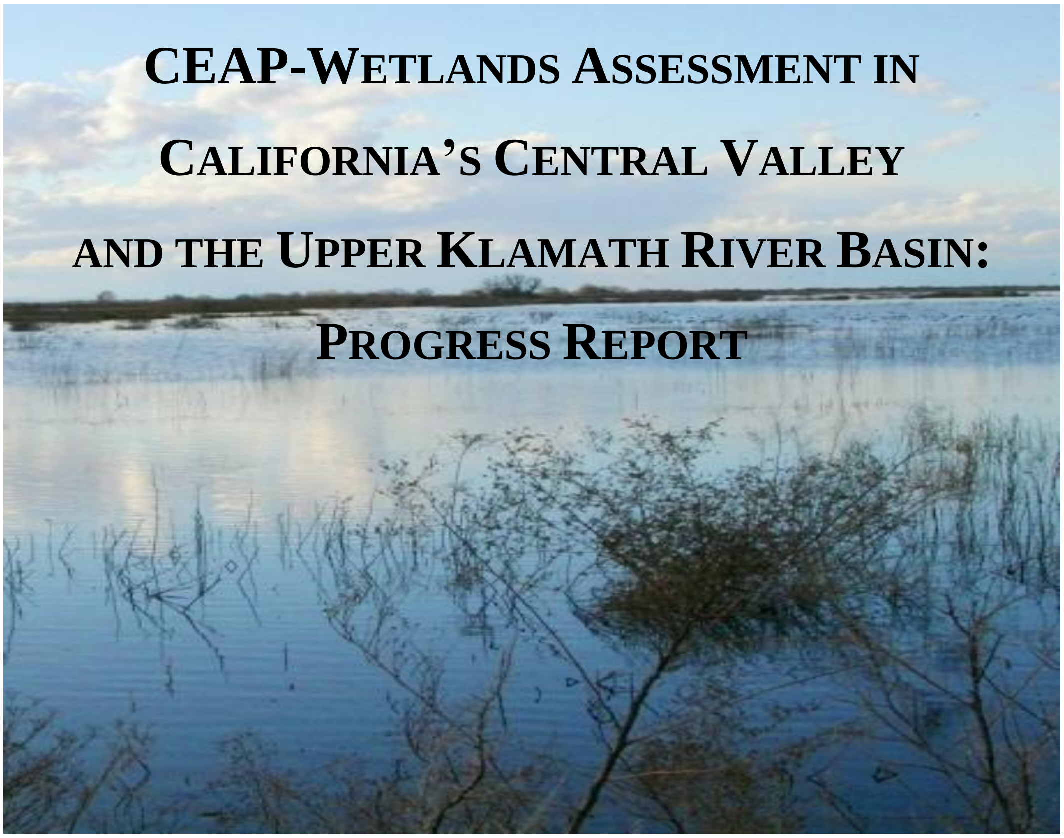
# CEAP-WETLANDS ASSESSMENT IN CALIFORNIA'S CENTRAL VALLEY AND THE UPPER KLAMATH RIVER BASIN: PROGRESS REPORT



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# CEAP-WETLANDS ASSESSMENT IN CALIFORNIA'S CENTRAL VALLEY AND THE UPPER KLAMATH RIVER BASIN: PROGRESS REPORT

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| A | RUSLE factor for average annual soil loss per unit area caused by rainfall |
| AML | Arc Macro Language |
| ANOVA | Analysis of variance |
| ANR | Analytical Lab at University of California, Davis |
| C | RUSLE cover management factor |
| CCV | California Central Valley |
| CEAP | Conservation Effects Assessment Project |
| EPA | U.S. Environmental Protection Agency |
| ESA | Endangered Species Act |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| K | RUSLE soil erodibility factor |
| LS | RUSLE slope length and steepness factors |
| NAIP | National Agriculture Imagery Program |
| NLCD | National Land Cover Dataset |
| NRCS | Natural Resources Conservation Service |
| NWR | National Wildlife Refuge |
| P | RUSLE supporting practice factor |
| R | RUSLE climatic erosivity factor *or* species richness |
| RUSLE | Revised Universal Soil Loss Equation |
| SAC | Sacramento sub-basin of the California Central Valley |
| SAN | San Joaquin sub-basin of the California Central Valley |
| TC | Total carbon |
| TIN | Triangulated Irregular Network |
| TN | Total nitrogen |
| TP | Total phosphorous |
| TUL | Tulare sub-basin of the California Central Valley |
| UKRB | Upper Klamath River Basin |

| | |
|---|---|
| USDA | U.S. Department of Agriculture |
| USGS | U.S. Geological Survey |
| UTM | Universal Transect Mercator |

# INTRODUCTION

The U.S. Department of Agriculture (USDA) administers a variety of programs intended to assist farmers and ranchers in addressing natural resource concerns on private lands. Among these is the Wetland Reserve Program (WRP) administered by the Natural Resources Conservation Service (NRCS), created as part of the 1990 Farm Bill (Gray 2005).

The WRP focuses on restoring degraded wetlands or those that have been converted to agricultural production. In California, NRCS has focused WRP on restoring freshwater wetlands that have seasonal or semi-permanent water regimes. During 2000 – 2006, USDA restored more than 15,000 ha of freshwater wetlands in the Central Valley (CCV) and Upper Klamath River Basin (UKRB).

Although WRP in California is widely viewed as benefiting ecological functions, there has been little or no evaluation or quantification of the ecological services provided to society from this program. Federal accountability initiatives require that federal agencies demonstrate the effectiveness of their programs in meeting program objectives and goals. Furthermore, assessing the effectiveness of conservation programs will provide information important in guiding future implementation of conservation programs. Results of this research will be used to develop spatially explicit integrated landscape models of ecosystem service benefits that may be expected from implementation of conservation practices or from expanding the program.

# OBJECTIVES

The objective of this research was to quantify ecosystem services provided by palustrine emergent wetlands restored or enhanced by USDA in the CCV and the UKRB (WRP easements). Ecosystem services are derived from wetland functions and were assessed along three gradients: 1) climatic, 2) management and 3) age of restoration. We measured the following five ecological services in WRP wetlands along these gradients: 1) native pollinator (bee) services, 2) biodiversity (amphibians, birds and fish), 3) soil erosion and sediment retention, 4) nutrient retention, including nitrogen, phosphorus and organic carbon, and 5) flood water storage.

## STUDY AREA:

### *CALIFORNIA'S CENTRAL VALLEY*

The Central Valley is an elongated sedimentary basin about 650 km long, 120 km wide, covering an area of 108,800 $km^2$ (Schoenherr 1992). It is often subdivided into the Sacramento River Valley in the north and San Joaquin and Tulare Valleys in the south (Figure 1). Topography is relatively flat throughout the valley, with elevation ranging from 120 m in the north and south to below sea level near San Francisco Bay (Schoenherr 1992). Boundaries of the valley are not precisely defined since valley grasslands grade into oak – grassland savannas of the foothills everywhere except the south, where desert conditions exist. Climate of the valley is Mediterranean, with warm, dry summers and mild, wet winters.

Air temperature varies little throughout the valley, with average July highs being 37.1$^{o}$C in both Bakersfield and Redding, while average December lows in Bakersfield (2.9$^{o}$C) are only slightly warmer than in Redding (2.7$^{o}$C). Annual precipitation, however, exhibits a distinct gradient, ranging from 16 cm in Bakersfield to 46 cm in Sacramento and 100 cm in Redding (Schoenherr 1992). Throughout the valley, more than 90% of annual precipitation falls as rain during November – May.

The largest freshwater wetland area in California was associated with Tulare, Buena Vista and Kern Lakes. These lakes contained as much as 3,360 km of freshwater marsh habitats along their shorelines, although the amount would vary naturally. Today, most of the wetlands (94%) in the CCV have been lost. Area of wetland habitats in the CCV prior to 1900 was estimated to be 1.6 - 2.0 million ha (Hartman and Goldstein 1994). Wetland area in the CCV had been reduced to 153,000 ha.

Since the 1980s, however, restoration programs have increased wetland coverage in the CCV to over 200,000 ha (Dahl 2006, Central Valley Joint Venture 2006). Human activities leading to wetland loss in the CCV are varied, but agricultural development and urbanization are chief among them.

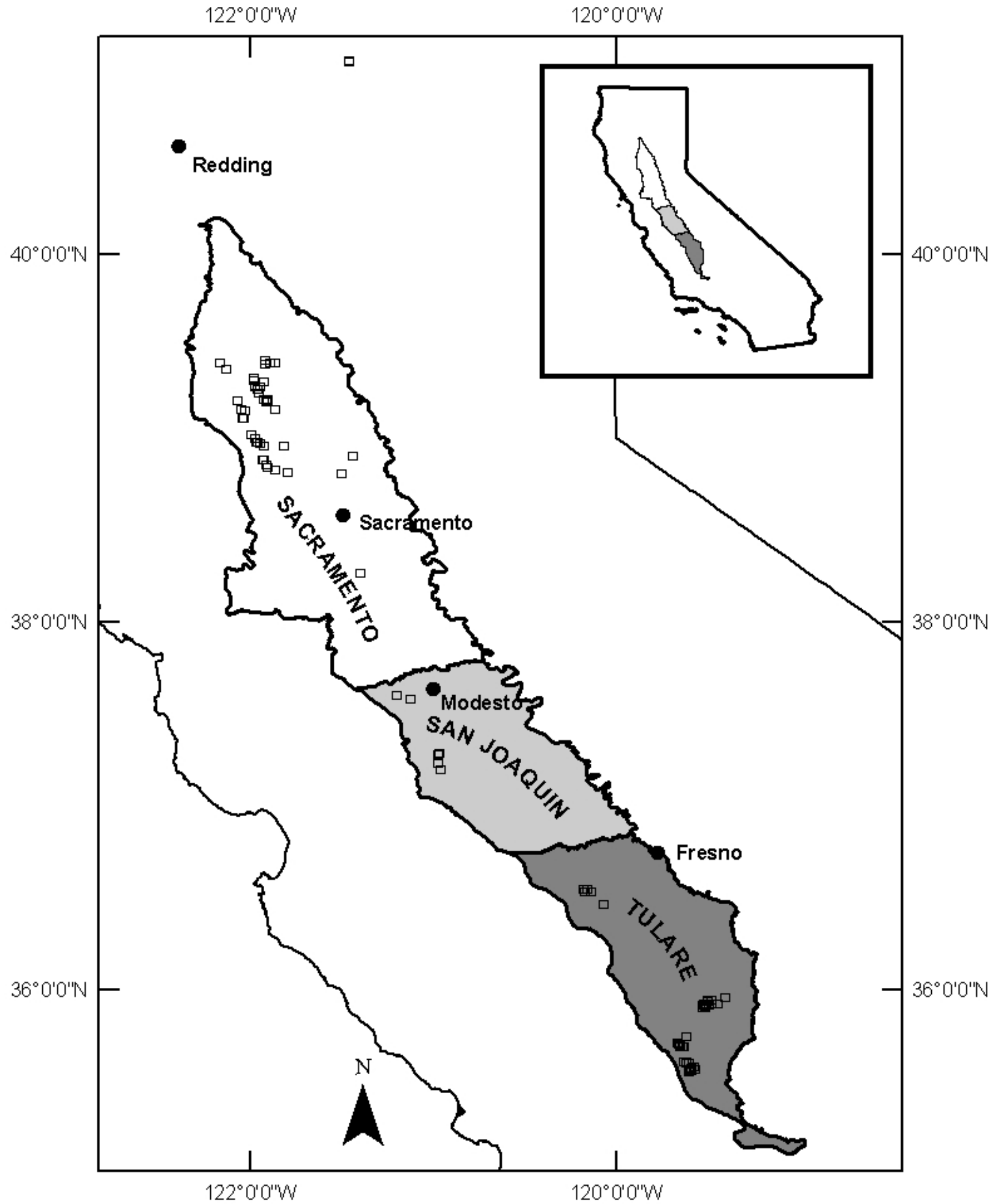


Figure 1. Location of 2008 and 2009 sampling sites (squares) on California's Central Valley. The CCV was divided into three major sub-basins shown from north to south; Sacramento (white); San Joaquin (light gray) and Tulare (dark gray).

### *Upper Klamath River Basin*

The secondary study area is the Upper Klamath River Basin (UKRB) region of California and Oregon (Figures 2 and 3). The Upper Klamath River Basin encompasses an area of 20,720 $km^2$ in northern California and southern Oregon, and is located within the southern Cascade physiographic region. Much of the area east and south of Upper Klamath Lake is relatively flat and less than 1,600 m elevation. Soils of the area are of volcanic, alluvial and wetland or lake bed origin. Palustrine emergent wetlands once covered expansive areas in this region, but most have been converted to agricultural lands. Surrounding this area elevation exceeds 2,000 m and accumulates large snowpacks during wet years (National Research Council 2007). Climate of the area grades from Mediterranean to undifferentiated upland. Annual precipitation averages 68 cm, but varies across the area and is only 30.5 cm at Klamath Falls (National Research Council 2007). Summers are hot and winters short but cold.

### ***Field sampling***

In 2008 we conducted a baseline survey of 47 WRP easements and 11 National Wildlife Refuges (NWR) sites in the Tulare, San Joaquin and Sacramento basins across three gradients of: (1) management intensity, (2) restoration age and (3) precipitation (latitudinal).

Data collection began in February 2008. A stratified random sampling approach was used to select sampling units across gradients. Wetland Reserve Program easements in the CCV are typically divided into manageable units referred to as “cells”, separated by levees. Cell levee boundaries correspond to the catchment boundary of a natural wetland. A representative cell within each selected WRP served as the primary sampling unit.

In 2009 we surveyed 50 WRP easements and five NWR sites in the CCV (Appendix I, Tables I-1, I-2, I-4). Data collection in 2009 began in March. Wetland Reserve Program easements and NWR sites were categorized into two broad age classes, relatively young (5 years or less since restoration) and relatively old (greater than 5 years since restoration work). Criteria for classification by management intensity were largely based on hydrological manipulation (Appendix I, Table I-3).

Edaphic, vegetation, and morphological variables were collected from representative cells of each WRP easement or NWR site.

As part of the U.S. Department of Agriculture (USDA), California Central Valley CEAP Wetlands Assessment, we sampled a limited number of wetlands in the UKRB. All wetlands sampled in the UKRB were located within USDA Wetland Reserve Program (WRP) easements. The objective of sampling in the UKRB was (1) to provide a preliminary assessment of ecosystem services provided by WRP wetlands in this region and (2) to extend the database on WRP wetland ecosystem services acquired for California's Central Valley.

A total of 11 wetlands were sampled in the UKRB for one or more ecosystem services in 2008 and 2009 (Figure 3, Table I-4). The limited number of WRP easements in this region precluded stratifying sampling across management intensity, restoration age and precipitation gradients. In 2008 we surveyed nine wetlands for amphibians, characterized vegetation and also assessed these wetlands for their potential to support native bees. Amphibian data are presented in this report, but because the land cover surrounding WRPs in the UKRB is predominated by pastures with limited flowering plants, we concluded that sampling native bees would not yield useful information. In 2009, we focused sampling on three riparian wetlands along the Sprague River. Data gathered in 2009 included wetland soil nitrogen, phosphorus and carbon content, plant community composition, and use of these wetlands by fish and birds.

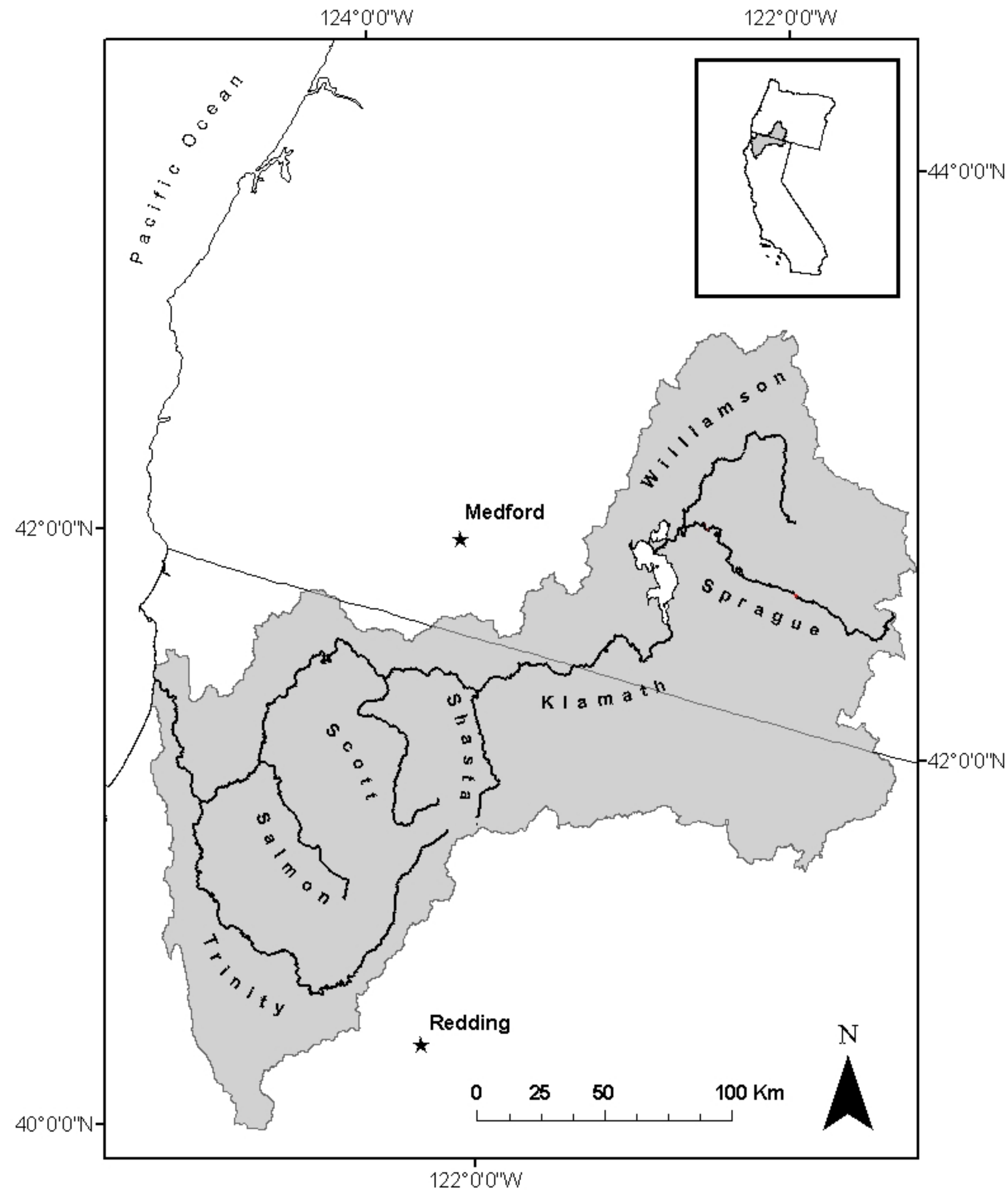


Figure 2. Map of the Klamath River Basin, California and Oregon.

