

CEAP Wetlands Assessment in California's Central Valley: Progress Report



Walter G. Duffy¹ and Sharon N. Kahara²

March 31, 2009

¹ U.S. Geological Survey, California Cooperative Fish and Wildlife Research Unit, Humboldt State University, Arcata, CA 95521, tel: 707-826-5644, fax: 707-826-3269, email: walter.duffy@humboldt.edu

² California Cooperative Fish and Wildlife Research Unit and Department of Wildlife, Humboldt State University, Arcata, CA 95521, tel: 707-826-3208, fax: 707-826-3208, email: snk6@humboldt.edu



TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	2
LIST OF TABLES	3
LIST OF FIGURES	4
INTRODUCTION	6
Objectives	6
Study Area	7
METHODS	9
Site Selection	9
Climate	9
Vegetation	12
Soils	12
Pollinators	13
Amphibians	13
Birds	14
PRELIMINARY RESULTS	14
Vegetation	14
Soils	23
Pollinators	27
Amphibians	31
Birds	34
Continuing Data Collection	36
LITERATURE CITED	37
APPENDICES	39

LIST OF TABLES

	Page
Table 1. Allocation of sample sites by restoration age and management intensity among sub-basins within California’s Central Valley (2008).	11
Table 2. Criteria for classification into the three management intensity categories.	11
Table 3. Abundance of native and honey bees collected in California’s Central Valley (March-May 2008) and associated flowering plants.	28
Table 4. Fifteen most abundant species of birds observed in WRP wetlands in the Central Valley of California during spring – summer 2008.	34
Table 5. Fifteen most frequently observed species of birds in WRP wetlands in the Central Valley of California during spring – summer 2008. Frequency is the number of sites, from a total of 316, at which the species was recorded. ...	35

LIST OF FIGURES

	Page
Figure 1. Location of sampling sites on California’s Central Valley. The CCV was divided into three major sub-basins shown from north to south; Sacramento, San Joaquin and Tulare.	8
Figure 2. Map of the Klamath River Basin, California and Oregon with CEA wetland assessment area along the Sprague River highlighted.	10
Figure 3. Visual obstruction measured at WRP easements classified by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Visual obstruction was estimated within each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow and SM = Shallow Marsh.	15
Figure 4. Visual obstruction measured at WRP easements by restoration age. Visual obstruction was estimated within each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow and SM = Shallow Marsh.	16
Figure 5. Visual obstruction measured at WRP easements by management intensity. Visual obstruction was estimated within each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow and SM = Shallow Marsh.	17
Figure 6. Width of each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow, SM = Shallow Marsh and OW = Open Water, classified by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.	18
Figure 7. Width of each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow, SM = Shallow Marsh and OW = Open Water, classified by restoration age.	19
Figure 8. Width of each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow, SM = Shallow Marsh and OW = Open Water, classified by management intensity.	20
Figure 9. Vegetation biomass (g m^{-2}) by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.	21
Figure 10. Vegetation biomass (g m^{-2}) by restoration age.	22
Figure 11. Vegetation biomass (g m^{-2}) by management intensity.	23

LIST OF FIGURES (continued)

	Page
Figure 13. Litter depth by restoration age.	24
Figure 14. Litter depth by management intensity.	25
Figure 15. Soil O-horizon by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.	25
Figure 16. Soil O-horizon by restoration age.	26
Figure 17. Soil O-horizon by management intensity.	26
Figure 18. Pinned bees collected in California’s Central Valley from March-May 2008 (Photo: Kim McFarland).	27
Figure 19. Percentage of bees collected at selected WRP easements in 2008.	30
Figure 20. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008.	31
Figure 21. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008 by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.	32
Figure 22. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008 by restoration age.	32
Figure 23. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008 by management intensity.	33
Figure 24. Average bird species richness (+ 1 S.D.) relative to age since restoration at 55 WRP wetland sites in the Sacramento River Basin and at 21 sites in the Tulare Basin.	36

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 USDA, Natural Resource 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 two areas of California, the Central Valley (CCV) and Upper Klamath River Basin (UKB).

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 is important because the results from these assessments can help guide 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 (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 ecological services in WRP wetlands along these gradients:

1. Native pollinator (bee) services,
2. Biodiversity (plants, amphibians and birds),
3. Soil erosion and sediment retention,
4. Nutrient retention,

5. Floodwater storage,
6. Nitrogen and phosphorus retention, and
7. Carbon accumulation.

Study Area

The primary study area will be the Tulare, San Joaquin, and Sacramento Basins of the CCV (Figure 1). The Central Valley is an elongated sedimentary basin about 650 km long, 120 km wide, covering an area of 108,800 km² (Schoenherr 1992). It is often subdivided into the Sacramento River Valley in the north and San Joaquin and Tulare Valleys in the south. 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°C in both Bakersfield and Redding, while average December lows in Bakersfield (2.9°C) and are only slightly warmer than in Redding (2.7°C). Annual precipitation, however, exhibits a distinct gradient, ranging from 16 cm in Bakersfield, to 46 cm in Sacramento and 100 cm in Redding. Throughout the valley, more than 90% of annual precipitation falls as rain during November – May. Native vegetation in the Central Valley was predominantly grasslands dominated by bunchgrasses, with extensive riparian forests and freshwater marshes. Freshwater marshes, fed by winter precipitation and snowmelt runoff, formerly covered about 1,638,000 ha of the valley. 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 1980's, 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.

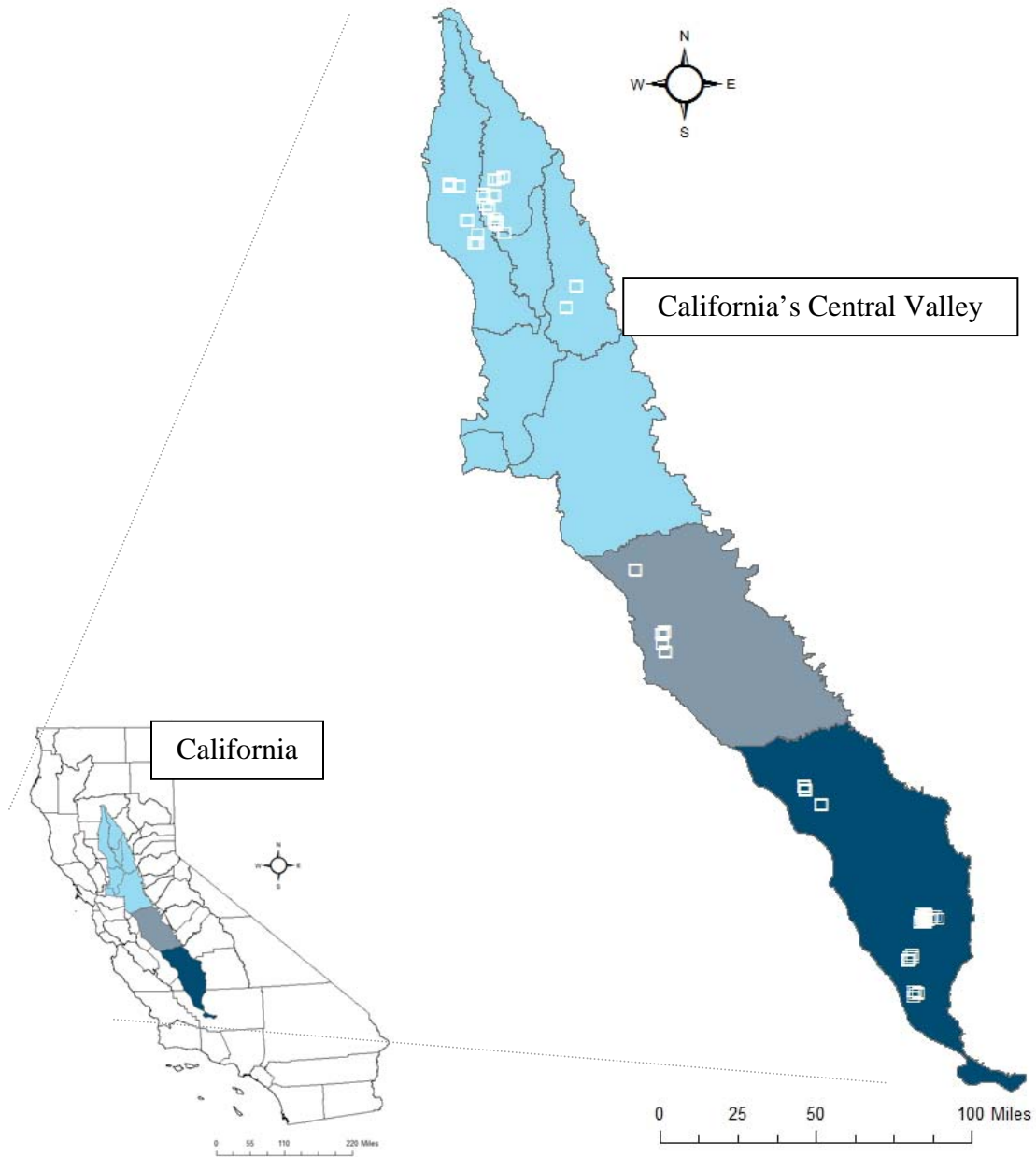


Figure 1. Location of sampling sites (white squares) on California's Central Valley. The CCV was divided into three major sub-basins shown from north to south; Sacramento (light blue); San Joaquin (gray) and Tulare (dark blue).

A secondary study area will include the Upper Klamath River Basin (UKRB) region of California and Oregon. The UKRB encompasses an area of 20,720 km² in northern California and southern Oregon. Paulustrine emergent wetlands once cover expansive areas in the UKRB, but most have been converted to agricultural lands. The UKRB is located within the southern Cascade physiographic region. Soils of the UKRB are of volcanic, alluvial and wetland or lake bed origin. Climate of the area grades from Mediterranean to undifferentiated upland. Summers are hot and winters short but cold.

