants in hedgerows and windbreaks that bring income to the farm can broaden the scope and appeal of farmscaping. Pomegranate, persimmon, mulberry, citrus, pineapple guava, rosemary, oregano, lavender, sage, thyme, lemon verbena, and a wide variety of other

Pomegranate hedge, with sweet alyssum in-field insectary in foreground.

medicinal and culinary herbs are a few of the potential crop species that can be considered. Ornamental plants for cut flowers and foliage, and trees for structural and fuel wood, are additional options.

When hedgerows or grassed waterways reach a point of growth when they are smothering weeds, some savings may be realized by the elimination of weeding or herbicide costs. The increase of resident beneficial insects in hedgerows has the potential to lead to a reduction in pest management costs by lowering the need to purchase beneficial insects or pest

Logo for Salmon-Safe, an eco-label.

control materials. Habitat plantings that minimize or stop soil erosion save farmers money spent in disposing of or hauling back onto the farm soil that has moved. Soil fertility that is maintained by the prevention of soil loss is also an economic benefit of conservation plantings. Regulatory actions and associated fees, as well as the possibility of conflicts with neighbors, may also be reduced or eliminated by the control of soil erosion.

A potential exists for leveraging habitat plantings for marketing programs utilizing eco-labels that promote a farm's stewardship and biodiversity values. Some programs such as Salmon-Safe are already functioning, to encourage consumers to purchase products associated with farms protecting water resources. Habitat plantings wider and larger than single rows can encourage more diversity of birds and wildlife, and can become an income-generating attraction for regional eco-tourism activities.

Barriers

Hedgerows can reduce impacts from potential pesticide drift, dust and noise arising from farm operations. Vegetation as a barrier is more permeable to wildlife than solid or wire fencing. Organic farms must have a distinct buffer zone between certified ground and neighboring conventionally farmed ground. Hedgerow plantings are an ideal way to provide a buffer zone that is more effective as a barrier to drift than a non-cropped or bare area.

Tall dense hedges filter dust and pollutants.

Air Quality

Windblown dust particles, as well as contaminants on these particles, can contribute to air quality problems. Hedgerows and windbreaks can modify wind patterns to trap and reduce the mobilization of dust. The San Joaquin Valley Air Pollution Control District has a regional program called Conservation Management Practice Program to reduce air pollutant emissions from agricultural sources, with farming techniques referred to as Conservation Management Practices (CMPs). Information about this program can be found on the Web site www.valleyair.org.

Shrubs and grasses extend habitat for wildlife.

On farms and in areas where wind can create air pollution problems, vegetation of varying heights can be planted to help reduce wind speeds and thereby decrease the amount of windblown dust that comes from unpaved roads, equipment yards and farm fields. Vegetation planted around confined animal facilities can reduce wind velocity, provide a visual barrier, lessen windblown objects such as feathers, and reduce odors.

Wildlife Habitat Creation

Some farmers and landowners are increasingly interested in creating habitat that can attract wildlife. Ponds, wetlands and developed vegetative plantings in natural areas of the farm can

Photo: Keith Abeles

Young native plants, with protective sleeves, will connect wildlife areas in riparian zone.

address the needs of various fish and wildlife species. These areas can be established with the assistance of qualified biologists and broaden the scope of hedgerow plantings. Several large vineyards in California are working on these types of habitat creation.

Introducing or removing vegetation that may attract rare and endangered species without instituting certain measures could cause problems for landowners. For example, removal of elderberry in some counties requires replanting of replacement plants in other locations and monitoring these new plants for the protected valley longhorn elderberry beetle for 10 years. New habitat plantings that could attract rare and endangered species may also be a concern to growers. Planting a hedgerow will not create rare and endangered species habitat unless all of the ecological needs of the species are met. The Safe Harbor concept, developed by the U.S. Fish and Wildlife Service (USFWS), offers agreements that provide a way for farmers to restore and maintain habitat for endangered species without fear of incurring additional regulatory restrictions. Contact USFWS or Environmental Defense for information on Safe Harbor agreements.

Creative farmscaping can provide opportunities for integrating wildlife needs with farming and ranching. On the landscape level, a wider variety of wildlife species may be accommodated by linking farms and ranches into wildway corridors, so that connectivity is created on local and regional levels. Connecting hedgerows to riparian zones, ponds, ditches, forests, chaparral,

This pond attracted a river otter.

With input from local biologists, ponds can create habitat for wildlife.

grasslands and woodlots provides more habitat opportunities for wildlife. In general, the wider the linkage, the better for wildlife. Restoring natural areas such as wetlands or grasslands with native plants adds wildlife values to the farm and provides ecosystem services, such as erosion control, groundwater recharge, and habitat for beneficial insects and pollinators. Lady beetle clusters on trees and shrubs in wildlands and the

Grasses and sedges control erosion along Yolo County road.

large diversity of predatory wasps found in some riverine habitat are examples of ecosystem services provided by natural areas. To address the issue of fragmentation and habitat loss, NRCS has produced a Conservation Corridor Handbook (1999) that contains a wide range of practices to improve habitat and enhance landscape functions.

Native Grasses, Sedges and Rushes

Native perennial grasses, sedges and rushes can be used effectively in hedgerow plantings as understory plants either by themselves or with other low-growing forbs. These plants are drought tolerant, can help stabilize the soil, keep out annual weeds, provide cover for beneficial insects, reduce erosion, improve water infiltration, provide wildlife habitat, and filter out sediments and nutrients. The types of plants selected

Native grasses grown for seed at Rana Creek, Carmel Valley.

will depend on location, soil type and moisture conditions expected throughout the year. Sedges and rushes generally grow best in moist areas, although there are some exceptions. Some native grasses spread through rhizomes, while others grow as tufted bunchgrasses. Creeping wildrye, which grows throughout California, forms dense, solid stands of vibrant grass and is very effective in stabilizing waterways, trapping sediments, and outcompeting annual weeds.

Rushes stabilize bank edges.

Planning and Planting a Hedgerow

Whole Farm Planning

Farm planning is essential for the production of commercial crops and can help with the efficient implementation of hedgerows and other conservation practices. A whole farm plan, including a conservation plan, can begin with a Site Inventory Checklist, that describes with maps and aerial photos the following components: regional setting; land use; topography; hydrology and drainage; soils; vegetation; wildlife; climate and microclimate; existing and planned buildings and structures; crop production areas; non-cropped areas; views; spaces and senses; activities and circulation; utilities; historical and archaeological resources; legal regulations; off-site factors; and neighbors. Hedgerows or other farmscaping projects can be planned by analyzing and coordinating a proposed project with the above-listed components of a Site Inventory Checklist.

Farmscaping with native plants provides a way to help accomplish whole farm goals, such as pest and weed control, soil erosion reduction, climate modification, wildlife habitat enhancement, and increase in biodiversity. Farmscape planting, whether a hedgerow, windbreak or grassed waterway, is a distinct farming operation and needs to be managed during the period of establishment as a separate crop.

Fence line: an ideal location for a hedgerow.

Site Selection and Evaluation

Many factors can determine the selection and evaluation of a site for a hedgerow. Frequently, growers have one or more areas where they would like to put plants, replace weeds, create habitat, attract beneficial insects, protect from wind, control runoff, or beautify a site. The first step is to identify non-cropped areas of the farm

Short varieties planted on berms can smother weeds, stabilize soil and provide habitat for beneficial insects.

that would be suitable for the planting of vegetation. The most common sites are along roads and fences, areas that usually have some existing vegetation such as annual weeds that need to be managed. Some areas will automatically be eliminated from consideration because they lack access to water or equipment, or may conflict with crop production areas. Areas that regularly flood may be suitable for durable riparian species, such as willows, rushes or sedges. Other major factors limiting site selection could be topographical (steep slope), hydrological (drainage problems), or cultural (adjacent land uses).

Site Analysis

Once a site has been selected, several parameters need to be thoroughly analyzed. The analysis of the proposed hedgerow site describes the

location, such as along a fence, a road, near buildings or driveways, next to a river or stream, or proximity to cropland and the types of crops grown. If the site is on the edge of the property, the boundary or property line may require surveying. The site can be on the edge of, but not be too close to, the production area of the cropped field or to neighboring property. The length and width of the area should be measured. Normally, a minimum planting space from 10-to-15 feet in width is optimal for shrubs and trees, although grasses and smaller plants can be installed in narrower sites.

Photo: Russ Hill

When mature, this hedge will protect the orchard and attract beneficials.

Identifying the local and regional ecosystem in which the farm exists helps to determine which plants are suitable, will grow well, and can support the widest variety of wildlife. Some plants seem to thrive over a wide variety of climates and soil types, yet knowing the ecology of the specific area is very helpful in making successful plant choices. The overall climate of the area, specifically the timing and amount of precipitation and the range of seasonal temperatures, is important information for predicting the requirements of the proposed planting. Determining the characteristics of the soils of the site, whether they are heavy, medium or light, is necessary for establishing and maintaining a successful planting. Understanding the hydrology of the area is essential, so that potential flooding, low and high spots, and overall drainage and runoff patterns are considered.

An irrigation system that will function for two or three years is critical for the establishment and survival of a hedgerow, if native plants are used. Whether the system is drip or tubing with emitters, sprinkler, flood or furrow, water truck or garden hose, some water is vital to get the plants through their first two or three hot, dry California summers. Plants that look fine in April may be dried up and dead by September without water. It is also important to make sure that the irrigation system is in place before the hedgerow is planted. Not only can the system be used for the essential pre-irrigation of the site, it can also provide the critical watering that newly planted plants require immediately.

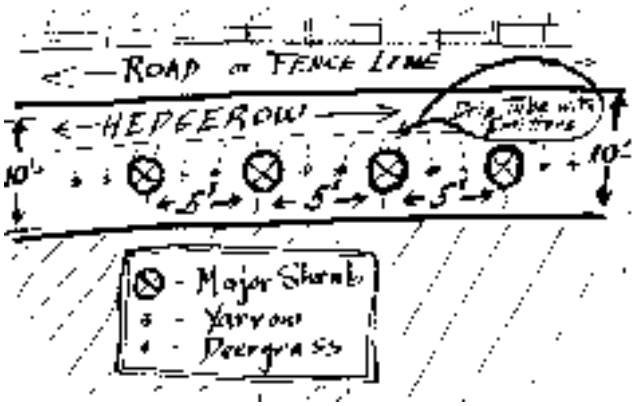
The height of the proposed hedgerow depends on its purpose and location. Commonly planted hedgerow shrubs are available in short, medium and tall forms, so a planting can be adapted to diverse situations. Smaller shrubs, forbs and grasses can be interplanted between the major plants. A tall planting that could include trees would be called for where protection from wind was desired. Where shade, overhead wires or traffic visibility could be a problem, shorter plants would be appropriate. Berms or drop-offs in the middle of cropped areas are common, and these sites are well suited for prostrate and spreading shrubs, forbs and grasses. Issues with neighboring land uses, such as potential shading or lateral spread, could also affect plant choices for the site.

Critical pre-irrigation with drip system.

Deer and rodents can destroy a planting or cause problems for adjacent crops. Plant selection and

plant protection can be evaluated on sites where animal pressure could be a problem.

Other site considerations would be access for equipment, off-site factors such as runoff from adjacent areas, and location of trees, fences, roadways, or other existing features that could be incorporated into the hedgerow.



Sample layout for hedgerow with drip-emitter system.

Planning and Design

With the site analysis completed, planning and design of the hedgerow can take place. Design can be complex or simple, with elaborate landscape-type drawings or basic sketches of the planned planting. Hedgerow design involves placing major shrubs or trees at a certain spacing with smaller shrubs, forbs or grasses in between. Plans for the irrigation system should be included in the design layout.

Plant Selection

Developing the plant list is an important step, as decisions on the size of the plants and their suitability to the environment, whether riparian, chaparral or irrigated cropland, need to be made. Some plants, such as ceanothus, coyote brush, coffeeberry and buckwheat, have short and tall varieties.

California contains a wide array of genetically distinct populations of native plant species. Growers are encouraged to use plants in hedgerows that naturally occur in local ecosystems. Many areas have nurseries that carry local plant stock, which some people feel is important because of the possibility of non-local natives hybridizing with resident native vegetation and reducing the purity of local genetic material. Others believe that at this point in history, much of the landscape has been degraded and any increase in biodiversity with the use of native plants can be beneficial. Local biologists should be consulted regarding the selection of appropriate non-native, non-invasive species to avoid impacting indigenous resources.

Some situations exist where non-native plants are desirable for hedgerows because of their beneficial insect-attracting potential or their possible economic return to the farm. Examples of these include the soapbark tree, citrus, pomegranate, rosemary and lavender.

Numerous resource materials are available that provide specific information about local ecosystems, and resource managers are encouraged to be familiar with these resources and with the basic components of local plant communities.

Hedgerow shrubs in economical nursery containers.

Organizations such as the Natural Resources Conservation Service (NRCS), California Native Plant Society and California Native Grass Association can provide specific recommendations and also help locate local nurseries that offer native plants. Botanical gardens and their staff are excellent sources of information and inspiration for selection of suitable plant species for

specific areas. Some of California botanical gardens are listed in Apppendix F.

The geography and climate of California are such that many plants used in hedgerows grow over a wide range of situations. Shrubs such as coyote brush, toyon, coffeeberry and ceanothus can be grown from northern to southern California, from the coast to the foothills of the Sierras. Furthermore, many plants are able to thrive outside their naturally occurring distributions. For example, the fog-loving coast redwood prospers in Bakersfield, Hollister and other hot inland areas. Many native grasses, such as creeping wildrye and red fescue, can be grown throughout the state.

Basic Hedgerow Plant List

Buckwheat spp.	*Eriogonum* spp.	Medium shrub
Ceanothus spp.	*Ceanothus* spp.	Major shrub
Coffeeberry	*Rhamnus californica*	Major shrub
Coyote Brush	*Baccharis pilularis*	Major shrub
Deergrass	*Muhlenbergia rigens*	In between shrubs
Quailbush/Saltbush	*Atriplex lentiformis*	Major shrub
Toyon	*Heteromeles arbutifolia*	Major shrub
Yarrow	*Achillea millefolium*	In between shrubs

Quailbush/Saltbush, shown here in the southern San Joaquin Valley, can be planted in hedgerows throughout the state.

Plants should be selected to match soil and hydrologic characteristics of the site. Water and soil conditions have been major issues on how well a hedgerow survives and thrives. Plant tolerances, potential future irrigation, possible flooding and crop changes need to be considered. Flammability, height and shading issues, and potential to become invasive on adjoining lands are other considerations. Hardy, long-lived species such as oaks are suitable for various situations.

Desired density and spacing will determine the number and sizes of plants to be chosen. Major shrubs can be spaced at four-to-five feet apart for dense hedges, and from six-to-eight feet apart for less density. In all hedges, one or two smaller plants can be planted between larger ones. Grasses and forbs can be added as the lower stratum in the hedgerow and can cover the soil, reduce weeds, and provide overwintering habitat for beneficial insects. The use of plants that spread, such as hedge nettle, goldenrod, aster, heliotrope, clematis, yarrow, creeping wildrye and others, may allow for wider spacing of larger shrubs. Trees can be spaced at 10 feet apart. Native grasses can be planted as either plugs or established from seed.

California buckwheat has multiple flower heads.

Hedgerow and vegetated berm in Salinas Valley.

Budget, Costs and Cost-Share

Once a draft plant list has been prepared, a budget can be developed including costs of planning, site preparation, irrigation system installation, soil amendments and mulch, plants, installation, and subsequent maintenance (irrigation, weeding, replanting and rodent control) over several years.

Generally, costs for establishing a hedgerow can range from $1–$4 per linear foot. Most one-gallon plants can be acquired for about $4, and smaller pots and treebands can be bought for about $1–$2. The more plants initially installed, the more quickly the ground will be covered, thereby reducing weed management costs. The use of spreading understory plants will also reduce future weeding costs.

Cost estimates for installation and maintenance can be found in *Bring Farm Edges Back to Life!,* on the Web site www.centralcoastwilds.com, and in *UCCE Central Coast Conservation Practices Estimated Costs and Potential Benefits for a Perennial Hedgerow Planting,* available on the Web site http://cesantacruz.ucdavis.edu.

There are many programs to help farmers and landowners pay for stewardship and habitat projects, including the installation of hedgerows, windbreaks and grassed waterways. Well-known programs include the Environmental Quality Incentives Program (EQIP) and the Wildlife Habitat Incentives Program (WHIP), administered by USDA NRCS; the Continuous Sign-up Conservation Reserve Program (CRP) managed by the USDA Farm Services Agency; and the Partners for Fish and Wildlife Program, administered by the US Fish and Wildlife Service.

A table listing many sources for cost-share programs is presented in *Bring Farm Edges Back to Life!* handbook, which also refers the reader to the Web site www.ceres.ca.gov/foreststeward/html/financial.html, where detailed information on cost share programs can be found in the document *Cost Share and Assistance Programs for Individual California Landowners and Indian Tribes*. Other financial assistance programs can be found on the NRCS websites www.ca.nrcs.usda.gov and www.nrcs.usda.gov/feature/buffers/pdf/BufferBr.pdf.