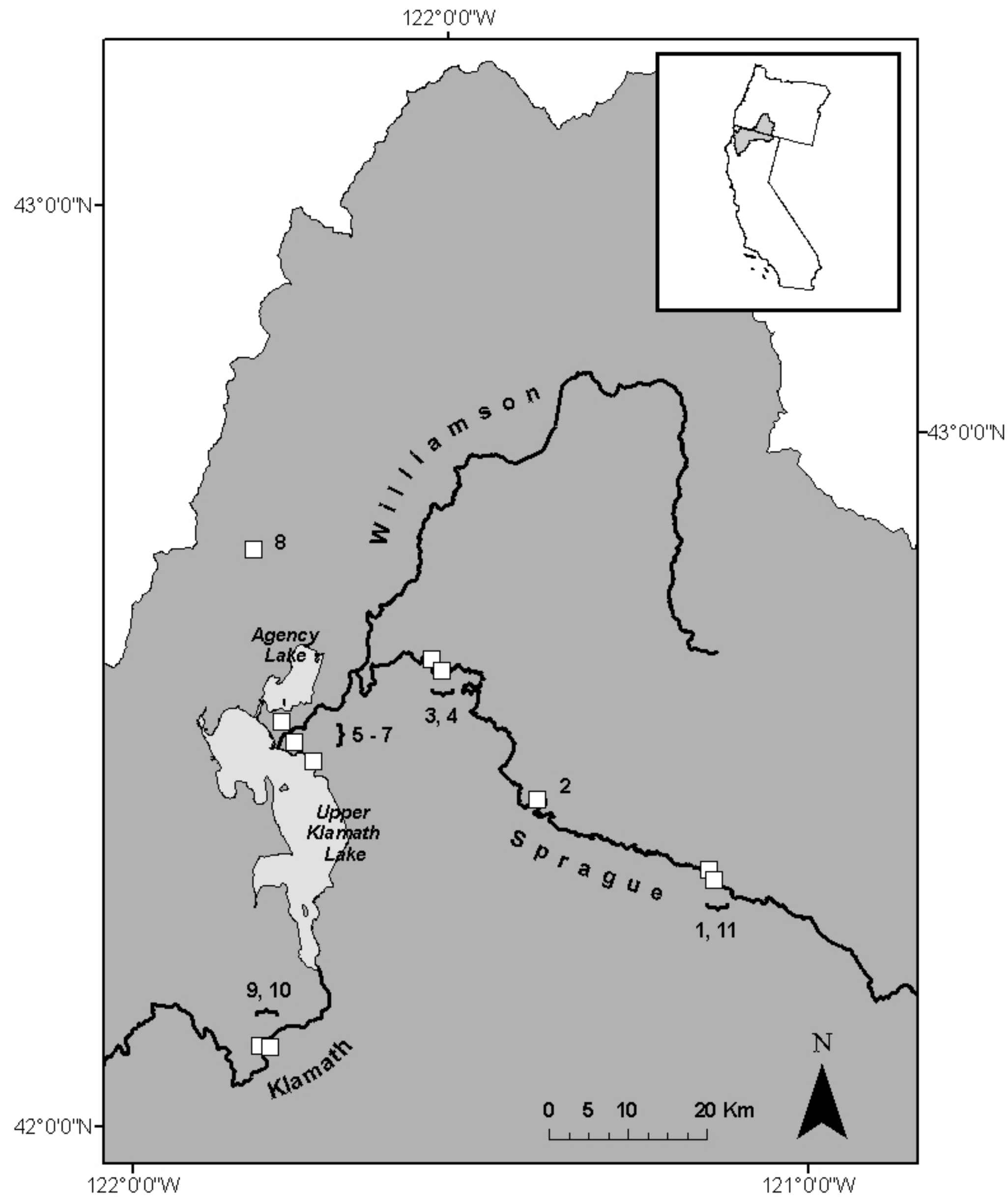


Figure 3. Map of the Upper Klamath River Basin with CEAP wetland sample sites numbered.

# CHAPTER A: HABITAT ASSESSMENT, VEGETATION BIOMASS, AND NUTRIENT STORAGE IN THE CCV

## OBJECTIVE

We sampled wetland vegetation to assess habitat characteristics of WRP easements in the CCV. We also evaluated biomass and nutrient storage in WRP wetland vegetation along latitudinal, age and management intensity gradients.

## METHODS

Visual estimates of proportional upland, wetland and open water, as well as adjacent land use, were made at each site. Information on habitat characteristics of each representative cell was gathered following procedures developed by USGS-Northern Prairie Wildlife Research Center (Kantrud and Newton 1996). Samples were collected along four transects extending from the perimeter of each cell to the center. Transect measurements were limited to 100 m in large WRPs and there was no fixed distance between transect locations. Width (m) of all vegetation zones bisected by transects was estimated and water depth (cm) recorded. Vegetation zones were delineated by plant species composition and water depth (Stewart and Kantrud 1971).

In each vegetative zone, a 1-$m^2$ quadrat was randomly sited along the zone transect, and vegetation cover (%) by taxon (Daubenmire 1959) and visual obstruction at plot center (Robel 1970) were estimated. In 2009, biomass clippings, vegetative cover estimates, and visual obstruction at plot center estimates were made only within the shallow marsh zone. Vegetation biomass was collected by placing a 0.25-$m^2$ quadrat in the center of the 1-$m^2$ quadrat and clipping all aboveground biomass (live and dead). Rare, endangered or threatened species when encountered were not collected for biomass estimates.

Samples were weighed at the end of each collection day and returned to Humboldt State University for dry mass determination. In 2008, dried samples were shipped to the Colorado State University Soil-Water-Plant Testing Laboratory. Total nitrogen (TN), total carbon (TC), and total phosphorous (TP) were determined following standard methods (Gavlak et al. 1994; Nelson and Sommers 1996).

In 2009, dried samples were shipped to the Agricultural and Natural Resources (ANR) Analytical Lab at University of California, Davis for determination of total phosphorus (TP), total nitrogen (TN) and total carbon (TC) (Meyer and Keliher 1992; Sah and Miller 1992; AOAC 1997).

The three management intensity categories for survey sites are defined in Table I-3.

## STATISTICAL ANALYSES

Average width (m) of upland, wetland and open water zones were analyzed along three gradients: latitudinal (sub-basin), age and management intensity. Wetland habitats were sub-divided into wet meadow, shallow marsh and deep marsh. Habitat data were not normally distributed and were analyzed by Kruskall-Wallis ANOVA. Vegetation biomass and nutrients were analyzed by one-way ANOVA.

## RESULTS AND DISCUSSION

### *Habitat Characteristics*

Sites in the Tulare sub-basin exhibited significantly larger upland zones, followed by the San Joaquin and Sacramento sub-basins (Figure A-1). Wet meadow zones dominated by annual wetland species and the open water zone were significantly larger in the Sacramento sub-basin (Figure A-2, A-3). Wetland zones did not differ by management. Younger sites exhibited larger upland zones, while older sites had significantly larger wet meadow and shallow marsh zones (Figures A-4, A-5 and A-6).

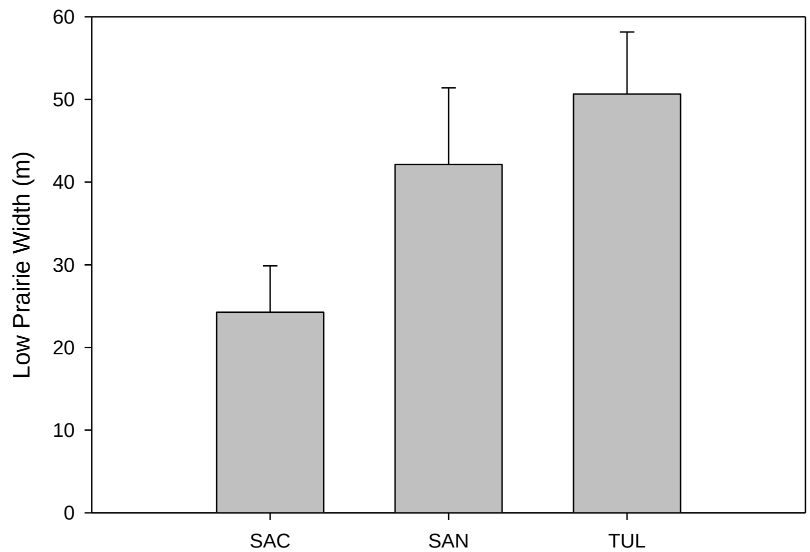


Figure A-1. Average low prairie zone width by sub-basin in meters. SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Standard error bars are shown.

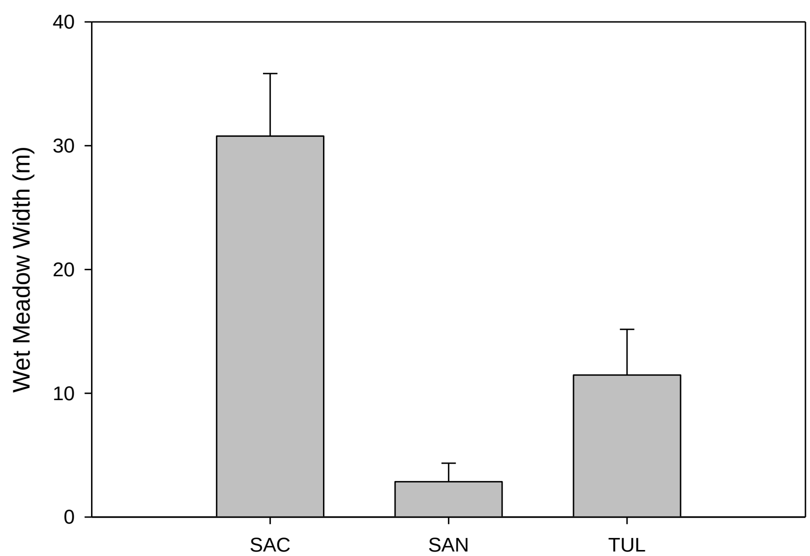


Figure A-2. Average wet meadow zone width in meters by sub-basin. SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Standard error bars are shown.

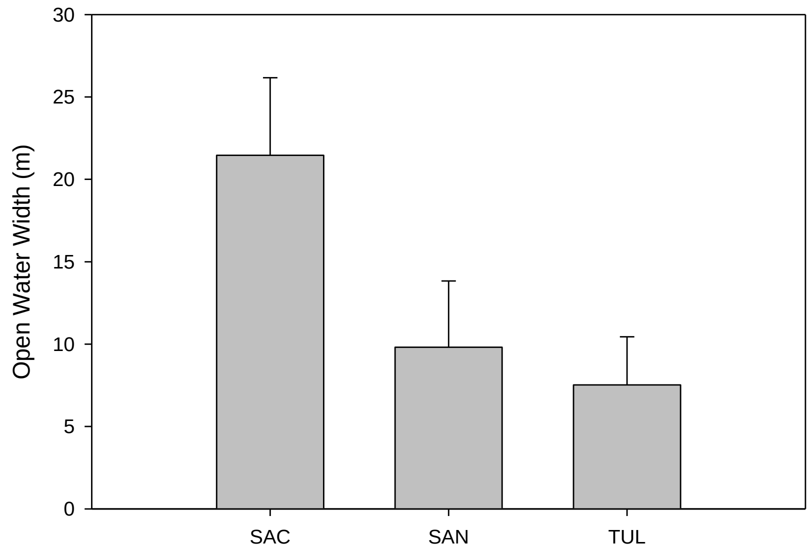


Figure A-3. Average open water zone width in meters. SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Standard error bars are shown.

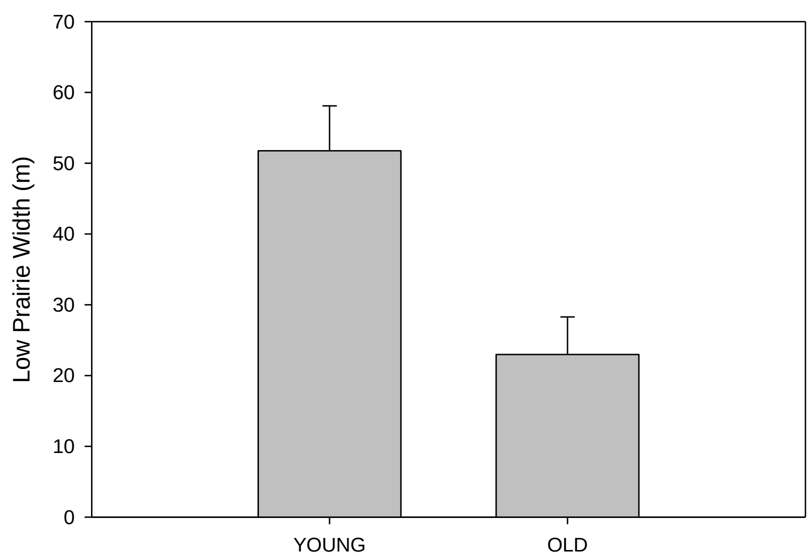


Figure A-4. Average low prairie zone width in meters by WRP age. “Young” sites are ≤ 5 years since restoration; “Old” are > 5 years. Standard error bars are shown.

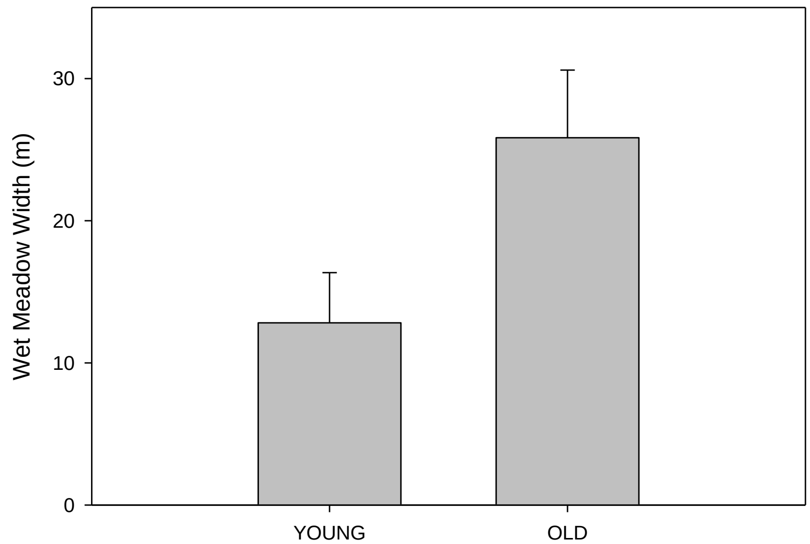


Figure A-5. Average wet meadow zone width in meters by WRP age. "Young" sites are ≤ 5 years since restoration; "Old" are > 5 years. Standard error bars are shown.

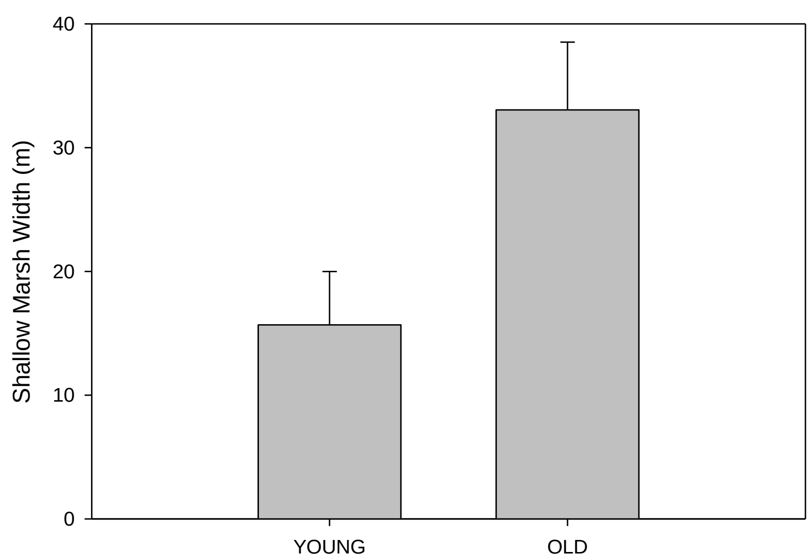


Figure A-6. Average shallow marsh zone width in meters by WRP age. "Young" sites are ≤ 5 years since restoration; "Old" are > 5 years. Standard error bars are shown.

***Vegetation Biomass and Nutrients***

Vegetation biomass differed significantly across sub-basins ($F_{2,63} = 7.98$, $p < 0.001$), with greater biomass in the Sacramento sub-basin and declining south in both years (Figure A-7).

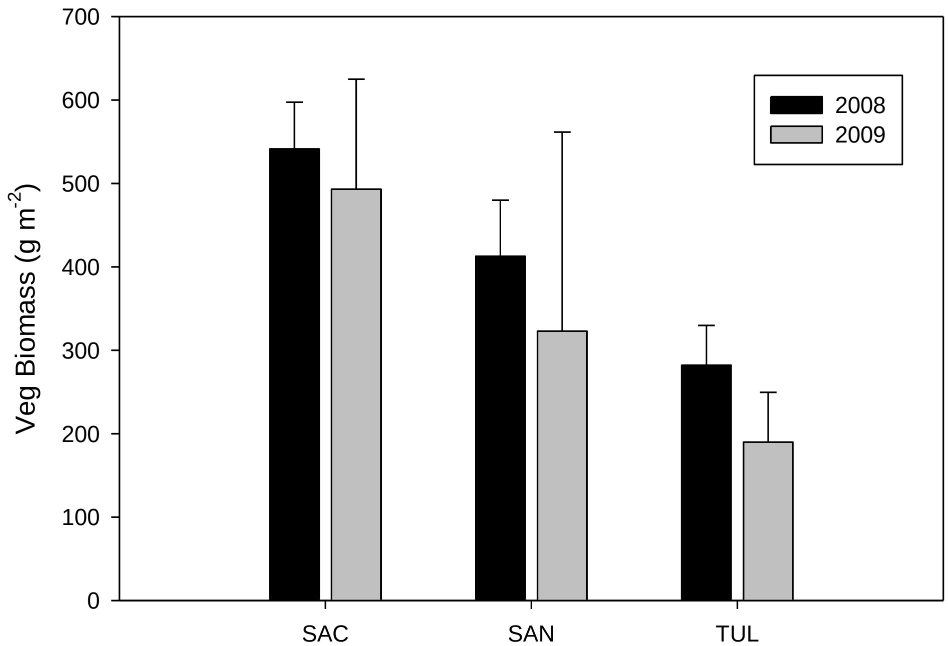


Figure A-7. Average vegetation biomass (g $m^{-2}$) by sub-basin. SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Standard error bars are shown.

Biomass did not differ statistically along management and age treatments; however, biomass on sites under low and intermediate management tended to be higher in older sites than younger ones, suggesting an increase over time (26 and 143% respectively). Whereas biomass on intensively managed sites was lower on older sites than younger ones, suggesting a decline over time (22%). Vegetation biomass in restored wetlands may represent a stock of sequestered carbon. Our data suggests that WRP easements in the CCV store between 4,330 and 392,618 tons of biomass in the shallow marsh zone alone. However, carbon stored in biomass may be lost as a result of activities related to intensive management practices such as mowing, frequent drainage and disking. Our data suggest a reduction in vegetation biomass over time in intensively managed sites, while biomass on low or intermediately managed sites increases over time.

Concentrations of nitrogen, phosphorous and carbon were analyzed in vegetation samples collected from shallow marsh zones as total nitrogen (TN), total phosphorous (TP) and total carbon (TC). Average TN concentrations were significantly higher in the San Joaquin sub-basin compared to other sub-basins (Figure A-8). Average TP and TC concentrations did not differ by sub-basin. Average TP and TN concentrations were greater in younger sites than older ones (Figures A-9, A-10). However, average TN, TP and TC did not differ along the management gradient. Our data suggest that nutrient concentrations in vegetation declined from young to old sites. When averaged over both years, TN concentrations differed by 16%, TC by 2% and TP by 20% between young and old sites. The greatest reductions occurred on intermediately managed sites for all nutrients (Table A-1). Average nutrient concentrations in vegetation were higher in younger sites than older ones. This may indicate a decline in nutrient retention over time, particularly on intermediately managed sites.

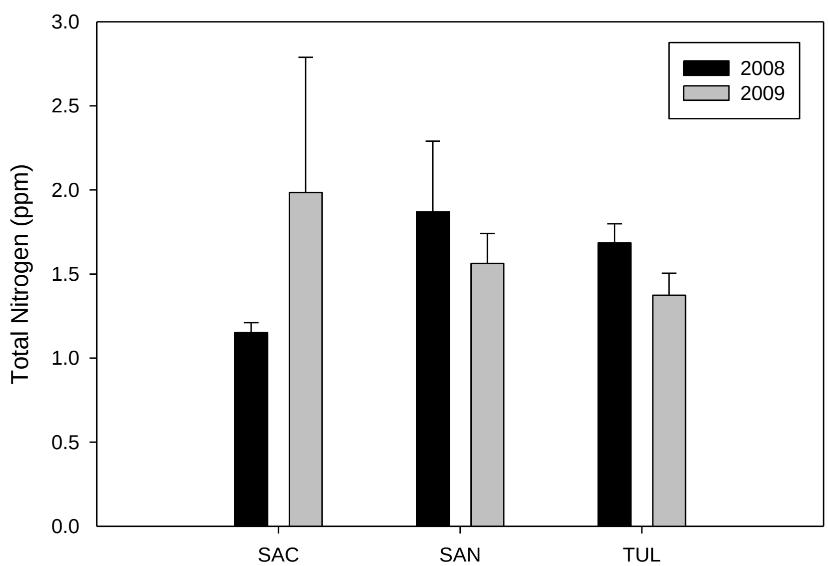


Figure A-8. Average nitrogen concentration in shallow marsh vegetation by sub-basin. SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Standard error bars are shown.