METHODS

Site selection

In 2008 we conducted a baseline survey of 44 WRP easements in the Tulare, San Joaquin and Sacramento basins. Key elements included sampling across gradients of; (1) management intensities, (2) restoration age and (3) precipitation from the arid Tulare Basin to the more temperate Sacramento Basin (Figure 1). Data collection began in February 2008. Within the three sub-basins, wetlands were stratified by restoration age and management intensity (Table 1). Easements were categorized into two broad age classes, relatively young (less than 5 years since restoration) and relatively old (more than 5 years since restoration work). Criteria for classification by management intensity were largely based on water management (Table 2).

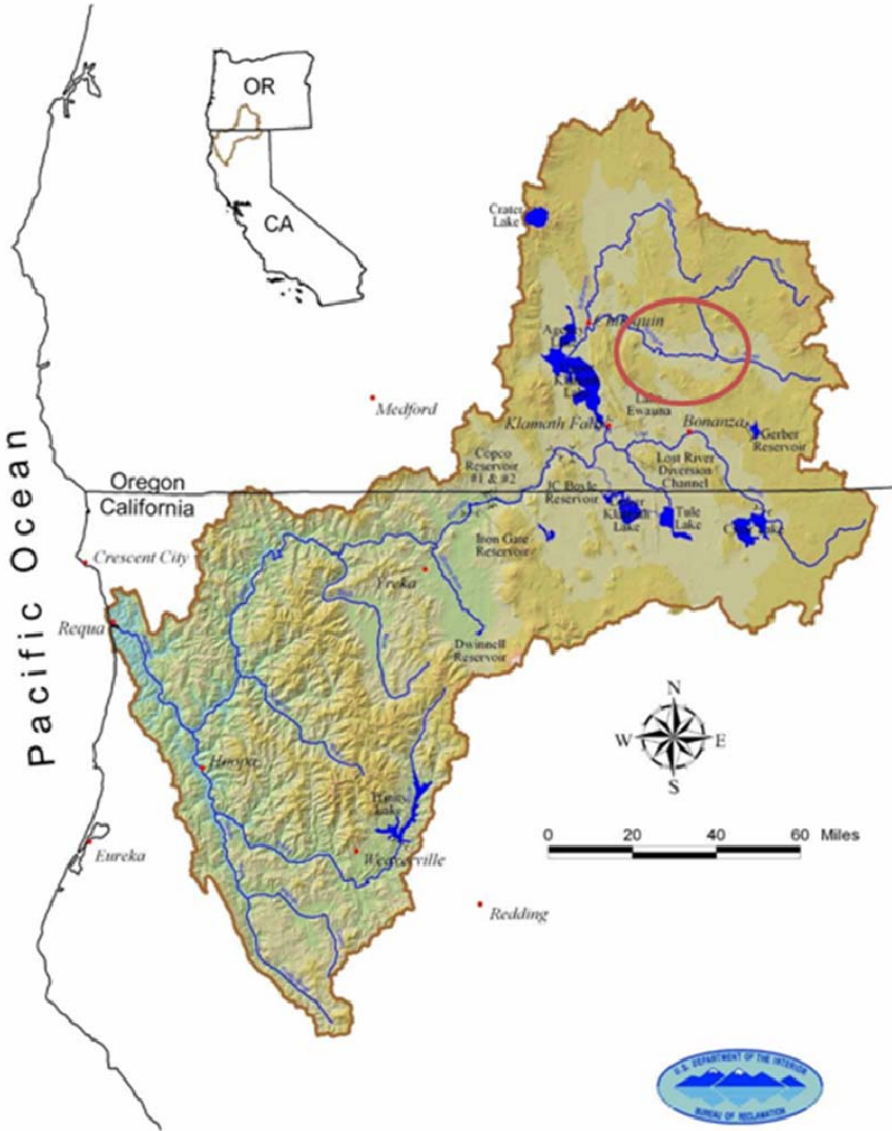
We also surveyed an additional nine WRP wetland easements in the UKRB during 1998. The nine easements in the UKRB were all riparian wetlands. Surveys of UKRB wetlands in 2008 were intended to gather information with which to characterize wetlands. While amphibian surveys were completed on UBRB wetlands in 2008, all other measures will be gathered in 2009.

Wetland Reserve Program easements in the CCV are typically divided into manageable units known as “cells”, separated by levees. Hydrologic connectivity is usually maintained between cells via canals, drainage ditches or swales (Figure 3). Edaphic, vegetation, and morphological variables were collected from representative cells of each WRP easement.

Climate

Average annual precipitation and temperature information was obtained from the National Oceanic and Atmospheric Administration’s National Climatic Data Center (NOAA) and the USGS Geospatial gateway.

Klamath River Basin



+

Figure 2. Map of the Klamath River Basin, California and Oregon with CEAP wetland assessment area along the Sprague River highlighted.

Table 1. Allocation of sample sites by restoration age and management intensity among sub-basins within California's Central Valley (2008).

Management Intensity	Restoration Age¹	<i>SUB-BASINS</i>		
		Sacramento	San Joaquin	Tulare
Low ²	< 5 yr	3	1	3
Low	> 5 yr	3		3
Intermediate	< 5 yr	3	2	3
Intermediate	> 5 yr	3	1	2
High	< 5 yr	3		3
High	> 5 yr	3	1	1
Reference ³	--	3		3
TOTALS		21	5	18

¹ Refers to time since initial earthwork was carried out to February 2008. ² Low management sites included unrestored sites, where no conservation practices were applied as of July 2008. ³ Reference sites included National Wildlife Refuges (Sacramento and Kern) and Wildlife Preserves (Cosumnes River, Audubon)

Table 2. Criteria for classification into the three management intensity categories.

<i>Management Intensity</i>	<i>Criteria</i>
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 .

Vegetation

Estimates derived for each wetland basin 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). Four equally spaced transects radiating out from the WRP cell center to the cell boundary were established. The width (m) of all wetland vegetation zones, as delineated by plant species composition, bisected by transects was estimated and average water depth (cm) recorded. Within each of these zones, a 1-m² 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. Vegetation biomass estimates were collected by placing a 0.25-m² quadrat in the center of the 1-m² quadrat and clipping all above ground biomass (live and dead). Plant taxa outside of the quadrat that were not collected were recorded¹. Biomass clippings were made within the shallow marsh zone, but if no shallow marsh was found, then clippings from the next wettest zone were collected. Biomass samples were stored in paper bags and returned to Humboldt State University for determination of dry mass. Following dry mass determination, samples were shipped to the Colorado State University Soil-Water-Plant Testing Laboratory for determination of total phosphorus (TP), total nitrogen (TN) total carbon (TC) and inorganic carbon (TIC) following standard methods (Klute 1986, Page et al. 1982).

Soils

Following vegetation surveys, soil samples were collected at depths of 0–15 cm ($n = 3$) from each WRP cell. Soil cores were examined to determine presence of an O-horizon. If present, the depth of the O-horizon was measured, separated from the remaining portion of the core and the two segments bagged separately in plastic Ziploc packets. If no O-horizon could be determined visually, the top 1 cm of the core was bagged separately. Samples were stored at about 4°C, until bulk density assessments were made at Humboldt State University. Completely dry samples were then sent to the Colorado State University Soil-Water-Plant Testing Laboratory for determination of TP, TN, TC and TIC using standard methods (Klute 1986, Page et al. 1982).

¹ Rare, endangered or threatened species when encountered were not collected for biomass estimates.

Pollinators

Native bees were sampled to assess WRP easements support of pollinators. A one hectare sampling plot was established within each WRP easement. Dry upland or moist bottomland meadows were selected as these are the most likely to support flowering plants used by bees. Efforts were made to maintain at least 2 km distance between sites, particularly where WRP easements were in close proximity.

Bee collection methods consisted of placing 15 pans (Solo brand PB6-0099 6 oz bowls) along two 50 m long transects, spaced at 5 m intervals. Five pans were painted fluorescent yellow, 5 fluorescent blue and 5 were left unpainted white. Pans were filled with a solution of 1 Tsp of Dawn brand blue soap per gallon of water, set in place before 9:00 am on the morning of data collection and left in place for at least 3 hr. Pan traps were collected in the afternoon, bees in pans were strained into a Whirlpak bag filled with 75% alcohol. Bees were then stored in a cooler until processing and identification at Humboldt State University. Bees were also netted (2 persons, 30 min each) along each transect. A sample of the host plant was also collected and placed in kill jars along with the netted bee. A GPS reading was taken at the approximate center of each plot. Percent cover of flowers in bloom was estimated using the Braun-Blanquet releve method (California Native Plant Society). A Kestrel® weather station (model 3000) was used to record temperature, relative humidity and wind speed. Cloud cover was estimated following methods established by the USDA Pacific Southwest Research Station.

Amphibians

Amphibians were surveyed via three methods; visual encounter, eye shine and auditory recording. For visual encounters, surveyors wore polarized sunglasses to help reduce reflective glare and captured individuals for identification and/or voucher collection purposes using dipnets. Survey zones included the waterline and shallow water zone (< 1 m) and all potential microhabitats.

Eye shine surveys were conducted to complement visual encounter surveys and to account for the nocturnal activities of adult anuran species. Surveyors used Miti Max II Halogen® headlamps and carried dipnets and aquarium nets to locate and capture individuals for identification and/or voucher collection purposes². Binoculars were used in conjunction with the

² Federal permit number: TE175386-0

lights to better locate and identify individuals. Surveyors walked slowly along the waterline around the perimeter of the wetland, stopping every 2-3 m to scan for the reflective eye-shine of amphibians. Potential hiding cover, such as ledges, debris, rocks and logs were explored.

Auditory surveys were conducted using a SM1 Song Meter installed along the northern perimeter of a representative wetland within the WRP. The instrument was programmed to record at 5 min intervals every hour between 2200 and 0500.