Many farmers pay for hedgerows out of their operating expenditures. Organizations such as CAFF and the Resource Conservation Districts occasionally receive funding from foundations and entities that covers some or all of the costs of hedgerow and habitat installation and maintenance.

Nursery Contact

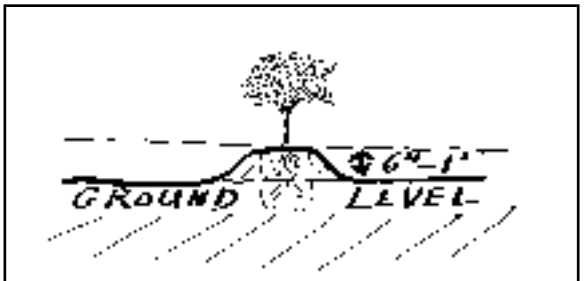
Once a final budget and funding sources for the project are in place, nurseries can be contacted to get prices and availabilities of plant materials. Every region has nurseries that offer local native plants, and some nurseries provide statewide

Laying out the pots for planting.

plant resources. Lists of nurseries and seed companies are attached in the Appendix E. Ordering well in advance can facilitate availability of desired plant stock.

Site Preparation and Planting

As with any agricultural operation, the proposed farmscape site needs to be prepared for planting. Different sites will require different levels of work, with some requiring very little and others substantial effort. Site preparation should involve weeding the area, and if the soil is heavy, ripping



Most California natives need to have their root crown elevated on a ridge to stay dry during summer months.

Plant to moisture (pre-irrigated planting hole).

and adding amendments. Before planting, an irrigation system should be installed that has the capability of providing water for the first two or three years. A long-term irrigation system may be justified in certain instances to extend available floral resources of certain insectary plants or to water plants that are bringing economic returns.

Planting California natives in areas that will receive summer moisture, generally through irrigation from adjacent fields, necessitates their

Installing short plants on a berm.

being planted on a berm or ridge, that is raised about one foot higher that the surrounding land level. If the entire site is not prepared in this manner, individual plants should be planted on small mounds, so that their root crowns will not be subject to summer water. Planting high on a

raised bed can also minimize effects from winter and spring flooding.

Plants in pots from the nursery should be watered and laid out along the site. A small amount of compost and/or rock phosphate or bone meal can be added to the planting site, and plants should be set into a moist planting hole. Planting in the fall at the beginning of the rainy season helps ensure adequate early watering of the planting, but as long as irrigation is available, hedgerows can be planted in California in any month of the year.

The use of native plants ensures that once established, they usually require little if any management other than some level of weed control. Over-fertilization and over-watering can kill or damage native vegetation. Various mulches, including almond shells and hulls and walnut hulls, can be used for keeping weeds down and retaining moisture. Care should be taken not to use mulch made from species that may carry the Sudden Oak Death pathogen. Hedgerow plantings should be designed so that they can be managed easily.

Signs will help in the survival of habitat plantings.

Signs should be posted in English and Spanish to prevent accidental damage to the hedgerow. Inexpensive signs can be printed, coated with 10 mil lamination and mounted on a post using wood screws. Painted metal stakes can be placed next to plants. Rows of visible indicator plants, such as deergrass or shrubs, can be used as an obvious border to delineate a grass planting.

Deergrass as a boundary marker.

Finally, wire cages or other protective sleeves should be installed to protect young plants in areas where deer, rabbits or other animals might cause harm. Gopher cages are expensive and are used only under extreme circumstances.

Maintenance and Follow-up

After the planting has been completed, maintaining the irrigation system, managing weeds and controlling rodents are the primary tasks to ensure the survival of the hedgerow. Generally, there is a big flush of weedy growth in the late winter and early spring that can overrun a planting. Weed prevention with mulches, weed fabric, hoeing, weed-eating, herbicides or

Controlling weeds in young hedgerows is essential.

flaming is necessary in early stages of hedgerow establishment. Catching the weeds when they are small saves a lot of work and reduces stress on the plants. Winters do not always provide even

Native perennial grasses control erosion and outcompete weeds.

and continuous rainfall, so it is critical to monitor plant moisture during the first winter and sometimes during the second. If a drip system is used, emitters should be checked periodically.

Managing the irrigation needs of the hedgerow is critical for successful establishment. Staying ahead of the rodents by early trapping can prevent their excessive colonization of a planting. Native plants generally thrive without additional fertilization, but some growers apply fertilizer several times a year for a few years after planting. Replanting some plants is generally necessary, since a small percentage plants tend to die from rodent damage, accidental injury, water problems, extreme temperatures, or various other causes.

Monitoring the successes and the failures, and attempting to record pertinent information, can inform the grower and the resource manager about plants and processes. Some plants will do very well in certain areas and others will not. Keeping records of the performance of hedgerow plants can be very helpful for future projects.

John Anderson, Hedgerow Farms, and friend.

Planning and Planting a Hedgerow – Summary Table

1. Farm Plan — Site Inventory Checklist

a. Regional Setting
b. Land Use
c. Topography
d. Hydrology and Drainage
e. Soils
f. Vegetation
g. Wildlife
h. Climate and Microclimate
i. Existing and Planned Buildings and Structures
j. Crop Production Areas
k. Non-Cropped Areas
l. Views
m. Spaces and Senses
n. Activities and Circulation
o. Utilities
p. Historical and Archaeological Resources
q. Legal Regulations
r. Off-Site Factors
s. Neighbors

2. Site Selection and Evaluation

a. Identify non-cropped areas of the farm suitable for vegetation planting.
b. Exclude from consideration areas that regularly flood, lack access to water or equipment, or may conflict with crop production areas.

3. Site Analysis

a. Description of location
b. Length and width of planting site
c. Ecosystem: complex of native plants and animals historically present
d. Climate
e. Soils
f. Hydrology: drainage patterns; low and high spots; potential for flooding
g. Irrigation system
h. Plant requirements: tall, medium, short; trees, shrubs, forbs, grasses
i. Animal pressure
j. Other considerations: access for equipment; off-site factors; existing trees, overhead powerlines or other features that can be incorporated

4. Planning and Design

a. Design and layout
b. Develop plant lists by matching plants to site (riparian, chaparral, irrigated cropland)
c. Develop budget for project
d. Investigate and initiate cost-share possibilities
e. Contact nurseries and order plants in advance, from local ecosystem if possible

5. Site Preparation and Planting

a. Soil preparation: clear weeds, chisel, build bed
b. Installation of irrigation system for 2-3 years of operation
c. Acquire compost, bone meal or rock phosphate, mulch
d. Dig holes; pre-irrigate
e. Lay out and plant plants
f. Install signs in English and Spanish to prevent accidental damage to hedgerow

6. Maintenance and Follow-up

a. Maintain irrigation system
b. Remove weeds while they are small
c. Control rodents where necessary
d. Replant where necessary
e. Track performance of plants

Problems with Hedgerows

Problems can occur for site-specific farmscape plantings, and solutions exist that involve thorough planning and analysis, fine-tuning the selection and location of plant materials or implementation of sound management practices.

Issues with planting hedgerows include:

- The possibility of attracting pest insects or diseases;
- The potential to attract birds or other vertebrates that damage crops;
- The time involved with management of weed control and irrigation;
- The problems associated with rodents and other animals that might spread disease vectors into adjacent crops;
- The risk of bringing in plants, mulch or soils that spread pathogens or diseases;
- Inadequate plant density leading to a sparse hedge with gaps; and
- The possible spread of some seeds into adjacent fields as weeds.

Using mulch to suppress weeds.

Specific Problems and Solutions

Weeds: Controlling weeds is an expensive and time-consuming task for growers, and needs to be handled in the early stages of planting a hedgerow. Various methods of weed control include pre-irrigation and cultivation, pre-plant flaming, mulching, weed fabric, herbicides, hand cultivation, and weed-eating. Planting into

Weed-eaters are effective tools for managing unwanted vegetative growth in habitat plantings.

a heavy mulch has proven successful in many situations. As hedgerows grow larger over time, fewer weeds grow underneath them, with some older and more established hedgerows being practically weed-free. Certain rhizomatous native grasses, such as creeping wildrye and red fescue, and some spreading forbs, such as aster, hedge nettle and goldenrod, can suppress annual weeds. The spread of seeds from a hedgerow into adjacent fields is normally not a problem when fields are cultivated, but in some cases, plants such as coyote brush can invade adjacent non-tilled fields. Mulches, which should be certified

Photo: Jack Kelly Clark

Lady beetles eat aphids.

pathogen-free, suppress weeds, with a secondary benefit of helping to regulate moisture. Mulches must be replenished periodically until the hedgerow plants cover the ground.

Photo: Gwen Huff

Steve Simmons with a resident of one of his barn owl boxes.

Pest Insects: It is important to be knowledgeable about the introduction of plants that harbor a known pest adjacent to a susceptible crop. In North Coast vineyards, certain commonly used hedgerow plants such as elderberry, mule fat, and California blackberry are hosts for the blue-green sharpshooter, a vector of Pierce's disease. Grape whitefly and stinkbugs have been observed on coffeeberry. Quailbush (saltbush) is a host for the beet leafhopper, which can transmit curly top virus to certain vegetable crops. It may not be necessary to eliminate these species entirely from a planned hedgerow, yet some caution and research should be applied before they are used.

Some pest insects are normally attracted to hedgerow plants, and these pests provide food for predators. To maintain natural enemies in the agroecosystem, it is important to have an appropriate number of the host pests.

Owls can help control rodents.

Rodents: Rodents can cause major problems and need to be managed, although not all hedgerow plantings have been reported to attract or cause an increase in rodent activity. Different kinds of plants and plant management have different characteristics that affect rodent activity. For example, the perennial grass creeping wildrye does not produce large amounts of seed, and as a result, mice are less common in these grass plantings than in areas colonized by seed-producing weeds. Many growers use owl boxes to attract rodent-eating barn owls. Food safety issues involving rodent feces and parts in mechanically harvested crops have emerged as an issue, with some grower-shipper certification groups requiring clean field borders in certain cases. Education and research are needed about these possible problems.

Diseases: Care needs to be taken to prevent the spread of pathogens and diseases from hedgerow plantings. Toyon, a member of the rose family and a widely used hedgerow plant, is susceptible to fire blight, and the causative pathogen may be transmitted via pollinating insects to nearby apple and pear orchards. The fungus Eutypa that can cause a disease in grapes has been associated with ceanothus and the timing of vineyard pruning. Sudden Oak Death Syndrome and Pierce's Disease are regional diseases that can be hosted by some of the plants recommended for hedgerows and in contaminated wood-chip mulches. These problems can be reduced or eradicated by specific management practices, including but not restricted to eliminating certain species from a site-specific plant list, purchasing certified disease-free plant materials or pruning affected branches. Key questions to be asked are: How good of a host for a disease is a certain plant? Is that plant commonly infected? How readily can an insect vector pick up a pathogen from the plant? Is the plant being installed in an area where a natural reservoir of the disease occurs?

Resource managers need to be knowledgeable about these issues and can get information from local university cooperative extension agents and pest control advisors.

Photo: Charles Peck

Birds eat pest insects.

Birds: In general, shrubs, particularly taller shrubs, attract birds. Many species of birds eat agricultural pest insects, and having birds in the hedgerows has been found to be acceptable by farmers with these plantings. Almost all songbirds are insectivores during the spring when they are raising chicks. However, once the nesting season is over, some species of birds, such as starlings, become fruit or berry eaters and can create problems for agricultural crops and need to be managed with the use of bird-control devices. A road or buffer five to ten feet wide between the crop and the hedge can help reduce the effects of certain birds feeding on seedlings.

Signs are an important part of a habitat planting.

Causes of Failure

Unintended destruction of hedgerows by tractors or work crews has been the number one cause of failure in plantings, and can be prevented with good signage. Other causes for the loss of hedgerow plantings are: deer and rodent damage; too many weeds; too much or too little water; water-sensitive plants not planted on raised beds or ridges; too much fertilizer; improper location or spacing of the planting; plant material too small or young to be planted; and lack of availability of desired plants leading to improper substitution of other plants.

Without signs, herbicides were applied and killed many planted shrubs.

Over time, hedgerows and farmscape plantings will generally require less care as they grow more established. It is easy for growers to neglect farmscape plantings, since the production of income from crops is obviously the top priority. However, these plantings do need some attention and should be thought of as a "crop" in their own right, existing as one of the elements that contributes to production of the entire farm. Once established, a thriving hedgerow, windbreak or grassed waterway brings a wide array of benefits to an agricultural operation, and besides its functional attainments, adds beauty and diversity to the farm.

APPENDICES

A hedgerow on Hedgerow Farms, Yolo County.

Appendix A
Plants Suitable for Various Regions

All plants are native to California unless otherwise notedin the Comment column.

Code for **Nectar & Pollen Source for** *column:* X–Predators and Parasites; B–Bees; H–Hummingbirds.

Code for **Suitable for Region** *column:* C– Coastal; CV–Central Valley; F–Foothill

Common Name	Scientific Name	Comment	Nectar & Pollen Source for	Suitable for Region
LARGE SHRUBS AND TREES				
Bay/California-Laurel	*Umbellularia californica*	Windbreak		**C,CV,F**
Black Walnut, California	*Juglans californica*	Deciduous		**C,CV,F**
Buck Brush	*Ceanothus cuneatus*		**X,B**	**C,CV,F**
Buckwheat, Giant (St. Catherine's Lace)	*Eriogonum giganteum*		**X,B**	**C,CV,F**
Button Willow	*Cephalanthus occidentalis*	Moist areas		**C,CV,F**
Catalina Cherry	*Prunus lyonii*	Deep summer watering inland	**X,B**	**C,CV,F**
Ceanothus, Blue Blossom	*Ceanothus thrysiflorus*		**X,B**	**C,CV,F**
Ceanothus, California Lilac	*Ceanothus spp.*	Many choices	**X,B**	**C,CV,F**
Ceanothus, Deerbrush	*Ceanothus integerrimus*		**X,B**	**C,CV,F**
Ceanothus 'Ray Hartman'	*Ceanothus "Ray Hartman"*	Tall, vigorous	**X,B**	**C,CV,F**
Citrus	*Citrus spp.*	Non-native, fruit		**C,CV,F**
Coffeeberry	*Rhamnus californica*		**X,B**	**C,CV,F**
Coyote Brush	*Baccharis pilularis ssp. consanguinea*		**X,B**	**C,CV,F**
Cypress, Monterey	*Cupressus macrocarpa*	Windbreak		**C,CV**
Desert Willow	*Chilopsis linearis*	Deciduous	**H**	**CV,F**
Dogwood, Western	*Cornus sericea*	Riparian		**C,CV,F**
Elderberry	*Sambucus mexicana*		**X,B**	**C,CV,F**
Euonymous, Evergreen	*Euonymous japonicus*	Non-native	**X**	**C,CV,F**
Flannel Bush	*Fremontodendron californicum*	Cultivars available	**B**	**C,CV,F**
Giant Sequoia	*Sequoiadendron giganteum*	Windbreak		**C,CV,F**
Hollyleaf Cherry	*Prunus ilicifolia*		**X,B**	**C,CV,F**
Incense Cedar	*Libocedrus decurrens*	Windbreak; slow growing		**C,CV,F**
Lemonade Berry	*Rhus integrifolia*		**B,H**	**C,CV,F**
Manzanita	*Arctostaphylos spp.*	Many choices	**B**	**C,CV,F**
Manzanita 'Sunset'	*Arctostaphylos (pajaroensis x hookeri)*		**B, H**	**C, CV**
Mountain Mahogany	*Cercocarpus betuloides*		**B**	**C,F,CV**
Mock Orange	*Philadephus lewsii*	Deciduous		**C,CV,F**
Mulberry, White	*Morus alba*	Non-native, fruit		**C,CV,F**
Mulefat	*Baccharis salicifolia*		**X,B**	**C,CV,F**
Myoporum	*Myoporum laetum*	Windbreak, Non-native		**C,CV,F**
Oak	*Quercus spp.*	Windbreak		**C,CV,F**
Pepper Tree	*Schinus molle*	Windbreak, Non-native	**X,B**	**C,CV,F**
Persimmon	*Diospyros virginiana*	Non-native, fruit		**C,CV,F**
Pineapple Guava	*Feijoa sellowiana*	Non-native, fruit		**C,CV,F**
Pomegranate	*Punica granatum*	Non-native, fruit	**H**	**C,CV,F**