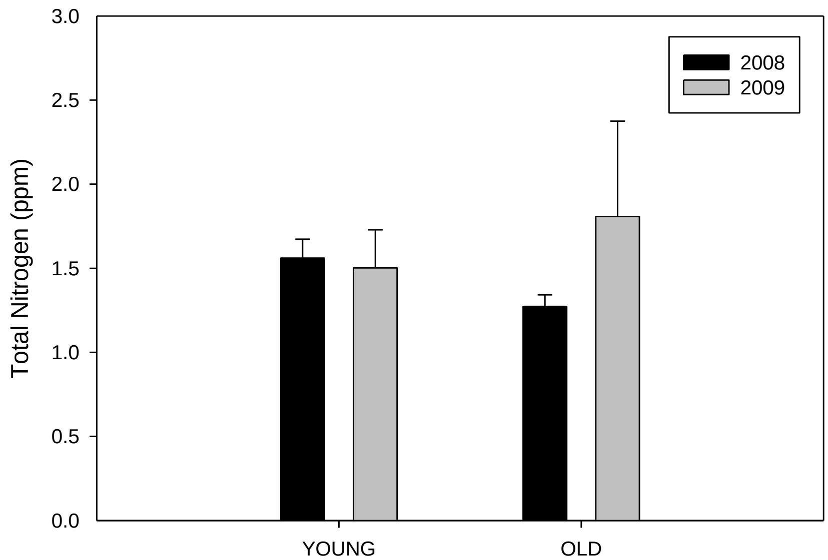


Figure A-9. Average nitrogen concentration in shallow marsh vegetation by WRP age. "Young" sites are ≤ 5 years since restoration; "Old" are > 5 years. Standard error bars are shown.

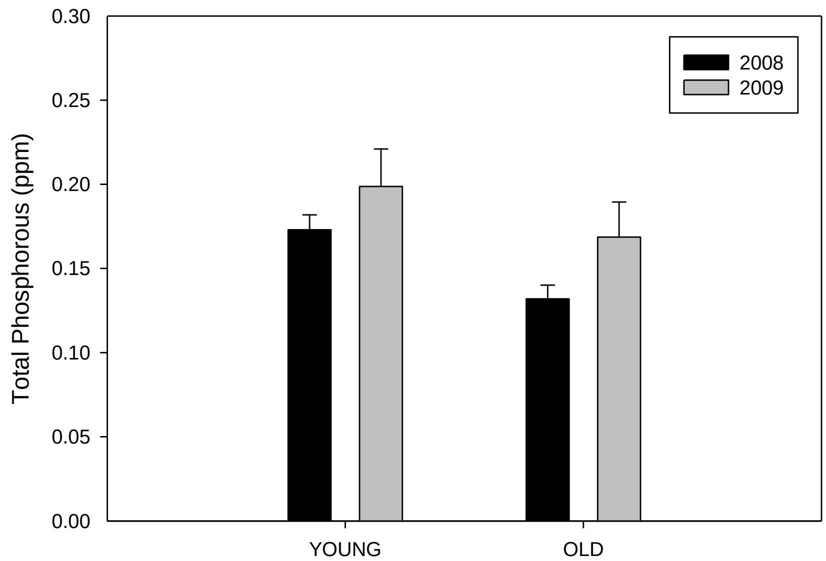


Figure A-10. Average phosphorous concentration in shallow marsh vegetation by WRP age. "Young" sites are ≤ 5 years since restoration; "Old" are > 5 years. Standard error bars are shown.

Table A-1. Percent difference in nutrient concentration between management intensities at WRP sites in the CCV. "Low" = sites under low or no management, "Intermediate" = sites under intermediate management, "High" = actively managed sites. Management intensity categories are defined in Table I-3.

| Management | TN (%) | TC (%) | TP (%) |
|---|---|---|---|
| Low | -7.73 | -0.41 | -13.39 |
| Intermediate | -27.82 | -2.56 | -26.87 |
| High | -12.06 | -2.08 | -18.45 |
| Average Difference | -15.87 | -1.68 | -19.57 |

# CHAPTER B: SOILS IN THE CCV

## OBJECTIVE

We characterized basic soil properties of WRP wetlands in the CCV to evaluate how those properties might reflect gradients of latitude, restoration age and management intensity. We also evaluated carbon storage in WRP wetland soils to determine whether restored seasonal and semi-permanent wetlands in the CCV have high potential for storing anthropogenic carbon emissions in their soils.

## METHODS

Soil sampling included digging 30 - 40 cm soil pits and collecting 15-cm deep soil cores at 35 sites in the CCV during both 2008 and 2009 (Appendix II, Table II-1). The following soil parameters were measured: the depth of the organic horizon, the depth of the plant litter layer, total carbon, total nitrogen, total $CaCO_3$, total phosphorus, and bulk density. In the laboratory, all samples were weighed, dried at 101$^{\circ}$C to a constant weight, and then re-weighed for bulk density determination.

In 2008, soil samples were then analyzed by the Colorado State University Soil, Water, and Plant Testing Laboratory in Fort Collins, CO. Samples were analyzed for total C and N using the methods outlined in Nelson and Sommers (1996) and Bremner (1996). Total P was analyzed by acid dissolution followed by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP) (Kuo 1996). $CaCO_3$ was determined according to the methods in U.S. Department of Agriculture (1996).

In 2009 following drying, samples were analyzed by the Agriculture and Natural Resources Laboratory of the University of California at Davis, CA. Analysis of total N and total C was conducted according to methods in AOAC (1997). Total P was analyzed by acid dissolution followed by ICP analysis (Sah and Miller 1992). Gravimetric determination of $CaCO_3$ was carried out according to the methods in U.S. Department of Agriculture (1954). All soil samples were ground and sieved through a 2 mm sieve before analysis.

The three management intensity categories for survey sites are defined in Table I-3.

## Statistical Analysis

Percent organic carbon, bulk density, % total nitrogen, % total phosphorus, mean litter layer, and mean O-horizon of soil samples collected during 2008 and 2009 were analyzed by two-way ANOVA across both management category and age class (using two different age class designations: (1) $\geq$ or < 5 years since restoration and (2) $\geq$ or < 10 years since restoration). Simple linear regressions were also performed between each variable and years since restoration. All variables were square-root transformed except litter, which was ln-transformed and O-horizon, which was $\log_{10}$-transformed, in order to approximate normality. Statistical analyses were performed using SYSTAT Version 10, SPSS Inc. (2000).

## Results

Among the soils characteristics, the most variable parameters were the depth of the O-horizon, which ranged from 0 - 17.5 cm, and the litter layer, which ranged from 0 - 9.7 cm. Percent organic carbon ranged between 0.6 and 3.8% (Figure B-1). Overall, the restored wetland sites had bulk densities of approximately 1 g $cm^{-3}$ and total % N and P well below 1%.

A two-way analysis of variance for each soil characteristic by management category and age class (using two different age class designations (1) $\geq$ or < 5 years since restoration, and (2) $\geq$ or < 10 years since restoration) showed no significant results for any factor or any interaction term at $p < 0.05$. Linear regressions between each soil variable and years since restoration also showed no significant results.

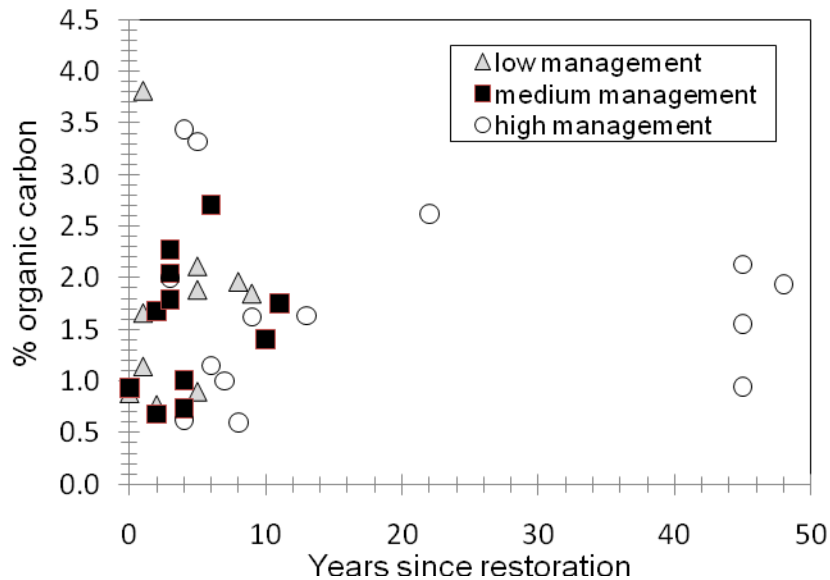


Figure B-1. Percent organic carbon vs. years since restoration.

## DISCUSSION

All of the restored seasonal and semi-permanent wetlands in this study contain mineral soils with low % organic carbon content that has not increased through time (Figure B-1). Because of this, other changes usually associated with organic matter accumulation such as nutrient increases and bulk density decreases have also not occurred (Bishel-Machung et al. 1996; Ballantine and Schneider 2009). None of the variance in any soil characteristic can be explained by the management intensity at the sites or time since restoration because none of the statistical analyses was significant. These results strongly suggest that there is another factor that controls organic matter accumulation besides management intensity and time since restoration.

We postulate that organic carbon accumulation is so low in restored CCV wetlands because annual artificial drainage spurs aerobic decomposition of most of the accumulated organic matter. We arrive at this overall conclusion because our results show that, even after more than forty years, organic carbon accumulation is low in these managed wetlands (Figure B-1). Both seasonal and semi-permanent wetlands are artificially drained either in spring or summer, which permits long, uninterrupted periods of drying during the hot, dry season from

May through October.  Under hot, drying conditions, microbial decomposition flourishes in the moist soils, precluding significant accumulation of organic matter.  In addition, cycles of soil saturation followed by drying appear to further stimulate the decomposition of organic matter in wetland soils (Collins and Kuehl 2001).

The distinct lack of organic carbon accumulation with time indicates that, under current management regimes, restored seasonal and semi-permanent wetlands in the CCV do not have high potential for mass sequestration of carbon pollution as do other wetland types such as the prairie potholes in the Midwestern United States (Euliss, Jr. et al. 2006).  Whether or not some of the CCV sites could be better managed to sequester carbon requires further study.  Future work focused on the individual impacts of particular management activities as well as the range of within-site variability would be very helpful in better understanding organic carbon accumulation in these restored wetlands.

# CHAPTER C: BIRD USE IN THE CCV

## OBJECTIVE

We surveyed bird use of WRP wetlands in the CCV to evaluate the avian use of WRPs along latitudinal, age and management gradients. We also examined relationships between bird use and habitat characteristics.

## METHODS

In 2008 bird surveys were conducted at 42 Central Valley WRP properties and one NWR site. In 2009 avian populations were surveyed at 16 CCV WRP properties. All surveys were conducted by PRBO Conservation Science staff. Each year, three survey methods were used: point counts and area searches in upland zones and wetland surveys in wetlands (Appendix III, Table III-1). These survey methods provide information on species occurrence, as well as secondary population parameters such as abundance (or density), species richness, and species diversity. For each survey method, species were grouped into 11 foraging guilds; species within these guilds share certain behavioral traits and have similar environmental requirements (Hickey et al. 2008).

The three management intensity categories for survey sites are defined in Table I-3.

### *Point Counts*

Five-minute variable circular point count surveys were conducted in accessible upland habitat following nationally standardized protocol (Ralph et al. 1995). In 2008, eight WRP properties and two NWR sites were surveyed with point counts. In 2009 four WRP properties were surveyed. Counts occurred between sunrise and 1000 hours between 3 May to 13 June in 2008 and 1 May to 25 June 2009.

For the 5-minute variable circular plot point count method, the distance from the observer to each individual bird (including aerially foraging raptors and swallows) was estimated (Ralph et al. 1995). We estimated detections in bands of 10 m outward to 50 m. Three bands extend further (50 - 75 m, 75 - 100 m, and >100 m). Distances to birds were estimated with the aid of range finders. Type of detection (i.e. song, visual, or call) and breeding behavior (e.g.

copulation, nest building, food carry to fledgling) were recorded. Birds flying over the point count station were recorded separately and excluded from analyses. All transects were surveyed 2 to 3 times ≥ 10 days apart during the height of songbird breeding (May – June). Surveys were completed within 4 hours of local sunrise by experienced observers trained in visual and auditory bird identification and distance estimation. Since detection rates of most species generally decrease beyond a 50 m distance from the observer, we have only included detections from within 50 m of each point count station for data analysis.

***Area Searches***

In 2008, two WRPs in the Sacramento sub-basin were surveyed between 5 May and 1 July. In 2009, area searches were conducted on 20 May and 11 June at one of the WRP easements surveyed by area searches in the preceding year. Surveys followed protocol described by Ralph et al. (1995). Area searches consisted of 20-minute "searches" in which a trained observer moved around in a predetermined area search plot. These surveys may be used to assess areas that are not adequately surveyed by other methods (e.g. sites that are too small for point counts).

***Wetland Surveys***

Scan-sampling (Reed et al. 1997) was used to survey wetland sites approximately once every 3 weeks. The 3-week survey interval allowed us to visit all the sites in our study area and conduct enough surveys at each site to capture a range of bird use through the survey period. In 2008, two NWR sites and 39 WRP properties were surveyed between 10 April and 9 December. Late summer and fall surveys were restricted to the Tulare sub-basin to assess seasonal variation in wetland bird populations. In 2009 wetland surveys were conducted at 13 WRPs between 19 April and 16 July.

Wetlands were searched from various vantage points for optimal survey coverage of each site. All bird species seen or heard in the wetland, including those aerial feeding, were recorded. Flying birds, other than those foraging aerially, were not recorded. Species counts were obtained for large flocks by estimating a block of birds within a given flock. Survey time and duration varied with number of birds, number of wetlands on the property, and size of the wetland(s).

## STATISTICAL ANALYSIS

Point count data and wetland surveys were analyzed separately by Kruskall-Wallis one-way ANOVA by ranks to assess differences along sub-basin and management gradients. Mann-Whitney U-tests were used to assess differences between age categories.

## RESULTS

### *Upland surveys*

Species diversity did not differ by sub-basin, management or age; however, diversity was significantly greater in July than in May at all sites in 2009 (Table C-1; $t = -3.56$, $p = 0.04$). Upland bird species were more common than other species in this zone (Table C-2). Species richness was greater in low or inactively managed sites. Fourteen special status species were observed on upland portions of sites throughout the CCV. Special status species appear in at least one of the following lists: Shuford and Gardali (2008), CDFG (2009b), USFWS (2008), or IUCN (2006). We found significantly greater abundance of aerial feeders and marsh birds in the Sacramento sub-basin. Aerial feeders, marsh birds and upland birds were most abundant in heavily managed sites. Foraging guilds did not differ by age. Aerial feeders, aerial predators, large wading birds, dabbling ducks, shorebirds and upland birds were most frequently observed on sites in the Sacramento sub-basin. All foraging guilds except upland birds occurred most frequently on heavily managed sites. All guilds were observed more frequently on older sites, except marsh birds, which were more frequent on younger sites.

Table C-1. Temporal variation in bird species diversity (transformed Shannon-Weiner Index) in the upland zone of four sites surveyed. The first visit took place on 1 May and the second on 25 June 2009.

| SITE | VISIT 1 | VISIT 2 |
|---|---|---|
| SAC-20 | 2.86 | 3.60 |
| SAC-13 | 1.39 | 1.97 |
| SAN-1 | 1.00 | 1.42 |
| SAN-6 | 1.81 | 1.93 |

Table C-2. Percent occurrence of foraging guilds by sub-basin, management and age. Number of sites is indicated in parentheses. SAC = Sacramento and SAN = San Joaquin. "Young" sites are ≤ 5 years since restoration; "Old" are > 5 years. "Low" = sites under low or no management, "Inter" = sites under intermediate management, "High" = actively managed sites. Management intensity categories are defined in Table I-3. Guilds are defined in Hickey et al. (2008).

| | Sub-basin (%) | | Management (%) | | | Age (%) | |
|---|---|---|---|---|---|---|---|
| | SAC | SAN | Low | Inter | High | Young | Old |
| Guild | (21) | (29) | (8) | (23) | (20) | (37) | (13) |
| Aerial feeders | 71 | 7 | 38 | 9 | 60 | 23 | 38 |
| Aerial predators | 10 | 3 | 0 | 4 | 10 | 0 | 8 |
| Large waders | 5 | 0 | 0 | 0 | 5 | 0 | 3 |
| Dabbling ducks | 19 | 0 | 12 | 0 | 15 | 8 | 8 |
| Marsh birds | 71 | 7 | 88 | 9 | 40 | 54 | 27 |
| Shorebirds | 5 | 0 | 0 | 0 | 5 | 0 | 3 |
| Upland birds | 95 | 93 | 75 | 100 | 90 | 77 | 100 |

***Wetland surveys***

In 2008, 203 species were recorded including 19 aerial feeders, 18 aerial predators, 8 large waders, 14 dabbling ducks, 4 geese and swans, 4 gulls, 12 marsh birds, 5 plunge divers, 15 surface divers, 32 shorebirds and 72 upland birds. In 2009, 111 species of birds were recorded, including 8 aerial feeders, 8 aerial predators, 6 large wading birds, 9 dabbling ducks, 2 geese, 1 gull, 11 marsh birds, 1 plunge diver, 8 shallow divers, 16 shorebirds, and 49 upland birds. Species diversity (measured as the transformed Shannon-Weiner Index) did not differ among sub-basins, management or age treatments; however, species richness was significantly greater in the San Joaquin sub-basin (Figure C-1). Aerial predators were significantly more abundant in the Tulare sub-basin. Geese were significantly more abundant in the Sacramento sub-basin and marsh birds were most abundant in the San Joaquin sub-basin (Figures C-2, C-3). Dabbling ducks and geese were more abundant on heavily managed sites than those sites managed under intermediate or low regimes (Figures C-4, C-5). Upland birds were significantly more abundant on sites restored more than 5 years ago (Figure C-6).

*Dabbling ducks* – Mallards were most common, occurring on 88% of sites in 2008 and 92% of sites in 2009.

*Geese* – Canada geese occurred most frequently in both years (17 and 42%).

*Marsh birds* – Red-winged blackbirds occurred the most frequently in both years (94 and 92% respectively).

*Plunge divers* – In 2008, Forster's terns were the most frequently observed (17%). In 2009, only the belted kingfisher was observed on one site.

*Gulls* – In 2008, California gulls, herring gulls, ring-billed gulls and an unidentified gull all occurred on 2% of all sites. In 2009 only ring-billed gulls were observed at 2 sites.

*Shallow divers* – Pied-billed grebes were the most common species observed in both years (48 and 58%).

*Shorebirds* – Killdeers were the most frequently observed species in 2008 (79%), while black-necked Stilts were most frequently observed in 2009 (75%).

*Upland birds* –Brown-headed cowbirds were the most common in both years (64.6 and 100%).

*Aerial predators* – Northern harriers were the most frequently observed species in 2008 (65%), while red tailed hawks were the most common in 2009 (75%).

*Breeding birds* - In 2008, breeding shorebirds were significantly more abundant in the San Joaquin sub-basin (Figure C-8). Shallow diver broods were significantly more abundant in heavily managed sites (Figure C-7). Site age did not affect breeding bird abundance.