To prevent the spread of disease, all organic matter was removed from nets, traps, boots and other surfaces that came into contact with water or possible sources of contamination before leaving each WRP site. These items were scrubbed with a Quat-128™ solution (1:60) and rinsed with clean water at a location that is a minimum of 30 m away from aquatic features.

Birds

Birds using wetlands were recorded at 79 sites located within 47 WRP easements during 2008. Each bird census was completed in the morning, before 100 hr. Designated observers walked the wetland perimeter and recorded all birds observed. Two methods were used i.e., point counts along transects and visual recordings. The former method was used where a tree line was present.

PRELIMINARY RESULTS

Vegetation

Vegetation samples were collected for nutrient analysis to estimate carbon sequestration (e.g., biomass) and nutrient sequestration. Samples were submitted to the Colorado State University Soil-Water-Plant Testing Laboratory for determination of total phosphorous, total nitrogen, total carbon, and total inorganic carbon in November 2008.

Five wetland zones were identified in CCV WRP easements starting from the wetland center; the open water zone, deep marsh zone, shallow marsh zone, wet meadow zone and wetland low prairie (upland) zone. Wetland zones were determined based on plant species composition, which reflects water permanence, underlying soils and groundwater. Visual obstruction in all three sub-basins was highest in the shallow marsh zone followed by the low-prairie zone (Figure 3). Younger sites tended to have larger upland zones than older sites, whereas older sites had larger wet-meadow and shallow marsh zones (Figure 4). All

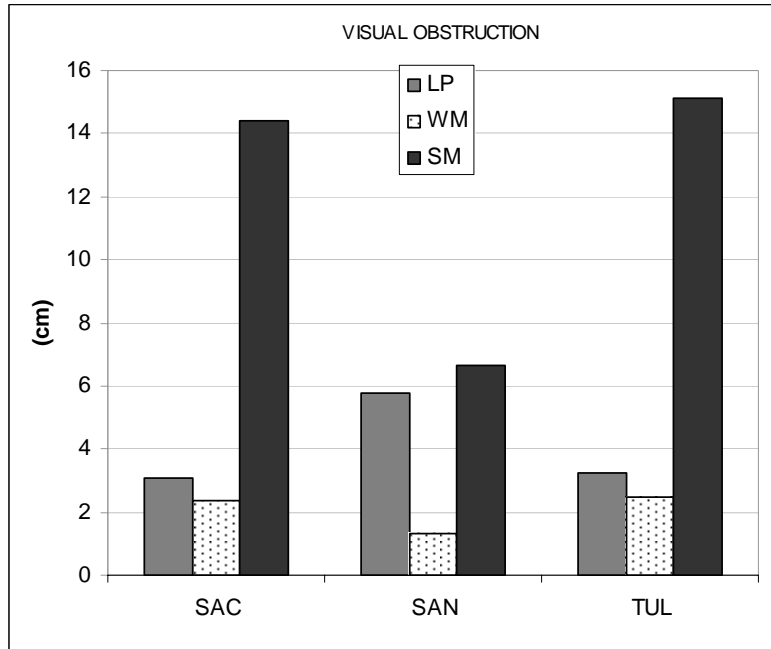


Figure 3. Visual obstruction measured at WRP easements classified by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare. Visual obstruction was estimated within each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow and SM = Shallow Marsh.

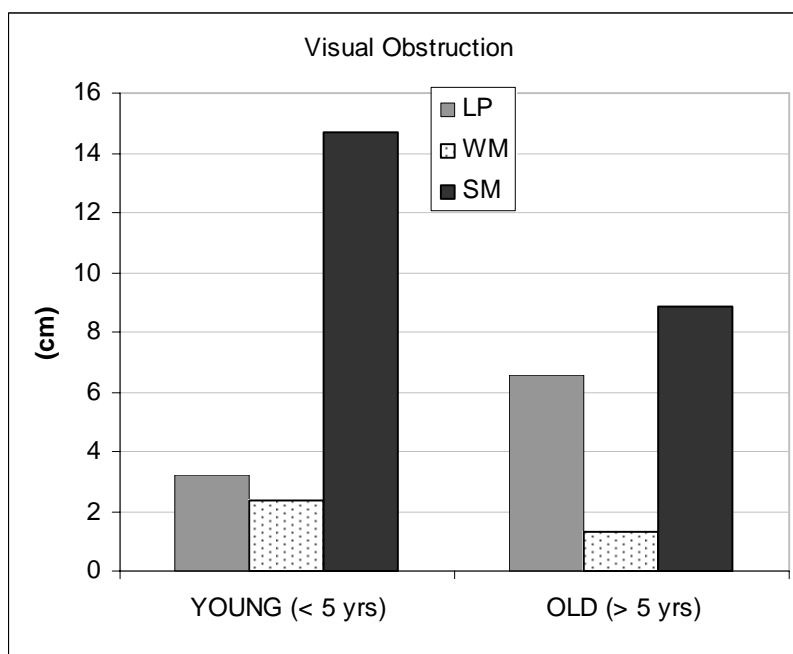


Figure 4. Visual obstruction measured at WRP easements by restoration age. Visual obstruction was estimated within each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow and SM = Shallow Marsh.

management intensities appeared to have relatively larger shallow marsh (Figure 5). Visual obstruction was greatest in the shallow marsh zone in both younger and older sites. Width and visual obstruction of each zone was measured in the field. Wetland easements in the San Joaquin and Tulare sub-basins had higher proportions of upland than other zonal types, whereas those in the Sacramento sub-basin exhibited larger wet-meadow zones (Figure 6). Younger and less intensively managed sites exhibited larger upland zones (Figures 7 and 8).

Vegetation biomass (g m^{-1}) was highest in the Sacramento sub-basin (Figure 9) and in older sites (Figure 10). Vegetation biomass was similar across management intensities (Figure 11).

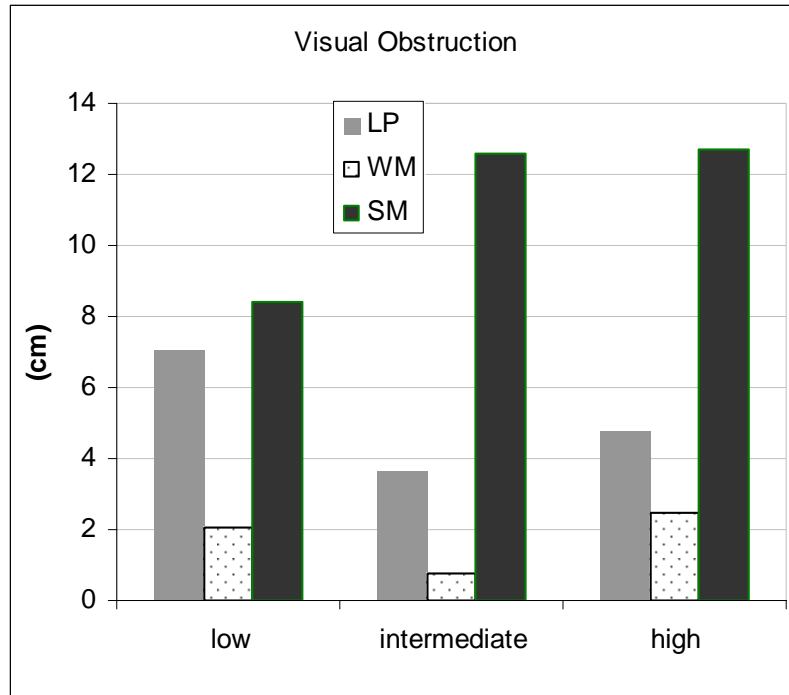


Figure 5. Visual obstruction measured at WRP easements by management intensity. Visual obstruction was estimated within each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow and SM = Shallow Marsh.

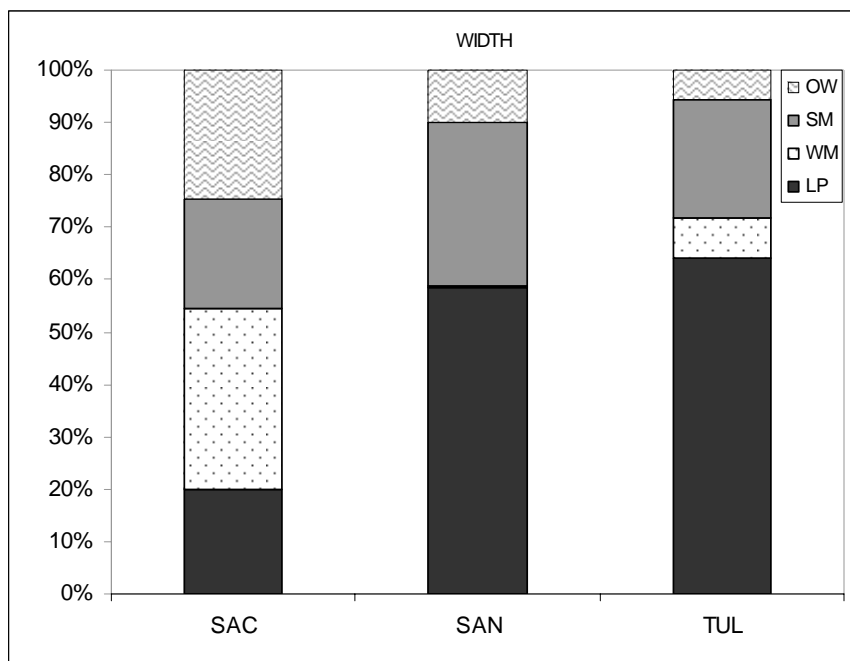


Figure 6. Width of each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow, SM = Shallow Marsh and OW = Open Water, classified by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.