Common Name	Scientific Name	Comment	Nectar & Pollen Source for	Suitable for Region
Redbud, Western	*Cercis occidentalis*		**B**	**C,CV,F**
Redwood, Coast	*Sequoia sempervirens*	Windbreak		**C,CV,F**
Rose, Wild	*Rosa californica*	Can be invasive	**B**	**C,CV,F**
Yellow Bells	*Tecoma stans*	Non-native	**X,B,H**	**C, CV**
Saltbush, Quailbush	*Atriplex lentiformis*			**C,CV,F**
Service Berry, Western	*Amelanchier alnifolia*			**C,CV,F**
Silktassel Plant	*Garrya elliptica*	Slow growing		**C,CV,F**
Silktassel Plant, Fremont	*Garrya fremontii*			**C,CV,F**
Soapbark Tree	*Quillaja saponaria*	Windbreak, Non-native	**X,B**	**C,CV,F**
Strawberry Tree	*Arbutus unedo*	Windbreak, Non-native		**C,CV,F**
Sugar Bush	*Rhus ovata*		**B**	**C,CV,F**
Toyon	*Heteromeles arbutifolia*		**X,B**	**C,CV,F**
Tree Mallow	*Lavatera assurgentiflora*	Protect from deer	**B**	**C**
Wax Myrtle	*Myrica californica*	Protect from extreme heat		**C,CV,F**
Willow	*Salix spp.*	Riparian	**X**	**C,CV,F**
MEDIUM SHRUBS				
Bee Plant, California	*Scrophularia californica*		**B**	**C,CV,F**
Blackberry, California	*Rubus ursinus*		**X,B**	**C,CV,F**
Blue Bush Germander	*Teucrium fruticans "Azureum"*			**C,CV**
Blue Hibiscus	*Alyogyne huegelii*	Non-native, attracts beneficials	**B**	**C,CV,F**
Buckwheat, California	*Eriogonum fasciculatum*		**X,B**	**C,CV,F**
Buckwheat, Coast	*Eriogonum latifolium*		**X,B**	**C**
Buckwheat, Santa Cruz Island	*Eriogonum arborescens*		**X,B**	**C,CV,F**
Buckwheat, Seacliff	*Eriogonum parvifolium*		**X,B**	**C,CV,F**
Bush Anemone	*Carpenteria californica*		**B**	**C,CV,F**
California Bladderpod	*Isomeris arborea*		**H**	**CV,F**
Ceanothus, "Yankee Point'	*Ceanothus griseus horizontalis*		**X,B**	**C,CV,F**
Ceanothus, California Lilac	*Ceanothus spp.*	Many choices	**X,B**	**C,CV,F**
Coffeeberry	*Rhmnus tomentella*		**X,B**	**C,CV.F**
Coffeeberry, 'Eve Case'	*Rhamnus californica*	Low growing	**X,B**	**C,CV,F**
Coffeeberry, 'Mound San Bruno'	*Rhamnus californica*	Low growing	**X,B**	**C,CV,F**
Coyote Brush, 'Pigeon Point'	*Baccharis pilularis*	Low growing	**X,B**	**C,CV,F**
Currant, Chaparral	*Ribes malvaceum,*		**H**	**C,CV,F**
Currant, Red-Flowering	*Ribes sanguineum*		**H**	**C,CV,F**
Goldenrod, California	*Solidago californica*		**X,B**	**C,CV,F**
Goldenrod, Western	*Euthamia occidentalis*		**X,B**	**C,CV,F**
Gooseberry	*Ribes californicum*			**C,CV,F**
Gumplant	*Grindelia camporum*		**X,B**	**C,CV,F**
Gumplant	*Grindelia stricta*		**X,B**	**C,CV,F**
Hibiscus, California	*Hibiscus lasiocarpus*	Moist areas		**C,CV,F**
Holly-leaf Redberry	*Rhamnus ilicifolia*		**B**	**C,CV,F**

Code for **Nectar & Pollen Source for** *column:* X–Predators and Parasites; B–Bees; H–Hummingbirds.

Code for **Suitable for Region** *column:* C–Coastal; CV–Central Valley; F–Foothill

Common Name	Scientific Name	Comment	Nectar & Pollen Source for	Suitable for Region
Lavatera	*Lavatera thuringiaca*	Non-native, attracts beneficials	**B**	**C,CV,F**
Lavender, English	*Lavandula angustifolia*	Non-native, herb	**B**	**C,F, CV**
Lavender, Spanish	*Lavandula stoechas*	Non-native, herb	**B**	**C,F,CV**
Lupine, Bush	*Lupinus albifrons*		**B,H**	**C,CV,F**
Manzanita, 'Howard McMinn'	*Arctostaphylos densiflora*		**H**	**C,CV,F**
Manzanita, Whiteleaf	*Arctostaphylos viscida*		**H**	**CV,F**
Mock Orange, California	*Philadelphus lewisii*	Deciduous; Protect from extreme heat	**H**	**C,CV,F**
Monkeyflower, Sticky	*Mimulus aurantiacus*		**H,B**	**C,CV, F**
Rosemary	*Rosemarinus officinalis*	Non-native, herb	**B**	**C,CV,F**
Sage	*Salvia spp.*	Many choices	**X,B,H**	**C,CV,F**
Sage, Black	*Salvia mellifera*	Herb	**X,B**	**C,CV,F**
Sage, Cleveland	*Salvia clevelandii*	Herb	**X,B**	**C,CV,F**
Sage, White	*Salvia apiana*	Herb	**B,H**	**C,CV,F**
Sagebrush, California	*Artemisia californica*		**B**	**C,CV,F**
Saltbush, Fourwing	*Atriplex canescens*		**X,B**	**C,CV,F**
Serviceberry, Western	*Amelanchier alnifolia*	Protect from extreme heat		**C,F**
Snowberry	*Symphoricarpos albus*		**X,B**	**C,CV,F**
Squaw Bush	*Rhus trilobata*			**F**
Twinberry	*Lonicera involucrata*	Moist areas	**H**	**C,CV,F**
Western Blue Flax	*Linum lewisii*			**C,CV,F**
Wooly Sunflower	*Eriophyllum staechadifolium*	.	**X,B**	**C**
SMALL SHRUBS AND FORBS				
Aster	*Aster chilensis*	Spreading	**X,B**	**C,CV,F**
Blanket Flower	*Gaillardia grandiflora*	Can be invasive		**C,CV,F**
Blue Flax, Western	*Linum lewisii*			**C,CV,F**
Buckwheat	*Eriogonum latifolium*		**X,B**	**C, CV**
Buckwheat, Sierra Sulfur	*Eriogonum umbellatum*		**X,B**	**F, CV**
California Poppy	*Eschscholzia californica*		**B**	**C,CV,F**
Ceanothus 'Carmel Creeper'	*Ceanothusgriseus horizontalis*	Prostrate	**X,B**	**C,CV,F**
Coyote Brush, 'Twin Peaks II'	*Baccharis pilularis*	Prostrate	**X,B**	**C,CV,F**
Coyote Mint	*Monardella villosa*		**B**	**C,CV,F**
Douglas Iris	*Iris douglasiana*			**C,CV,F**
Dutchman's Pipe	*Aristolochia californica*			**C,CV,F**
Fuschia, California	*Epilobium canum*	Many varieties	**H**	**C,CV,F**
Gloriosa Daisy	*Rudbeckia hirta*	Non-native, attracts beneficials		**C,CV,F**
Goldenrod, California	*Solidago californica*	Spreading	**X,B**	**C,CV,F**
Goldenrod, Western	*Euthamia occidentalis*	Spreading	**X,B**	**C,CV,F**
Hedge Nettle	*Stachys ajugoides*	Spreading	**B**	**C,CV,F**
Hedge Nettle	*Stachys bullata*	Spreading	**B**	**C,CV,F**
Heliotrope	*Heliotropium curassivicum var. Oculatum*	Riparian	**X,B**	**C,CV,F**
Lemon Verbena	*Aloysia triphylla*	Non-native, herb	**X,B**	**C,CV,F**

Common Name	Scientific Name	Comment	Nectar & Pollen Source for	Suitable for Region
Lupine, Bush	*Lupinus albifrons*		**H,B**	**C,CV,F**
Milkweed, Narrowleaf	*Asclepias fascicularis*		**X,B**	**C,CV,F**
Milkweed, Showy	*Asclepias speciosa*		**X,B**	**C,CV,F**
Monkeyflower, Seep	*Mimulus guttatus*	Riparian, spreading	**H**	**C,CV,F**
Monkeyflower, Sierra Bush	*Mimulus bifidus*		**H**	**C,F**
Mugwort	*Artemisia douglasiana*	Riparian		**C,CV,F**
Oregano	*Origanum vulgare*	Non-native, herb	**X,B**	**C,CV,F**
Penstemon, Foothill	*Penstemon heterophyllus*		**H**	**C,CV,F**
Phacelia	*Phacelia californica*		**X,B**	**C,F**
Phacelia	*Phacelia spp.*		**X,B**	**C,CV,F**
Rabbitbush, Gray	*Chrysothamnos nauseosus*		**X,B**	**F, CV**
Sage, Black - 'Terra Seca'	*Salvia mellifera*	Prostrate, herb	**X,B,H**	**C,CV**
Snowberry, Common	*Symphoricarpos albus*		**X,B**	**C,CV,F**
Spineflower	*Chorizanthe staticoides*	Annual	**X,B**	**C,F**
Strawberry	*Fragaria chiloensis*		**X,B**	**C,CV,F**
Thyme	*Thymus vulgaris*	Non-native, herb	**X,B**	**C,CV,F**
Wild Licorice	*Glycyrrhiza lepidota*			**CV**
Yarrow	*Achillea millefolium*	Spreading	**X,B**	**C,CV,F**
VINES				
Clematis	*Clematis lasiantha*		**X,B**	**C,CV,F**
Clematis	*Clematis ligusticifolia*		**X,B**	**C,CV,F**
Honeysuckle	*Lonicera hispidula*		**H**	**C,F**
Wild Grape	*Vitis californica*		**X**	**C,CV,F**
GRASSES, SEDGES AND RUSHES				
Bentgrass	*Agrostis exarata*	Moist		**C,CV,F**
Blue Wildrye	*Elymus glaucus*			**C,CV,F**
California Oniongrass	*Melica californica*			**C,CV,F**
Creeping Wildrye	*Leymus triticoides*	Spreading		**C,CV,F**
Deergrass	*Muhlenbergia rigens*		**X**	**C,CV,F**
Giant Wildrye	*Leymus condensatus*	Tall; good visual or dust barrier		**C,CV,F**
Gray Rush	*Juncus patens*	Grows in dry areas		**C,CV,F**
Meadow Barley	*Hordeum brachyantherum*			**C,CV,F**
Nutka Reed Grass	*Calamagrostis nutkaensis*			**C**
Purple Needlegrass	*Nassella pulchra*			**C,CV,F**
Red Fescue	*Festuca rubra*	Spreading		**C,CV,F**
Rush	*Juncus phaeocephalus*	Riparian		**C**
Saltgrass	*Distichlis spicata*			**C,CV,F**
Sedge	*Carex tumulicola*			**C,F**
Slender Sedge	*Carex praegracilis*			**C,CV,F**
Slender wheatgrass	*Elymus trachycaulus*			**CV,F**
Soft Rush	*Juncus effusus*	Riparian		**C,CV,F**
Spike Rush	*Eleocharis spp.*	Riparian		**C,CV,F**
Three-Week Fescue	*Vulpia microstachys*			**C,CV,F**
White Root Sedge	*Carex barbarae*	Needs little or no summer water; vigorous in water-ways		**C,CV,F**
Wire Rush	*Juncus balticus*			**C,CV,F**

Appendix B
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Appendix C
Web Sites

General

Appropriate Technology Transfer for Rural Areas (ATTRA) — National Sustainable Agriculture Information Service, funded by the US Department of Agriculture, is managed by the National Center for Appropriate Technology. It provides information and other technical assistance to farmers, ranchers, Extension agents, educators, and others involved in sustainable agriculture in the United States.

www.attra.org

California Native Grass Association (CNGA) — The mission of the California Native Grass Association is to develop, promote, preserve and restore native grasses and grassland ecosystems of California.

www.cnga.org

California Native Plant Society (CNPS) — The mission of CNPS is to increase understanding and appreciation of California native plants, and to conserve them and their natural habitats through education, science, advocacy, horticulture and land stewardship.

www.cnps.org

Calflora is a nonprofit that provides information on wild California plants for conservation, education, and appreciation. Through Calflora, scientists, citizens, and policymakers have quick and easy access to data they need for analyzing species distributions, modeling spread of invasive species, or identifying consequences of habitat loss.

www.calflora.org

California State Water Resources Control Board (SWRCB) — The State Board's mission is to preserve, enhance and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations. This Web site has information about the agricultural Waiver of Waste Discharge Requirements.

www.swrcb.ca.gov/

Central Coast Wilds Restoration, Nursery and Consulting — Dedicated to restoring ecological structure and function to degraded ecosystems, creating and enhancing wildlife habitat, and the conservation of local genetic resources through native plant revegetation.

www.centralcoastwilds.com

Community Alliance with Family Farmers (CAFF) — Since 1978, CAFF has been a membership-based non-profit that is building a movement of rural and urban people to foster family-scale agriculture that cares for the land, sustains local economies and promotes social justice. CAFF has been increasing farm biodiversity with native plant hedgerow and farmscaping projects in the Central Coast, North Coast and San Joaquin Valley regions since 2001.

www.caff.org

Cornflower Farms — Growers of quality California native and water wise plants since 1981, and originators of some pioneering hedgerow and habitat work.

www.cornflowerfarms.com

Dietrick Institute for Applied Insect Ecology — A nonprofit, non-membership institute providing training and education about biological pest control as an alternative to the use of toxic chemicals in agriculture. Our mission is to develop and offer learning opportunities that promote ecologically based pest management. We start with practical strategies that restore biodiversity in soil and aerial food webs. We work mainly with farmers to monitor and manage habitats so that beneficial organisms take care of pests and disease.

www.dietrick.org

Environmental Defense (ED) — A leading national nonprofit organization representing more than 400,000 members. Since 1967, we have linked science, economics and law to create innovative, equitable and cost-effective solutions to society's most urgent environmental problems. The Safe Harbor concept was developed by Environmental Defense and the U.S. Fish and Wildlife Service to encourage private landowners to restore and maintain habitat for endangered species without fear of incurring additional regulatory restrictions. To date, nearly three million acres of land in states across the country have been enrolled in several Safe Harbor agreements, benefiting a variety of imperiled animals.

www.environmentaldefense.org

Hedgerow Farms — specializes in producing the finest quality seed of California native grasses, sedges and forbs. Single species, seed mixes, plug plants and native grass straw are available for habitat restoration, erosion control and landscaping. Our services include consulting, custom growing and environmental education.

www.hedgerowfarms.com

Lady Bird Johnson Wildflower Center — A nonprofit center that is a great resource for native plant information. Can supply lists of suitable plant species for many areas.

www.wildflower.org

Natural Resources Conservation Service (NRCS) – As part of the US Department of Agriculture, the NRCS provides leadership in a partnership effort to help people conserve, maintain, and improve our natural resources and environment. A wide range of technical information and assistance is available to land users.

www.ca.nrcs.usda.gov

NRCS eFOTG Technical guides are the primary scientific references for NRCS that contain technical information about the conservation of soil, water, air, and related plant and animal resources, including hedgerows and grassed waterways.

www.nrcs.usda.gov/technical/efotg

NRCS Wildlife Habitat Management Institute Web site — Information about soils, water, air, plant and animals.

www.whmi.nrcs.usda.gov

North American Pollinator Protection Campaign — A consortium of conservation groups, government agencies, universities, and private industries from the United States, Mexico, and Canada. NAPPC participants share information and work together for the common good of pollinators across our continent.

www.nappc.org

Rana Creek Habitat Restoration — Rana Creek is an active, sustainable agricultural center for environmental consultation and restoration, specializing in native plant and seed products.

www.ranacreek.com

Resource Conservation Districts (RCDs) Watershed Information Sharing Project — Local leadership in watersheds begins with RCDs. Very cool visual website. Look up the RCD for your county.

www.carcd.org/wisp/countyframe.htm

Rincon-Vitova Insectaries — RVI produces insects and distributes insects and other organisms for biological control of pests of gardens, farms, stables, and compost yards, and provides programs to control key pests of garden, greenhouse, farm and stable.

www.rinconvitova.com

Salmon-Safe — one of the nation's leading regional ecolabels with more than 30,000 acres of farmland certified. The Salmon-Safe retail campaign has been featured in 200 supermarkets and natural food stores. Salmon-Safe is a nonprofit devoted to restoring agricultural and urban watersheds so that salmon can spawn and thrive.

www.salmonsafe.org

San Joaquin Valley Air Pollution Control District (Valley Air District) — is committed to improving the health and quality of life for all Valley residents through effective and cooperative air quality programs. Information on the Conservation Management Practice Program (CMP) can be found on the Web site.

www.valleyair.org

Society for Ecological Restoration (SER) — is a non-profit organization infused with the energy of 2300 members – individuals and organizations who are actively engaged in ecologically-sensitive repair and management of ecosystems through an unusually broad array of experience, knowledge sets and cultural perspectives.

www.ser.org

Soil and Water Conservation Society (SWCS) — Fosters the science and the art of soil, water and related natural resource management to achieve sustainability. We promote and practice an ethic recognizing the interdependence of people and the environment. SWCS publishes the Journal of Soil and Water Conservation, a bi-monthly journal of applied research and conservation news.

www.swcs.org

Hedgerows can help stabilize the banks of waterways.