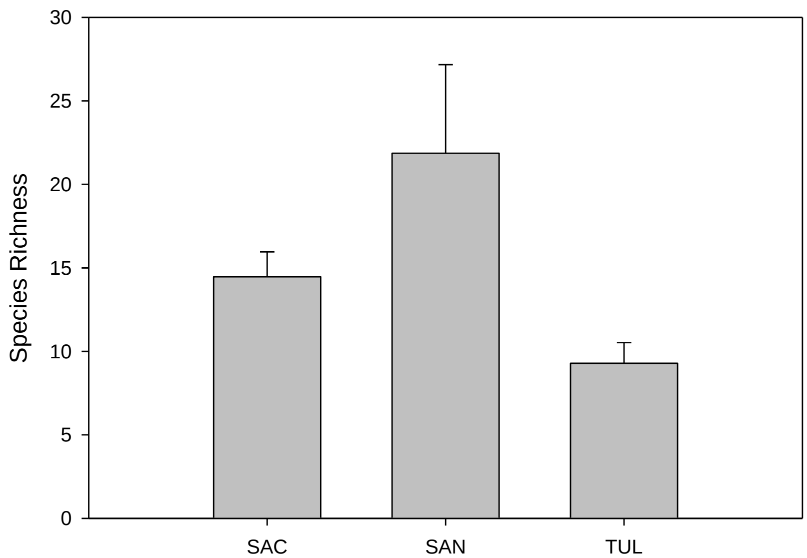


Figure C-1. Average bird species richness (transformed Shannon-Weiner Index) by sub-basin with standard error bars shown. SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.

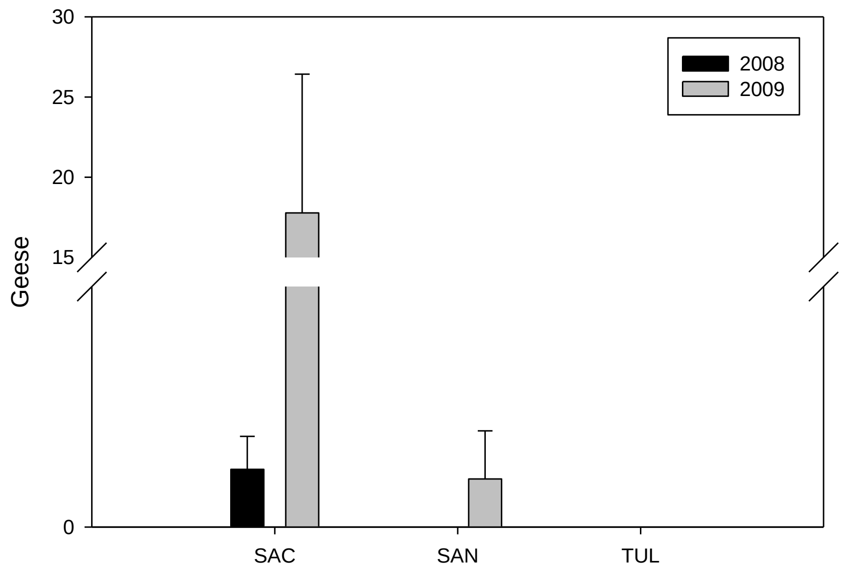


Figure C-2. Average abundance of geese by sub-basin. SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Standard error bars are shown.

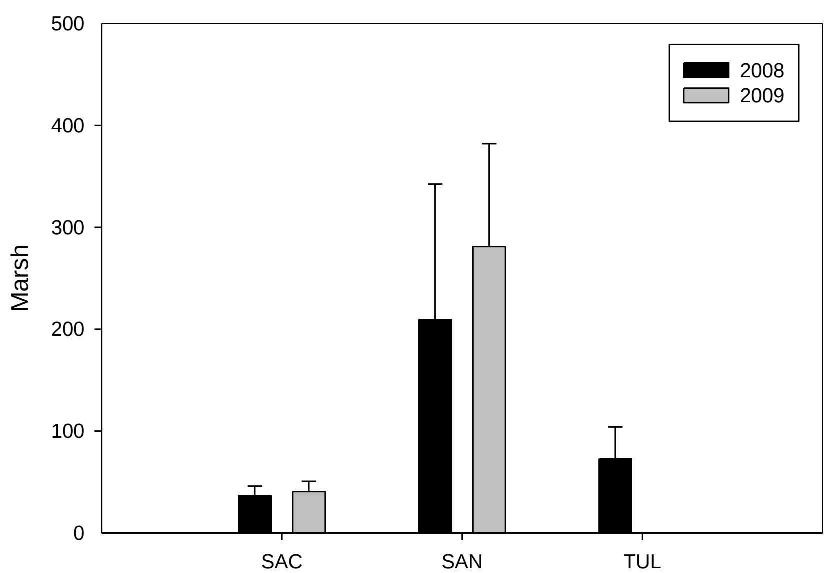


Figure C-3. Average abundance of marsh birds by sub-basin. SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Standard error bars are shown.

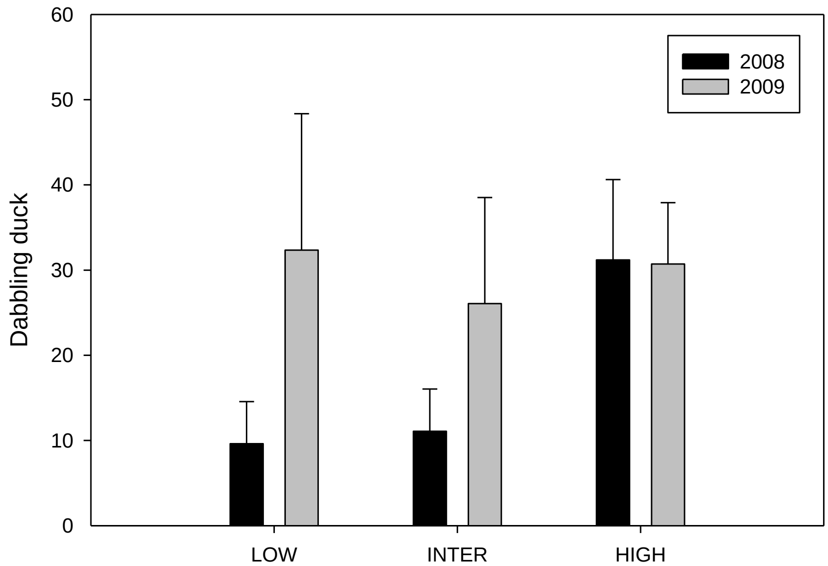


Figure C-4. Average abundance of dabbling ducks by management. Standard error bars are shown. LOW = sites under low or no management, INTER = sites under intermediate management, HIGH = actively managed sites. Management intensity categories are defined in Table I-3.

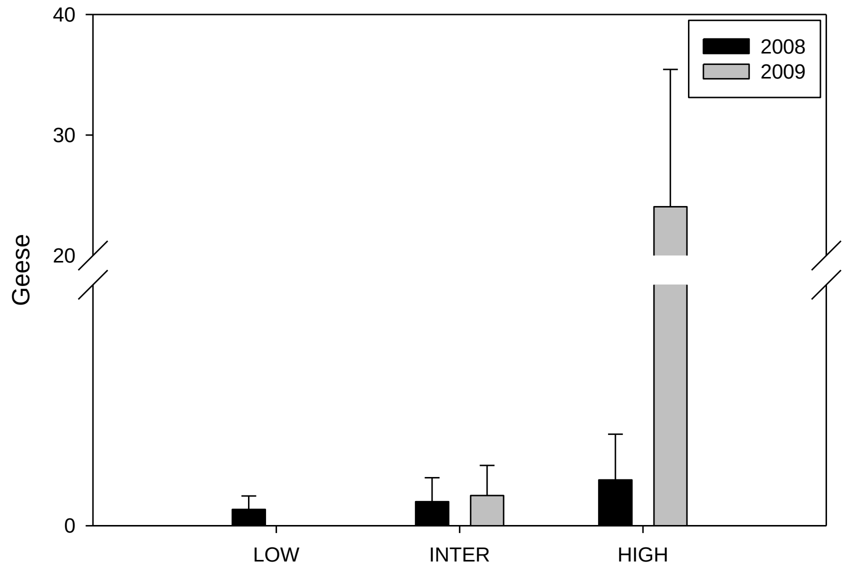


Figure C-5. Average abundance of geese by management. LOW = sites under low or no management, INTER = sites under intermediate management, HIGH = actively managed sites. Management intensity categories are defined in Table I-3. Standard error bars are shown.

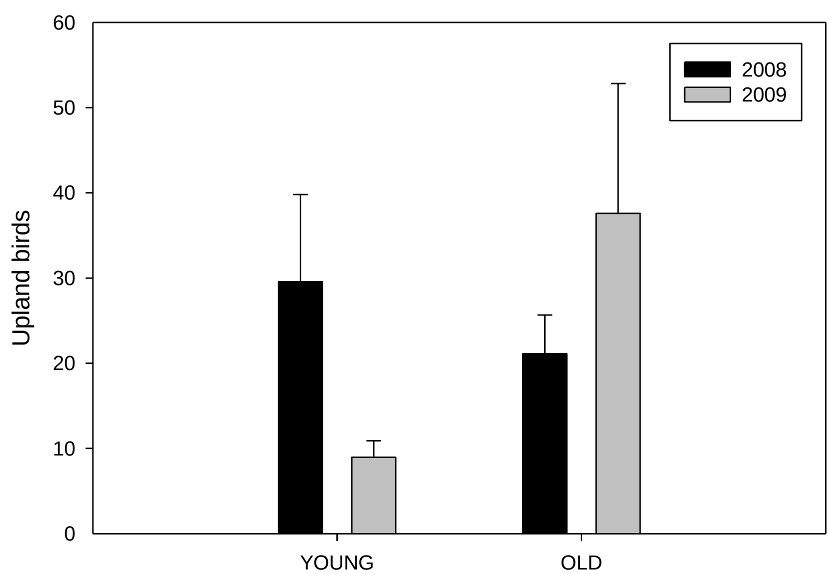


Figure C-6. Average abundance of upland birds by WRP age. “Young” sites are ≤ 5 years since restoration; “Old” are > 5 years. Standard error bars are shown.

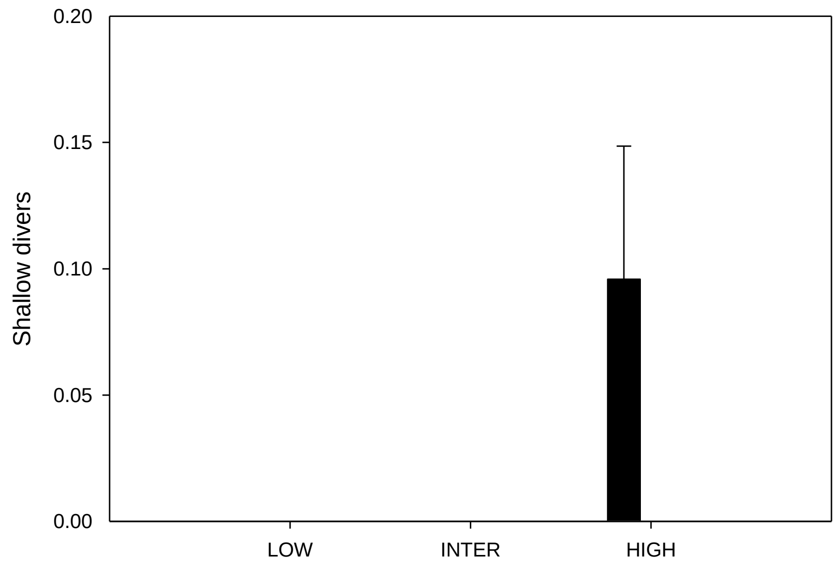


Figure C-7. Average abundance of shallow divers by management; LOW = sites under low or no management, INTER = sites under intermediate management, HIGH = actively managed sites. Management intensity categories are defined in Table I-3. Standard error bars are shown.

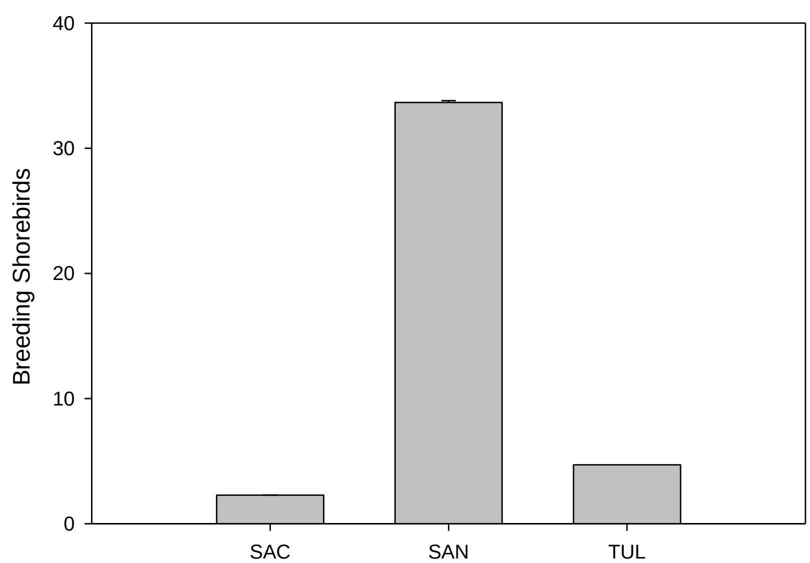


Figure C-8. Average abundance of breeding shorebirds by sub-basin. SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Standard error bars are shown.

## DISCUSSION

The CCV is one of the most important waterfowl breeding and wintering areas in the Pacific Flyway. It supports more shorebirds than any other inland site in North America during winter and spring (Central Valley Joint Venture 2006; Hickey et al. 2008). About 250 bird species have been recorded in the CCV (Binford 1986; Engilis 1995) despite heavy losses in wetland and upland habitat to agriculture. Our study detected over 200 species at sites surveyed in 2008 and 111 in 2009, which are similar to or higher than numbers observed in other studies conducted in managed sites in the same area (Hickey et al. 2008). Diversity and abundance were found to increase considerably in the late summer and early fall in the Tulare sub-basin, which has been reported in previous studies (Gilmer et al. 1998) indicating the return of fall migrants to the region.

Surveys of the upland portions of WRP indicated higher use by almost all foraging guilds in the Sacramento sub-basin compared to the San Joaquin. Lack of information on the Tulare sub-basin precluded assessment. The majority of all remaining upland riparian habitat is located in the Sacramento sub-basin and may have contributed to higher use (Central Valley Joint Venture 2006). Presence of trees within semi-permanent wetlands of the Sacramento valley was also reported to contribute to higher avian biodiversity (Harris 2001). Wetland surveys indicate that the Sacramento sub-basin supported a higher number of geese, whose numbers were positively correlated to the proportion of wet meadow and open water zones in WRP. Wet meadow and open water zones were found to be significantly larger on sites in the Sacramento sub-basin than sites further south. Wet meadow zones are typically dominated by short annual wetland species that may be favored by grazing birds such as geese. The Sacramento sub-basin also supports a greater proportion of crops such as rice, small grains and pasture which may also be attractive to grazing species such as geese.

Surveys conducted on the wetland portions of WRP indicate greater numbers of aerial predators in the Tulare sub-basin compared to the Sacramento or San Joaquin. Aerial predators include species that often prey on wetland birds. Aerial predators were highly correlated with the proportion of upland habitat which dominated sites in the Tulare sub-basin. Upland zones on WRP sites typically support grasses such as *Distichlis spicata* (salt grass) and *Phalaris canariensis* (reed canarygrass). Furthermore, a large proportion of sites are under low or inactive management.  These large expanses of open upland habitat may support aerial predator foraging activity.

Marsh birds occurred in greatest abundance in the San Joaquin sub-basin compared to other sub-basins.  Marsh birds include Red-winged Blackbirds, Marsh Wrens, American Coots and Common Yellowthroat, among others.  Presence of marsh birds was negatively correlated with proportion of upland habitat; however, there was no evidence to show that sites in the San Joaquin had less upland habitat.  Breeding shorebirds were also more abundant in the San Joaquin sub-basin.  This is in contrast to previous studies that suggest the Tulare sub-basin to be more important for breeding shorebirds (Central Valley Joint Venture 2006, Hickey et al. 2008).

Upland nesting cover is well distributed throughout the CCV; however, Butte, Colusa and Suisun are potentially the most important basins for breeding waterfowl in the CCV based on the distribution of potential upland nesting cover, rice fields and wetlands (Central Valley Joint Venture 2006).  Wintering shorebirds also depend on the Grasslands; it is one of a few key wintering areas in the world for mountain plovers (*Charadrius montanus*) (Knopf and Rupert 1995).  We also found that species richness was significantly greater in the San Joaquin compared to other sub-basins.  Shuford et al. (1998) reported that shorebird species richness tended to be highest in the San Joaquin Valley.  About one third of all wetlands in the San Joaquin sub-basin is privately managed and lies within the Grasslands ecosystem.

Surveys of upland habitat revealed a higher abundance of aerial feeders, marsh birds and upland birds on heavily managed sites.  All foraging guilds except upland birds were observed most frequently on heavily managed sites.  Heavily managed sites typically receive more active management and conservation practices such as riparian buffer and native grass planting.  Although species diversity and richness did not differ statistically among management regimes, data indicate an increasing trend from low to high management.  Surveys of the wetland habitats found a greater abundance of dabbling ducks on heavily managed sites.  These sites tend to have more dynamic hydrological regimes and many are actively managed to attract breeding and wintering waterfowl.  The largest proportion of heavily managed sites is located in the Sacramento sub-basin; however, previous studies suggest that sites in the Tulare sub-basin may receive more use due to the shortage of alternative habitat.  Our data indicated significantly greater dabbling duck use in heavily managed sites of both the Sacramento and Tulare sub-basins. Geese and shallow divers were also more abundant on actively managed WRP easements.

Upland species diversity and foraging guild abundance did not differ among age treatments. However, all guilds were observed more frequently on older sites with the exception of marsh birds. Wetland surveys indicated a higher abundance of upland birds on older sites despite older sites exhibiting smaller upland habitat and larger wet meadow and shallow marsh zones. However, older sites may have more riparian habitat. At sites re-vegetated with native plants in the Sacramento River that were greater than five years old, bird diversity approached that of remnant woodland (Golet et al. 2003).

In Iowa, VanRees-Siewert and Dinsmore (1996) found that the mean number of breeding birds was significantly higher in older restored wetlands and that species richness increased with percent cover of emergent vegetation. A shift in bird species composition with wetland age was also reported by VanRees-Siewert and Dinsmore (1996) who found that wetland physiognomy was the most important factor influencing total bird diversity.

# CHAPTER D: REDUCTION OF SOIL LOSS IN THE CCV

## OBJECTIVE

We evaluated erosion to quantify potential of WRP to reduce soil loss under three possible cropland erosion scenarios and the potential of WRPs for reducing sediment loading to streams in the CCV.

## METHODS

We estimated change in soil erosion since the establishment of WRP in the CCV under three scenarios using Environmental Protection Agency (EPA) Arc Macro Language (AML) scripts in ArcGIS 9.3 (Van Remortel et al. in review). These scripts model watershed soil sheet and rill erosion on a cell-by-cell basis, based on the Revised Universal Soil Loss Equation (RUSLE),

A = R*K*LS*C*P, where:

A = estimated average annual soil loss per unit area caused by rainfall

R = climatic erosivity factor (erosion force of rainfall as determined by kinetic energy and 30 minute intensity)

K = soil erodibility factor (susceptibility of soil to erosion and rate of runoff)

L and S = slope length and steepness factors

C = cover management factor (effect of plants, soil cover, soil biomass and soil disturbance activities on erosion)

P = supporting practice factor (impact of supporting practices on erosion rate)

R and K factors were supplied by the EPA from standard datasets (PRISM climate group, State Soil Geographic Databases). The LS factor was computed from ArcHydro-processed National Elevation Dataset 30-m mosaicked rasters. The P factor was assigned a value of one in all CEAP RUSLE models (Van Remortel et al. in review). C factors were assigned to National Land Cover Dataset (NLCD) 2001 landcover types based on Smithsonian Environmental Research Center NLCD 1992 values, with cultivated cropland areas set at either low (0.01), medium (0.205), or high (0.4) (Homer et al. 2004; Boomer et al. 2008; personal communication, Boomer, K., Smithsonian Environmental Research Center, 14 August 2009, Appendix IV). Soil loss was modeled for two restoration scenarios: (1) "before" WRP restoration, with all WRP easements treated as cultivated cropland and (2) "after" WRP restoration, with all WRP easements treated as wetlands.