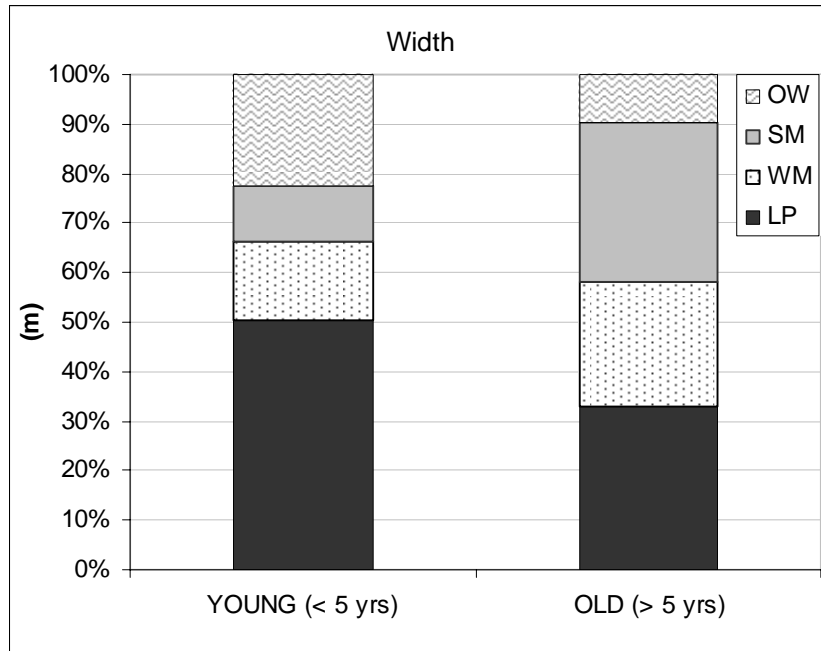


Figure 7. Width of each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow, SM = Shallow Marsh and OW = Open Water, classified by restoration age.

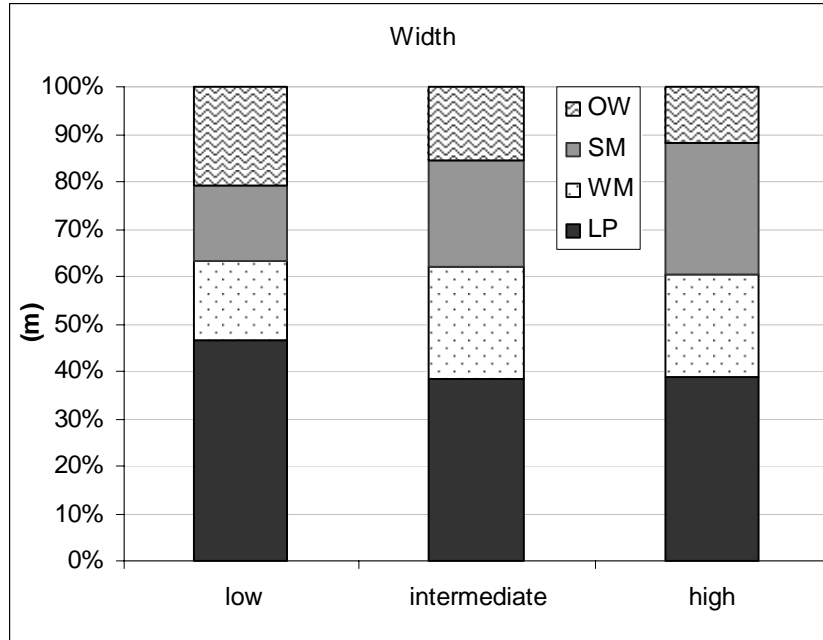


Figure 8. Width of each wetland zone i.e., LP = Low Prairie, WM = Wet Meadow, SM = Shallow Marsh and OW = Open Water, classified by management intensity.

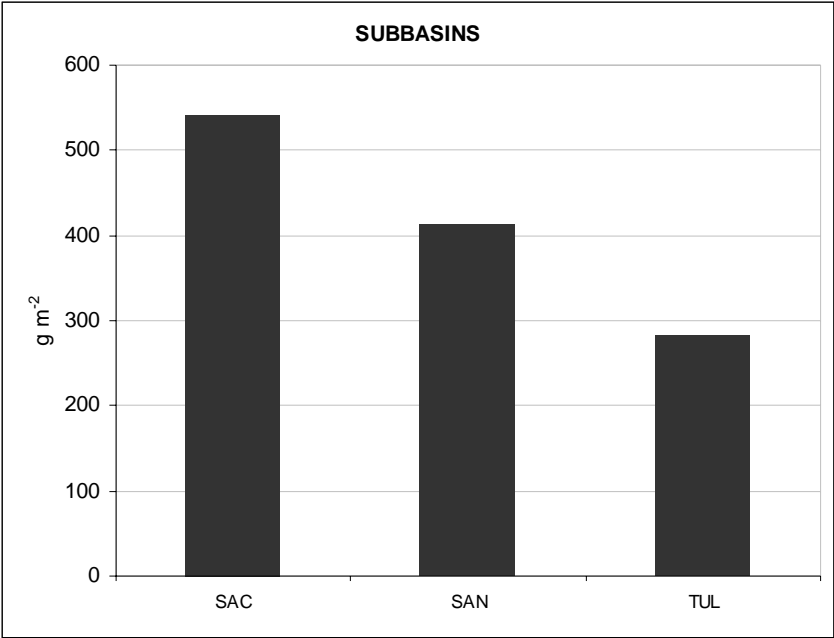


Figure 9. Vegetation biomass (g m^{-2}) by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.

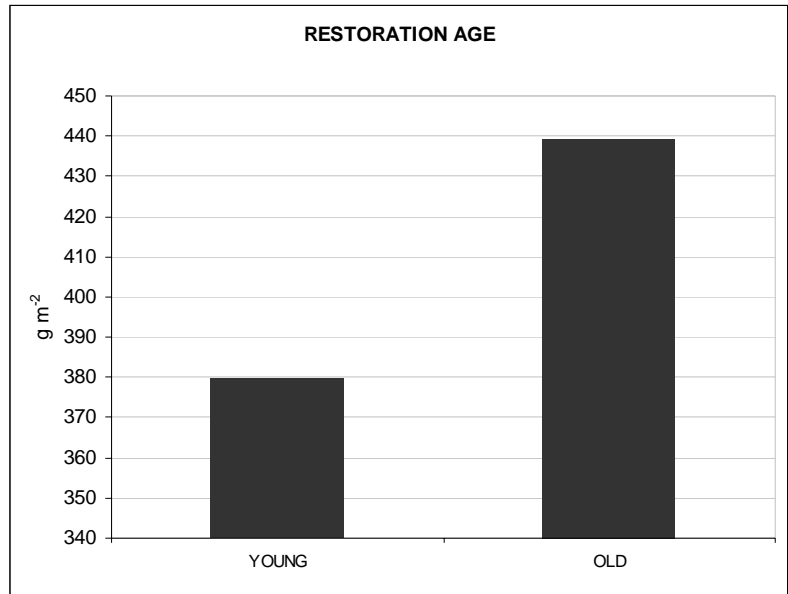


Figure 10. Vegetation biomass (g m^{-2}) by restoration age.

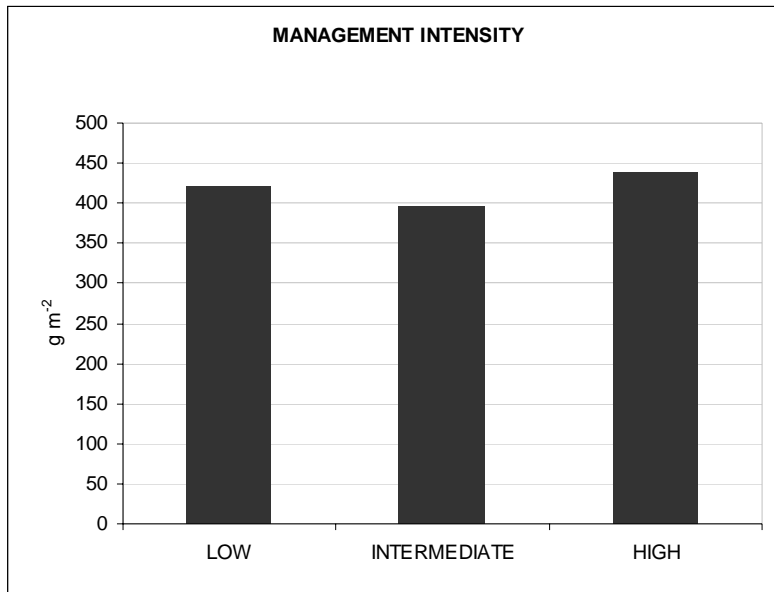


Figure 11. Vegetation biomass (g m^{-2}) by management intensity.

Soils

Soil samples were collected for nutrient analysis to estimate carbon sequestration and nutrient sequestration. Samples were submitted to the Colorado State University Soil-Water-Plant Testing Laboratory for determination of total phosphorous, total nitrogen, total carbon, and total inorganic carbon in November 2008. Litter depth and O-horizon measurements collected in the field are presented here. Litter depth appeared to be greatest in the Tulare sub-basin (Figure 12), and older sites had deeper litter layers (Figure 13). Intensively managed sites had greater litter depths than low or intermediate sites (Figure 14). O-horizon depths were greatest in the San-Joaquin sub-basin (Figure 15). Older sites had deeper O-horizons (Figures 16), whereas low management intensity sites exhibited deeper O-horizons (Figure 17).

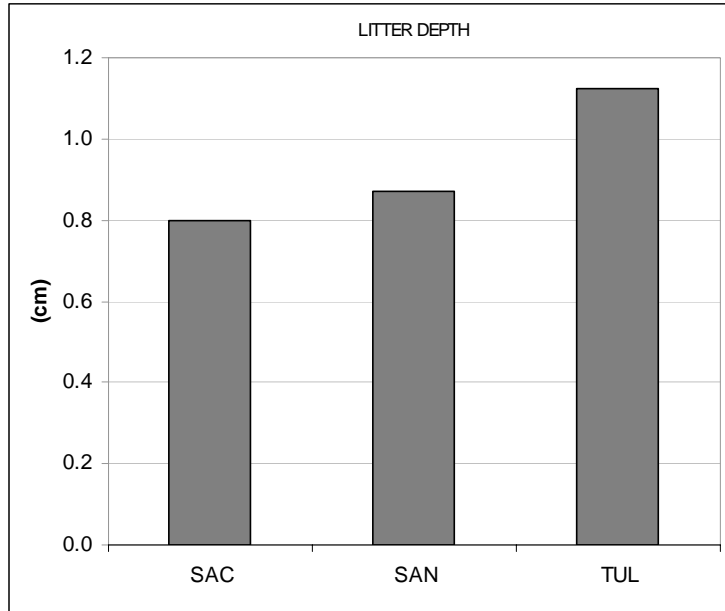


Figure 12. Litter depth by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.