University of California Agriculture and Natural Resources — UC ANR conducts agricultural research and outreach through county cooperative extension offices and agricultural experiment stations.

http://ucanr.org/index.shtml

UC ANR Statewide Integrated Pest Management Program — Information, research and extension projects.

www.ipm.ucdavis.edu

University of California Cooperative Extension, Santa Cruz County (UCCE) — The mission of UCCE is to develop and extend the use of research-based knowledge to improve specific practices and technologies. Local Research and Reports on the Web site has detailed cost information on Conservation Practices, including hedgerows and grassed waterways.

http://cesantacruz.ucdavis.edu

University of Nebraska — Windbreaks in Sustainable Agricultural Systems

http://ianrpubs.unl.edu/forestry/ec1772.htm

U.S. Department of Agriculture (USDA) Agroforestry Center, a partnership with USDA Forest Service and USDA NRCS, with technical information about the benefits, planting, maintenance, and impact on wildlife of windbreaks, hedgerows and snowfences.

www.unl.edu/nac/

U.S. Fish and Wildlife Service (USFWS) — developed the Safe Harbor Program with Environmental Defense to encourage private landowners to restore and maintain habitat for endangered species without fear of incurring additional regulatory restrictions. To date, nearly three million acres of land in states across the country have been enrolled in several Safe Harbor agreements, benefiting a variety of imperiled animals.

www.fws.gov

Yolo County Resource Conservation District — Bridging agricultural issues with science, education, and government, the RCD is an information network between landowner resource problems and the best solutions. The Yolo county RCD has pioneered hedgerow, grassed waterways and other habitat work, and has published technical manuals.

www.yolorcd.org

Wild Farm Alliance (WFA) — works to promote a healthy viable agriculture that protects and restores wild nature. WFA envisions community supported ecologically managed farms and ranches that are seamlessly integrated into landscapes that accommodate the full range of native species and ecological processes.

www.wildfarmalliance.org

The Xerces Society — A nonprofit dedicated to preserving the diversity of life through the conservation of invertebrates. Xerces runs education and conservation projects and produces information materials. Through its Pollinator Conservation Program, the Society offers practical advice on habitat management for pollinator insects and has published *Providing Bee Habitat on Farms: Guidelines for Farmers*.

www.xerces.org

Shrubs and grasses replace weeds and cover bare soil.

Sudden Oak Death Syndrome

California Oak Mortality Task Force and others — Information on Sudden Oak Death Syndrome (SODS).

www.suddenoakdeath.org

http://cemarin.ucdavis.edu/index2.html

http://californiaagriculture.ucop.edu/0301JFM/resupd.html

http://kellylab.berkeley.edu/SODmonitoring/

USDA Animal and Plant Health Inspection Service (APHIS) — is responsible for protecting and promoting U.S. agricultural health, administering the Animal Welfare Act, and carrying out wildlife damage management activities. This Web site has information about SODS.

www.aphis.usda.gov/lpa/news/2004/03/sod_ppq.html

Cost Share Programs

California Forest Stewardship Program provides technical and financial assistance to influence positive changes to forestland management, assists communities in solving common watershed problems, and helps landowners. The on-line publication "Cost Share and Assistance Programs for Individual California Landowners and Indian Tribes," produced by the University of California Cooperative Extension Forestry (UCCE), has a long list of cost share programs.

www.ceres.ca.gov/foreststeward/html/financial.html

Conservation Reserve Program (USDA Farm Services Agency) — The CRP program provides assistance to encourage farmers to convert environmentally sensitive acreage to vegetative cover.

www.nrcs.usda.gov/programs/crp

Environmental Quality Incentives Program (USDA Natural Resources conservation Service) — The EQIP program supports the implementation of conservation plans that include structural, vegetative, and land management practices on eligible land.

www.ca.nrcs.usda.gov/programs/eqip

Natural Resources Conservation Service (NRCS) — On the Web site, enter "Financial Assistance" in the Search box to locate numerous entries. NRCS is the federal agency that worked with private landowners to help protect natural resources through voluntary science-based assistance, partnerships, and cooperative problem solving at the community level.

www.ca.nrcs.usda.gov

Natural Resources Conservation Service (NRCS) Information on Buffers, continuous Conservation Reserve Program (CRP) and other cost share programs.

www.nrcs.usda.gov/feature/buffers/pdf/BufferBr.pdf

Partners for Wildlife (US Fish and Wildlife Service) — This program provides assistance to private (non-federal) landowners to voluntarily restore wetlands or other fish and wildlife habitats on their land.

http://partners.fws.gov

Wildlife Habitat Incentives Program (USDA Natural Resources conservation Service) — WHIP is a voluntary program for people who want to develop and improve wildlife habitat primarily on private lands.

www.nrcs.usda.gov/programs/whip

Photo: Will Stockwin

Tours to hedgerows educate farmers and resource professionals about habitat plantings.

Appendix D
Summaries of Selected Hedgerow and Farmscaping Articles

The following articles have been selected to present a short look at some of the research that is being done to determine to what extent vegetative plantings contribute toward pest control. The Bibliography lists many more references concerning this topic. The use of in-field insectaries (planting annuals within cropped fields) is showing some pest control results, and combining these plantings with perennial borders or hedgerows that act as longer-term refugia for the insects is showing some promise for farmscape plantings to be functioning as a system.

Andow, D.A. 1991. Vegetational diversity and arthropod population response. Annual Review of Entomology 36:561-586.

This article provides an overview of 209 studies on the response of arthropods to vegetational diversity by comparing polycultures to monocultures. "Polycultures" included systems with spatially intimate mixtures of different plant species (multiple crops, crop and weed, or crop and beneficial noncrop), whereas monocultures referred to single crop systems with bare ground. The studies covered a total of 287 herbivore species and 130 natural enemies (predators and parasitoids). Overall, polycultural systems supported lower numbers of herbivores (51%) and higher numbers of natural enemies (53%) when compared to monocultures. The effect, however, is less clear with herbivores that have more than one host plant. Essentially, with increasing complexity (i.e. herbivores that have more than one host plant and perennial systems as opposed to annual), the responses are more difficult to predict. Higher herbivore abundances found in monocultures have been attributed to both the resource concentration hypothesis and the natural enemies hypothesis. The resource concentration hypothesis suggests that herbivore populations, especially those with narrow host ranges, are more likely to colonize where resources are abundant, such as in the case of monocultures. The natural enemies hypothesis, on the other hand attributes lower number of herbivores in polycultural systems to suppression by natural enemies (as opposed to lack of resources). Although current evidence better supports the resource concentration hypothesis, both mechanisms most likely influence arthropod populations. Andow suggests using a demographic analysis to evaluate the relative importance of colonization, fecundity, mortality, etc. on arthropod response. Andow writes "While some of the Gordian knot of vegetational diversity can be perceived, we are a long way from unraveling its complexity.….a theory that predicts when natural enemies will exert significant mortality in polycultures is entirely lacking."

Azeez, G. 2000. The Biodiversity Benefits of Organic Farming. U.K. Soil Association. www.soilassociation.org

A number of studies have been done comparing the effect of organic and conventional farming on groups of wildlife. Twenty-three studies of lowland farms are reviewed, nine in full and the remainder have the findings briefly presented. Both abundance of plants, birds and invertebrates and diversity of plants and invertebrates were substantially higher on the organic farms than comparable conventional farms.

Baggen L.R., Gurr G.M., and Meats A. 1999. Flowers in tri-trophic systems: mechanisms allowing selective exploitation by insect natural enemies for conservation biological control. Entomologia Experimentalis et Applicata 91 (1): 155-161.

Many insects have coevolved with certain angiosperm taxa to act as pollinators. However, the nectar and pollen from such flowers is also widely fed upon by other insects, including entomophagous species (reproducing within insects). Conservation biological control seeks to maximize the impact of these natural enemies on crop pests by enhancing availability of nectar and pollen-rich plants in agroecosystems. A risk with this approach is that pests may also benefit from the food resource. We show that the flowers of some plants (viz., buckwheat, Fagopyrom esculentum Moench and dill, Anethum graveolens L.), and the extrafloral nectaries of faba bean (Vicia faba L.) benefit both the parasitic wasp Copidosoma koehleri Blanchard (Hymenoptera: Encyrtidae) and its host, the potato pest, Phthorimaea operculella Zeller (Lepidoptera: Gelechiidae). In contrast, phacelia (Phacelia tanacetifolia Benth) and nasturtium (Tropaeoleum majus L.) benefited only the parasitoid. When adult moths of P. operculella were caged with flowers of phacelia or nasturtium, longevity of males and females, egg laying life, fecundity, average oviposition rate, and number of eggs in ovaries at death were no greater than in the control treatment with access to shoots without flowers plus water. All the foregoing measures were increased compared to the control when the moths were allowed access to dill, buckwheat or faba bean extrafloral nectaries. Such "selectivity" has the potential to make the use of floral resources in conservation biological control more strategic.

Bugg, R.L. 1994. Farmscaping: providing habitat for beneficial arthropods. Proceedings of the Association of Specialty Cut Flower Growers, Annual Meeting, November 11, 1994, Red Lion Inn, San Jose, CA.

Hedgerows and other border plantings can have important impacts on biointensive integrated pest management. Properly designed and managed hedgerows and vegetationally diverse field borders can assist in both biological and cultural control of arthropod pests in agriculture. Beneficial arthropods include parasites and predators. Parasites are usually more restricted as to which insects they will attack. Some predators may be fairly specialized, as well, but many are generalists – feeding opportunistically on various insects and mites. Generalist predators may be especially important, because they can persist in the absence of pests, may arrive in the crop first, and may act to prevent or slow down pest outbreaks. Some important beneficial insects have special plant associations. Nectar-bearing plants and those that harbor alternate hosts or prey are particularly important in sustaining various beneficial arthropods; so are plants that afford shelter for dormant phases or for nesting. Such plants, including some that can serve as cut flowers, can be incorporated into farmscaping schemes.

Chaney, W. 1998. Biological Control of Aphid in Lettuce Using In-Field Insectaries, p. 73-83. In C. H. Pickett and R. L. Bugg, eds. Enhancing biological control: habitat management to promote natural enemies of agricultural pests. University of California Press, Berkeley, CA.

There has been very limited successful use of traditional biological control methods in commercial fresh market vegetables. Attempts to control aphids, a major pest of lettuce in coastal California, have not been successful in most large scale commercial applications. The importance and impact of plant diversity of providing food and shelter to beneficial insects are well recognized. Presented here are the results of a study designed to evaluate the use of in-field insectaries using sweet alyssum to aid in the biological control of aphid and other pests in lettuce. The field trials demonstrated that the density of beneficial insects could be increased near the insectary planting and that the aphid population could be reduced. It would be appropriate to assume that insectary strips every 33m or so should be effective. This would correspond to every 20th bed in a 1m (40 inch) bed system. Other cultural practices, such as combining sweet alyssum with a taller plant, such as a cereal grain, or leaving small areas of winter cover crops undisturbed through crop production period, might be explored.

Colley, M.R., and J.M. Luna. 2000. Relative attractiveness of potential beneficial insectary plants to aphidophagous hoverflies (Diptera: Syrphidae). Environmental Entomology*: 29(5):1054–1059.*

Establishing flowering plants in and around fields to provide pollen and nectar resources for natural enemies has shown promise as a strategy to enhance biological control of crop pests. Natural enemies are selective in their flower feeding, however, and show preferences for certain plant species. In this study the relative attractiveness of 11 flowering plant species to aphidophagous hoverflies (Diptera: Syrphidae) was evaluated at the Oregon State University Vegetable Research Farm. Six of these plant species were also evaluated at two other farm sites. Of the 12 species of hoverflies collected, *Meliscaeva cinctella* (Zetterstedt), *Toxomerus marginatus* (Say), *Toxomerus occidentalis* (Curran), *Sphaerophoria sulfuripes* (Thomson), and *Scaeva pyrastri* (L.) were common to all three sites. Attractiveness of flowering plants to foraging hoverflies was assessed by conducting timed observations of feeding-visit frequencies. Flowering periods varied between plant species and comparisons were made only for plant species flowering on a particular date. Relative attractiveness of plant species to hoverflies differed between dates and sites. Among early-season flowering species, coriander, *Coriandrum sativum* (L.), was fed from most frequently. Among late-season flowers, yarrow, *Achillea millefolium* (L.), fennel, *Foeniculum vulgare* (Miller), and Korean licorice mint, *Agastache rugosa* (Fischer & C. A. Meyer) were fed from most frequently. These results help in the selection of plants to enhance biological control, but final selection of plants for this purpose requires considering flower, natural enemy, and pest phenologies, and pollen and nectar quality and availability.

Denys, Christine and Teja Tscharntke. 2002. Plant-insect communities and predator-prey ratios in field margin strips, adjacent crop fields, and fallows. Oecologia130: 315-324.

The management of field margin strips for the enhancement of biodiversity of plant-insect communities and natural-enemy populations was studied on experimental farms near Göttingen (Germany). Young and old, sown and naturally developed field margin strips were compared and differences to large fallows established. The five types of field margin strips (around cereal fields) were: (1, 2) 1- or 6-year-old naturally developed strips, (3) strips sown with a Phacelia mixture, (4) strips sown with a mixture of 19 wild flower species, and (5) strips sown with winter wheat or oat as a control. The naturally developed vegetation of the field margin strips was dominated by aggressive weeds, presumably due to the intensive farming practices and the fertile soils. Cirsium arvense populations decreased, while Elymus repens populations increased with age of habitat. Sowings were suitable to suppress these aggressive weeds. Potted plants of mugwort (*Artemisia vulgaris*)

and red clover (*Trifolium pratense*) were exposed in the field margin strips to study arthropod colonization of these experimentally standardized plant patches. Arthropod species richness did not differ between field margin types, reflecting the overall similarity in floristic diversity, but sprayed and strip-free edges of cereal fields had a reduced diversity. Dispersal of insect populations of red clover into the cereal fields decreased with increasing distance, but benefited from adjacent field margin strips. Populations of predators (mainly spiders) as well as predator-prey ratios were significantly larger in 6-year-old than in 1-year-old strips emphasizing the importance of habitat age for natural enemies and possible biological control. Predator-prey ratios were also higher on old than young fallows. Large fallows had greater predator-prey ratios than small field margin strips emphasizing the trophic-level hypothesis of island biogeography in that the relative importance of natural enemies increased with habitat area.

Ehler, Les E., C.G. Pease, and R.F. Long. 2002. Farmscape ecology of a native stink bug in the Sacramento Valley. Fremontia: Vol. 30: 3-4: pp. 59-61.

This article outlines the seasonal life history of a native stink bug and describes how replacing exotic weeds with native perennial grasses can be employed in stinkbug management. It also notes the importance of economic benefits linked to the restoration of native vegetation in agricultural landscapes. The consperse stink bug has a complex of natural enemies, which can be slow to colonize tomato crops. An alternative approach to weed management is elimination of exotic weeds and restoration of native vegetation (certain perennial grasses), which outcompete weeds and preclude development of the first generation of consperse stinkbug at that site. Beneficial insects such as hover flies, green lacewings, ladybird beetles, and damsel bugs are found in the perennial grasses. Roadside restoration provides an economic benefit in the form of pest reduction.

Holland, J. and L. Fahrig. 2000. Effect of woody borders on insect density and diversity in crop fields: a landscape-scale analysis. Agriculture, Ecosystems and Environment 78:115-122.

The relationship between density and richness of herbivorous insects in alfalfa fields, and the amount (total length) of woody field border in the landscapes surrounding the fields was studied. Insects (predominantly herbivorous) were sampled in 35 alfalfa fields in 1995 and 24 fields in 1996, and the total length of woody field borders within the one-kilometer radius circular landscape surrounding each field was measured. There was no effect of amount of woody border in the landscape on insect density. There was a significant positive effect of amount of woody border in the landscape on overall family richness of insects in the alfalfa fields. The results of this study suggest that woody borders increase diversity but not density of herbivorous insects within crop fields in agro-ecosystems. This suggests that woody borders play a role in maintaining biodiversity in agro-ecosystems, and that this role extends beyond the borders themselves, into the crop fields.

Long, R.F., A. Corbett, C. Lamb, C. Reberg-Horton, J. Chandler, and M. Stimmann. 1998. Movement of beneficial insects from flowering plants to associated crops. California Agriculture 52:23-26.

Marking studies demonstrated that lady beetles, lacewings, syrphid flies and parasitic wasps fed on nectar and pollen provided by borders of flowering plants around farms; many insects moved 250 feet into adjacent field crops. Studies using the elemental marker rubidium also showed that syrphid flies, parasitic wasps and lacewings fed on flowering cover crops in orchards and that some moved 6 feet high in the tree canopy and100 feet away from the treated area. The use of nectar of pollen by beneficial insects helps them survive and reproduce. Therefore, planting flowering plants and perennial grasses around farms may lead to better biological control of pests in nearby crops.

Long R.F., M. Kimball, and P.Thompson. 2003. Establishing a Hedgerow. Video. University of California Agriculture and Natural Resources, Publication No. V02-A.