## RESULTS AND DISCUSSION

The RUSLE has been widely used to estimate average annual soil loss per unit area via surface runoff. The equation estimates the effects of specific cropping systems, management strategies and erosion control practices on average annual erosion. We applied a procedure developed by Van Remortel et al. (in review) to estimate watershed level soil loss in GIS. The computer algorithm generates grids for each component used to calculate the RUSLE. Although reliable estimates of slope length, current land use, cropping history and erosion control are dependent upon spatial and temporal resolution of the input variables, we believe the method provides an opportunity to examine effects at large scales that would otherwise be logistically difficult.

We estimated relative reduction in soil loss through conversion of cultivated cropland and grazing land to WRP at the watershed level under three cropland erosion rates: low, medium and high. Overall, percent declines in soil loss were found to be very low even under high rates of soil erosion. On average, soil losses across the CCV were reduced by 0.04, 2.44 and 4.58 kg $m^{-1}yr^{-1}$ respectively. Under low cropland erosion rates, soil loss in the CCV could be reduced by 0.7%, medium cropland erosion by 8.1% and high cropland erosion by 10%. These suggest that establishment of WRP reduced overall soil loss in the CCV by 1, 55 or 103 kg $m^{-1}yr^{-1}$ under low, medium or high cropland erosion rates respectively. Impact of WRP on mitigating soil loss was greatest in the northern CCV and Lower Cosumnes-Lower Mokulumne watershed under all three scenarios (Figures D-1, D-2, and D-3). Furthermore, it is assumed that easement enrolled under WRP and other USDA programs accrue soil loss reductions over time such that time since restoration may greatly increase reduction benefits.

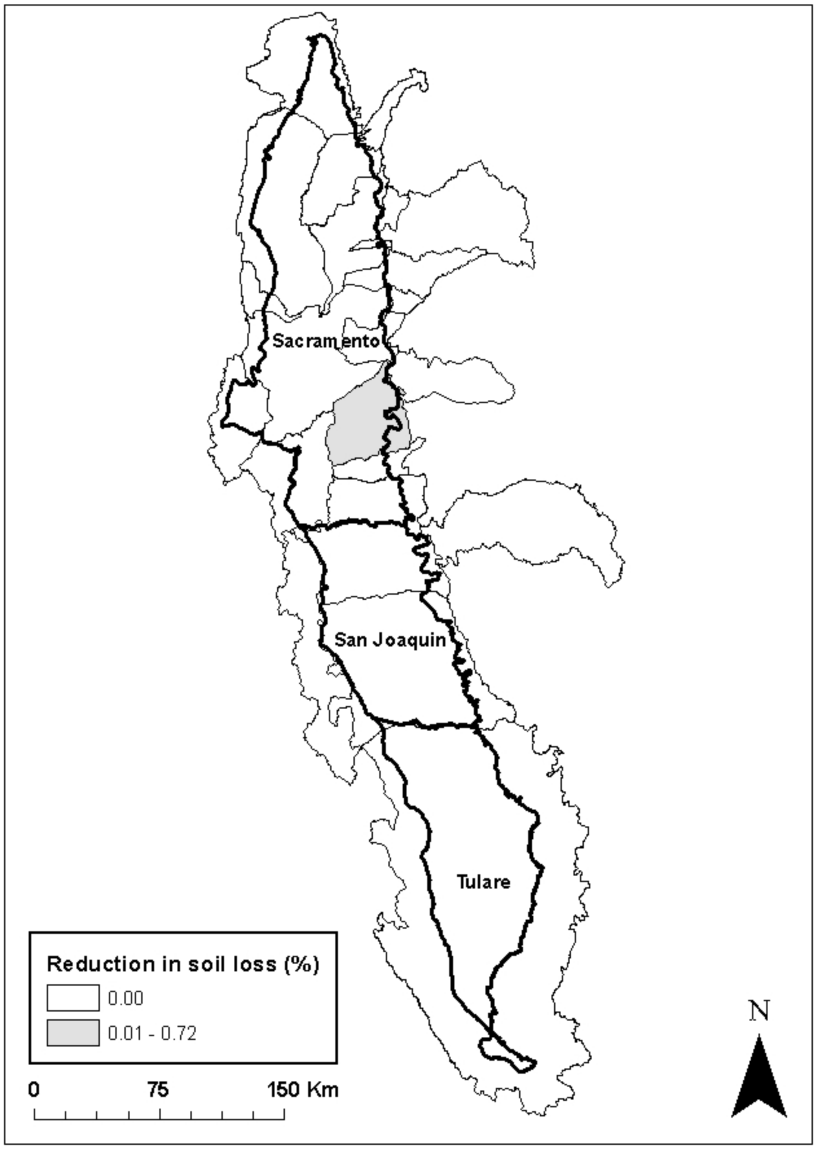


Figure D-1. Percent reduction in soil loss in CCV watersheds through conversion of crop and grazing lands to WRP under low cropland erosion rates.

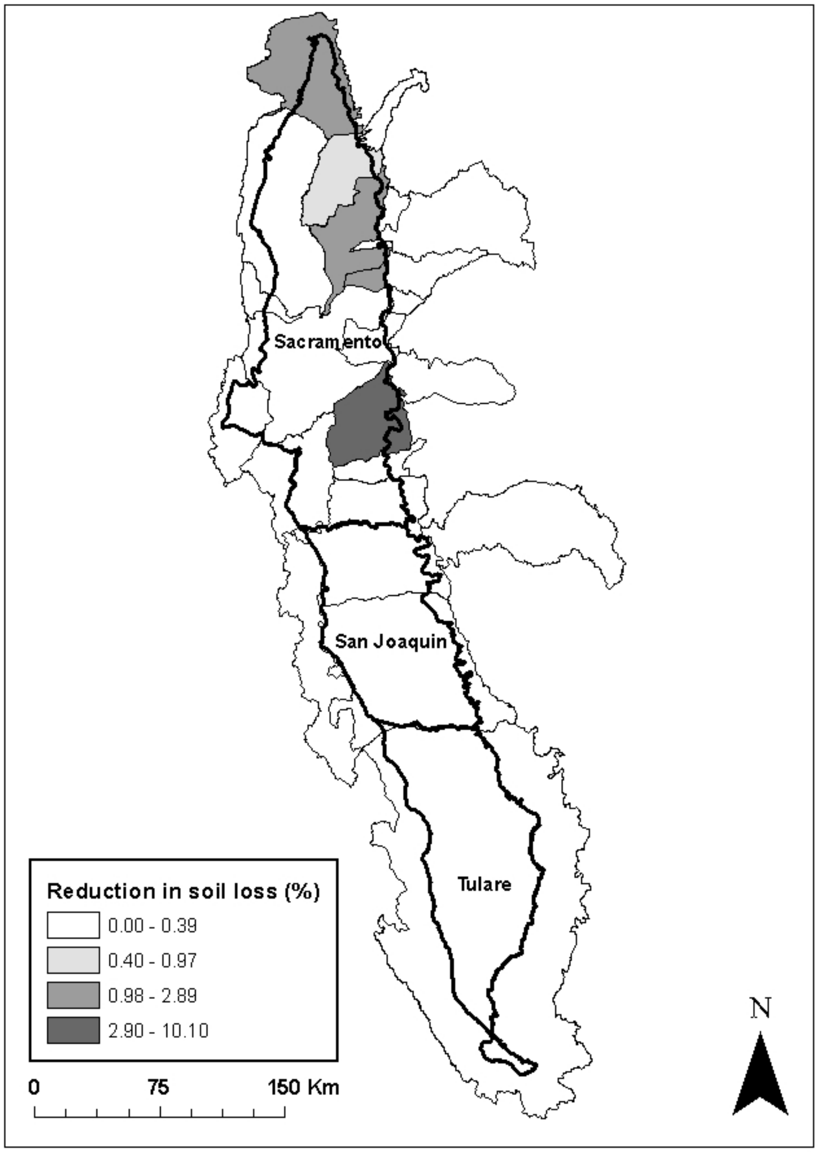


Figure D-2. Percent reduction in soil loss in CCV watersheds through conversion of crop and grazing lands to WRP under medium cropland erosion rates.

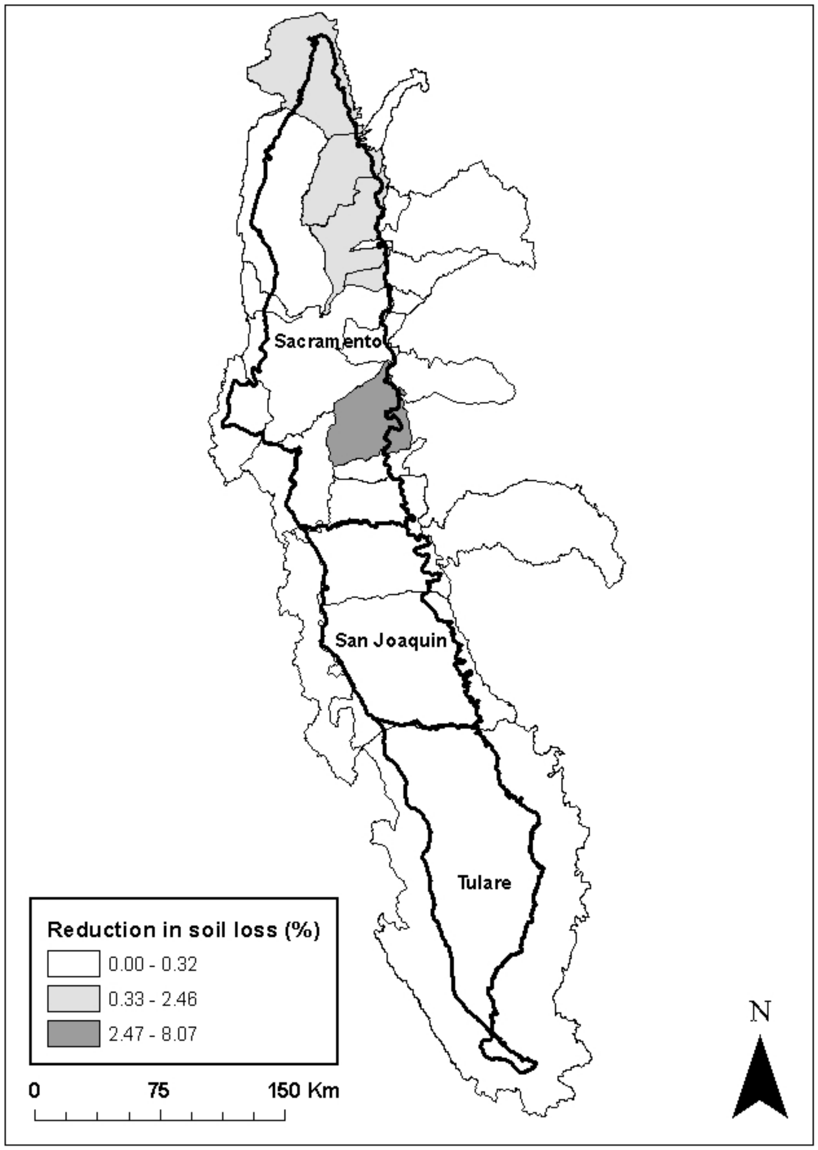


Figure D-3. Percent reduction in soil loss in CCV watersheds through conversion of crop and grazing lands to WRP under high cropland erosion rates.

# CHAPTER E: UKRB

## SITE SELECTION

Site selection of easements in the Upper Klamath River Basin (UKRB) was constrained by the number of WRP easements available. Furthermore, we wished to assess fish use of WRP easements in this region, which further constrained site availability. In 2008, we surveyed amphibians in nine WRP easements (sites UKRB-2 and UKRB-4 to -11) in the UKRB, assessed potential fish access to these WRPs, and conducted vegetation habitat assessment on two of the nine easements. In 2009, we sampled three riparian WRP easements along the Sprague River, site UKRB-4 that had been identified in 2008 and sites UKRB-1 and -3 (Figure 3). The limited number of WRP easements in this region precluded stratifying sampling across management intensity, restoration age and precipitation gradients. Data collection was conducted during April – July 2008 and March – June 2009.

Most of the wetlands we sampled on WRP easements in the UKRB had a seasonal hydroperiod, flooding in the winter or spring and drying in the summer and fall. Within this regime, however, some sub-basins within these wetlands had more of a semi-permanent hydroperiod, retaining water into the summer or fall. Most of the wetlands we sampled also received little or no management. Exceptions included sites UKRB-3 and -4, where some water management occurred via water control structures opened in spring to allow riparian flooding. All of the wetlands we sampled in the UKRB were also relatively young, $\leq$ 5 years since restoration was completed. The relatively short period since completion of restoration is reflected in soil development and biological communities.

# UKRB: Habitat Assessment

## Objective

We assessed habitat characteristics and nutrient storage of WRP easements in the UKRB to compare with more numerous CCV WRP sites.

## Methods

Vegetation was surveyed and cover estimated at five wetlands in the UKRB during July 2008 (sites UKRB-9 and -10) and March 2009 (sites UKRB-1, -3 and -4). Time since restoration was completed at the five wetlands varied from 1 – 5 years; being one year at site UKRB-1, two years at site UKRB-10 and four to five years at sites UKRB-3, -4 and -9. Management of the wetlands varied. Sites UKRB-3 and -4 have received moderate management, consisting of water application, during recent years. Site UKRB-1 received no active management, while level of management at sites UKRB-9 and UKRB-10 was unknown. All of the wetlands surveyed were classified as having a seasonal hydroperiod.

Visual estimates derived for two wetland basins in the UKRB in 2008 (sites UKRB-9 and -10) and three wetland basins in 2009 (sites UKRB-1, -3 and -4) included the percentage of area covered by open water and emergent vegetation, wetland cover type, and adjacent land use. Detailed vegetation information was gathered following procedures developed by USGS-Northern Prairie Wildlife Research Center (Kantrud and Newton 1996). One transect was established in each of four corners of the WRP property or corners of a cell. There was no fixed distance between transect locations. The width (m) of all wetland vegetation zones, as delineated by plant species composition, bisected by transects was estimated and water depth (cm) recorded. Within each of these zones, a 1-$m^2$ quadrat was randomly sited along each transect. Vegetation cover (%) by taxon (Daubenmire 1959), litter depth (cm), and visual obstruction at plot center (Robel 1970) were estimated.

## Statistical Analysis

The limited sample size required all data to be assessed qualitatively.

## RESULTS

Predominant cover at four of the five wetlands was grasses (*Poa* spp.), and grasses comprised the overwhelming majority of cover at two sites (Table E-1). Tule was predominant at site UKRB-10 where spikerush (*Eleocharis* spp.) was also common. Cattail (*Typha* spp.) covered 10 - 25% of the wetlands at four sites, but was absent from site UKRB-10. Willow (*Salix* spp.) was present at the three Sprague River riparian wetlands (sites UKRB-1, -3 and -4), but absent at the other two sites.

## DISCUSSION

Grasses predominated the cover in four of five wetlands surveyed during 2008 and 2009. The predominance of grasses likely reflects natural riparian conditions in UKRB, as we observed grasses to be common on non-WRP wetlands as well as on WRP easement wetlands. The single site that we are aware of having received vegetation management was site UKRB-4, where vegetation management consisted of willow planting. The percentage of willow cover at this site was slightly higher than at sites UKRB-1 and -3, the other riparian WRP wetlands along the Sprague River. The vegetation cover at site UKRB-10 was different than at the other four wetlands sampled and was dominated by tule. This is undoubtedly the result of site UKRB-10 being young, ≤ 2 years since restoration, and being located on Oregon Department of Fish and Game wildlife management lands.

Table E-1. Percent cover by plant type and open water at five wetlands within WRP easements in the Upper Klamath River Basin during 2008.

| | Percent Cover | | | | | | |
|---|---|---|---|---|---|---|---|
| Site | Grasses | Cattail | Sedge | Spikerush | Tule | Willow | Open water |
| UKRB-1 | 75 | 10 | 10 | 0 | 0 | 5 | 0 |
| UKRB-3 | 35 | 25 | 0 | 0 | 10 | 5 | 25 |
| UKRB-4 | 40 | 15 | 5 | 0 | 10 | 10 | 20 |
| UKRB-9 | 80 | 10 | 9.5 | 0 | 0 | 0 | 0.5 |
| UKRB-10 | 0 | 0 | 0 | 35 | 55 | 0 | 10 |

# UKRB: SOILS

## OBJECTIVE

We sampled soils at WRP wetlands in the UKRB to characterize basic soil properties.

## METHODS

Soil samples were collected in July 2009 at three WRPs in the UKRB (sites UKRB-1, -3 and -4). Samples were taken at corners of the WRP property as a whole or of (a) wetland cell(s) within the WRP. At each of three sampling locations two cores were taken and bagged separately in plastic Ziploc packets, for a total of six soil samples per WRP. The first core was taken to a depth of approximately 1 cm. The depth of the second core varied from 16.4 to 24.9 cm, depending on ease of auguring the sample.

The following soil parameters were measured: litter depth, total carbon, total nitrogen, total $CaCO_3$, total phosphorus, and bulk density. In the laboratory, all samples were weighed, dried at 101$^{\circ}$ C to a constant weight, and then re-weighed for bulk density determination. In 2009, samples were analyzed by the Agriculture and Natural Resources Laboratory of the University of California at Davis, CA. Analysis of total N and total C was conducted according to methods in AOAC (1997). Total P was analyzed by acid dissolution followed by ICP analysis (Sah and Miller 1992). Gravimetric determination of $CaCO_3$ was carried out according to the methods in U.S. Department of Agriculture (1954). All soil samples were ground and sieved through a 2 mm sieve before analysis.

## STATISTICAL ANALYSIS

The limited sample size required all data to be assessed qualitatively.

## RESULTS

Soil core depth was slightly shallower at site UKRB-1 than at sites -3 and -4, but was adequate to characterize litter depth. Soil litter depth ranged from 2.29 – 3.87 cm (Table E-2) and decreased from site UKRB-1 through site -3.

Percentage of total nitrogen (TN), total carbon (TC), total phosphorus (TP) and $CaCO_3$ declined from site UKRB-1 through site -4. This pattern was consistent for both the upper 1 cm of soil and for the total core depth (Table E-3). Percentage of nutrients was about two times greater in the upper 1 cm of soil than in the entire core. The exception was $CaCO_3$ at site UKRB-1, where replicate samples were lacking.

Table E-2. Average depth of soil cores and depth of litter in cores at three wetlands within WRP easements in the Upper Klamath River Basin. Averages are based on five measurements per core; numbers in parentheses are one standard deviation of the average.

| Site | Core depth (cm) | | Litter depth (cm) | |
|---|---|---|---|---|
| UKRB-1 | 18.85 | (1.79) | 3.87 | (1.80) |
| UKRB-3 | 23.75 | (0.46) | 2.87 | (1.20) |
| UKRB-4 | 23.47 | (0.66) | 2.29 | (2.09) |

## DISCUSSION

Percentage nutrient concentration of soils in the three riparian WRP wetlands illustrated a gradient, with highest concentrations in soils from the upstream site and lowest concentrations in soils at the most downstream site. This may be an artifact of small sample size, but we suspect that it reflects actual conditions. Although the most upstream WRP, site UKRB-1, has been under easement only a few years, the site is undisturbed and likely received only grazing before being enrolled. The two downstream sites (UKRB-3 and -4) border a rural subdivision, contain extensive levees and were likely disturbed prior to restoration. Litter depth in UKRB wetlands sampled was deeper than in most CCV wetlands (Drexler et al. in review). Percentages of nitrogen and carbon in the UKRB wetlands we sampled were also higher than percentages in CCV wetlands. Percentage of soil phosphorus, however, did not appear to differ between UKRB and CCV wetlands (Drexler et al. in review).