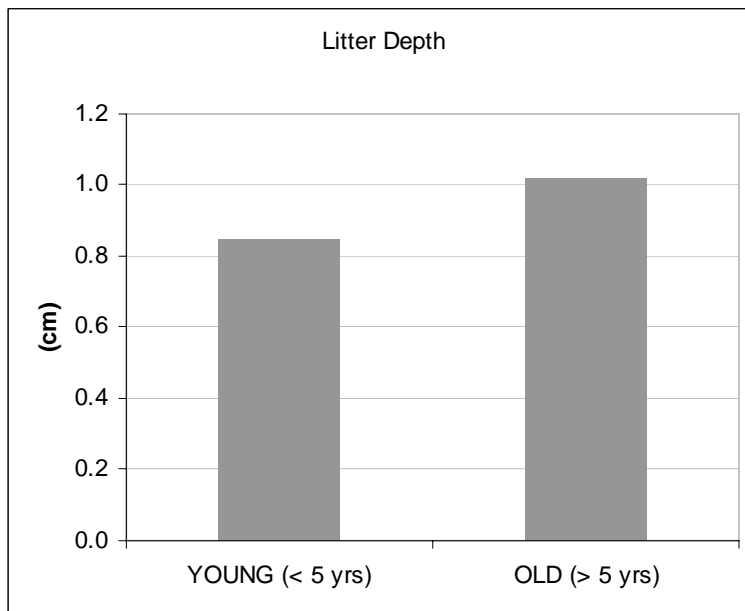


Figure 13. Litter depth by restoration age.

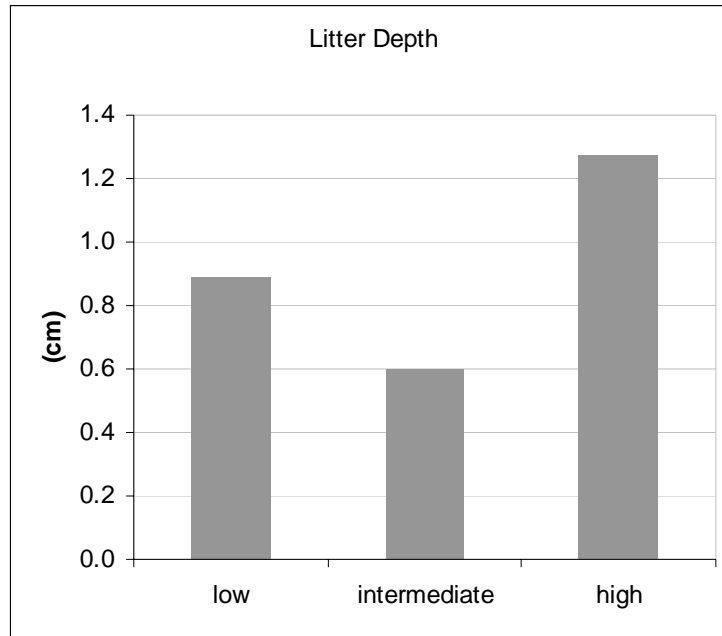


Figure 14. Litter depth by management intensity.

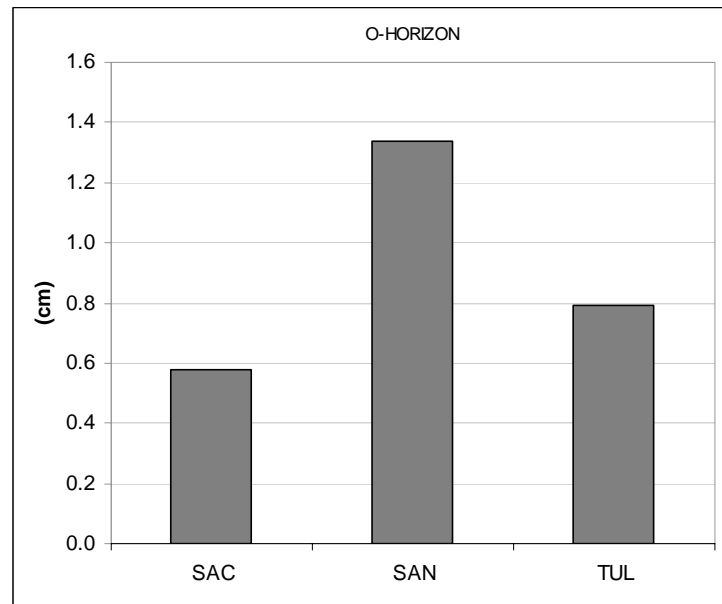


Figure 15. Soil O-horizon by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.

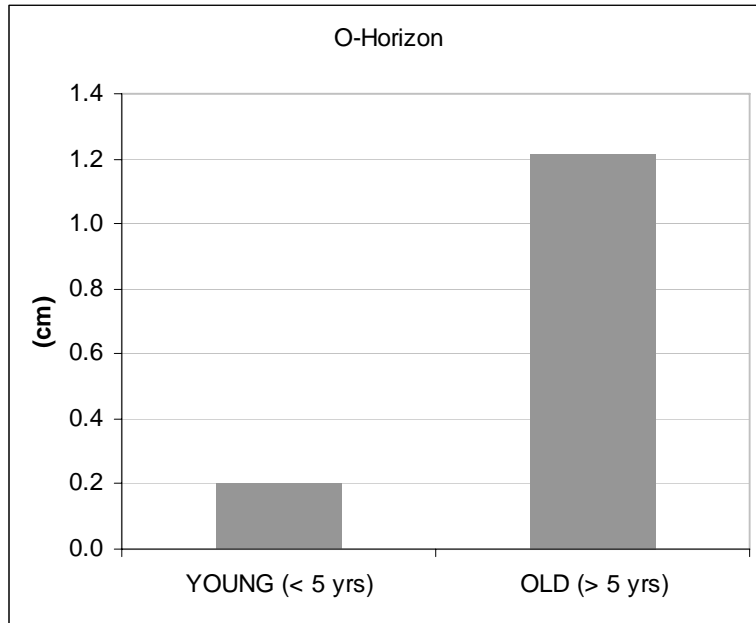


Figure 16. Soil O-horizon by restoration age.

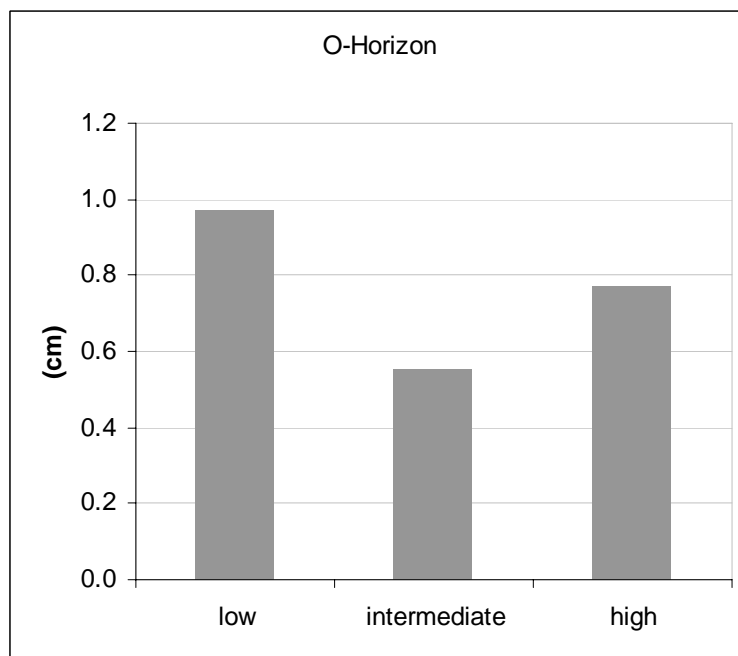


Figure 17. Soil O-horizon by management intensity.

Pollinators

A census of bee pollinators was conducted in the spring and summer of 2008. Preparation and of bee samples was conducted at Humboldt State University (Figure 18) and taxonomic identification is currently underway. Of more than 20,000 individuals were captured by pan trapping and netting, more than 80% were classified as honey bees (*Apis mellifera*) (Figure 19). Bees were collected on more than 50 flowering plants (Table 3). The highest number of bees (native and honey) was captured on black mustard flowers (*Brassica nigra*).