There is a great deal of interest in planting hedgerows of shrubs, trees, and perennial grasses around farms for habitat and food for wildlife and beneficial insects, weed control in non-farmed areas, sediment traps, wind breaks, and as barriers between agricultural and urban lands. This video focuses on how to plant hedgerows, including design, plant selection, selecting a location, weed control, irrigation, and costs associated with these practices. Through a three-year research project, we determined that it costs about $3,200 to establish a 1,200 ft- long single row hedgerow with a 15-foot-wide swath of perennial grasses next to it in the first two years. Plants must be adapted locally to the soil and climate; linear designs worked best for hedgerow management; irrigation was critical for the first two years; and constant weed control was essential.

Long R.F. and C.G. Pease. 2001. Quantifying pest and beneficial insects in hedgerows. Yolo County University of Cooperative Extension. http://ceyolo.ucdavis.edu.

A two-year project was conducted to look at the abundance and diversity of insects associated with hedgerows of perennial shrubs and native grasses planted on field crop farms. Bi-weekly sampling in the hedgerows throughout the growing season in the Northern Sacramento Valley showed that most of the visitors to the shrubs were beneficial insects. Pests that were found on the shrubs were present mid-to-late in the growing season. Bi-weekly sampling of insects in nearby weedy vegetation showed an abundance of pests compared with the low levels in our hedgerow shrubs and native grasses. Presumably the pests preferred the seed pods of the weedy vegetation over our woody shrubs because of the higher energy source.

Patt, J.M., G.C. Hamilton, J.H. Lashomb. 1997. Impact of strip-insectary intercropping with flowers on conservation biological control of the Colorado potato beetle. Advanced Horticultural Science, 11:175-181.

Predators of Colorado potato beetle (*Leptinotarsa decemlineata*) (CPB) are an important component of CPB suppression by biological control in New Jersey (USA) eggplant fields. Here we report the results of a preliminary study on the effects of strip-insectary intercropping with flowers on predator abundance and CPB suppression in experimental eggplant fields. Strip-insectary intercropping with flowers is known to increase beneficial insect survivorship, fecundity and retention and crop pest suppression in agroecosystems. However, little is known about the compatibility of predator foraging ability with floral architecture, i.e., the spatial relationship of the nectary with other floral parts. This is a critical factor in the selection of "proper" floral host plants, i.e., those having pollen and nectar that is accessible to predators. To measure the effect of strip-insectary intercropping with "proper" flowers on CPB suppression, the fate of 120 eggmasses and resultant larvae placed on individual sentinel eggplant plants was followed during two nine-day periods in 100 m x 40 m eggplant fields intercropped with two rows of either dill or coriander and in a flowerless control field. In addition, coccinellid species richness and abundance was censused weekly in each test field from early July to mid-August. Throughout this study, the numbers of coccinellids observed during each census were significantly higher in the fields interplanted with dill and coriander than in the flowerless control field. Although there were not differences among treatments in the number of hatched CPB eggmasses, significantly more CPB eggmasses were consumed in the dill-intercropped fields than in the control fields. Survivorship of CPB larvae at the end of each survey was highest in the control field and lowest in the dill field. These results suggest that strip-intercropping with "proper" flowers can greatly enhance CPB predator conservation and augmentation in vegetable cropping systems.

Pfiffner, L., and H. Luka. 2000. Overwintering of arthropods in soils of arable fields and adjacent semi-natural habitats. Agriculture, ecosystems & environment. v. 78:p. 215-222.

In order to determine the significance of field margins for the overwintering of arthropods in agricultural landscapes, different sites of an integrated and of an organically managed farm were investigated in the northwest of Switzerland. The abundance of arthropods in the arable fields was significantly lower than in the adjacent semi-natural habitats. Highest abundances and species diversities were found in a sown wildflower strip, a hedge, a permanent meadow and a meadow under the cherry trees of the organic farm. With a total of 90 arthropod species in the semi-natural habitats, five times more species were found than in the arable fields. Staphylinids, carabids, spiders and chilopods were the most abundant arthropod groups. The data showed that undisturbed semi-natural habitats and extensively managed field margins play a key role as overwintering sites for many predatory arthropods.

Sengonca, C., J. Kranz and P. Blaeser. 2002. Attractiveness of three weed species to polyphagous predators and their influence on aphid populations in adjacent lettuce cultivations. Anz. Schadlingskunde/ Journal of Pest Science 75, 161-165.

The utilization of olfactory responses of predators and parasitoids to the allelochemicals emitted by phytophagous arthropods (insects which feed on plants) and their host plants is becoming more important in biological pest control. The effects of three weed species, i.e. wormwood (*Artemisia vulgaris*) L., tansy (*Tanacetum vulgare*) L. and stinging nettle (*Urtica*) L., which were planted as accompanying vegetations into a lettuce field, were examined for the predatory species *Coccinella septempunctata* L., *Adalia bipunctata* L., *Propylea quatuordecimpunctata* L. (Coleoptera, Coccinellidae) and *Chrysoperla carnea* (Steph.) (Neuroptera, Chrysopidae), as well as for aphids during the summer of 2000. The presence of weeds significantly increased the density of adults and larvae of the predators on the lettuce plants in relation to the control (lettuce field without weeds). However, the differences remained smaller for eggs and pupae. *C. septempunctata* tended to be the most abundant species, followed by *P. quatuordecimpunctata*. Remarkable differences among the attractiveness levels of the weeds in the 3 treatments were not observed. The increased populations of predators were accompanied by significantly reduced infestation rates with aphids in the treatments in relation to the control.

Steffan, S. A. 1997. Flower-visitors of *Baccharis pilularis de Candolle* subsp. *consanguinea* (de Candolle) E.B. Wolf (Asteraceae) in Berkeley, California. The Pan-Pacific Entomologist 73(1): 52-54.

Coyote brush (*Baccharis pilularis De Condolle* subspecies *consanguinea* (De Conadolle) C.B. Wolf (Asteraceae)) is a dioecious evergreen perennial, native throughout cismontane California, Baja California, and as far north as Oregon. This paper provides a list of insect flower-visitors collected in Strawberry Canyon in 1992. Representatives of at least 55 insect species were collected (five orders and 32 families). Hymenoptera (wasps) comprised approximately 81% of all insect specimens, Diptera (flies) accounted for 10%, and the remaining orders, 9%.

Wratten, S., H.F. van Emden, and M.B. Thomas. 1998. Within-field and border refugia for enhancement of natural enemies, p. 375-403, In C. H. Pickett and R. L. Bugg, eds. Enhancing Biological Control: Habitat Management to Promote Natural Enemies of Agricultural Pests. University of California Press, Berkeley, CA.

The idea that diversification of a crop or its margins can benefit the natural enemies of pests is intuitively logical and seems to involve common-sense ecological principles. However the mechanisms behind these purported interactions are usually barely understood. Among the mechanisms involved in the interaction between pest dynamics and within-field or border refugia are: the provision of overwintering or aestivation sites; the enhancement of the quantities of pollen and/or nectar available to predators and parasitoids; the provision of alternative prey for predators or alternatively the hosts of parasitoids. All of these processes have potential negative as well as positive effects on population dynamics of pests. Sometimes the improvement or creation of refugia benefits beneficial arthropods other than those with potential in biological control. It does not follow that making an agricultural landscape more diverse will necessarily lead to greater predator-prey stability. Margin strips of *Sinapsis arvensis* and *Phacelia tanacetifolia* led to higher densities of polyphagous predators (those that have more than one host plant) in the strips and in adjacent fields than in wheat plots without strips. There was a trend toward lower aphid populations in the field with adjoining strips. We need to understand better three related processes: 1) the spatial dynamics of beneficial arthropods on farmland; 2) the potential negative effects of refugia; and 3) the mechanisms involved in the functioning of refugia.

Native grass production at Hedgerow Farms, Winters, California

Appendix E
Nurseries & Seed Companies

Nurseries

Alternatives Nursery
P.O. Box 1100
Nevada City, CA 95959
(530) 263-2874

Appleton Forestry Nursery
1369 Tilton Road
Sebastopol, CA 95472
(707) 823-3776

Aquatic Resources
P.O. Box 2169
Sebastopol, CA 95472
(707) 829-1194

Blue Oak Landscape Supply
2731 Mountain Oak Lane
Rescue, CA 95672
(530) 677-2111

Cache Creek Nursery
2815 Road 40A
Rumsey, CA 95679
(530) 796-3521

California Conservation Corps-Napa Native Plant Nursery
P.O. Box 7199
Napa, CA 94588
(707) 253-7783

California Deptartment of Forestry & Fire Protection
L.A. Moran Reforestation Center
P.O. Box 1590
Davis, CA 95617
(530) 753-2441

California Flora Nursery
P.O. Box 3
Fulton, CA 95439
(707) 528-8813
www.calfloranursery.com

Central Coast Wilds
114 Liberty Street
Santa Cruz, CA 95060
(831) 459-0656/Fax 459-1606
www.centralcoastwilds.com

Circuit Rider Productions, Inc.
9619 Old Redwood Highway
Windsor, CA 95492
(707) 838-6641

Cornflower Farms Wildland/Agriculture Catalog
P.O. Box 896
Elk Grove, CA 95759
(916) 689-1015
www.cornflowerfarms.com

Elkhorn Native Plant Nursery
P.O. Box 270
Moss Landing, CA 95039
(831) 763-1207/Fax 763-1659
www.elkhornnursery.com

Freshwater Farms
5851 Myrtle Avenue
Eureka, CA 95503
(800) 200-8969
www.freshwaterfarms.com

Hartland Nursery
13737 Grand Island Road
Walnut Grove, CA 95690
(916) 775-4021
www.hartlandnursery.com

Hedgerow Farms
21740 County Road 88
Winters, CA 95694
(530) 662-4570

Intermountain Nursery
30443 N. Auberry Road
Prather, CA 93651
(559) 855-3113/Fax 855-8809
www.intermountain@psnw.com

Lockeford Plant Materials Center
21001 North Elliott Road
Lockeford, CA 95237
(209) 727-5319

Morningsun Herb Farm
6137 Pleasants Valley Road
Vacaville, CA 95688
(707) 451-9406
www.morningsunherbfarm.com

Mostly Natives Nursery
27235 Highway One
Tomales CA 94971
(707) 878-2009
www.mostlynatives.com

Native Here Nursery
101 Golf Course Drive
Tilden Park, CA 94708
(510) 549-0211

Native Oak Nursery
45 Webb Road
Watsonville, CA 95076
(831) 728-8662

Native Revival
2600 Mar Vista Drive
Aptos, CA 95003
(831) 684-1811
www.nativerevival.com

North Coast Native Nursery
P.O. Box 660
Petaluma, CA 94953
(707) 769-1213
www.northcoastnativenursery.com

Rana Creek Habitat Restoration
Native Grasses & Plants
35351 East Carmel Valley Road
Carmel Valley, CA 93924
(831) 659-3820
www.ranacreek.com

Royal Oaks Nursery
1070 San Miguel Canyon Rd.
Watsonville, CA 95076
(831) 724-7032

Sierra Azul/Rosendale Nurseries
2660 E. Lake Avenue
Watsonville, CA 95076
(831) 728-2599
www.sierrazul.com

Sierra Valley Farms
P.O. Box 79
Beckworth, CA 96129
(530) 832-0114

Specialty Gardens
P.O. Box 567451
Modesto, CA 95357
(209) 527-5889

Suncrest Nursery
400 Casserly Road
Watsonville, CA 95076
(831) 728-2595/Fax 728-3146
www.suncrestnursery.com

Elderberry provides nectar, pollen and cover for insects.

Sweetland Farm & Nursery
27443 Sweetland Road
North San Juan, CA 95690
(530) 292-9033

Valley Transplants
23000 Bruella Road
Acampo, CA 96220
(209) 368-6093

Yerba Buena Nursery
19500 Skyline Blvd.
Woodside, CA 94062
(650) 851-1668

You Bet Farms
15595 You Bet Road
Grass Valley, CA 95945
(530) 292-9450

Seed Companies

Comstock Seed
917 Highway 88
Gardnerville, NV 89410
(775) 746-3681

Conservaseed
P.O. Box 455
Rio Vista, CA 94571
(916) 775-1676

Clyde Robin Seed Company
P.O. Box 2366
Castro Valley, CA 94546
(510) 785-6463

Environmental Seed Producers
P.O. Box 2709
Lompoc, CA 93438
(805) 735-8888

Harmony Farm Supply
P.O. Box 460
Graton, CA 95444
(707) 823-9125
www.harmonyfarm.com

Hedgerow Farms
21740 County Road 88
Winters, CA 95694
(530) 662-4570

Kamprath Seeds
205 Stockton Street
Manteca, CA 95337
(800) 325-4621

Larner Seeds
P.O. Box 407
Bolinas, CA 94924
(415) 868-2592
www.larnerseeds.com

Native Solutions
P.O. Box 222652
Carmel, Ca 93922
(831) 214-0711

Pacific Coast Seed
6144 Industrial Way, Bldg. A
Livermore, CA 94550
(925) 373-4417

Peaceful Valley Farm Supply
110 Springhill Boulevard
Grass Valley, CA 95945
(530) 272-4769
www.groworganic.com

Rana Creek Habitat Restoration
35351 E. Carmel Valley Road
Carmel Valley, CA 93924
(831) 659-3820
www.ranacreek.com

S & S Seed
P.O. Box 1275
Carpenteria, CA 93014-1275
(805) 684-0436

Stover Seed Company
P.O. Box 21488
Los Angeles, CA 90021
(800) 621-0315
www.stoverseed.com

TS & L Seed Company
37331 Highway 16
Woodland, CA 95776
(530) 666-1239

Fence line hedgerow.

Appendix F
Botanical Gardens

Refer to Sunset Western Garden Book for a complete listing of California botanical gardens.

Luther Burbank Home & Gardens
Santa Rosa Avenue at Sonoma Avenue
Santa Rosa, CA 95402
(707) 524-5445
www.lutherburbank.org

Rancho Santa Ana Botanic Garden
1500 N. College Avenue
Claremont, CA 91711
(909) 625-8767
www.rsabg.org

Regional Parks Botanic Garden
Tilden Regional Park
Wildcat Canyon Road
Berkeley, CA 94708
(510) 841-8732
www.nativeplants.org

Santa Barbara Botanic Garden
1212 Mission Canyon Road
Santa Barbara, CA 93105
(805) 682-4726
www.sbbg.org

Strybing Arboretum & Botanical Gardens
Golden Gate Park
Ninth Avenue at Lincoln Way
San Francisco, CA 94122
(415) 661-1316
www.strybing.org

UC Botanical Garden
200 Centennial Drive
Berkeley, CA 94720
(510) 643-2755
www.mip.berkeley.edu/garden

UC Santa Cruz Arboretum
1500 High Street
Santa Cruz, CA 95064
(831) 427-2998
www2.ucsc.edu/arboretum

Successful establishment of shrubs and grasses on High Ground Organic Farms, Watsonville.

NOTES

Additional Resource Materials

Included in Hedgerows for California Agriculture Manual, A Resource Guide

- **Establishing Hedgerows for Pest Control and Wildlife,** from "Bring Farm Edges Back to Life," Yolo County RCD.

- **Farmscaping to Enhance Biological Control.** National Center for Appropriate Technology (NCAT)/ Appropriate Technology Transfer for Rural Areas (ATTRA)

- **Hedgerow Establishment. Practices and Costs for Field Crop Farms in the Sacramento Valley.** Brochure from UC Cooperative Extension and Yolo County RCD

- **Hedgerow Planting: Conservation Practice Standard,** Code 422. 2002. Natural Resources Conservation Service.

- **Hedgerow Planting: Practice Requirements.** USDA Natural Resources Conservation Service, California.

- **Hedgerow Planting: Practice Specifications.** USDA Natural Resources Conservation Service.

- **Hedgerows: Benefits to Farmers, Benefits to Wildlife.** Brochure from Santa Cruz County NRCS/RCD and CAFF.

- **Insects Associated with Native Hedgerows.** Pamphlet by Corin Pease, UC Davis.

- **Dietrick Institute for Applied Insect Ecology.** Perennial Plants Selected to Attract Beneficial Insects to Manage Aphids, Caterpillars Mites, Thrips, and Whitefly

- **Project Description.** Extending Hedgerow Systems in California Agriculture

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

HEDGEROW PLANTING

(Ft.)

CODE 422

DEFINITION

Establishment of dense vegetation in a linear design to achieve a natural resource conservation purpose.

PURPOSE

Providing at least one of the following conservation functions:

- Food, cover and corridors for terrestrial wildlife.
- Food and cover for aquatic organisms that live in watercourses with bank-full width less than 5 feet.
- To intercept airborne particulate matter.
- To reduce chemical drift and odor movement.
- To increase carbon storage in biomass and soils.
- Living fences
- Boundary delineation
- Contour guidelines
- Screens and barriers to noise and dust
- Improvement of landscape appearance

CONDITIONS WHERE PRACTICE APPLIES:

This practice applies wherever it will accomplish at least one of the purposes stated above.

CRITERIA

General Criteria Applicable to All Purposes

Hedgerows shall be established using woody plants, or perennial bunch grasses producing erect stems attaining average heights of at least 3 feet and persisting well over winter.

Plants selected must be suited and adapted to the soils, climate and conservation purpose.

No plant listed by the state as a noxious weed shall be established in a hedgerow.

