# APPENDIX C

Restoration Design

# Site Specific Plant Design for the Llano Seco Riparian Sanctuary Unit of the Sacramento River National Wildlife Refuge

## Introduction

During Phase I of the Riparian Sanctuary Project (Riparian Restoration Feasibility Study for the Riparian Sanctuary, Llano Seco Unit) technical experts evaluated three alternatives for the riparian restoration to take place on the Riparian Sanctuary Unit of the Sacramento River National Wildlife Refuge (SRNWR). The alternatives considered were:

- No action
- Full riparian planting
- Site specific riparian planting

The 'no action' and 'full riparian planting' alternatives were eliminated. 'No action' was eliminated as the site is not actively recruiting riparian vegetation, and so does not meet the goals set forth in the SRNWR *Comprehensive Conservation Plan* (CCP) (USFWS 2005). The 'full riparian planting' alternative was eliminated as hydraulic modeling showed that high density riparian woodland across the entire site could adversely affect the State flood control system.

The 'site specific riparian planting' was determined to be the only alternative which both met SRNWR management objectives, while also remaining flood neutral (no adverse effect to the flood control system). Further discussion can be found in the Riparian Restoration Feasibility Study for the Riparian Sanctuary (River Partners, 2005).

## Purpose of this document

Using site assessment information from Phase I of this project, this site specific plant design was developed to maximize project goals and USFWS management objectives. Further discussion can be found in the Riparian Restoration Feasibility Study for the Riparian Sanctuary (River Partners, 2005).

The site-specific planting design, in addition to meeting flood conveyance goals, also addresses the USFWS management objective of creating habitat for federally listed, candidate, and other wildlife species. The following table lists the Federal and State-listed endangered, threatened and candidate species which occur or potentially occur at the Sacramento River National Wildlife Refuge.

*Federal and State-listed Endangered, Threatened, and Candidate Species Occurring or Potentially Occurring at Sacramento River National Wildlife Refuge.*

| Name | Scientific Name | Status |
|---|---|---|
| Chinook Salmon, Sacramento River winter-run ESU | *Oncorhynchus tshawytscha* | FE, CE |
| Chinook Salmon, Central Valley spring-run ESU | *Oncorhynchus tshawytscha* | FT, CT |
| Chinook Salmon, Central Valley Fall-run and late fall-run ESU | *Oncorhynchus tshawytscha* | FC, CSC |
| Steelhead, Central Valley ESU | *Oncorhynchus mykiss* | FT |
| Green Sturgeon SDP | *Ascipenser medirostris* | FT, CSC |
| Valley Elderberry Longhorn Beetle | *Desmocerus californicus diamorphus* | FT |
| Western Red Bat | *Lasiurus blossevillii* | CSC |
| Bald Eagle | *Haliaeetus leucocephalus* | CE |
| Peregrine Falcon | *Falco peregrinus anatum* | FSC, CE |
| Western Yellow-billed Cuckoo | *Coccyzus americanus occidentalis* | FC, CE |
| White-tailed Kite | *Elanus leucurus* | FSC |
| Burrowing Owl | *Athene cunicularia* | FSC |
| Swainson's Hawk | *Buteo swainsoni* | FSC, CT |
| Willow Flycatcher | *Empidonax trailii* | FSC, CE |
| Bank Swallow | *Riparia riparia* | FSC, CT |
| Least Bell's Vireo (extirpated) | *Vireo bellii pusillus* | FE, CE |

ESU – Evolutionary Significant Unit
FE – Federal-listed Endangered Species
FT – Federal-listed Threatened Species
FC – Federal Candidate Species
FSC – Federal Species of Concern
CE – California State-listed Endangered Species
CT – California State-listed Threatened Species
CSC – California Species of Concern

## Riparian Sanctuary Plant Design

Utilizing the Excel grid included in the Feasibility Study, River Partners made a plant design map delineating each planting community (Figure 1). This plant design follows the contours determined by hydraulic analysis in Phase I. The species list for inclusion in the restoration was designed in Phase 1 (Figure 2). The purpose of the meeting with River Partners and USFWS was to determine the planting density and frequencies of each community, and to capture design details relevant to the USFWS' objectives.

Figure 1 shows the following plant communities: Valley oak woodland, Mixed riparian forest, Elderberry savannah, Valley oak savannah and Great valley grassland.

## Restoration planting densities

All berms for the project will be aligned parallel to flow to accommodate conveyance. Using the hydraulic model as a guide, the berms will be roughly aligned north to south.