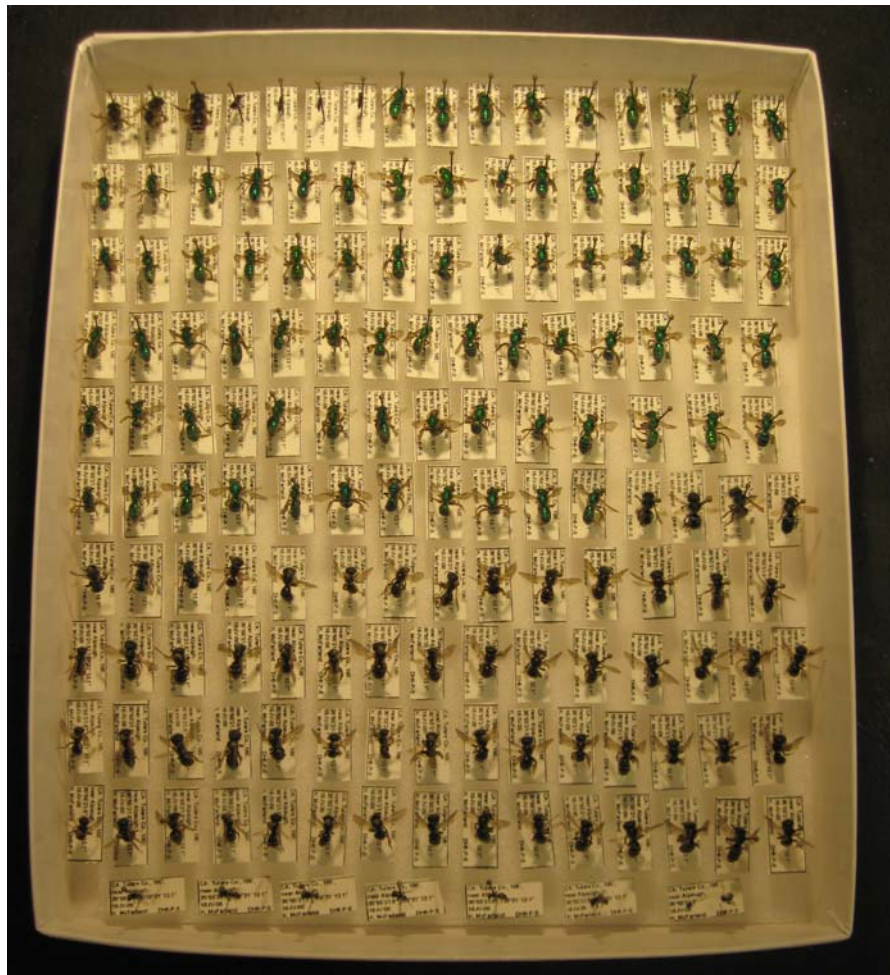


Figure 18. Pinned bees collected in California's Central Valley from March-May 2008 (Photo: Kim McFarland).

Table 3: Abundance of native and honey bees (*Apis malifera*) collected in California's Central Valley (March-May 2008) and associated flowering plants.

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

Table 3. (Continued).

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

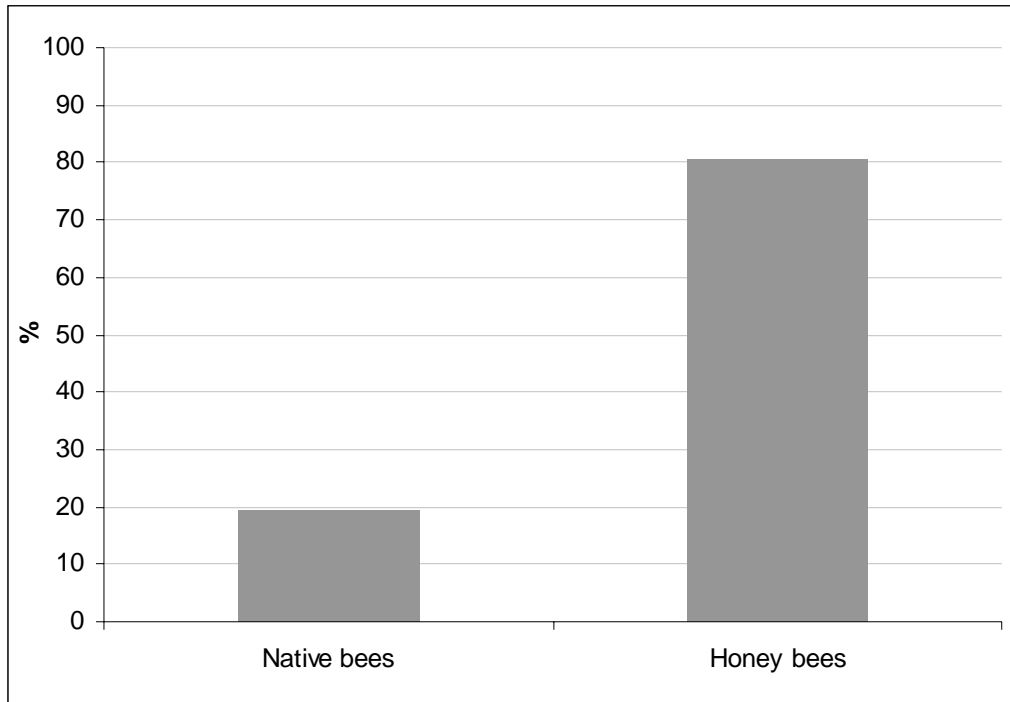


Figure 19. Percentage of bees collected at selected WRP easements in 2008.

Amphibians

Four amphibian species were observed on CCV WRPs. These included the American bullfrog (*Rana catesbeiana*), Pacific tree frog (*Pseudacris regilla*), Western toad (*Bufo boreas*) and the Western spadefoot toad (*Spea hammondi*). The most common species across all WRP easements was the Pacific tree frog followed by the American bullfrog (Figure 20). More species were recorded in the Tulare sub-basin than the Sacramento and San Joaquin (Figure 21). All species except the Pacific tree frog were more common on older WRP easements than younger ones (Figure 22). 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 under low management (Figure 23).

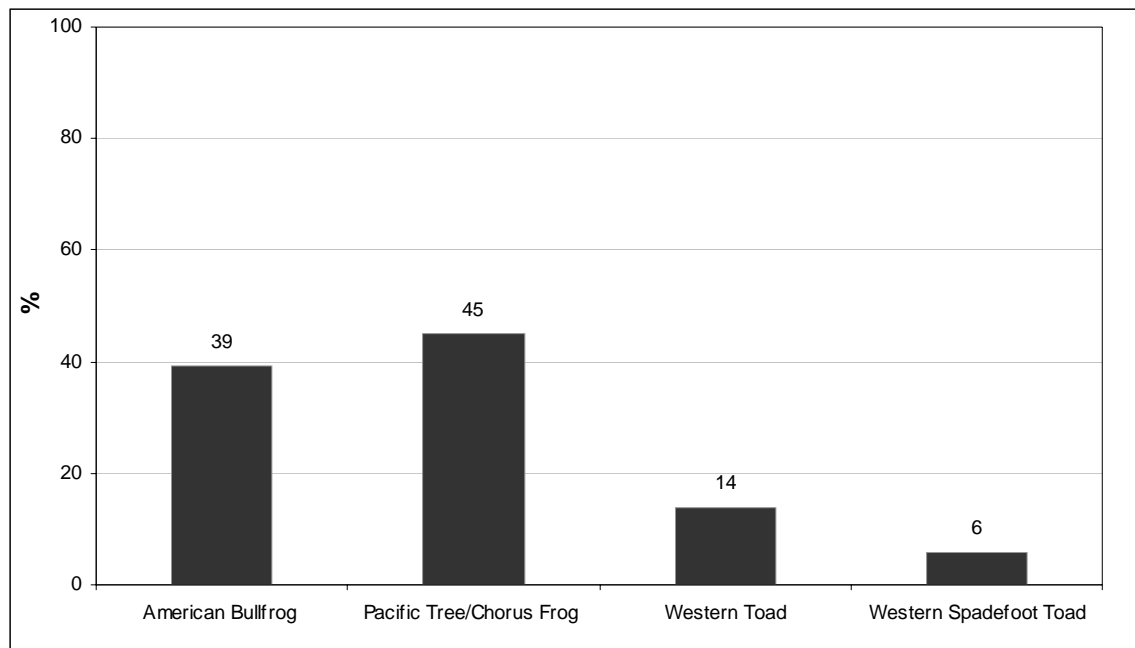


Figure 20. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008.

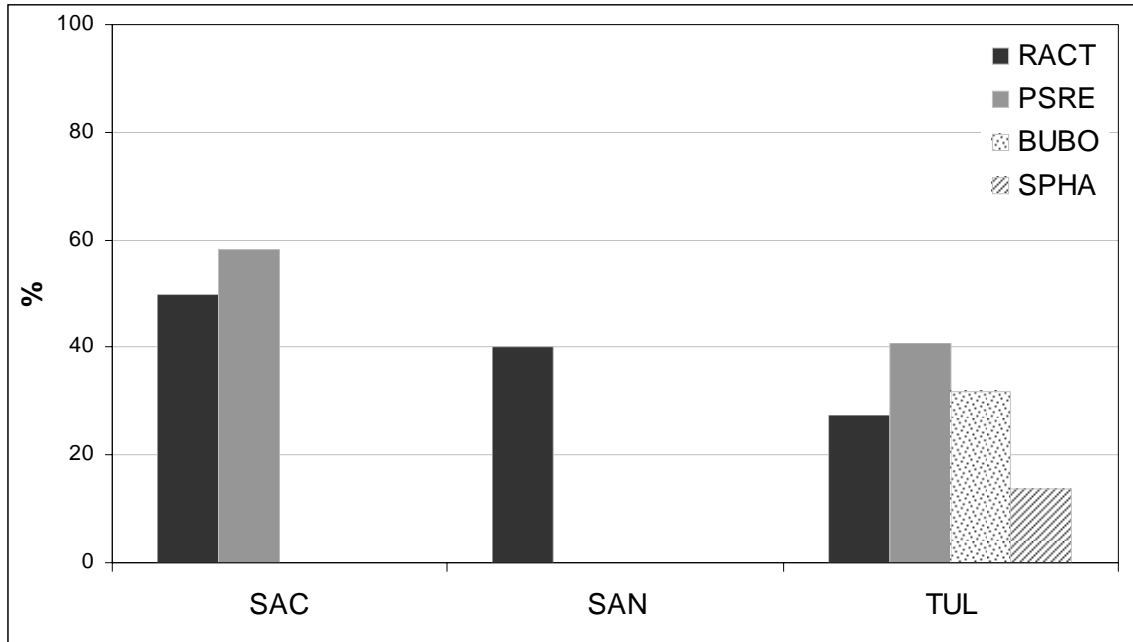


Figure 21. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008 by sub-basin; SAC = Sacramento, SAN = San Joaquin and TUL = Tulare.