The practice shall be protected from livestock grazing and trampling to the extent necessary to ensure that it will perform the intended purpose(s).

Competing vegetation shall be controlled until the hedgerow becomes established. Control shall continue beyond the establishment period, if necessary.

All planned work shall comply with federal, state and local laws and regulations.

Additional Criteria for Wildlife Food, Cover and Corridors

Establish at least two species of native vegetation.

Selected plants shall provide cover and/or food to support the landowner's wildlife objectives.

Minimum hedgerow width, at maturity, shall be 15 feet. This may necessitate the establishment of more than one row of plants.

In plantings adjacent to small watercourses, the plantings shall be site-adapted, large enough at maturity and installed close enough to shade the watercourse.

NRCS, NHCP
October 2003

Additional Criteria for Living Fences

Selected plants shall attain a size adequate to create a barrier to contain livestock or humans, as needed.

If the purpose is to contain livestock, selected plants shall not be poisonous or hazardous to the animals.

Additional Criteria for Boundary Delineation

Hedgerows shall be aligned along boundaries of fields, or forestlands to differentiate land management units.

Additional Criteria for Contour Guidelines

Hedgerows shall be aligned so they provide permanent contour markers supporting implementation of Contour Farming (330) or Stripcropping (585). Refer to those conservation practice standards for alignment criteria.

Additional Criteria for Screens and Noise Barriers

Screening hedgerows provide privacy, hide unsightly areas from view or reduce noise.

Hedgerows shall be located where they most completely obstruct a line of sight or offensive sound.

Selected plants shall attain a height and fullness sufficient to break the line of sight or baffle sound.

Additional Criteria for Improvement of Landscape Appearance

The hedgerow design shall meet the aesthetic objectives of the landowner.

Plants shall be selected based upon the landowner's preferences for color, texture and growth habit.

Additional Criteria for Reducing Particulate Matter Movement

The hedgerow will be oriented as close to perpendicular to the prevailing wind direction as possible.

Hedgerow density on the upwind side shall be at least 50% at maturity.

Hedgerow density adjacent to the particulate source shall be at least 65% at maturity.

Additional Criteria to Reduce Odor Movement and/or Chemical Drift

Orientation of the hedgerow shall be as close to perpendicular to the prevailing wind direction during the period of concern, and between the source of the odor or chemical drift and the sensitive and the sensitive areas.

Hedgerows shall be located upwind of the odor producing area and the chemical application area.

Tree and shrub species used shall have foliar and structural characteristics that optimize interception, adsorption and absorption of airborne chemicals or odors.

CONSIDERATIONS

General

Planting a hedgerow larger than the minimum length and width will increase the amount of carbon stored in the soil and biomass.

Hedgerows can be planned in combination with other practices to develop complete conservation systems that enhance landscape aesthetics, reduce soil erosion, improve sediment trapping, improve water quality and provide wildlife habitat.

Hedgerows following land contours create meandering lines on the landscape, produce a natural appearance and increase the availability of "edge" wildlife habitats.

Hedgerows containing a mixture of native shrubs and small trees provide greatest environmental benefits.

Use of bareroot and containerized seedlings will accelerate hedgerow development.

Consider the amount of shading a hedgerow will provide at maturity. Shading may impact growth of adjacent plants, microclimate and aesthetics.

Limiting renovation events to one-third of a hedgerow's length or width will prevent sudden elimination of the practice's wildlife habitat function.

NRCS, NHCP
October 2003

Periodic root pruning can reduce nutrient and water robbing from adjacent cropland.

Consider avoiding the use of plants that spread by root suckers as hedgerow may expand beyond the desired treatment area.

Wildlife Food, Cover and Corridors

Hedgerows can provide travel lanes, or corridors that allow wildlife to move safely across a landscape.

Generally, wider corridors accommodate more wildlife use.

Linking fragmented habitats may increase wildlife use of an area.

In grassland ecosystems, hedgerows may adversely affect area-sensitive nesting birds by fragmenting habitat patches and increasing the risk of predation.

Hedgerows can complement the availability of naturally occurring wildlife foods.

Hedgerows can provide wildlife with cover for feeding, loafing, nesting and caring for young.

Dense or thorny shrub thickets provide songbirds with important nesting sites and a refuge to escape predators.

Establishment of evergreen plants provides year-round concealment and thermal cover for wildlife.

Establishment of herbaceous vegetation along the edges of a hedgerow can further enhance the habitat functions of a hedgerow.

Installation of artificial nest boxes with predator guards can encourage cavity-nesting birds and small mammals to utilize a hedgerow.

Living Fences

Thorny shrubs and trees can improve a living fence's barrier effect.

Screens and Noise Barriers

From eye-level, hedgerows reduce the line-of-sight across open areas, concealing objects behind them from view.

Consider the design from viewpoints on both sides of the screen.

Locate noise barriers as close to the source of noise as possible.

Combination of shrubs and/or trees can create more effective screens than single species plantings.

Evergreens provide foliage that can maintain a screen's year-round effectiveness.

Improving Landscape Appearance

Consider plants' seasonal display of colors on bark, twigs, foliage, flowers and fruit.

Consider plants' growth habits (outline, height and width).

Water Quality and Quantity

Water quality benefits may arise from:

- Arresting sediment movement and trapping sediment-attached substances.
- Infiltration and assimilation of plant nutrients.
- Water cooling effects resulting from increased shade on small watercourses.

A hedgerow will increase surface water infiltration by improving soil structure around its root zone. However, evapotranspiration may reduce groundwater recharge benefits.

Incidental Trapping of Snow or Soil

Although not a primary purpose, hedgerows may incidentally trap wind blown snow or soil.

Consider installing hedgerows on alignments that prevent trapping and accumulation of snow and sand on public roads.

Refer to the Windbreak/Shelterbelt Establishment (380) standard for criteria when snow or sand trapping is a primary conservation purpose.

PLANS AND SPECIFICATIONS

Plans and specifications for this practice shall be prepared for each site. Plans and specifications shall be recorded using approved specification sheets, job sheets, or narrative documentation in the conservation plan, or other acceptable documentation.

NRCS, NHCP
October 2003

OPERATION AND MAINTENANCE

Vegetation shall be maintained to ensure continued control of odor movement and chemical drift.

Supplemental planting may be required when survival is too low to produce a continuous hedgerow.

Vegetation shall be protected from unwanted fire and grazing throughout its life span.

Pests shall be monitored and controlled.

Periodic applications of nutrients may be needed to maintain plant vigor.

Renovation activities shall be scheduled to prevent disturbance during the wildlife nesting season.

REFERENCES

National Biology Handbook, Part 614.4, “Conservation Corridor Planning at the Landscape Level”. Natural Resources Conservation Service, August 1999.

NRCS, NHCP
October 2003

U.S DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
CALIFORNIA

PRACTICE REQUIREMENTS

FOR

422 - HEDGEROW PLANTING

For: Business Name_____

Job Location_____

County_____ RCD_____ Farm/Tract No._____

Referral No._____Prepared By_____ Date_____

IT SHALL BE THE RESPONSIBILITY OF THE OWNER TO OBTAIN ALL NECESSARY PERMITS AND/OR RIGHTS, AND TO COMPLY WITH ALL ORDINANCES AND LAWS PERTAINING TO THIS INSTALLATION.

Installation shall be in accordance with the following drawings, specifications and special requirements. NO CHANGES ARE TO BE MADE IN THE DRAWINGS OR SPECIFICATIONS WITHOUT PRIOR APPROVAL OF THE NRCS TECHNICIAN.

1. Drawings, No._____ _____ _____

2. Practice Specifications_____,_____,_____

3. Planting Stock: _____

   Planting Stock: _____

   Planting Stock: _____

4. Fertilizer: _____ rate: _____

_____

_____

_____

_____

_____

_____

5. Special Requirements:_____

_____

_____

PRACTICE APPROVAL:

Job Classification: (Ref: Section 501 NEM)
Show the limiting elements for this job. This job is classified as, Class _____

Limiting elements:	Units
Area Planted_____	_____ac
Lenth of Row_____	_____ft
_____	_____
_____	_____

Approved by:_____ Date:_____

_____

LANDOWNER'S/OPERATOR'S ACKNOWLEDGEMENT:

The landowner/operator acknowledges that:

a. He/she has received a copy of the drawings and specifications, and that he/she has an understanding of the contents, and the requirements.

b. He/she has obtained all the necessary permits.

c. No changes will be made in the installation of the job without prior concurrance of the NRCS technician.

d. Maintenance of the installed work is necessary for proper performance during the project life.

Accepted by:_____ Date:_____

_____

PRACTICE COMPLETION:

I have made an on site inspection of the site (or I am accepting owner/contractor documentation), and have determined that the job as installed does conform to the drawings and practice specifications.
Completion Certification by:

/s/_____ Date _____

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE SPECIFICATION

422 - HEDGEROW PLANTING

I. SCOPE

The work shall consist of furnishing all materials and placing them in the designated areas to the limits as shown on drawings or staked in the field and performing all the cultural operations to grow and maintain healthy p

lants.

II. SITE PREPARATION

The land on which trees and shrubs will be planted must be essentially free of sod and perennial weeds before planting. Where grass sod or alfalfa exist, they are to be destroyed. This may be accomplished by mechanical and/or chemical control.

A. Sites with sod or perennial vegetation:

   Where no wind erosion hazard exists, destroy sod or perennial vegetation on the entire site the year prior to planting by mechanical or chemical means.

   Where an erosion hazard exists, destroy sod or perennial vegetation by mechanical or chemical means on an area extending a minimum of three (3) feet (6 feet total strip) from where the seedling is to be planted.

B. Sites that have been in row or small grain crops the year prior to planting:

   Where no erosion hazard exists, sites may be prepared just prior to planting.

   Where an erosion hazard exists, prepare seedbed, leave stubble over the winter, and prepare a six-foot strip prior to planting by mechanical or chemical means on an area extending a minimum of three (3) feet (6 feet total strip) from where the seedling is to be planted .

C. Where wind erosion is a problem, the plants may be planted directly into the site and a 3-foot diameter circle cleared around each plant at the time of planting. Methods of control include chemical and mechanical control.

D. Fallowing will be accomplished in areas having less than 20 inches of annual precipitation.

E. The irrigation system will be planned and installed prior to planting. Set up will be just after planting

III. PLANTING STOCK AND CARE OF SEEDLINGS

Proper care of seedlings at all times, from lifting at the nursery to the actual planting, cannot be overemphasized. Negligence at any of these stages can cause complete failure regardless of the care taken when planting. Do not obtain seed≠lings from the nursery until shortly before planting is to begin.

Keep seedling roots moist at all times, from the time they are removed from the bale until they are planted. Seedlings may be stored in bales for a short period of time: two or three days. Extreme care must be taken, however, to make sure roots do not dry out, that the seedlings do not heat, and reasonable efforts must be made to keep them from freezing. Seedling bales must be watered at least once every 48 hours and protected against sun and wind, yet well ventilated. Seedling bales should be examined daily and shifted as necessary to avoid heating. Where freezing occurs the bales should not be handled, but left until completely thawed out by warmer weather. Where it is necessary to store seedlings for periods in excess of three days, it is better to heel them out in thin layers and bed them in a sandy or loamy soil and make sure they remain moist.

Extreme care must be taken to keep seedling roots from becoming dried out while planting. Dry soil on the roots is evidence that seedlings are not being cared for properly. Ample water, or a water saturated material, must be kept in all planting containers to make sure the seedling roots remain moist.

Only viable planting stock grown from locally adapted seed or vegetative material should be planted. Planting stock should be maintained in good condition from the time received until planted. This will include, but not limited to, unpacking, storage, heeling in, transport to the planting site, and keeping plants protected and moist until and during planting.

Care of Seedlings.

1. Bareroot stock care before planting:
   (a) Store plants in enclosed areas from 34 to 40 degrees F. off the floor.
   (b) If ice is utilized, do not allow contact with the roots.
   (c) Bales of plants should not be piled higher than 3 feet.
   (d) Roots will be facing one way for periodic watering and fungicide treatment. Seedling roots will be kept moist.
   (e) Heel-in beds. Make a trench with one 30 to 45 degree backslope. Line out planting stock against sloped side and backfill. Pack soil firmly around the roots. Keep roots 1 to 2 inches below the ground line. Water as needed. A moderately course-textured soil is preferred. The heel-in bed should be shaded and protected.
2. Bareroot stock care during planting. Keep seedlings covered and moist while planting. Ample water, or a water saturated material (burlap, sawdust moss, etc.) must be kept in all planting containers to insure the seedlings remain moist.
3. Containerized stock care - including all stock in any type of container (tar paper, gallon cans, containers, etc).
   (a) Seedlings will be stored at 34 to 40 degree F temperatures.
   (b) The soil medium will be kept damp.
   (c) The seedlings will be shaded and protected.

IV. PLANTING

Machine planting or hand planting with any tool that will accomplish desirable results is acceptable.

The hedgerow will be staked or otherwise marked to assure proper alignment of rows and spacing.

Machine furrows or holes made with hand tools must be free of trash. Do not plant during freezing weather or when the ground is frozen.

Plantings will be made after the danger of heavy freezing has past and soil conditions are proper.

Plant in adequately sized, sod-free holes or furrows for proper root development.

Special attention to the actual planting operations is essential to the establishment of hedgerows:

Depth

Plant each seedling at the same depth or slightly deeper (1/2 to 1 inch) than it grew in the nursery.

Condition of Roots

Plant seedling roots straight down, not twisted, balled, or U-shaped. Roots must extend 8 to 12 inches below the ground surface.

Pruning

Do not prune tops or roots. The nursery practice of pruning the roots to about 10 inches when lifting has made further pruning unnecessary and is, therefore, not required.

Straightness

Plant seedlings as near vertical as possible.

Firmness

Pack the soil firmly around the planted seedlings with no air pockets left in machine furrows or dibble holes. Do not overpack on clayey soils.

Seedlings Per Space

Plant only one seedling per planting space.

Avoid planting on hot, dry, windy days, during freezing weather, or when the ground is frozen.

V. IRRIGATION

The irrigation system for each hedgerow planting shall be designed, installed and operational prior to planting. Except in MLRA 4, plantings shall receive supplemental irrigation for the first three years after planting (see applicable IRRIGATION SYSTEM standards and specifications).

VI. MAINTENANCE

Replace all dead seedlings (annually) for at least three years after the planting is made.

Replant with the same species or one that is suitable to the soils and is compatible with original planting.

Plant competition can be removed by hand, mechanical, or chemical means. Do not disturb or otherwise damage seedlings by the improper use of chemicals, tools or machinery. When mechanical cultivation is used do not cultivate deeper than 3 inches, as the plant roots can be damaged.

Use mechanical and/or herbicides to control weeds, grasses or other competitive vegetation. Control competitive vegetation until the surrounding ground surface is completely or nearly completely shaded by the trees and shrubs during the growing season.

If at all possible, maintain an isolation strip of at least 8 feet for the entire life of the planting.

When weed control is done chemically, 1/ the following precautions will be observed:

Chemicals must be applied on no less than a 24-inch band to each side of the row.

Plantings will be protected from rodents, rabbits, hares, and deer. Means of animal control may include either chemical repellents or mechanical devices such as fences, screens, traps, rodent guards, general cleanup, etc.

Where net wire fencing is used to control rabbits and hares, it will extend at least 4 inches below ground surface. When individual trees are wrapped with burlap or tar paper, the material will be removed in the spring.

Prune and shape storm damaged trees.

Drip irrigation systems must be maintained weekly during irrigation season to make sure emitters are not plugged and restricting water flow.

Individual Tree Protection

Based on limited observation, especially to younger plants, the following species normally require protection to control damage due to wildlife browsing:

native plum, skunkbush sumac, fourwing saltbush, lilac, dogwood, poplar spp., birch spp., willow spp..

Chicken wire tree protection. Chicken wire with a mesh that does not exceed 1 inch will be shaped to form a cylinder a minimum of 5 inches in diameter and 18 inches high. A minimum of one 24 inch 1x2 stake with 18 inches extending above the ground will be used to support the stake by 2 evenly spaced staples or tie wires. The chicken wire will be flush with the ground. The barrier must be removed when the trunk diameter is within one-half inch of the chicken wire diameter.

Rigid polypropylene - mesh tube tree protection. Tubes will be of a diamond pattern with a minimum 30 mil. strand diameter. The tubes will be a minimum of a 5 inch diameter and 18 inches high. The tubes will be fastened to a 24 inch 1x2 stake with 18 inches extending above the ground by one staple or a tie wire. The tubes will be flush with the ground. Tubes must be capable of UV breakdown in 2 to 5 years.

Rigid polypropylene - twin-walled extrusion. Tubes will be a minimum of 3 inches and a maximum of 6 inches in diameter. Height will be a minimum of 24 inches. Tubes will be fastened to a 24 inch 1x2 stake with at least 8 inches extending into the ground. Tubes will be fastened to the stake by at least one tie device. Tubes will be seated appropriately 1 inch into the ground surface. Tubes will be capable of remaining intact for at least five years. Color may range from white (low light conditions) to brown. Where cavity nesting birds or other wildlife entering the tubes may be a problem the tops of the tubes will be covered with a mesh sleeve to prevent entry.