Table E-3. Average percentage of total nitrogen (TN), total carbon (TC), total phosphorus (TP) and calcium carbonate ($CaCO_3$) in soil samples from two core depths at three wetlands within WRP easements in the Upper Klamath River Basin. Averages are based on five measurements per core; numbers in parentheses are one standard deviation of the average.

| | TN (%) | TC (%) | TP (%) | CaCO3 (%) |
|---|---|---|---|---|
| Site | 1 cm depth core | | | |
| UKRB-1 | 1.23 (0.38) | 15.71 (3.73) | 0.10 (0.02) | 0.50 ( -- ) |
| UKRB-3 | 0.39 (0.38) | 5.06 (5.49) | 0.06 (0.03) | 0.80 (0.14) |
| UKRB-4 | 0.23 (0.09) | 2.58 (1.06) | 0.05 (0.01) | 0.80 (0.44) |
| | ~ 20 cm depth core | | | |
| UKRB-1 | 0.74 (0.36) | 8.17 (3.39) | 0.06 (0.02) | 0.60 ( 0.20) |
| UKRB-3 | 0.16 (0.11) | 1.79. (1.17) | 0.04 (0.02) | 0.53 (0.12) |
| UKRB-4 | 0.15 (.04) | 1.75. (0.39 ) | 0.04 (0.01) | 0.45 (0.35) |

# UKRB: Amphibians

## Objective

We surveyed amphibian use of WRPs in the UKRB as part of our assessment of biodiversity, as well as to evaluate the distribution and relative abundance of anuran species in the UKRB.

## Methods

Amphibian surveys were conducted on nine WRP easements in the UKRB between June and July 2008. Survey techniques included visual encounter surveys and nighttime auditory recordings. Visual encounter surveys were conducted during daylight, between 0900 and 1600 hours. This technique required two surveyors to slowly walk around the wetland perimeter at the waterline, stopping often to scan ahead for amphibians. One surveyor focused on the land-water interface while the other focused on the shallow water zone ($\leq$ 1m). Overhangs, ledges and vegetation were investigated for the presence of amphibians. Surveyors wore polarized sunglasses to reduce the reflective glare on the water's surface and carried dipnets to collect individuals for identification or voucher collection purposes. All collected amphibians were identified using a variety of guides, including Altig et al.'s (2007) Tadpoles of the United States and Canada: a tutorial and key and Stebbins' (2003) A field guide to western reptiles and amphibians.

At several larger easements, 25% of the wetland perimeter was sub-sampled. These sub-samples were apportioned relative to habitat type (e.g. forested and non-forested, vegetated and non-vegetated, etc.) and were distributed around the wetland perimeter.

Auditory recordings were used to detect the presence of the nocturnal breeding activities of adult, male anuran species that may not have been observed during visual surveys. At each WRP easement, a single SM1 Wildlife Acoustic Song Meter recorder was installed along the northern perimeter of the wetland. Recorders were programmed to record the first 20 minutes of each hour between 2000 hours and 0200 hours (i.e., 2000 – 2020 hours, 2100 – 2120 hours, etc.).

Recordings were reviewed at Humboldt State University. The first five minutes (e.g., 2000 – 2005 hours, 2100 – 2105 hours, etc.) of each hourly recording was reviewed at a standardized volume and all amphibian vocalizations were identified and tallied. If the first five-minute interval could not be reviewed (due to wind, static, or other factors), the second five-minute interval (e.g., 2005 – 2010 hours, 2105 – 2110 hours, etc.) was reviewed, and so on.

## Statistical Analysis

Data on anuran distribution and abundance was limited to two visits. These visits yielded categorical estimates of abundance and fragmentary distribution observations, neither of which supported statistical analyses.

## Results

Four species of amphibians were detected in the nine WRP wetlands surveyed (Table E-4). Abundance was recorded categorically (i.e. 101 – 1,000, 1,001 – 10,000, etc.).All individuals were detected by aural or visual survey methods. Abundance of most species and life stages was low, 10 or fewer. Exceptions included Pacific chorus frog (*Pseudacris regilla*) larvae, with an abundance of 101 – 1,000 at site UKRB-4 and 1,001 – 10,000 at site UKRB-8; western toad (*Bufo boreas*) larvae, with an abundance of 101 – 1,000 at site UKRB-4, and American bullfrog (*Lithobates catesbeianus*) larvae and juvenile/adults, each with an abundance of 11 - 100 at site UKRB-11.

Amphibian species richness (R) was low, ranging from 1.0 at three sites to 4.0 at one site. Average R among the nine sites was 2.0 (standard deviation 1.0). The American bullfrog was the most common species encountered and was detected at eight of nine sites. Pacific chorus frogs were detected at five sites, while western toads and long-toed salamanders (*Ambystoma macrodactylum*) were each detected at two sites.

Table E-4. Species of amphibians detected at sites sampled in the Upper Klamath River Basin in June and July 2008. Life stages detected were egg (E), larvae (L) and juveniles or adults (J/A).

| Site | Long-toed salamander | Western toad | Pacific chorus frog | American bullfrog |
|---|---|---|---|---|
| UKRB-2 | | | | J/A |
| UKRB-4 | L | L | L-J/A | E-L-J/A |
| UKRB-5 | | | | J/A |
| UKRB-6 | | | | L-J/A |
| UKRB-7 | | L-J/A | J/A | |
| UKRB-8 | L | | L-J/A | L-J/A |
| UKRB-9 | | | J/A | J/A |
| UKRB-10 | | | J/A | J/A |
| UKRB-11 | | | | L-J/A |

## DISCUSSION

We found four species of amphibians at the nine wetlands surveyed in 2008. The most common species encountered was American bullfrog, an introduced species. Pacific chorus frog, a native species, was found at five of the nine sites, while two other species were each found at two sites. Numbers of amphibians were generally less than 10, with a few exceptions. Those exceptions included eggs and larvae of American bullfrog and Pacific chorus frog, which were abundant at several sites. Overall, amphibian diversity at UKRB wetlands sampled was low, with species richness averaging 2.0 and ranging from 1 – 4.

# UKRB: BIRDS

## OBJECTIVE

We surveyed bird use of WRPs in the UKRB as part of our assessment of biodiversity.

## METHODS

Five-minute variable circular point count surveys were conducted at three WRP easements along the Sprague River in the UKRB in March (site UKRB-3) and July 2009 (sites UKRB-1 and -4) following nationally standardized protocol (Ralph et al. 1995).

For the 5-minute variable circular plot point count method, the distance from the observer to each individual bird (including aerially foraging raptors and swallows) is estimated (Ralph et al. 1995). We estimated detections in bands of 10 m outward to 50 m. Three bands extend further (50 - 75 m, 75 - 100 m, and >100 m). Type of detection (i.e. song, visual, or call) and breeding behavior (e.g. copulation, nest building, food carry to fledgling) were recorded. Birds flying over the point count station were recorded separately and excluded from analyses. All transects were observed a single time in March (sites UKRB-4A and -4B) or July of 2009 (sites UKRB-1 and -3). Surveys were completed within 4 hours of local sunrise by experienced observers trained in visual and auditory bird identification and distance estimation. Since detection rates of most species generally decrease beyond a 50 m distance from the observer, we have only included detections from within 50 m of each point count station for data analysis.

## STATISTICAL ANALYSIS

The limited sample size required all data to be assessed qualitatively.

## RESULTS

Twenty taxa of birds were observed at riparian wetlands within the three WRP easements along the Sprague River (Table E-5). Species richness was seven to eight at the sites surveyed in July 2009 (sites UKRB-1 and -4) and four at site UKRB-3, surveyed in March 2009. Four species were observed at two or more sites: Mallard, Red-winged Blackbird, Song Sparrow and unidentified swallows. All other species were observed at only one site. None of the species observed was abundant.

Birds observed at the three sites represented eight foraging guilds (Table E-6), groupings of birds that share ecological requirements and behaviors (Hickey et al. 2008). Six species were from the upland bird guild and three species were from the marsh bird guild. Species from each of these guilds were observed at all three sites. The other six guilds were represented by one or two species.

Table E-5. Number of birds of different species observed at three WRP easement wetlands in the Upper Klamath River Basin in 2009.

| | | | UKRB-Site | | | |
|---|---|---|---|---|---|---|
| Common name | Genus | Species | 1 | 3 | 4A | 4B |
| American goldfinch | *Carduelis* | *tristis* | 1 | 0 | 0 | 0 |
| American white pelican | *Pelecanus* | *erythrorhynchos* | 0 | 0 | 0 | 15 |
| Barn swallow | *Hirundo* | *rustica* | 1 | 0 | 0 | 0 |
| Brewer's blackbird | *Euphagus* | *cyanocephalus* | 0 | 0 | 0 | 1 |
| Canada goose | *Branta* | *canadensis* | 0 | 4 | 0 | 0 |
| Great blue heron | *Ardea* | *herodias* | 0 | 0 | 1 | 0 |
| Killdeer | *Charadrius* | *vociferus* | 0 | 2 | 0 | 0 |
| Mallard | *Anas* | *platyrhynchos* | 0 | 3 | 0 | 1 |
| Marsh wren | *Cistothorus* | *palustris* | 0 | 0 | 0 | 2 |
| Northern flicker | *Colaptes* | *auratus* | 5 | 0 | 0 | 0 |
| Red-winged blackbird | *Agelaius* | *phoeniceus* | 1 | 0 | 11 | 20 |
| Sandhill crane | *Grus* | *canadensis* | 0 | 3 | 0 | 0 |
| Song sparrow | *Melospiza* | *melodia* | 1 | 0 | 4 | 3 |
| Unidentified sparrow | *Emberizidae* | | 1 | 0 | 0 | 0 |
| Unidentified swallow | *Hirundinidae* | | 4 | 0 | 22 | 0 |
| Virginia rail | *Rallus* | *limicola* | 0 | 0 | 0 | 1 |
| Unknown waterbird | *(duck or grebe)* | | 0 | 0 | 7 | 0 |
| Western meadowlark | *Sturnella* | *neglecta* | 0 | 0 | 1 | 0 |
| Unknown goldfinch | *Carduelis* | | 0 | 0 | 0 | 4 |
| Unidentified sandpiper | *Scolopacidae* | | 0 | 0 | 2 | 0 |

Table E-6. Foraging guilds of birds, the number of birds belonging to each guild, the number of species belonging to each guild and the number of sites at which the members of the guild were observed at three WRP easement wetlands in the Upper Klamath River Basin in 2009 during a single visit. Guilds based on PRBO Conservation Science foraging guilds, groupings of birds that share ecological requirements and behaviors (Hickey et al. 2008).

| Guild | Number | Number species | Number sites |
|---|---|---|---|
| Aerial feeders | 27 | 2 | 2 |
| Dabbling ducks | 4 | 1 | 2 |
| Geese | 4 | 1 | 1 |
| Large wading birds | 4 | 2 | 2 |
| Marsh birds | 33 | 3 | 3 |
| Shorebirds | 2 | 1 | 1 |
| Surface divers | 15 | 1 | 1 |
| Upland birds | 21 | 6 | 3 |

## DISCUSSION

We observed 20 species of birds, representing eight foraging guilds, using riparian WRP wetlands along the Sprague River.

One species, the sandhill crane, is classified as threatened. All other species observed are not classified as threatened or endangered. Numbers of birds observed were not large, likely because the time of surveys (March and July) did not coincide with migration. The eight guilds observed suggests riparian WRP wetlands we sampled are providing a variety of habitats for birds, ranging from divers to shorebirds to upland species.

# UKRB: FISH

## OBJECTIVE

We sampled fish in riparian WRP wetlands to evaluate their use of these habitats and, more specifically, use of these wetlands by endangered sucker species.

## METHODS

Riparian wetlands on three WRP easements adjacent the Sprague River in the UKRB (Figure 3, sites UKRB-1, -3, -4), were sampled during April - June 2009. Sampling was designed to determine wetland use by the larval stage of three sucker species: Lost River sucker (*Deltistes luxatus)*, shortnose sucker (*Chasmistes brevirostris)* and Klamath large-scale sucker (*Catostomus snyderi*). Other fish species encountered were also enumerated. The Lost River sucker and shortnose sucker were listed under the Endangered Species Act (ESA) in 1988 (Tomelleri 2007a, 2007b).

We used belt transect surveys and dip netting to visually estimate presence and abundance of larval suckers. Habitats sampled included the mainstem Sprague River, backwaters directly connected to the mainstem such as alcoves, and wetland areas behind flood gate structures and levees. Species diversity was noted when non-sucker species were encountered.

Notochord length was recorded, as were water temperature, dissolved oxygen (mg/L), and pH in sampling areas.

## STATISTICAL ANALYSIS

Data on fish distribution and abundance were gathered during three sampling visits in 2009, during the period when riparian wetlands normally flood. However, 2009 was a dry year and riparian wetland flooding was inconsistent from site to site. Because of these limitations, data on the distribution and abundance of fish species were analyzed qualitatively. Emphasis was placed on looking for consistency, or lack thereof, in distribution and abundance.

## RESULTS

A total of 620 fish were collected during sampling, 414 with dipnets and 216 using electrofishing gear. Visual surveys yielded 343 suckers and 45 non-suckers. The most common species collected were larval suckers that could not be identified to species (Tables E-7 and E-8). Sucker larvae made up 85% of the fish collected using dipnetting and 14% of the fish collected with electrofishing gear. Blue chub were the most common species collected with electrofishing gear, making up 41% of the fish collected with that gear. Other species represented from 0 - 5% of the total fish collected using dipnetting and from 0.4 – 13% of the total collected using electrofishing.

Table E-7. Number of six species of fish collected using dipnets from three riparian wetlands within WRP easements along the Sprague River, Oregon. Week = week of the year, species codes are: SU = sucker species, BC = blue chub, BNB = brown bullhead, CHUB = unidentified chub, SC = sculpin and SD = speckled dace.

| Week | SU | BC | BNB | CHUB | SC | SD |
|---|---|---|---|---|---|---|
| | | | UKRB-4 | | | |
| 16 | 159 | 0 | 0 | 0 | 0 | 0 |
| 17 | 106 | 0 | 0 | 0 | 0 | 0 |
| 19 | 28 | 0 | 2 | 6 | 8 | 0 |
| 22 | 1 | 0 | 0 | 0 | 0 | 0 |
| | | | UKRB-3 | | | |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 23 | 0 | 0 | 0 | 0 | 0 |
| 19 | 33 | 0 | 0 | 3 | 9 | 0 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | UKRB-4 | | | |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 36 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 |

Table E-8. Number of 11 species of fish collected with electrofishing gear from three riparian wetlands within WRP easements along the Sprague River, Oregon. Week = week of the year, species codes are: SU = sucker species, BC = blue chub, BNB = brown bullhead, BKB = black bullhead, SC = sculpin, SD = speckled dace, FM = fathead minnow, SB = spotted bass, YP = yellow perch, TC = tui chub, and RBT = rainbow trout.

| | | | | | | UKRB-4 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Week | SU | BC | BNB | BKB | SC | SD | FM | SB | YP | TC | RBT |
| 17 | 10 | 8 | 0 | 0 | 2 | 18 | 0 | 0 | 3 | 0 | 0 |
| 19 | 3 | 0 | 12 | 0 | 2 | 1 | 0 | 1 | 5 | 0 | 1 |
| 22 | 1 | 3 | 5 | 4 | 0 | 1 | 1 | 0 | 2 | 0 | 0 |
| | | | | | | UKRB-3 | | | | | |
| 17 | 0 | 51 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 17 | 15 | 0 | 0 | 0 | 4 | 8 | 0 | 0 | 2 | 0 |
| | | | | | | UKRB-1 | | | | | |
| 17 | 0 | 3 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 2 | 1 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 0 | 9 | 0 | 0 | 3 | 1 | 2 | 0 | 0 | 4 | 2 |

## DISCUSSION

Eleven species of fish were found using WRP wetland habitats along the Sprague River. The most abundant fish species collected were larvae of suckers. Although larval suckers cannot now be reliably distinguished, information on adult spawning behavior suggest the sucker larvae we collected were predominantly shortnose sucker, an ESA endangered species, with an unknown proportion being Klamath large-scale sucker. Significantly more sucker larvae were collected at sites UKRB-3 and -4 than at site UKRB-1, despite the nearness of site UKRB-1 to sucker spawning habitat.

The 11 species of fish we documented using wetlands in the UKRB suggests these WRP wetlands are providing a valuable ecosystem service. The fish community of the UKRB, which includes Upper Klamath Lake, includes 18 species of native fishes and 18 species of nonnative fishes, some of which are strains or subspecies of the native species (National Research Council 2007). Our results suggest a high proportion of the UKRB fish community, including important endangered species, use riparian WRP wetland habitat along the Sprague River.

# CHAPTER F: AMPHIBIANS IN THE CCV

## OBJECTIVE

The objective of 2008 surveys was to evaluate the distribution and relative abundance of anuran species in the CCV. The objective of 2009 surveys was to assess whether Western spadefoot toad, *Spea hammondii*, shifts breeding with late flooding events, and to determine optimal detection time for calling males.

## METHODS

In 2008, 39 WRP properties and seven NWR sites were surveyed by visual encounter, dipnet, and auditory recordings. For visual encounters and dipnet surveys, surveyors wore polarized sunglasses to help reduce reflective glare. Captured individuals were identified and on occasion vouchered for verification purposes.[1] All collected amphibians were identified using a variety of guides, including Altig et al. (2007) and Stebbins (2003). Survey zones included the waterline, shallow water zone (< 1 m) and all potential microhabitats.

Auditory surveys were conducted using SM1 Wildlife Acoustic Song Meters. One meter was installed along the northern perimeter of a representative wetland within each WRP. The instrument was programmed to record 5-minute intervals every hour between 2200 and 0500 hours.

All organic matter was removed from nets, boots and other surfaces before leaving each WRP site. These items were scrubbed, soaked in Quat-128™ solution (1:60) and rinsed with clean water.

In 2009, auditory recordings were used to assess the frequency and timing of Western spadefoot toads (*Spea hammondii*) at three adjacent WRP wetlands located in Kern County in the Tulare sub-basin. *Spea hammondii* is a Species of Special Concern (CDFG 2009a) in California and was detected at several WRPs during the 2008 survey season. The aim of 2009 studies was to assess whether *Spea hammondii* shifts its breeding activities to correspond with late flooding

[1] Federal permit number: TE175386-0

events, and whether there is an optimal time period following flooding or an optimal hour of the night to best detect calling males.

Four aural recorders were dispersed between three WRP wetlands between March and August, 2009. The location of each recorder was chosen based on *Spea hammondii* observations from 2008 and the presence of potentially suitable habitat. Some recorders were moved throughout the field season to maintain a close proximity to flooded areas. The recorders were programmed to record the first 20 minutes of each hour between 2000 hours and 0200 hours (i.e., 2000 – 2020 hours, 2100 – 2120 hours, etc.).

The first five minutes (e.g., 2000 – 2005 hours, 2100 – 2105 hours, etc.) of each hourly recording were reviewed at a standardized volume and all *Spea hammondii* vocalizations were tallied. If the first five-minute interval could not be reviewed (due to wind, static, or other factors), then the second five-minute interval (e.g., 2005 – 2010 hours, 2105 – 2110 hours, etc.) was reviewed, and so on.

## RESULTS

In 2008, four amphibian species were observed on CCV WRPs. These included the American bullfrog (*Rana catesbeiana*), Pacific chorus frog (*Pseudacris regilla*), Western toad (*Bufo boreas*) and the Western spadefoot toad (*Spea hammondii*). The most common species across all WRP easements was the Pacific chorus frog followed by the American bullfrog (Figure F-1).

More species were recorded in the Tulare sub-basin than the Sacramento and San Joaquin (Figure F-2). All species except the Pacific chorus frog were more common on older WRP easements than younger easements (Figure F-4). All species occurred more commonly on intensively managed sites than other management regimes. Surprisingly, more species occurred at sites that were either not managed or were under low management (Figure F-3).