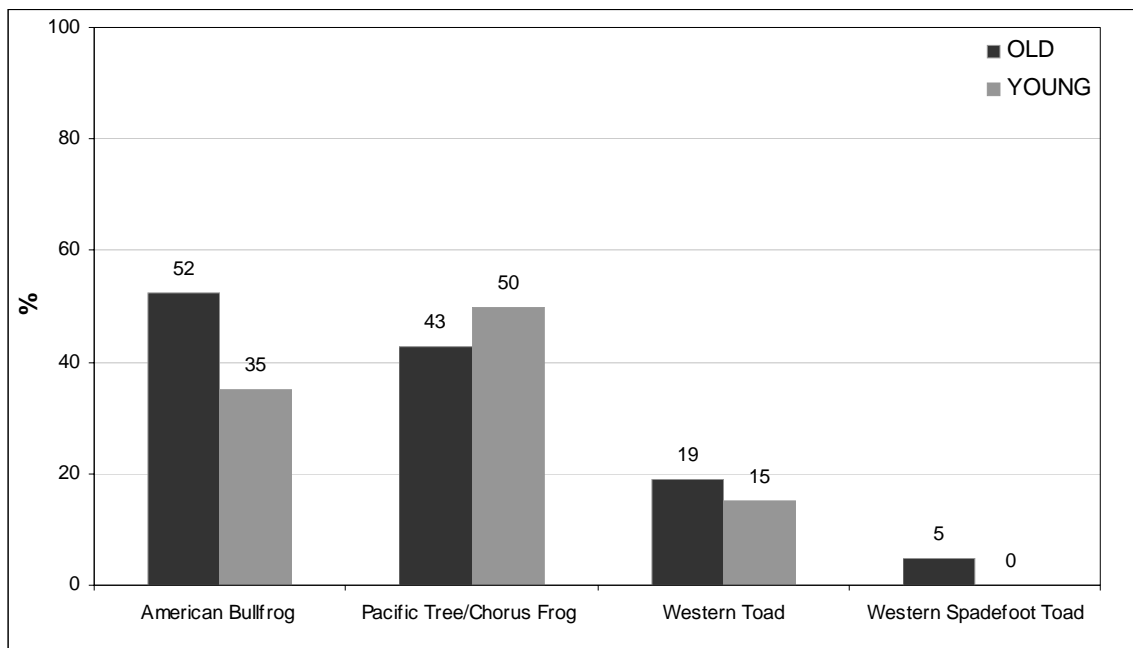


Figure 22. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008 by restoration age.

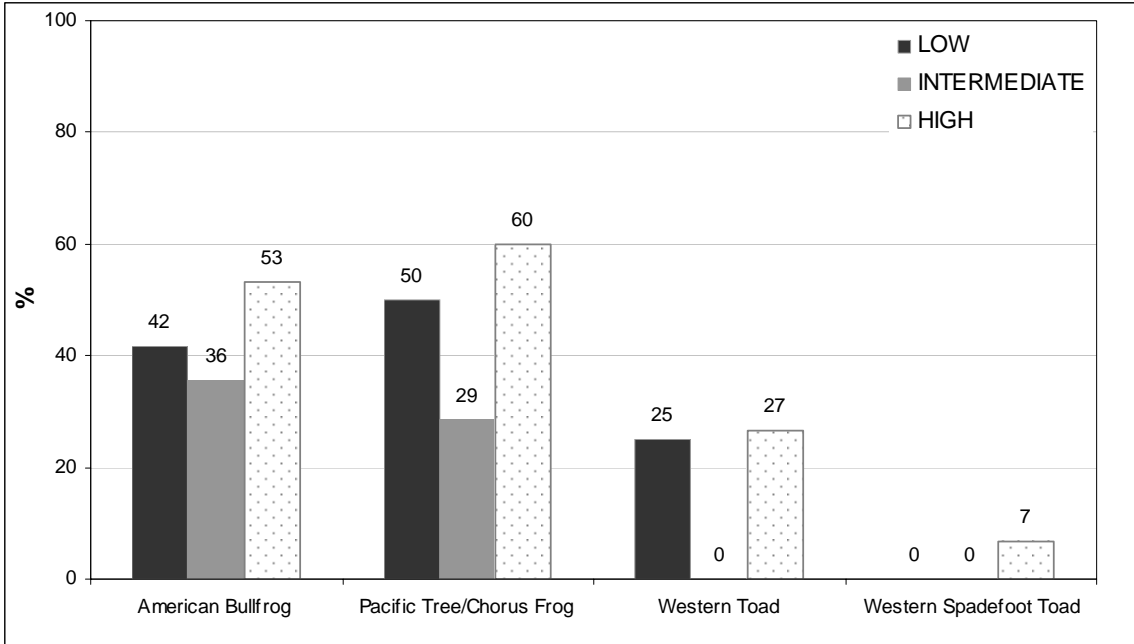


Figure 23. Percent occurrence of each amphibian species recorded on selected WRP easements in 2008 by management intensity.

Birds

A total of 63,934 individual adult birds were observed at WRP easements in the CCV during 2008 (Appendix A). Most abundant species included several species of resident waterfowl, shorebirds and passerine birds (Table 5). These abundant species all use wetland habitats for feeding, nesting and/or brood rearing.

A total of 182 bird taxa were observed at WRP easements in the CCV during 2008 (Appendix A). Most of the taxa were species, but a few were genera for which a species could not be assigned. Seven of the most frequently observed species were also among the most abundant (Table 6). However, several species such as black phoebe, great blue heron and ring necked pheasant were observed at a high proportion of WRP sites even though they were not abundant. Bird species richness was slightly higher in the Sacramento River Basin than in the Tulare Basin (Figure 24). Bird species richness declined with age of the WRP restoration in the Tulare Basin, but not in the Sacramento River Basin.

Table 4. Fifteen most abundant species of birds observed in WRP wetlands in the Central Valley of California during spring – summer 2008.

Common name	Total Number
American Coot	11879
Red-winged Blackbird	9525
White-faced Ibis	5562
Tree Swallow	3915
Mallard	3618
Western Sandpiper	2177
White-crowned Sparrow	1953
Marsh Wren	1877
Cinnamon Teal	1410
Least Sandpiper	1369
Savannah Sparrow	1363
Gadwall	1305
Song Sparrow	1047
Yellow-headed Blackbird	1016
Cliff Swallow	976

Table 5. Fifteen most frequently observed species of birds in WRP wetlands in the Central Valley of California during spring – summer 2008. Frequency is the number of sites, from a total of 316, at which the species was recorded.

Common name	Frequency
Marsh Wren	242
Red-winged Blackbird	235
Song Sparrow	231
Western Meadowlark	183
Western Kingbird	162
Mallard	160
American Coot	127
Brown-headed Cowbird	118
Killdeer	118
Tree Swallow	114
Great Egret	108
Great Blue Heron	108
Black Phoebe	102
Cliff Swallow	97
Ring-necked Pheasant	95

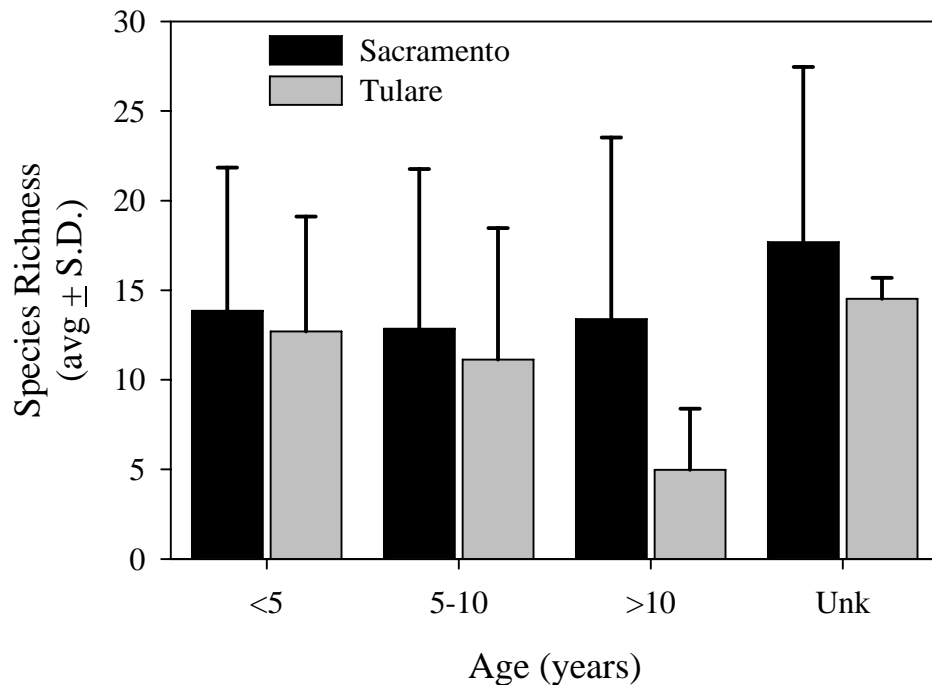


Figure 24. Average bird species richness (+ 1 S.D.) relative to age since restoration at 55 WRP wetland sites in the Sacramento River Basin and at 21 sites in the Tulare Basin.

Continuing Data Collection

The following data are currently being collected include; 1) land-use history and current management intensity survey, 2) climate, 3) landscape features and wetland inventories, 4) wetland construction and elevation information, 4) soils and 5) fish. Sources include NRCS archival documents, NRCS-Web Soil Survey, California Department of Water Resources (DWR), the National Oceanic and Atmospheric Administration (NOAA), USGS gauging stations, USDA CRP and WRP land units, National Land Cover Database (NLCD, US-EPA) and the Central Valley Joint Venture (CVJV). NRCS digital soil survey maps will be used to determine WRP soil type.