VII. OTHER REQUIREMENTS

The owner, operator, contractor, and other persons shall conduct all work and operations in accordance with proper safety code for the type of construction being performed with due regards to the safety of all persons and property.

The Districk Institute for Applied Insect Ecology

Perennial Plants Selected to Attract Beneficial Insects to Manage Aphids, Caterpillars, Mites, Thrips, and Whitefly

Plant	Attracts these Beneflcials	Pest Managed	Flowers	Description	Height
Achillea millefolium Common Yarrow	Hoverflies, wasps, lady beetles	Mites, scale	Apr-Jul	Spreading fern-like	2-3 ft.
Achilles millefollum 'Paprika' Red Yarrow	Same as above	Same as above	Apc-Jul	Spreading fern-like	8-12″
Achilles 'Salmon Beauty' Salmon Yarrow	Same as above	Same as above	Apr-Jul	Spreading fern-like	8″
Asclepias fascicularis Narrowleaf milkweed	Same as above also Host to Monarch butterfly	Same as above	Jul-Oct	Upright, long narrow leaves	2-3
Atriplex lentiformis Brewer saltbush, big leaf form	Lady beetles, Cover for quail	Mites, scale	Jul-Oct	Semi-deciduous shrub	5-10
Baccharis 'Centennial' Hybrid Coyote Brush	Wasps, tachinid flies, hover-flies	Caterpillars, Whitefly, mites	Oct-Jan	Evergreen shrub, Very heat tolerant	5 X 3 wide,
Baccharis pilularis Coyote Brush	Same as above	Same as above	Oct-Jan	Evergreen shrub	4-6 X 4-8″ wide
Baccharis pilularis Coyote Brush, compact form	Same as above	Same as above	Oct-Nov	Low-growing shrub	12-18 X5-6
Baccharis viminea (*B. saliafolis)* Mule Fat	Hoverflies, lady beetles	Same as above	Mar-May	Erect shrub. Long foliage	6-10
Ceanothus 'Concha' Wild Lilac	Wasps, lady beetles, hoverflies	Mites, thrips, whitefly	Mac-Apr	Evergreen shrub, Toler-ant coast/inland/ summer watering	6-8
Ceanothus cuneatus Buckbrush	Same as above	Same as above	Feb-Apr	Upright evergreen. Very drought tolerant	8
Ceanothus g. var. *h* 'Yankee Point' Yankee Point Carmel Creeper	Same as above	Same as above	Mar-May	Evergreen,shrub, large leaves. Coastal and inland	3-5 X 6-8
Ceanothus 'Ray Hartman' Treasure Island Blue Blossom	Same as above	Same as above	Feb-Apr	Small tree, Evergreen	8-15 X 10-15 wide
Ceanothus thyrsiflorus Blue Blossom	Same as above	Same as above	Mar-May	Evergreen shrub Hardy	6-20 X 8-30 wide
Eriogonum arborescens Santa Cruz Island Buckwheat	Hoverflies, wasps, minute pirate bug, tachinid flies	Caterpillars, whitefly, mites	May-Oct	Evergreen shrub, loosely branched	2-5 X2-5 wide
Eriogonum fasciculatum var. *foliolosum* California Buckwheat	Same as above	Same as above	May-Dec	Evergreen shrub, Narrow wooly leaves	2-5
Eriogonum giganteum St. Catherine's Lace	Same as above	Same as above	Jun-Nov	Large open shrub	4-5 X 3-4-wide

Plant	Attracts these Beneflcials	Pest Managed	Flowers	Description	Height
Heteromeles arbutifolia- Toyon	Hoverflies, wasps, tachinid flies	Caterpillars	May-Jun	Evergreen shrub, Small tree. Tolerates sun, partial shade, smog, wind, heavy or light soils	8-15 up to 25
Isomeris arborea Bladder Pod	Stinkbug predators		Feb-May	Dense evergreen, mounding shrub	3-6 X 3-6 wide
Myoporum parvifollurn Creeping Boobialla	Wasps, hoverflies, tachinid flies	Caterpillars	Jun-Oct	Ground cover, Fast-growing	3″ X 9 wide
Polygonum aubertii Silverlace Vine	Same as above. big eyed bug	Mites, whitefly, caterpillar	Apr-Nov	Deciduous vine, hardy, fast-growing	
Prunus illcifolia Hollyleaf Cherry	Lacewings, lady beetles, hoverflies, wasps	Mites, thrips, wh'rtefly	Apr-May	Evergreen shrub/tree	20-40
Quillaja saponaria Soapbark, Tree	Same as above	Mites, thrips, whitefty	May-Jun	Evergreen tree, Dense to ground when young, Can be pruned to tall hedge	30
Rnamnus californica Coffeeberry	Lady beetles, hoverflies, wasps	Caterpillars	Apr-May	Evergreen shrub	12-15
Rhamnus californica Corfeeberry Var. 'Eve Case"	Same as above	Same as above		More compact	3-8 X 3-8
Rhamnus califomica Corfeeberry Var *tomemtella*	Same as above	Same as above		Greyer foothill form	
Rubus vitifolius (R. ursinus) California Blackberry	Parasitic wasps		Spring	Deciduous vine, mounding, Large trifoliate leaves	
Salix goodlngii Gooding's Black Willow	Lady beetles. wasps, hoverflies	Mites, scale	Mar-Apr	Deciduous tree, Narrow leaves	20-30
Safix laevigata Red Willow	Same as above	Same as above	Mar-May	Large deciduous tree	20-40
Salix lasiandra (S. *lucida* ssp *lasiandra)* Western Black Willow	Same as above	Same as above	Mar-Apr	Deciduous tree, Large leaves	20-30 X 20 wide
Salix lasiolepsis Arroyo Willow	Same as above	Same as above	Jan-Feb	Deciduous shrub/tree	6-20
Sambucus mexicana Mexican Elderberry	Hoverflies, wasps		Apr-Nov	Deciduous shrub/tree	4-10 to 40

The Dietrick Institute for Applied Insect Ecology, based in Ventura, is committed to educating the public in methods for natural pest control. If your group would like a speaker for a meeting or material for a school project please contact us.

The Dietrick Institute for Applied Insect Ecology

P. O.Box2506 Ventura, CA 93002 805-643-3169

Publication Funded by UCSAREP

PROJECT DESCRIPTION

Extending Hedgerow Systems in California Agriculture

A Project of the Community Alliance with Family Farmers, funded by Western Region Sustainable Agriculture Research and Education Professional Development Program 2004

With funding from the Western Region Sustainable Agriculture Research and Education (WSARE) Professional Development Program, Community Alliance with Family Farmers (CAFF) has prepared this resource guide, as part of the project "Extending Hedgerow Systems in California Agriculture." The objectives of the project are to: 1) Increase the knowledge of agricultural professionals about hedgerows as a system component that can help reduce pesticide use, increase on-farm biodiversity and on-farm habitat for beneficial organisms and wildlife, reduce wind and water erosion of soil, beautify the environment, and diversify farm products; 2) Extend the use of hedgerows as conservation and management tools to areas of California where they are not currently common; and 3) Create a hedgerow resource base for farmers and agricultural professionals that can be easily utilized throughout the state.

CAFF is partnering with resource personnel in the field of on-farm habitat restoration to hold four training workshops over a two-year period for California agricultural professionals. These workshops will educate staff members of the Natural Resources Conservation Service (NRCS), Resource Conservation Districts (RCD), Pest Control Advisors, 4-H Advisors, University Cooperative Extension Service and others about the use of hedgerows on farms. A team of experts has been formed that includes farmers who have hedgerows on their farms, NRCS and RCD staff who have expertise in hedgerows, employees of the National Center for Appropriate Technology (NCAT), agricultural and environmental consultants, owners of native plant nurseries and CAFF staff members. This team developed educational materials and determined the format for the workshops and served as speakers and evaluators of the project.

Workshops to train agriculture professionals in the creation of on-farm habitat using native plant hedgerows were held in four regions of the state where CAFF is active: North Coast, Central Coast, Northern and Central San Joaquin Valley. Within each of these regions, regional teams were formed to assist in local development and execution of the training sessions. Included as part of the training sessions were subsequent visits to local hedgerow demonstration sites at various stages of development. CAFF developed materials for use by participants after training that will help them discuss hedgerow options with farmers. Resource materials are available to help farmers identify plants and their associated beneficial insects. A list of native plant nurseries statewide is included in resource materials along with steps to building and maintaining a successful hedgerow. All of these resources are available on the CAFF Web site.

A Hedgerow Education Fund was set aside from the WSARE grant money to provide"mini-grants" which were used to encourage the extension of knowledge gained in the workshops to farmers and farm communities within trainees' regions. In addition to providing incentive to trainees, this tool assisted in the evaluation process of the training sessions. When coupled with periodic surveys, success of the project was measured both by the number of projects resulting and the geographic extent of these projects.

Establishing Hedgerows for Pest Control and Wildlife

Mary Kimball & Celia Lamb, Yolo County RCD

Growers in Yolo County have found a solution to the problem of maintaining field borders and other noncrop farm areas. By planting hedgerows of non-invasive native plants, they create wildlife habitat areas that attract beneficial insects and provide competition against invasive weeds. With careful establishment and management techniques, hedgerows can provide a useful and attractive alternative to continuously scraping, spraying, and cultivating field edges and other "unfarmed" areas that would otherwise become sources of weed seeds.

What is a Hedgerow?

Hedgerows are lines or groups of trees, shrubs, perennial forbs, or grasses that are planted along field edges or other unused areas. For agricultural areas in California, we recommend using a variety of native grasses, perennial forbs, shrubs, and trees that attract different types of beneficial insects, mammals, reptiles, and birds (including raptors). Native plants work extremely well in hedgerows because they require very little care after an establishment period of about three years. Many native plants have deep roots that hold soil and increase water permeability. Hedgerow areas suppress weeds by providing competition, and are less susceptible to wind and water erosion than bare soil. They can also filter surface runoff water, preventing silt, nutrients, and pesticides from entering waterways.

Image by Celia Lamb

Young hedgerow at a Yolo County farm

Selecting a Site

Any unused farm area with good soil and access to water may make a good hedgerow site. The native plant species that we recommend using in an insectary hedgerow are very water sensitive; some plants like a great deal of water, while others can develop root and crown rot if overwatered. In order to combat this challenge, we recommend using drip irrigation tubes with adjustable emitters. Drip irrigation is the most effective, efficient and successful method of watering your new hedgerow. A secondary, very effective method is furrow irrigation. It is imperative to select a site that can be irrigated by one of these methods; access and availability of water to a new hedgerow planting is the single-most important factor in plant survival in the first year.

Another important factor in site selection is vulnerability to flooding and/or standing water. As previously discussed, many native plant species are very sensitive to overwatering, and if a site is known for its tendency to flood or have standing water during the winter months (or due to overwatering of a field crop), DO NOT use this site for a hedgerow planting. If possible, try to select a site that is either on higher ground or that you are absolutely sure does not collect water at any time of year. Of course, in high water years, this may not be avoided, but do not place a hedgerow on low ground and expect many of the plants to survive.

A third consideration is equipment. Make sure the area is out of the way of equipment; placing the hedgerow too close to a road or high-traveled area may be problematic if the equipment damages the plants. Hedgerows can certainly be planted next to roads, but recognize that many of these shrubs and trees will grow to 10-15 feet in width; be sure to leave enough room for this growth. This may mean planning spaces in the hedgerow for equipment to drive through, or choosing an alternate site that would be less intrusive.

Choosing Plants

Plants should be selected according to the purpose you want the hedgerow to serve, but local species are likely to be best adapted to conditions on your farm. It is important to look at the water needs of each plant. Some natives, such as Toyon, Ceanothus spp., and California buckwheat, are extremely drought-tolerant and will die if their root crowns get wet for too long. These are best planted in well-drained soils. Others, such as willows and cottonwoods, prefer wetter areas. Within a given site, you may have varying soil types or lower areas that are more prone to flooding. In this case, choose plants with these differences in mind; i.e. select water-loving plants for some areas, and drought-tolerant plants for others. If you take the time beforehand to choose plants according to *your* site, rather than just using an "example" hedgerow recommendation, you will have much more success with plant survival; plants will grow faster, be healthier, and be better able to resist disease and pest insect pressure.

If you would like your hedgerow to serve as a windbreak, then you should design a hedgerow with many tall-growing shrubs and trees. Recommended species include cottonwoods, willows, native oaks, redbuds, and elderberry. Remember too, that as these trees grow, their understory will be less vegetated, and you may want to include shrubs in between trees to provide habitat and erosion control closer to the ground. By including shrubs, you will also gain more insectary value to the hedgerow. For lists of possible species for different settings in the Yolo County area, please see the attached list.

Coyote brush leaf and flower

If your primary goal is to use plants to attract beneficial insects (i.e. insects that prey on or parasitize crop pests), you should plant species with plentiful nectar and pollen. If you are unsure whether a plant will attract beneficial insects, observe one during its flowering stage to see if bees and other insects are using it. For example, flowering Ceanothus and coyote brush tend to have large quantities of hoverflies and bees feeding on their pollen and nectar, whereas flowering oleander bushes attract very few insects. Consider the time of year during which each species flowers, and try to use a good variety of plant species so that flowering will take place almost year-round. Many beneficials are looking for nectar and pollen in early spring and late fall, when nearby crops are just being planted or are being harvested. By using plant species that flower during these times, you will encourage greater use of the hedgerow, as these insects do not have other habitat in the area. The diagram on the following page contains information you may use to plan a hedgerow with staggered flowering periods.

Image by Celia Lamb

Installing a hedgerow along a fenceline

Design, Site Preparation and Planting

Unless the future hedgerow site has been kept free of weeds, it is best to begin regular disking, burning, and/or spraying at least one year before you intend to plant. Reducing the weed seed bank in this way will be especially important if you intend to plant grasses. Depending on the layout of your hedgerow and your irrigation method, you may need to prepare one or more planting beds for native grasses. Preparation for seeding is no different than preparing a seed bed for wheat, alfalfa, or most other crops. It is important to cultivate the area, depending on the soil type, by disking thoroughly and then harrowing to prepare an even, well-drained bed that is free of large clods of soil that can impede grass germination.

The best time to plant native grass seed is during the fall. You may want to wait for a rainstorm to bring up the first flush of weeds, and then spray, burn and/or

Flowering Periods of California Native Insectary Plants

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Willow spp.	■	■	■	■								
Ceanothus spp.		■	■	■	■							
Coffeeberry				■	■							
Hollyleaf cherry				■	■							
Yarrow				■	■	■	■					
Silverlace vine				■	■	■	■	■	■	■	■	
Toyon					■	■						
Golden sticky monkeyflower					■	■	■	■	■			
Elderberry					■	■	■	■	■			
California Buckwheat					■	■	■	■	■	■	■	■
Deergrass					■	■	■	■	■			
Creeping boobialla					■	■	■	■	■	■		
California fuchsia					■	■	■	■	■	■		
Narrowleaf milkweed					■	■	■	■	■	■		
St. Catherine's lace					■	■	■	■	■	■	■	
Coyotebrush	■									■	■	■

harrow the weeds before planting. You can also control weeds in the first 1-2 weeks after planting by spraying glyphosphate before the native grasses emerge. Native grasses tend to take 2-3 weeks to emerge, but this is very weather dependent; be sure to inspect the site for germination before spraying. Native grass seed can be drilled, but most often the seed is broadcast with the use of a "belly grinder" (available from the RCD or your native grass supplier). After spreading, the grass seed should be harrowed in lightly (only 1/8" is necessary), so that seeds won't dry out and die. If harrowing isn't possible, a light covering of hay can also be used. The harrowing can be done with a 4-wheel ATC and light chain harrow, which also allows for getting on the site even after numerous rains. Please refer to the article "Strategies for Establishing California Native Grasses by Direct Seeding in the Sacramento Valley and Adjacent Foothills," (in this book) for more specific instructions.

Most native forbs, shrubs, and trees should be planted in the fall, although some become dormant at that time. Consult with your plant supplier for the best transplanting time. When planting, be sure to allow the shrubs and trees enough room to spread. A good rule of thumb is to plant them at centers 13-15 feet apart from each other. If you are using perennial forbs and small shrubs in your hedgerow, these can be placed in between the larger shrubs and trees, at a center spacing of 7-8 feet. Placing any of these plants any closer can inhibit growth in years to come, and is not necessary both economically and physically.

Before transplanting shrubs and trees, you may need to pre-soak the area to be planted to make hole-digging easier. Pre-soaking holes before transplanting is also a good way to reduce the likelihood of transplant shock. You may want to consider using fertilizer tablets for woody shrubs and trees. Dig a hole about twice the width and 1 1/2 times the depth of the original root

ball, drop the fertilizer tablet in, and cover with a small amount of soil so that the tablet is not in direct contact with the roots. Mound soil in the base of the hole so that the top of the root ball is roughly at the surrounding ground level. Remove the plant gently from its container and place it in the hole. If you need to loosen the root ball from the sides of the container, roll the container around in your hands, but *never* pull the plant out by its stem. Pack soil gently around the rootball to ensure good soil contact and minimize settling. Cover the top of the rootball with 1/4"- 1/2" of soil to prevent it from drying out. Be sure not to cover the top of the rootball too much, especially if the plant is a drought-tolerant shrub; the soil can hold water against the root crown, killing the shrub. Soak the new plantings well to minimize transplant shock and settle any air pockets around the rootball.