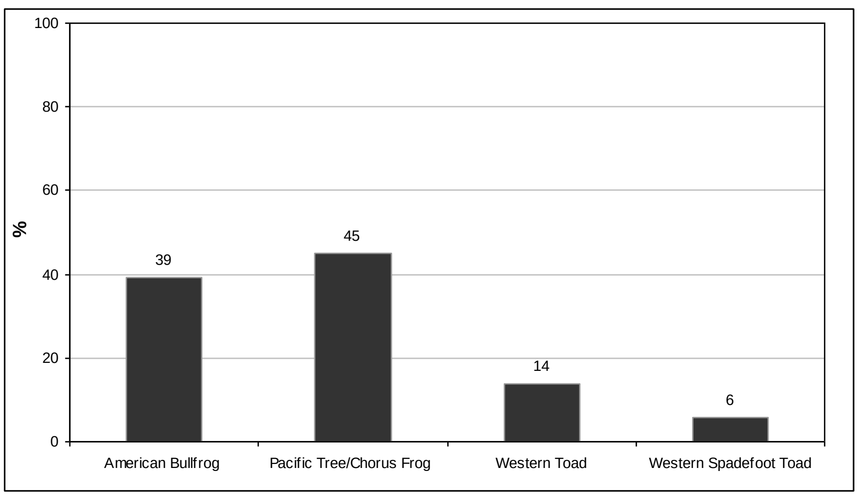


Figure F-1. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008.

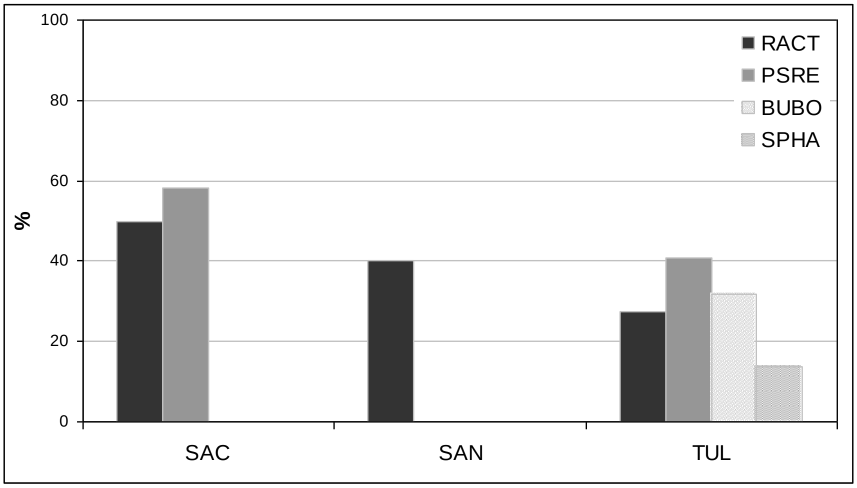


Figure F-2. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008 by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. BUBO = Western toad; PSRE = Pacific chorus frog; RACT = American bullfrog; SPHA = Western spadefoot toad.

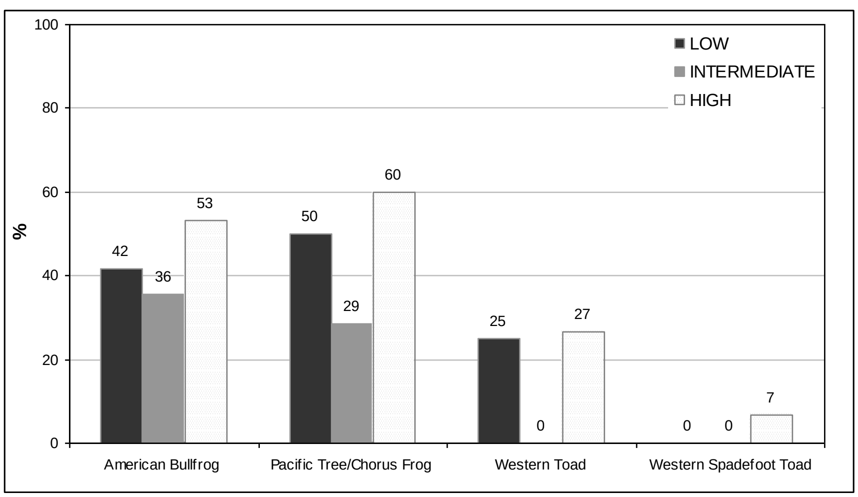


Figure F-3. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008 by management intensity. LOW = sites under low or no management, INTERMEDIATE = sites under intermediate management, HIGH = actively managed sites. Management intensity categories are defined in Table I-3.

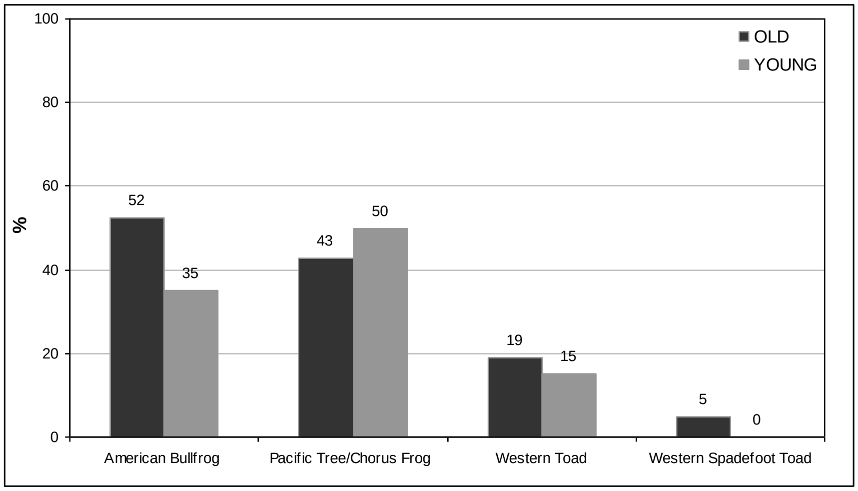


Figure F-4. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008 by WRP age. “Young” sites are ≤ 5 years since restoration; “Old” are > 5 years.

Auditory recordings made in 2009 are currently being transcribed and compiled in a database by a trained technician. Preliminary analysis will begin in spring 2010 and results will be discussed in the final report.

# CHAPTER G: POLLINATORS IN THE CCV

## OBJECTIVE

The objective of this study was to assess WRP easements' support of pollinators.

## METHODS

In 2008, native bees were sampled at 39 WRP properties and eight NWR sites every two to four weeks between early March and early June. In 2009, native bees were sampled at 19 WRPs and four NWR sites from late February to early June in 2009.

A one ha sampling plot was established within each WRP easement. Plots were located on levee banks and dry upland or moist bottomland meadows where flowering plants used by bees are found. Efforts were made to maintain at least 2 km distance between sampling plots, particularly where WRP easements were in close proximity.

Bee collection methods consisted of passive pan trapping and active collection with aerial nets at floral resources. Thirty pans (Solo brand B200-0100 2 oz. soufflé portion cups) were placed along two 50 m long transects, spaced at 5 m intervals. Ten pans were painted fluorescent yellow (Ace Glo Spray Fluorescent, Solar Yellow 17052/17052A), 10 fluorescent blue (Ace Glo Spray Fluorescent, Blue 19716/19716A) and 10 were painted white (Krylon Fusion, 2320 Gloss White). Pans were filled with a solution of one generous squirt of Dawn brand blue soap per gallon of tap water, set in place before 0900 hours and collected the same day after 1500 hours. Pan trapped specimens were stored by sample plot in Whirlpak bags in a 70% ethyl alcohol solution until processing and identification at Humboldt State University. For one hour in the morning and one hour in the afternoon, one person netted at all flowers in the one ha plot. Bee surveyors took care to cover all areas of the plot with equal effort and record the flower from which each specimen was collected. Bees collected at flowers were pinned the same day and brought to Humboldt State University for identification. A GPS reading was taken at the approximate center of each plot with a Garmin GPS 12 (minimum accuracy of +/- 15 m). Percent cover of flowers in bloom was estimated using the Braun-Blanquet relevé method (California Native Plant Society 2004). A Kestrel ® weather station (model 3000) was used to record temperature, relative humidity and wind speed.

## RESULTS

A census of bee pollinators was conducted in the spring and summer of 2008. Of more than 20,000 individuals captured by pan trapping and netting, more than 80% were classified as honey bees (*Apis malifera*) (Figure G-1). Bees were collected on more than 50 flowering plants (Table V-1). The highest number of bees (native and honey) was captured on black mustard flowers (*Brassica nigra*). Remaining 2008 samples are being identified to genus by a Humboldt State University Masters student and a trained technician. Pinning and processing of 2009 specimens is nearly complete. Data analysis is pending and will be discussed in the next progress report.

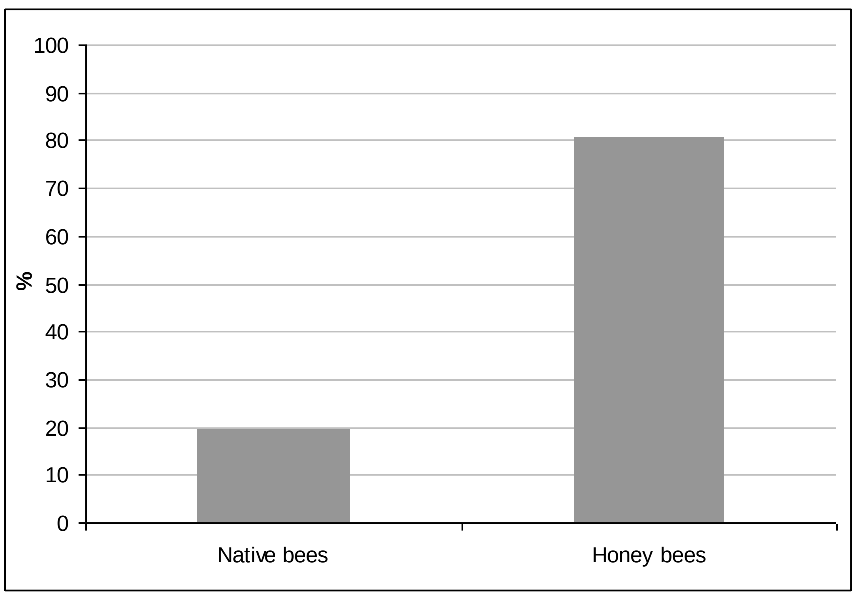


Figure G-1. Percentage of bees collected at selected WRP easements in 2008.

# CHAPTER H: FLOODWATER STORAGE CAPACITY IN THE CCV (PENDING DATA ANALYSIS)

## OBJECTIVE

Obtain an estimate of the floodwater storage capacity of CCV WRP wetlands.

## METHODS

Floodwater storage capacity was surveyed in 2009. A Sokkia SET530R3 total station (Prism Surveying & Construction Systems, Inc., San Diego, CA) and GPS unit (Garmin GPS 12, minimum accuracy of +/- 15 m) were used to survey the bathymetry of ten WRP and two NWR study sites during dry periods in the summer of 2009. Ten out of the 12 sites were split into smaller survey parcels to allow accurate sighting of survey points and proper functioning of the total station laser.

At the first site, measurements points were randomly selected on both the levees and the interior of the WRP. However, this method was found to be difficult to repeat. The subsequent 11 sites were surveyed using two transects per parcel, with survey points every 250 m along each transect. Levee points at all four corners of the site and at half way between each corner, as well as at every interior levee point encountered, were surveyed. This made for an average of 19.7 points per parcel. Data collected at each point were all in relation to the total station setup location, and included survey point type (levee, resectioning, inlet or interior), and the northing, easting and z (depth) in relation to the total station. UTM northing and easting were also recorded with the GPS unit at all survey and total station setup points. Drainage outlets to each wetland cell were identified with the assistance of NRCS field offices, NWR employees, and landowners, and the height of outlet drainage pipes or of the topmost outlet flashboard relative to total station setup location were measured at subsequent field visits.

Survey northing, easting, and z data were then manually entered into Microsoft Office Excel and projected into ArcMap 9.3 over National Agriculture Imagery Program (NAIP) 2006 aerial imagery showing individual wetland cells. In ArcMap, projected points were modeled in 3-D using an array of methods.

Sites that had not yet been developed or developed sites with current, to-scale engineering plans were not surveyed.

## CURRENT STATUS

Four potential methods have been developed to calculate wetland volume in ArcGIS, based on an extensive literature search. Methods vary in whether or not survey points are manually added to better define the wetland perimeter, and in whether volume is analyzed through a Triangulated Irregular Network (TIN) or raster. A pilot volume analysis on seven WRPs is being conducted with all four methods, and a single protocol will be selected to determine volume.

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# APPENDIX I: STUDY SITES

Table I-1. Allocation of 2008 sample sites by restoration age and management intensity among sub-basins within California's Central Valley. Management intensity categories are defined in Table I-3.

| | | SUB-BASINS | | |
|---|---|---|---|---|
| Management Intensity | Restoration Age[1] | Sacramento | San Joaquin | Tulare |
| Low[2] | ≤ 5 yr | 4 | 1 | 3 |
| Low | > 5 yr | 4 | 0 | 3 |
| Intermediate | ≤ 5 yr | 5 | 2 | 4 |
| Intermediate | > 5 yr | 3 | 1 | 2 |
| High | ≤ 5 yr | 5 | 0 | 4 |
| High | > 5 yr | 3 | 1 | 2 |
| NWR[3] | | 6 | -- | 5 |
| TOTALS | | 30 | 5 | 23 |

[1] Refers to 2008 less years since initial earthwork carried out. [2] Low management sites included unrestored sites, where no conservation practices were applied as of July 2008. [3] National Wildlife Refuges: Sacramento, Kern and Pixley. All are high management intensity, > 5 yr.

Table I-2. Allocation of 2009 sample sites by restoration age and management intensity among sub-basins within California's Central Valley. Management intensity categories are defined in Table I-3.

| | | SUB-BASINS | | |
|---|---|---|---|---|
| Management Intensity | Restoration Age[1] | Sacramento | San Joaquin | Tulare |
| Low[2] | ≤ 5 yr | 3 | 1 | 4 |
| Low | > 5 yr | 4 | 0 | 2 |
| Intermediate | ≤ 5 yr | 5 | 2 | 7 |
| Intermediate | > 5 yr | 3 | 1 | 2 |
| High | ≤ 5 yr | 4 | 0 | 2 |
| High | > 5 yr | 5 | 1 | 4 |
| NWR[3] | | 1 | -- | 4 |
| TOTALS | | 25 | 5 | 25 |

[1] Refers to 2009 less years since initial earthwork carried out. [2] Low management sites included unrestored sites, where no conservation practices were applied as of December 2009. [3] National Wildlife Refuges: Colusa, Kern and Pixley. All are high management intensity, > 5 yr.

Table I-3. Criteria for classification into the three management intensity categories.

| Management Intensity | Criteria |
|---|---|
| Low/ None | No active management following restoration or less than 50% of time since restoration. No recent flooding or drainage. |
| Intermediate | Flooded, drained annually or more than 50% of time since restoration. Intermittent weed control and emergent cover management. |
| High | Flooded, drained annually since restoration. Regular weed control, moist soil management, emergent cover. Mowed, disked, burned, grazed, chemical weed control. |

Table I-4. CEAP sites and survey types, 2008 – 2009. Bold sites were included in soils analysis by Judith Drexler. Abbreviations are: S = soil, VH = vegetation habitat, VB = vegetation biomass, A = amphibian, Be = bees, Bi = birds, F = fish, Adj = adjacent agriculture and FS = flood water storage.

| CEAP site code | 2008 | | | | | | 2009 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | VH | VB | A | Be | Bi | S | VH | VB | A | Be | Bi | F | Adj | FS |
| SAC-1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- |
| SAC-2 | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-3 | -- | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-4 | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **SAC-5** | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-6 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-7 | -- | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-8 | -- | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-9 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-10 | X | X | X | X | X | X | X | X | X | -- | X | X | -- | X | -- |
| SAC-11 | X | X | X | X | X | X | -- | -- | -- | -- | X | -- | -- | -- | -- |
| **SAC-12** | X | X | X | X | X | -- | -- | -- | -- | -- | X | -- | -- | -- | -- |
| SAC-13 | -- | -- | -- | X | -- | X | X | X | X | -- | -- | X | -- | -- | -- |
| SAC-14 | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-15 | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **SAC-16** | -- | -- | -- | -- | -- | X | X | X | X | -- | -- | X | -- | -- | -- |
| SAC-17 | -- | -- | -- | -- | -- | -- | X | X | X | -- | -- | -- | -- | -- | -- |
| **SAC-18** | -- | -- | -- | -- | -- | -- | X | X | X | -- | -- | -- | -- | X | X |
| **SAC-19** | -- | -- | -- | -- | -- | -- | X | X | X | -- | -- | -- | -- | X | -- |
| **SAC-20** | X | X | X | X | X | X | X | X | -- | -- | X | X | -- | X | -- |
| SAC-21 | X | X | X | X | X | X | -- | -- | -- | -- | X | -- | -- | -- | -- |
| **SAC-22** | -- | -- | -- | -- | -- | X | X | X | X | -- | -- | X | -- | -- | -- |
| SAC-23 | -- | -- | -- | -- | -- | -- | X | X | X | -- | -- | X | -- | X | X |
| **SAC-24** | -- | -- | -- | -- | -- | -- | X | X | X | -- | -- | -- | -- | -- | X |
| **SAC-25** | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-26 | X | X | X | X | X | X | -- | -- | -- | -- | X | -- | -- | -- | -- |
| SAC-27 | -- | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **SAC-28** | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-29 | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | -- | -- | -- | -- |
| **SAC-30** | -- | -- | -- | -- | -- | -- | X | X | X | -- | -- | -- | -- | -- | -- |
| SAC-31 | X | -- | -- | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-32 | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | X | -- | -- | X |
| **SAC-33** | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |

Table I-4 (continued).

| CEAP site code | 2008 | | | | | | 2009 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | VH | VB | A | Be | Bi | S | VH | VB | A | Be | Bi | F | Adj | FS |
| SAC-34 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- |
| **SAC-35** | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAC-36 | -- | X | X | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **SAC-37** | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | X | -- | -- | X |
| SAC-38 | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | -- | -- | X | X |
| SAC-39 | X | -- | -- | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **SAC-40** | X | X | X | X | X | X | -- | -- | -- | -- | X | -- | -- | -- | -- |
| SAC-41 | -- | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **SAC-42** | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | X | -- | -- | -- |
| SAC-43 | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | X | -- | -- | -- |
| SAC-44 | -- | -- | -- | -- | -- | -- | X | X | X | -- | -- | X | -- | -- | X |
| SAC-45 | -- | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **SAN-1** | X | X | X | X | X | X | X | X | -- | -- | X | X | -- | -- | -- |
| SAN-2 | X | X | X | X | X | X | X | X | -- | -- | -- | X | -- | -- | -- |
| **SAN-3** | X | X | X | X | X | X | X | X | -- | -- | X | X | -- | -- | -- |
| SAN-4 | -- | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAN-5 | X | X | X | X | X | X | X | X | X | -- | -- | X | -- | -- | -- |
| **SAN-6** | -- | -- | -- | -- | -- | -- | X | X | X | - | -- | X | -- | -- | -- |
| **TUL-1** | X | X | X | X | X | -- | X | X | X | -- | X | -- | -- | X | -- |
| **TUL-2** | X | X | X | X | X | -- | X | X | X | -- | X | -- | -- | X | X |
| **TUL-3** | X | X | X | X | X | X | X | X | X | -- | X | -- | -- | X | -- |
| TUL-4 | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| TUL-5 | -- | -- | -- | -- | X | -- | -- | -- | -- | -- | X | -- | -- | -- | -- |
| TUL-6 | X | X | X | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- |
| **TUL-7** | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| TUL-8 | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| TUL-9 | X | X | X | X | X | X | -- | -- | -- | -- | X | -- | -- | -- | -- |
| TUL-10 | -- | X | X | X | X | X | X | X | X | -- | X | -- | -- | -- | X |
| **TUL-11** | X | X | X | X | X | X | -- | -- | -- | -- | X | -- | -- | -- | -- |
| **TUL-12** | -- | -- | -- | -- | -- | -- | X | X | -- | - | -- | -- | -- | X | -- |
| **TUL-13** | -- | -- | -- | -- | X | -- | X | X | -- | X | -- | -- | -- | X | -- |
| TUL-14 | -- | -- | -- | -- | -- | -- | X | X | X | -- | -- | -- | -- | -- | X |
| **TUL-15** | X | X | X | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- |
| TUL-16 | -- | -- | -- | X | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **TUL-17** | X | X | X | -- | X | -- | -- | -- | -- | -- | X | -- | -- | -- | -- |
| **TUL-18** | -- | -- | -- | -- | -- | -- | X | X | X | -- | -- | -- | -- | -- | -- |
| TUL-19 | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | -- | -- | -- | -- |
| **TUL-20** | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | -- | -- | X | -- |
| TUL-21 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | X | -- | -- | -- | -- |