**Valley Oak Woodland and Mixed Riparian Forest**: These two communities occur on the eastern and western edges of the site, and generally are higher in elevation. Modeling showed that these areas can be densely planted, and soil analysis determined that the appropriate plant mix would be Valley oak woodland and mixed riparian forest. In these areas planting berms will spaced with 20' between them, and the in-row plant spacing will be 10'. This provides a planting density of 218 plants per acre. Many of these plants are grasses, vines or shrubs. Trees per acre are 122 for Mixed Riparian Forest and 104 for Valley Oak Woodland. The area between the berms will be planted with creeping wild rye.

**Elderberry Savannah and Valley Oak Savannah**: These communities occur at slightly lower elevations and at the southern end of the site. It was determined in Phase I that lower density planting would be needed in these areas in order to accommodate conveyance. It will also be possible to mitigate here for any disturbed elderberries from the revetment removal on the upstream parcel. For example, elderberry shrubs could be transplanted from the upstream parcel to the restoration and incorporated into the plant design. In these areas planting berms will be spaced with 40' between them, and the in-row plant spacing will be 10'. This provides a planting density of 109 plants per acre. There are 37 trees per acre in the Elderberry Savannah, and 33 trees per acre in the Valley Oak Savannah. The area between the berms will be planted with a mix of creeping wild rye, blue wild rye, meadow barley and purple needlegrass.

**Great Valley Grassland**: This community is where the highest velocities will occur during high flow events. It will be planted with few woody species in order to minimize roughness during flooding. In these areas planting berms will be spaced with 60' between them, and the in-row spacing will be 10'. This provides a planting density of 73 plants per acre. There are 6 trees per acre. The area between the berms will be planted with a mix of creeping wild rye, blue wild rye, meadow barley and purple needlegrass.

## Planting acreages

| Community | Density | Trees per acre | Acres | Estimated Total plants |
|---|---|---|---|---|
| Valley Oak Woodland | 217 plants/acre | 104 trees/acre | 58 | 12,632 |
| Mixed Riparian Forest | 217 plants/acre | 122 trees/acre | 91 | 19,820 |
| Elderberry Savannah | 109 plants/acre | 37 trees/acre | 37 | 4,029 |
| Valley Oak Savannah | 109 plants/acre | 33 trees/acre | 97 | 10,563 |
| Great Valley Grassland | 73 plants/acre | 6 trees/acre | 116 | 8,422 |
| | | | | **55,466** |

## Plant community frequencies

The USFWS and River Partners suggest the following species and frequencies for each of the five planting communities.

| | | Valley Oak Woodland | | | Mixed Riparian | | | Valley Oak Savanna | | | Elderberry Savanna | | | Great Valley Grassland | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Scientific name | acres: 58.0 | | | acres: 91.00 | | | acres: 97 | | | acres: 37 | | | acres: 116 | | |
| | | Species comp. (%) | Density plant/acre | Approx. Number | Species comp. (%) | Density plant/acre | Approx. Number | Species comp. (%) | Density plant/acre | Approx. Number | Species comp. (%) | Density plant/acre | Approx. Number | Species comp. (%) | Density plant/acre | Approx. Number |
| Box elder | *Acer negundo* L. | 4 | 9 | 505 | 6 | 13 | 1189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Buttonbush | *Cephalanthus occidentalis* | 0 | 0 | 0 | 4 | 9 | 793 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| California blackberry | *Rubus ursinus* Chain. & Schldl. | 12 | 26 | 1516 | 10 | 22 | 1982 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Clematis | *Clematis ligusticifolia* | 4 | 9 | 505 | 4 | 9 | 793 | 4 | 4 | 423 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coyote bush | *Baccharis pilularis* DC. | 4 | 9 | 505 | 6 | 13 | 1189 | 6 | 7 | 634 | 14 | 15 | 564 | 6 | 4 | 505 |
| Dutchman's pipevine | *Aristolochia californica* | 4 | 9 | 505 | 4 | 9 | 793 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Elderberry | *Sambucus mexicanas* | 12 | 26 | 1516 | 10 | 22 | 1982 | 12 | 13 | 1268 | 28 | 30 | 1128 | 4 | 3 | 337 |
| Fremont cottonwood | *Populus fremontii* S.Watson ssp. fremontii | 2 | 4 | 253 | 6 | 13 | 1189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Herbaceous plugs | *Various species* | 6 | 13 | 758 | 0 | 0 | 0 | 38 | 41 | 4014 | 38 | 41 | 1531 | 78 | 57 | 6569 |
| Mule fat | *Baccharis salicifolia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oregon ash | *Fraxinus latifolia Benth* | 4 | 9 | 505 | 4 | 9 | 793 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Poison oak | *Toxicodendron diversilobium* | 10 | 22 | 1263 | 6 | 13 | 1189 | 8 | 9 | 845 | 6 | 7 | 242 | 4 | 3 | 337 |
| Valley oak | *Quercus lobata* Nee | 18 | 39 | 2274 | 12 | 26 | 2378 | 18 | 20 | 1901 | 6 | 7 | 242 | 4 | 3 | 337 |
| Western sycamore | *Platanus racemosa* Nutt. | 4 | 9 | 505 | 2 | 4 | 396 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wild rose | *Rosa californica* Cham. & Schldl. | 12 | 26 | 1516 | 10 | 22 | 1982 | 14 | 15 | 1479 | 8 | 9 | 322 | 4 | 3 | 337 |
| Arroyo willow | *Salix lasiolepis* Benth. | 0 | 0 | 0 | 4 | 9 | 793 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gooding's black willow | *Salix goodingii* C.R. Ball | 2 | 4 | 253 | 8 | 17 | 1586 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sandbar (narrow-leaf) willow | *Salix exigua* Nutt. | 2 | 4 | 253 | 4 | 9 | 793 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | | | 218 | 12,632 | | 218 | 19,820 | | 109 | 10,563 | | 109 | 4,029 | | 73 | 8,422 |