Hedgerow Maintenance

Hedgerows need to be "farmed" during the first 2-3 years. This entails controlling invasive weeds and irrigating during dry periods. The most important maintenance that is necessary for hedgerow success is weed control. Even though you've planted native grasses, shrubs and trees, weeds will still be a problem for several years.

NATIVE GRASSES

After the initial spraying of glyphosphate after planting, you must carefully monitor weed pressure in native grass stands. In most cases, winter annuals such as annual rye grass, chickweed, yellow star thistle, annual sow thistle, wild oats, and mustard species can be prevalent and cause major problems. Since native grasses are slower growing, the annual weed growth can quickly surpass that of the natives and shade them out, thus preventing them from becoming established. Use selective herbicides for broadleaf weeds in the early spring to make sure that they don't get too large and produce seed. Annual grasses are hard to manage, but the best method is to mow your native grass stand before the annuals go to seed so that they are unable to reproduce for the following year.

HEDGEROW PLANTS

In the first year of growth, we have found that applying the pre-emergent herbicide Oxadiazon (granular formulation--see label for application restrictions) along the hedgerow just after planting is the most effective in controlling winter annuals throughout the winter season and even beyond. You can use glyphosphate and 2-4D to spot spray (using a backpack-sprayer), but must be extremely careful to not hit any of the shrubs or trees with any of the herbicide. Be sure to spray on very calm days, and use your judgement as to how close to a plant to spray. Hand-hoeing during the summer months, although labor-intensive, is very effective.

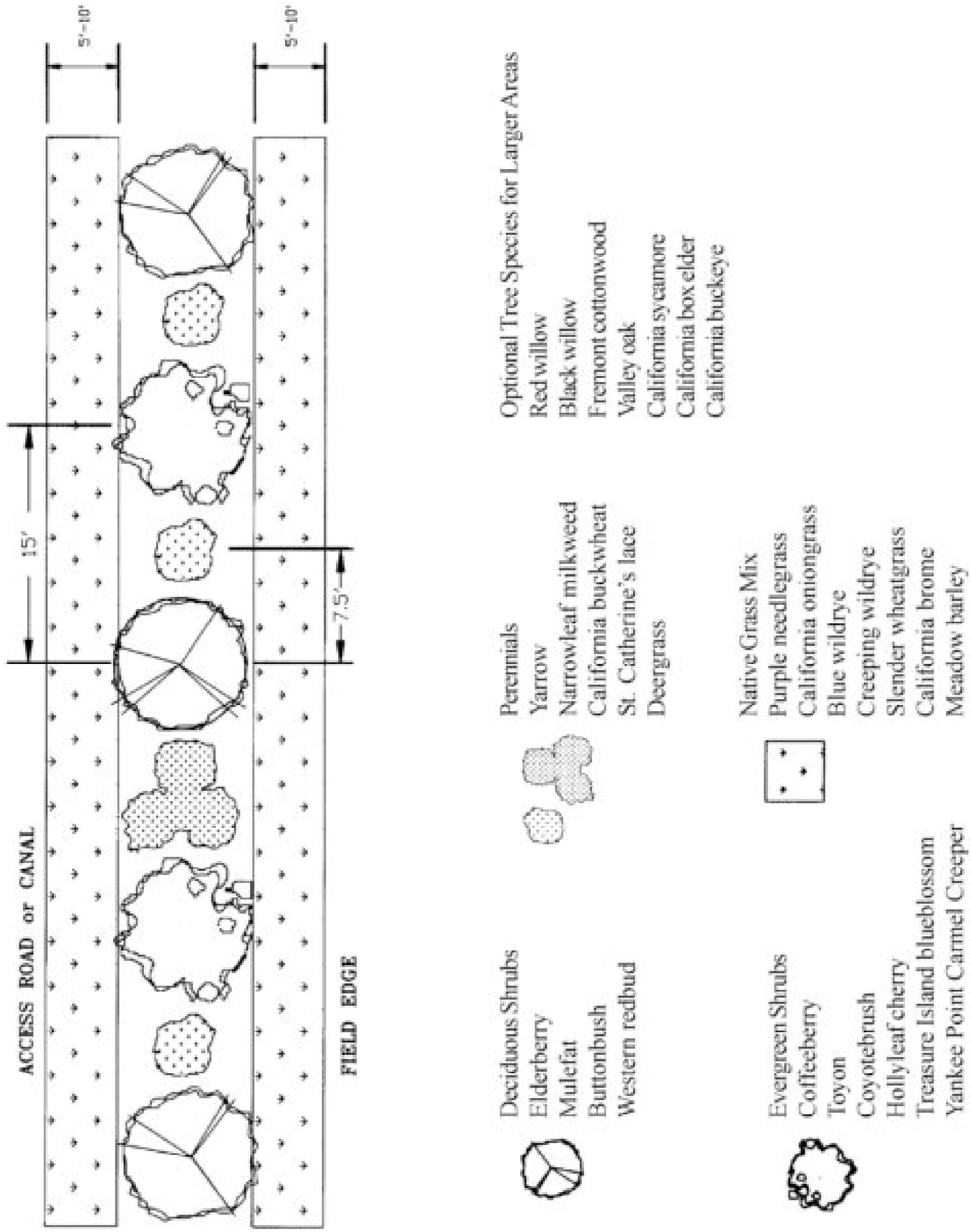
IRRIGATION

Find out the water needs of your plants from your supplier. Native grasses do not need summer watering because they become dormant at that time. Most shrubs and trees will need watering about every 2-4 weeks during drought months (March-November, depending on the year). After the 2-3 year establishment period, irrigation should no longer be necessary (depending on the plant species), and weed control measures can be considerably reduced. You may wish to keep notes on insect and wildlife visitation, weed problems and control methods you use in the hedgerow, weather conditions, and plant species that seem especially suited to your area, so you can share your results with others. The Yolo RCD has planted several hedgerows, and we would be very interested in hearing your questions and comments regarding your own hedgerow as we continue to monitor our hedgerows and work on improving our establishment methods.

Treasure Island blueblossom plant (left) and leaf and flower (right)

Sample Design of Insectary Hedgerows

Jae Lee, NRCS



Plant List for Oak Woodland and Savannah Situations*
(Adaped for "Insectary" Plantings in Small Areas)

Jae Lee, NRCS

The following is a list of possible plants for hedgerow designs in valley oak woodland/savannah situations. The notes provide information to help determine planting combinations that allow individual species appropriate sunlight, water, and adequate space. General growth habits may also be included. Hedgerows comprised of a mix of trees and shrubs are generally long lived. Trees are typically longer lived than shrubs. However, many shrubs can have life spans of more than 15 - 20 years. The Ceanothus species have one of the shortest life spans—5-10 years is typical. All of these plants (with the exception of the cool season native grasses) do require irrigation during their establishment period of 2-4 years.

Small Trees (Deciduous)

Common Name	Scientific Name	Notes
Western redbud	*Cercis occidentalis*	Many branched shrub to multiple trunk tree, 6'-20' tall, 10'-15' wide, tolerates partial shade to full sun. Occasional summer water.
Blue elderberry	*Sambucus mexicana*	Shrub 4'-10' tall or tall tree to 40', commonly found in moist places but can tolerate some drought. Flowers April - Nov. Occasional summer water.

Small Trees (Evergreen)

Common Name	Scientific Name	Notes
Treasure Island blueblossom	*Ceanothus* 'Ray Hartman'	Mounding shrub with 1"-2" leaves; 8'-15' tall, 10'-15' wide, train to small tree, needs full sun. Infrequent summer water. Flowers Feb.-April.
Blue blossom	*Ceanothus thyrsiflorus*	Hardy, 6'-20', full sun. Flowers March-May. Infrequent summer water.
Toyon	*Heteromeles arbutifolia*	Dense shrub 6'-10' or multi-trunked small tree, 15'-25', grows in full sun or partial shade. Flowers May-June. Looks better with occasional summer water.
Hollyleaf cherry	*Prunus ilicifolia*	Moderate growth rate, 20'-40' tall (large and old specimens resemble California live oak), best in full sun, can take light shade. Flowers April-May. Looks better with infrequent deep summer water.
Coffeeberry	*Rhamnus californica*	Mounding shrub, reaches 12'-15', variety 'Eve Case' is more compact, 3'-8' tall and wide, grows in full sun to half shade. Flowers April-May. Looks better with occasional summer water.

Shrubs (Deciduous)

Common Name	Scientific Name	Notes
Quail bush	*Atriplex lentiformis*	Densely branched, sometimes spiny; 3'-10' tall, 6'-12' wide, needs full sun. Flowers July - October. Plant in areas isolated from sugarbeet production.
Brewer saltbush	*Atriplex lentiformis ssp. breweri*	Almost evergreen, not spiny; 5'-7' high, 6'-8' wide. Plant in areas isolated from sugarbeet production.
Mule fat	*Baccharis viminea*	6'-10' tall. Flowers March - May. Drought tolerant but looks better with occasional water.

* This list of native species is for general information only. The Natural Resources Conservation Service does not imply or consent to the use of this information as a recommendation for species selection. Plant establishment success is not implied. Varying environmental and human factors, including, but not limited to, soil type, climate, topography, weed management, and watering regime will invariably affect the establishment of these plants.

Shrubs (Evergreen)

Common Name	Scientific Name	Notes
Coyote brush	*Baccharis pilularis*	Tough, 4'-8' wide and high. Looks better with occasional summer water. Males flower Oct.-Nov., females Oct.-Jan.
Wild lilac	*Ceanothus* 'Concha'	Densely clad, small leaves, 6'-8' tall and wide. Flowers March-April. Infrequent summer water.
Buckbrush	*Ceanothus cuneatus*	8' tall. Flowers Feb.-April. Very drought tolerant.

Small Shrubs/Ground Cover

Common Name	Scientific Name	Notes
Common yarrow	*Achillea millefolium*	Spreading perennial with fernlike foliage and flowers' stems up to 3', needs full sun, care-free. Flowers April-July. Tolerates dry conditions well.
Narrowleaf milkweed	*Asclepias fascicularis*	Upright perennial, 2'-3' tall with long narrow leaves, needs full sun. Flowers July-Oct. Tolerates dry conditions.
Coyote brush	*Baccharis pilularis*, compact form	Dense, 12"-18" tall with 5'-6' spread, needs full sun. Can flower Oct.-Jan. Looks better with occasional summer water.
Yankee Point Carmel creeper	*Ceanothus g.* var. *h. Yankee Point'*	Fast-growing, 3'-5' tall, 6'-8' wide, good ground cover, needs full sun. Flowers March-May. Looks better with occasional summer water.
California buckwheat	*Eriogonum fasciculatum* var. *foliolosum*	Forms 2'-5' tall, 4' wide clump, with wide, woolly leaves, needs full sun. Flowers May-Dec. Best on drier sites.
St. Catherine's lace	*Eriogonum giganteum*	Large open form, 4'-5' tall. Flowers June-Nov. Best on drier sites.

Grass (Seed combinations, totaling 15 lbs. drilled or 25 lbs. broadcast**, should be mixed according to site conditions. Many species available in plugs.)

Common Name	Scientific Name	Notes
Three-awn	*Aristida hamulosa*	Warm season clumping, 10" tall. Very drought tolerant.
California brome	*Bromus carinatus*	Cool season, annual/biennial, 1.5'-3' tall. Deep soils.
Blue wildrye	*Elymus glaucus*	Cool season perennial bunchgrass, 2'-3' tall. Establishes rapidly, deep good soils.
Yolo slender wheatgrass	*Elymus trachycaulus majus*	Cool season perennial bunchgrass, 18"-4' tall, tolerates full sun to light shade. Deep good soil.
Idaho fescue	*Festuca idahoensis*	Cool season tufted perennial, 1'-2', tall. Tolerates dry conditions.
Meadow barley	*Hordeum brachyantherum*	Tufted, perennial bunchgrass, 1' tall, 8" wide. Adapted to wet conditions.
California barley	*Hordeum californicum*	Adapted to upland dry meadows, 2'-4' tall. Tolerant of winter and spring flooding.
Creeping wildrye	*Leymus triticoides* 'Rio'	Cool season, perennial, spreads by rhizomes, 2'-3' tall. Suited to wetter conditions.
Onion grass	*Melica californica*	Cool season grass growing 1'-2' tall with flower spikes, tolerates full sun to partial shaded. Well-drained soils, deep or shallow.
Nodding needlegrass	*Nassella cernua*	Cool season spreading bunchgrass, 1'-2' tall. Well-drained soils, deep or shallow.
Purple needlegrass	*Nassella pulchra*	Cool season bunchgrass, 1'-2' tall, flower stocks to 30" in spring. Widely adapted.
Foothill needlegrass	*Nassella lepida*	Cool season perennial bunchgrass, 1'- 2' tall. Adapted to dry conditions.
Pine bluegrass	*Poa secunda*	Cool season tufted perennial bunchgrass, 2.5' tall summer dormant. Adapted to shallow soils.
Squirrel tail	*Sitanion jubatum*	Cool season, clumping, 1.5'-5' tall, tolerates full sun. Dry soils.

** On challenging sites (e.g. low fertility soil, steep slopes, disturbed areas), use up to 20 lbs. drilled and 30 lbs. broadcast.

Hedgerow Installation and Maintenance Cost Estimates

For one hedgerow 1400 feet long x 15 feet wide (~ 0.5 ac.) planted with a strip of native grasses next to a line of shrubs.

Labor Costs are estimated at $10/hour. The source of hourly Equipment Costs is UCCE's "Sample Costs to Produce Processing Tomatoes in Yolo County--1997." For the purpose of this study, only operating costs are used to portray Equipment Costs (Repairs, Fuel & Lube).

Task	Date	Labor	Material Cost $/hour	Equipment Cost	Total
Hedgerow Installation					
Hedgerow design	6-11/96	$260.00	Survey flags: $8.00		$268.00
Glyphosate: summer weed control	8/96	$20.00	Glyphosate $30.00	ATV+sprayer: $8.08	$58.08
Disc: pre-plant weed control	10/96	$10.00		Tractor+disc: $18.09	$28.09
Bed preparation: plants/grasses	10/96	$10.00		Tractor+bedshaper: $14.33	$24.33
Fertilize - preplant (tablets)	11/96	$20.00	Fertilizer: $43.50		$63.50
Plant trees, shrubs, and forbs	11/96	$120.00	Plants: $500.00		$620.00
Install 2' tree tubes	11/96	$50.00	tree tubes: $172.50		$222.50
Plant grasses (broadcast)	11/96	$20.00	Seed: $275.00		$295.00
Harrow to cover grass seed	11/96	$10.00		ATV+harrow: $4.04	$14.04
Glyphosate: annual weed control	11/96	$10.00	Glyphosate: $15.00		$25.00
Oxadiazon: apply in plant row	11/96	$10.00	Oxadiazon: $75.00		$85.00
Install drip irrigation system	3/97	$100.00	Drip supplies: $200.00		$300.00
TOTAL INSTALLATION		$640.00	$1,319.00	$44.54	2,003.54
Hedgerow Maintenance					
2,4-D: Broadleaf weed control	3/97	$10.00	2,4-D: $20.00	ATV+sprayer: $4.04	$34.04
Hoe hedge plant row*	3-9/97	$250.00			$250.00
Irrigate 2X/month	3-10/97	$250.00	Emitters/plugs: $8.25		$258.25
Mow grasses: annual weed cntrl	4/97	$10.00		Tractor+mower: $10.19	$20.19
Remove tree tubes	4-5/97	$20.00			$20.00
Glyphosate: spot-spray	5-6/97	$20.00	Glyphosate: $15.00		$35.00
Fertilize: preplant (tablets)	9/97	$10.00	Fertilizer: $8.70		$18.70
Replant trees, shrubs & forbs	9/97	$80.00	Plants: $100.00		$180.00
2,4-D: spot-spray in grasses	9/97	$10.00	2,4-D: $10.00		$20.00
Flame: annual grass weed cntrl	10/97	$10.00	Propane: $15.00	ATV+flamer: $4.04	$29.04
Oxadiazon: entire hedgerow	10/97	$20.00	Oxadiazon: $225.00		$245.00
Mow grasses 2X: weed control	3-5/98	$20.00		Tractor+mower: $20.38	$40.38
Hoe hedge plant row	3-5/98	$120.00			$120.00
Irrigate 2X/month	4-9/98	$200.00			$200.00
Hoe hedge plant row	6-7/98	$120.00			$120.00
Herbicide: 2,4-D (in grasses)	8/98	$10.00	2,4-D: $10.00		$20.00
TOTAL MAINTENANCE		$1,160.00	$411.95	$38.65	$1,610.60
TOTAL COST		**$1,800.00**	**$1,730.95**	**$83.19**	**$3,614.14**

*Use of Oxadiazon in plant row reduced hoeing cost by one-half compared to non-Oxadiazon sites.