Table I-4 (concluded).

| CEAP site code | 2008 | | | | | | 2009 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | VH | VB | A | Be | Bi | S | VH | VB | A | Be | Bi | F | Adj | FS |
| **TUL-22** | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| TUL-23 | X | X | X | X | X | X | X | X | -- | X | X | -- | -- | X | -- |
| **TUL-24** | X | X | X | -- | -- | -- | -- | X | -- | X | -- | -- | -- | X | -- |
| TUL-25 | X | X | X | X | X | X | -- | -- | -- | -- | X | -- | -- | -- | -- |
| **TUL-26** | X | X | X | X | X | X | X | X | X | X | -- | -- | -- | X | -- |
| TUL-27 | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | -- | -- | -- | -- |
| **TUL-28** | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | -- | -- | -- | -- |
| TUL-29 | X | X | X | X | X | X | -- | -- | -- | -- | -- | -- | -- | X | -- |
| **TUL-30** | X | X | X | X | X | X | X | X | X | -- | -- | -- | -- | X | X |
| TUL-31 | X | X | X | X | X | X | X | X | X | -- | X | -- | -- | -- | X |
| UKRB-1 | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | X | X | -- | -- |
| UKRB-2 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| UKRB-3 | -- | -- | -- | -- | -- | -- | X | X | -- | -- | -- | -- | X | -- | -- |
| UKRB-4 | -- | -- | -- | X | -- | -- | X | X | -- | -- | -- | X | X | -- | -- |
| UKRB-5 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| UKRB-6 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| UKRB-7 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| UKRB-8 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| UKRB-9 | -- | X | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| UKRB-10 | -- | X | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| UKRB-11 | -- | -- | -- | X | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

# APPENDIX II: SOILS IN THE CCV

Table II-1. Descriptions of study sites in the CCV. Management intensity is explained in Table I-3. Dominant vegetation consists of four main categories: (1) dominated by *Typha* spp., *Schoenoplectus, Juncus, Cyperus* spp., (2) dominated by *Bassia hyssopifolia* (five horn Bassia) and/or *Layia platyglossa* (tidy tips), (3) dominated by upland grasses, and (4) dominated by upland grasses and trees. NA = not available.

| Site Code | Area (ha) | Years Since Restoration | Management Intensity | Seasonal (S) or Semi-Permanent (SP) Wetland | Dominant vegetation class |
|---|---|---|---|---|---|
| SAC-5 | 69 | 48 | High | S | 1 |
| SAC-12 | 20.7 | 8 | Low | S | 1 |
| SAC-16 | 98.6 | 6 | Medium | S | 1 |
| SAC-18 | 134 | 22 | High | S | 1 |
| SAC-19 | 153 | 11 | Medium | S | 1 |
| SAC-20 | 1.4 | 4 | High | SP | 1 |
| SAC-22 | 50.8 | 9 | High | SP | 1 |
| SAC-24 | 45.3 | 5 | Low | S | 1 |
| SAC-25 | 10.8 | 1 | Low | SP | 1 |
| SAC-28 | 20.3 | 2 | Low | S | 1 |
| SAC-30 | 6.2 | 3 | Medium | SP | 1 |
| SAC-33 | 207 | 2 | Medium | S | 1 |
| SAC-35 | 18.7 | 2 | Medium | S | 3 |
| SAC-37 | 66 | 4 | Medium | S | NA |
| SAC-40 | 231 | 5 | High | S | 1 |
| SAC-42 | 445 | 4 | High | S | 1 |
| SAN-1 | 55.7 | 8 | High | S | 4 |
| SAN-3 | 79.4 | 1 | Low | SP | 1 |
| SAN-6 | 816 | 7 | High | S | 1 |
| TUL-1 | 340 | 45 | High | SP | 1 |
| TUL-2 | 348 | 45 | High | S | 1 |
| TUL-3 | 66 | 45 | High | S | 1 |
| TUL-7 | 113 | 9 | Low | S | 3 |
| TUL-11 | 336 | 10 | Medium | S | 3 |
| TUL-12 | 73.0 | 0 | Medium | S | 2 |
| TUL-13 | 370 | 3 | High | S | 2 |
| TUL-15 | 233 | 13 | High | S | 1 |
| TUL-17 | 195 | 5 | Low | S | 3 |
| TUL-18 | 51.4 | 0 | Low | S | 2 |

Table II-1 (concluded).

| Site Code | Area (ha) | Years Since Restoration | Management Intensity | Seasonal (S) or Semi-Permanent (SP) Wetland | Dominant vegetation class |
|---|---|---|---|---|---|
| TUL-20 | 34.2 | 1 | Low | S | 2 |
| TUL-22 | 621 | 5 | Low | S | 1 |
| TUL-24 | 197 | 3 | Medium | S | 2 |
| TUL-26 | 246 | 3 | Medium | S | 2 |
| TUL-28 | 68.2 | 4 | Medium | S | 1 |
| TUL-30 | 131 | 6 | High | S | 1 |

# APPENDIX III: BIRD USE IN THE CCV

Table III-1. Bird survey sites and survey type, 2008 – 2009.

| CEAP site code | 2008 Wetland Site Count | 2008 Point Count | 2008 Area Search | 2009 Wetland Site Count | 2009 Point Count | 2009 Area Search |
|---|---|---|---|---|---|---|
| SAC-1 | X | -- | -- | -- | -- | -- |
| SAC-3 | X | X | -- | -- | -- | -- |
| SAC-10 | X | -- | -- | X | -- | -- |
| SAC-11 | X | -- | -- | -- | -- | -- |
| SAC-13 | X | X | X | -- | X | X |
| SAC-14 | X | -- | -- | -- | -- | -- |
| SAC-15 | X | -- | -- | -- | -- | -- |
| SAC-16 | X | -- | -- | X | -- | -- |
| SAC-20 | X | -- | -- | -- | X | -- |
| SAC-21 | X | -- | -- | -- | -- | -- |
| SAC-22 | X | -- | -- | X | -- | -- |
| SAC-23 | -- | -- | -- | X | -- | -- |
| SAC-26 | X | X | X | -- | -- | -- |
| SAC-27 | X | -- | -- | -- | -- | -- |
| SAC-28 | X | -- | -- | -- | -- | -- |
| SAC-31 | X | -- | -- | -- | -- | -- |
| SAC-32 | -- | -- | -- | X | -- | -- |
| SAC-33 | X | -- | -- | -- | -- | -- |
| SAC-34 | X | -- | -- | -- | -- | -- |
| SAC-36 | X | X | -- | -- | -- | -- |
| SAC-37 | -- | -- | -- | X | -- | -- |
| SAC-39 | X | X | -- | -- | -- | -- |
| SAC-40 | X | X | -- | -- | -- | -- |
| SAC-41 | -- | X | -- | -- | -- | -- |
| SAC-42 | -- | -- | -- | X | -- | -- |
| SAC-43 | -- | -- | -- | X | -- | -- |
| SAC-44 | -- | -- | -- | X | -- | -- |
| SAC-45 | X | X | -- | -- | -- | -- |
| SAN-1 | -- | X | -- | -- | X | -- |
| SAN-2 | X | -- | -- | X | -- | -- |
| SAN-3 | X | -- | -- | X | -- | -- |
| SAN-4 | X | -- | -- | -- | -- | -- |
| SAN-5 | X | -- | -- | X | -- | -- |
| SAN-6 | -- | -- | -- | X | X | -- |
| TUL-1 | X | -- | -- | -- | -- | -- |
| TUL-6 | X | -- | -- | -- | -- | -- |
| TUL-7 | X | -- | -- | -- | -- | -- |
| TUL-8 | X | -- | -- | -- | -- | -- |
| TUL-9 | X | -- | -- | -- | -- | -- |

Table III-1 (concluded).

| CEAP site code | 2008 Wetland Site Count | 2008 Point Count | 2008 Area Search | 2009 Wetland Site Count | 2009 Point Count | 2009 Area Search |
|---|---|---|---|---|---|---|
| TUL-10 | X | -- | -- | -- | -- | -- |
| TUL-11 | X | -- | -- | -- | -- | -- |
| TUL-15 | X | -- | -- | -- | -- | -- |
| TUL-16 | X | -- | -- | -- | -- | -- |
| TUL-22 | X | -- | -- | -- | -- | -- |
| TUL-23 | X | -- | -- | -- | -- | -- |
| TUL-25 | X | -- | -- | -- | -- | -- |
| TUL-26 | X | -- | -- | -- | -- | -- |
| TUL-29 | X | -- | -- | -- | -- | -- |
| TUL-30 | X | -- | -- | -- | -- | -- |
| TUL-31 | X | -- | -- | -- | -- | -- |
| UKRB-1 | -- | -- | -- | -- | -- | -- |
| UKRB-4 | -- | -- | -- | -- | -- | -- |

# APPENDIX IV: REDUCTION OF SOIL LOSS IN THE CCV

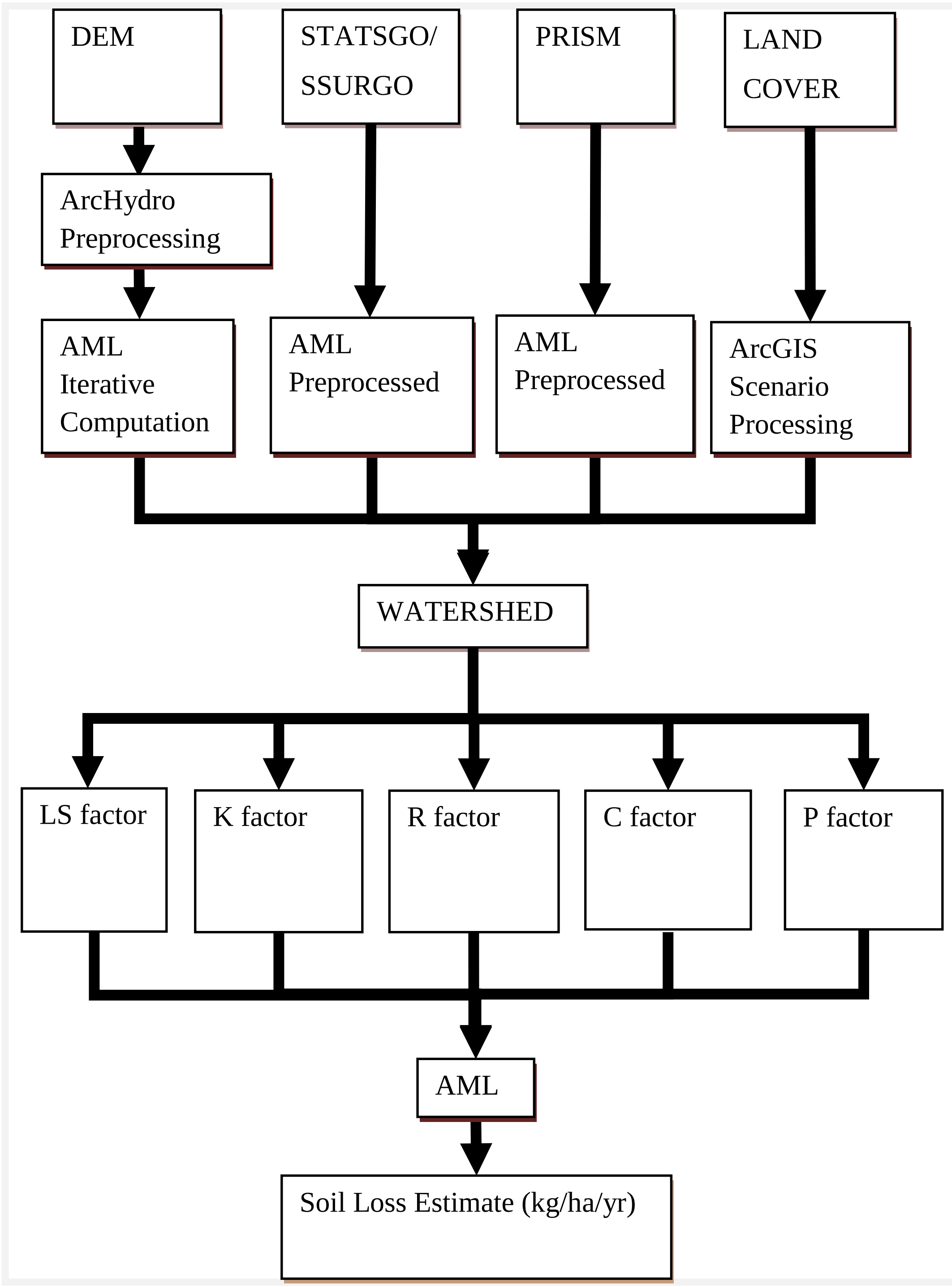


Figure IV-1. Flow chart depicting processing of Van Remortel et al. soil loss models.

Table IV-1. Revised Universal Soil Loss Equation (RUSLE) factors and source data used in processing of Van Remortel et al. soil loss models.

| Layer | Description | Input Layers | Processing | Programs |
|---|---|---|---|---|
| LS factor | Slope length and steepness | 30m DEM and Watershed Shapefile | ArcHydro and AML iterative computation | ArcHydro and AML |
| K factor | Soil erodibility | STATSGO/ SSURGO and Watershed Shapefile | Preprocessed by AML program | AML |
| R factor | Rainfall erosivity | PRISM data and Watershed Shapefile | Preprocessed by AML program | AML |
| C factor | Surface cover | NLCD 2001 and Watershed Shapefile | ArcGIS value reclassification | ArcGIS |
| P factor | Conservation practices | NLCD 2001 and Watershed Shapefile | ArcGIS value reclassification | ArcGIS |

## APPENDIX V: POLLINATORS IN THE CCV

Table V-1. Abundance of native and honey bees (*Apis malifera*) collected in California's Central Valley (March - May 2008) and associated flowering plants.

| Family | Genus | Specific epithets | Common Name | Native bees | Honey bees |
|---|---|---|---|---|---|
| Aizoaceae | *Sesuvium* | *verricosum* | Western sea-purslane | 11 | 2 |
| Apiaceae | *Conium* | *maculatum* | poison hemlock | 8 | 57 |
| Apiaceae | *Torilis* | *arvensis* | Torilis | 1 | 0 |
| Asclepoadaceae | *Asclepias* | *sp.* | milkweed | 0 | 3 |
| Asteraceae | *Anthemis* | *cotula* | stinkweed | 39 | 206 |
| Asteraceae | *Centaurea* | *solstitialis* | yellow star-thistle | 7 | 6 |
| Asteraceae | *Chicorium* | *intybus* | chickory | 30 | 74 |
| Asteraceae | *Cirsium* | *vulgare* | bull thistle | 1 | 26 |
| Asteraceae | *Hemizonia* | *Pungens ssp. pungens* | common spikeweed | 8 | 0 |
| Asteraceae | *Lasthenia* | *sp.* | goldfields | 122 | 228 |
| Asteraceae | *Picris* | *echoides* | oxtongue | 0 | 1 |
| Asteraceae | *Silybum* | *marianum* | blessed milk thistle | 27 | 138 |
| Asteraceae | *Sonchus* | *arvensis* | perennial sow thistle | 10 | 0 |
| Asteraceae | *Taraxacum* | *officinale* | dandelion | 3 | 0 |
| Boraginaceae | *Amsinkia* | *sp.* | fiddleneck | 8 | 1 |
| Boraginaceae | *Heliotropium* | *curassavicum* | heliotrope | 6 | 0 |
| Brassicaceae | *(unknown)* | *sp.* | mustard | 17 | 56 |
| Brassicaceae | *Brassica* | *nigra* | black mustard | 125 | 3043 |
| Brassicaceae | *Capsella* | *bursa-pastoris* | shepard's purse | 1 | 0 |
| Brassicaceae | *Lepidium* | *latifolium* | pepperwort | 1 | 55 |
| Brassicaceae | *Raphanus* | *sativus* | radish | 56 | 269 |
| Brassicaceae | *Sinapis* | *arvensis* | charlock | 98 | 47 |
| Brassicaceae | *Sisymbrium* | *altissimum* | tumble mustard | 54 | 0 |
| Brassicaceae | *Sisymbrium* | *irio* | london rocket | 67 | 1 |
| Caryophyllaceae | *Silene sp.* | *sp.* | campion | 13 | 29 |
| Caryophyllaceae | *Spergularia* | *macrotheca* | sand-spurrey | 4 | 0 |
| Convolvulaceae | *Convolvulus* | *arvensis* | bindweed | 103 | 92 |
| Convolvulaceae | *Cressa* | *truxillensis* | alkali weed | 1 | 0 |

Table V-1 (concluded).

| Family | Genus | Specific epithets | Common Name | Native bees | Honey bees |
|---|---|---|---|---|---|
| Fabaceae | *Astragalas* | *sp.* | milkvetch | 1 | 0 |
| Fabaceae | *Lotus* | *corniculatus* | birdfoot trefoil | 49 | 302 |
| Fabaceae | *Melilotus* | *alba* | white sweetclover | 5 | 32 |
| Fabaceae | *Melilotus* | *indica* | sourclover | 125 | 91 |
| Fabaceae | *Trifolium* | *fragiferum* | strawberry clover | 0 | 4 |
| Fabaceae | *Vicia* | *benghalensis* | vetch | 1 | 0 |
| Fabaceae | *Vicia* | *villosa ssp. varia* | hairy vetch | 46 | 2 |
| Geraniaceae | *Erodium* | *circulatum* | red stem filaree | 11 | 4 |
| Geraniaceae | *Erodium* | *sp.* | erodium | 1 | 0 |
| Hydrophyllaceae | *Nemophila* | *menziesii* | baby blue-eyes | 0 | 0 |
| Hydrophyllaceae | *Phacelia* | *ciliata* | valley pacelia | 109 | 3 |
| Lamiaceae | *Marrubium* | *vulgare* | horehound | 3 | 1 |
| Lamiaceae | *Mentha* | *pulegium* | pennyroyal | 2 | 27 |
| Lamiaceae | *Stachys* | *ajugoides* | hedge nettle | 1 | 0 |
| Liliaceae | *Brodiaea* | *elegans ssp. elegans* | harvest brodiaea | 2 | 0 |
| Lythracea | *Lythrum* | *hyssopifolium* | loosestrife | 7 | 7 |
| Malvaceae | *Malva* | *leprosa* | alkali-mallow | 1 | 9 |
| Malvaceae | *Malva* | *parviflora* | cheeseweed | 7 | 4 |
| Onagraceae | *Epilobium* | *densiflorum* | willow herb | 1 | 0 |
| Plantaginaceae | *Plantago* | *sp.* | plantain | 0 | 1 |
| Polygonaceae | *Rumex* | *crispus* | dock | 0 | 2 |
| Polygonaceae | *Rumex* | *pulcher* | dock | 1 | 0 |
| Rosaceae | *Rosa* | *californica* | California rose | 3 | 24 |
| Rosaceae | *Rosa* | *sp.* | rose | 5 | 62 |
| Rosaceae | *Rubus* | *discolor* | himalayan blackberry | 7 | 65 |
| Rosaceae | *Rubus* | *sp.* | rubus | 5 | 157 |
| Salicaceae | *Salix* | *sp.* | willow | 46 | 26 |
| Verbenaceae | *Phyla* | *lanceolata* | phyla | 6 | 79 |