## Potential herbaceous plugs for plant design

| Common name | Scientific name |
|---|---|
| Creeping wild rye | *Leymus triticoides* |
| Deergrass | *Muhlenbergia rigens* |
| Hoary nettle | *Urtica dioecia* |
| Mugwort | *Artemisia douglasiana* |
| Primrose | *Oenothera elata* |
| Santa Barbara sedge | *Carex barbarae* |
| Showy milkweed | *Asclepias speciosa* |
| Western goldenrod | *Euthamia occidentalis* |

## Other plant design notes

Since this site historically contained high numbers of mature valley oaks, the USFWS wants the plant design to include a high percentage of oaks.

The berms in the Savannah communities and the Great Valley Grassland will use the La Barranca II grassland plant design (River Partners, 2010) as a model. This design includes a mix of woody and herbaceous species planted at 10' spacing.

Arroyo willows will be limited to the west side of the project.

A 15' buffer will be maintained around all USFWS roads. A special forb mix, which will be determined at a later date, will be planted in the buffer area. No elderberry shrubs will be planted within 20' of a USFWS maintained road.

## Irrigation and plant maintenance

Drip irrigation will be used to deliver water to each plant. Because of the dry summers typical of the climate in the area, irrigation will be required to establish a high density riparian forest. Irrigation will be applied with the goal that plants will become self-sufficient after the third growing season.

### Plant protectors

Plant protectors (one-quart milk cartons) should be installed with about 2 inches of wood shavings applied as mulch to hold soil moisture and minimize weed growth. These help protect the plant from desiccation, herbivory, and drift from herbicide applications.

### Weed Control

Weed control is necessary for the successful establishment of native plants and improvement of habitat.

During the growing season, weeds along the planting rows should primarily be controlled by the timely spraying of Roundup® or a generic herbicide brand with glyphosate as the active ingredient. Rows will also be mowed with side mower and weed eater as needed. The aisles between the planted rows (centers) should be mowed or disked to minimize weed growth and propagation. Spraying and/or mowing should be implemented every 3-6 weeks during the growing season for at least the first two years.

In areas to be planted with herbaceous species, we will spray and mow for at least one year before planting. Once the herbaceous species are planted, mowing and spraying with chemicals which target grasses (ie Goal) will be used. Chemicals to target broadleaved plants will be used in native grass areas.

## Irrigation schedule

Because of the dry summers typical of the climate in the area, irrigation will be required for plant establishment and survival in the riparian forest design. Irrigation will be applied with the goal that plants will become self-sufficient by the end of the third growing season.

In the first growing season, the rapidly growing seedlings have roots only in the surface (the top 1-2 feet) of the soil profile. The rooting zone must be kept moist through the season to ensure optimum growth and survival. Because of the sandy soils at the site and water table depths of over 20 feet, the soil moisture of the fields planted with woody species will need to be closely monitored. The intervals between irrigations are dependent upon soil texture, depth to water table, the weather conditions, and plant water stress. Because we propose a mixture of species with different water demands, the plants must be carefully observed to maintain a balance of soil moisture that is acceptable for xeric species like valley oak and elderberry as well as more mesic species like cottonwood and willow.

The strategy for the second and third year is to train the roots to grow deep. Roots at depth (5-15 feet) will need less water and may be able to tap into the water table on the site and outcompete more shallow-rooted weeds. Less frequent, deep watering will encourage roots to grow deeper, well below the roots of the weeds, allowing the tree exclusive use of this deep moisture. As the tree's roots grow deeper, the times between irrigations become longer; this allows the soil surface layers to dry, thereby reducing weed vigor.

We anticipate that the well-drained, sandy soils, and relatively deep groundwater present on the site, will require frequent irrigations and careful observation of water stress. These areas may dictate the frequency of watering on the site. Field managers should use a combination of methods including evapotranspiration estimates, soil probes, and plant water stress signs to assess soil moisture and alter the irrigation regime.
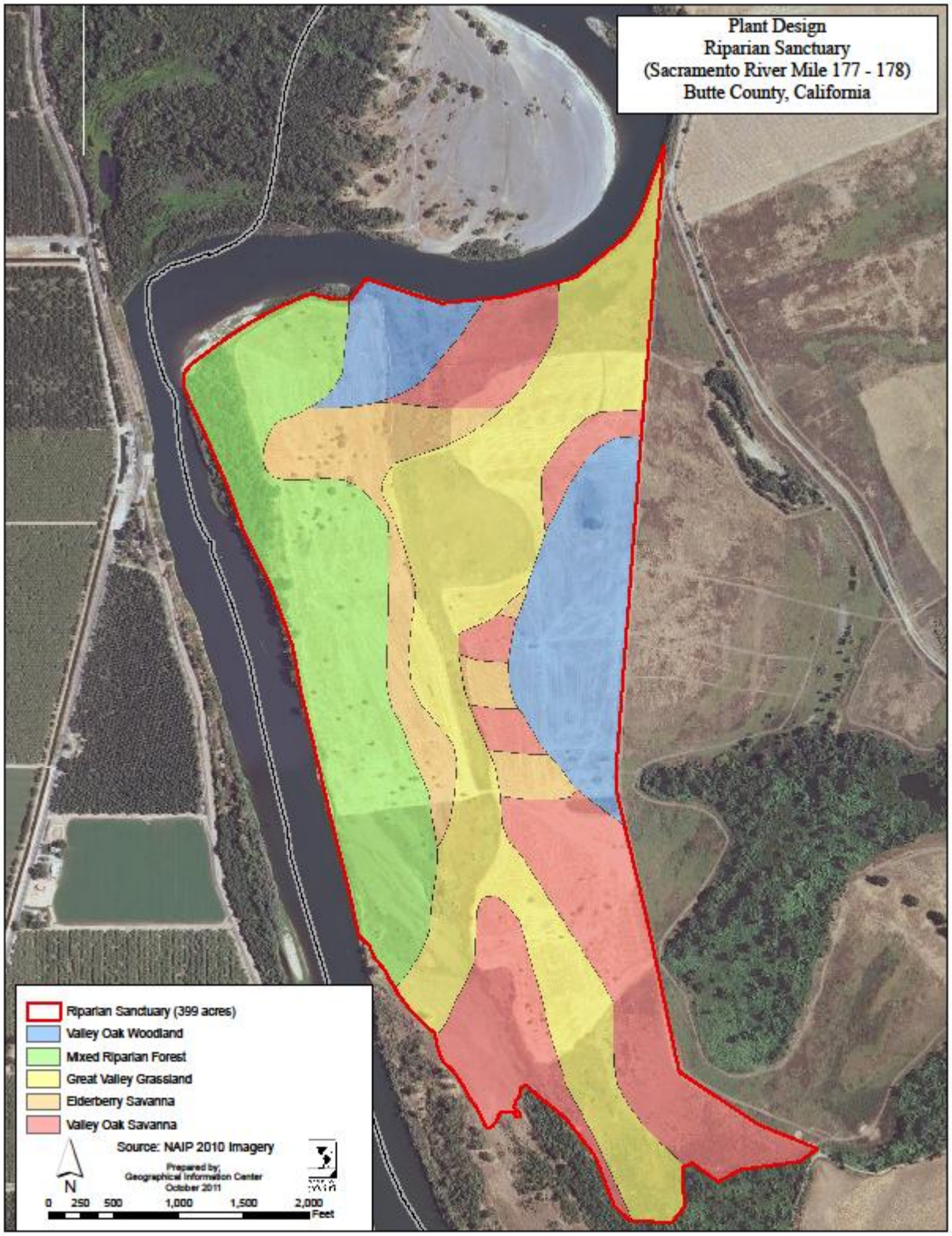
*Figure 1. Plant Design Map for Riparian Sanctuary*