LITERATURE CITED

- Burnham, K. P., and D. R. Anderson. 2002. Model selection and inference: a practical information – theoretic approach, second edition. Springer, New York.
- Central Valley Joint Venture. 2006. Central Valley Joint Venture implementation plan conserving bird habitat. U. S. Fish and Wildlife Service, Sacramento, CA
- Dahl, T. E. 2006. Status and trends of wetlands in the conterminous United States 1998 to 2004. U. S. Department of the Interior; Fish and Wildlife Service, Washington, D.C. 112 pp.
- Daubenmire, R. F. 1959. Plants and environment. John Wiley & Sons, Inc. 422 pp.
- Gray, R. L. 2005. Wetlands Reserve Program: A partnership to restore wetlands and associated habitats. USDA, Forest Service, General Technical Report PSW-GTR-191, Washington, DC.
- Hartman, J. R., and J. H. Goldstein. 1994. The impact of federal programs on wetlands Volume II: The Everglades, coastal Louisiana, Galveston Bay, Puerto Rico, California's Central Valley, western riparian areas, southeastern and western Alaska, The Delmarva Peninsula, North Carolina, northeastern New Jersey, Michigan and Nebraska. U. S. Department of the Interior, Washington D.C.
- Hickman, J. C. (ed). 1993. The Jepson manual: higher plants of California. University of California Press, Berkeley.
- Kantrud, H. A., and W. E. Newton. 1996. A test of vegetation-related indicators of wetland quality in the prairie pothole region. *Journal of Aquatic Ecosystem Health* 5:177-191.
- Klute, A. (Ed.). 1986. Methods of Soil Analysis. Part 1 – Physical and Mineralogical Methods. 2nd Edition. Soil Science Society of America. Madison, WI.
- LeBuhn, G., T. Griswold, R. Minckley, S. Droege, T. Roulston, J. Cane, F. Parker, S. Buchmann, V. Tepedino, N. Williams, C. Kremen and O. Messinger. 2003. A standardized method for monitoring bee populations – the bee inventory (BI) plot. <http://online.sfsu.edu/~beeplot/>.
- Page, A.L., R.H. Miller and D.R. Keeney (Eds.). 1982. Methods of Soil Analysis. Part 2 – Chemical and Microbiological Properties. 2nd Edition. Soil Science Society of America. Madison, WI.
- Robel, R. J., J. N. Briggs, A. D. Dayton, and L. C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. *Journal of Range Management* 23:295-297.

- Schoenherr, A. A. 1992. A Natural History of California. University of California Press, Berkeley, CA.
- USDA, Natural Resource Conservation Service. 2006. Conservation effects assessment project national assessment – wetlands component. USDA, Natural Resource Conservation Service, Resource Inventory and Assessment Division, Beltsville, MD.
- U. S. Environmental Protection Agency. 2002. Methods for evaluating wetland condition: using amphibians in bioassessments of wetlands. Office of Water, U. S. Environmental Protection Agency, Washington, DC. EPA-822-R-02-022.

Appendix A. Bird species observed using WRP habitats in the Central Valley of California during summer 2008. Total is the total number of adult individuals observed, freq is the number of WRP site x sample period combinations at which the species was observed. Maximum frequency was 316.

Common name	Genus	Species	Total	Freq
Acorn Woodpecker	Melanerpes	formicivorus	1	1
Unidentified Clark or Western Grebe	Aechmorphus		1	1
Green-winged Teal	Anas	crecca	157	20
American Avocet	Recurvirostra	americana	334	40
American Bittern	Botaurus	lentiginosus	54	24
American Coot	Fulica	americana	11879	127
American Crow	Corvus	brachyrhynchos	3	2
American Goldfinch	Carduelis	tristis	349	77
American Kestrel	Falco	sparverius	5	4
American Pipit	Anthus	rubescens	152	19
American Robin	Turdus	migratorius	131	46
American Wigeon	Anas	americana	84	16
Anna's Hummingbird	Calypete	anna	12	7
Ash-throated Flycatcher	Myiarchus	cinerascens	115	50
American White Pelican	Pelecanus	erythrorhynchos	290	14
Bald Eagle	Haliaeetus	leucocephalus	2	2
Bank Swallow	Riparia	riparia	2	2
Barn Owl	Tyto	alba	2	2
Barn Swallow	Hirundo	rustica	79	25
Black-bellied Plover	Pluvialis	squatarola	100	4
Black-chinned Hummingbird	Archilochus	alexandri	8	6
Black-crowned Night-Heron	Nycticorax	nycticorax	215	44
Belted Kingfisher	Ceryle	alcyon	10	9
Bewick's Wren	Thryomanes	bewickii	112	29
Brown-headed Cowbird	Molothrus	ater	416	118
Black-headed Grosbeak	Pheucticus	melanocephalus	116	39
Blue Grosbeak	Passerina	caerulea	67	45
Black Phoebe	Sayornis	nigricans	168	102
Black Tern	Chlidonias	niger	1	1
Barn Owl	Tyto	alba	2	2
Black-necked Stilt	Himantopus	mexicanus	723	44
Brewer's Blackbird	Euphagus	cyanocephalus	251	47
Bufflehead	Bucephala	albeola	1	1
Bullock's Oriole	Icterus	bullockii	105	32
Burrowing Owl	Athene	cunicularia	17	6
Bushtit	Psaltriparus	minimus	205	39
Blue-winged Teal	Anas	discors	35	9
Cattle Egret	Bubulcus	ibis	205	19
Canada Goose	Branta	canadensis	72	12
California Towhee	Pipilo	crissalis	69	31
Canvasback	Aythya	valisineria	5	3
California Quail	Callipepla	californica	97	33

Caspian Tern	Sterna	caspia	4	3
Cedar Waxwing	Bombycilla	cedrorum	42	2
Chipping Sparrow	Spizella	passerina	2	1
Cinnamon Teal	Anas	cyanoptera	1410	87
Clark's Grebe	Aechmophorus	clarkii	6	5
Cliff Swallow	Petrochelidon	pyrrhonota	976	97
Cooper's Hawk	Accipiter	cooperii	3	3
Common Moorhen	Gallinula	chloropus	119	33
Common Raven	Corvus	corax	12	5
Common Yellowthroat	Geothlypis	trichas	88	61
Double-crested Cormorant	Phalacrocorax	auritus	71	24
Unidentified Dowitcher	Limnodromus		576	15
Downy Woodpecker	Picoides	pubescens	39	18
Dusky Flycatcher	Empidonax	oberholseri	1	1
Dunlin	Calidris	alpina	794	6
Eared Grebe	Podiceps	nigricollis	1	1
European Starling	Sturnus	vulgaris	37	16
Forster's Tern	Sterna	forsteri	89	8
Gadwall	Anas	strepera	1305	91
Great Blue Heron	Ardea	herodias	209	108
Golden-crowned Sparrow	Zonotrichia	atricapilla	4	3
Great Horned Owl	Bubo	virginianus	22	17
Golden Eagle	Aquila	chrysaetos	2	2
Great Egret	Ardea	alba	604	108
Green Heron	Butorides	virescens	6	4
Greater Roadrunner	Geococcyx	californianus	4	4
Grasshopper Sparrow	Ammodramus	savannarum	1	1
Greater Yellowlegs	Tringa	melanoleuca	146	22
Great-tailed Grackle	Quiscalus	mexicanus	61	22
Greater White-fronted Goose	Anser	albifrons	1	1
Hermit Warbler	Dendroica	occidentalis	1	1
House Finch	Carpodacus	mexicanus	280	77
Horned Lark	Eremophila	alpestris	24	8
House Sparrow	Passer	domesticus	6	6
House Wren	Troglodytes	aedon	82	21
Killdeer	Charadrius	vociferus	393	118
Lark Sparrow	Chondestes	grammacus	29	14
Lazuli Bunting	Passerina	amoena	31	13
Long-billed Curlew	Numenius	americanus	272	7
Long-billed Dowitcher	Limnodromus	scolopaceus	68	6
Lesser Goldfinch	Carduelis	psaltria	71	27
Lesser Nighthawk	Chordeiles	acutipennis	1	1
Least Sandpiper	Calidris	minutilla	1369	25
Lesser Scaup	Aythya	affinis	14	5
Lesser Yellowlegs	Tringa	flavipes	19	3
Lincoln's Sparrow	Melospiza	lincolnii	33	15
Loggerhead Shrike	Lanius	ludovicianus	160	94

Mallard	Anas	platyrhynchos	3618	160
Marsh Wren	Cistothorus	palustris	1877	242
Merlin	Falco	columbarius	2	2
Mourning Dove	Zenaida	macroura	275	87
Northern Flicker	Colaptes	auratus	4	3
Northern Harrier	Circus	cyaneus	107	79
Northern Mockingbird	Mimus	polyglottos	37	29
Northern Pintail	Anas	acuta	258	25
Northern Rough-winged Swallow	Stelgidopteryx	serripennis	11	7
Northern Shoveler	Anas	clypeata	468	45
Nuttall's Woodpecker	Picoides	nuttallii	83	33
Oak Titmouse	Baeolophus	inornatus	31	15
Orange-crowned Warbler	Vermivora	celata	14	4
Olive-sided Flycatcher	Contopus	cooperi	1	1
Osprey	Pandion	haliaetus	3	3
Pied-billed Grebe	Podilymbus	podiceps	468	92
Peregrine Falcon	Falco	peregrinus	1	1
Prairie Falcon	Falco	mexicanus	2	2
Pacific-slope Flycatcher	Empidonax	difficilis	3	1
Ruby-crowned Kinglet	Regulus	calendula	2	2
Redhead	Aythya	americana	23	5
Ring-necked Duck	Aythya	collaris	28	8
Red-necked Phalarope	Phalaropus	lobatus	13	4
Ross' Goose	Chen	rossii	1	1
Ring-necked Pheasant	Phasianus	colchicus	166	95
Red-shouldered Hawk	Buteo	lineatus	4	4
Red-tailed Hawk	Buteo	jamaicensis	81	53
Ruddy Duck	Oxyura	jamaicensis	98	24
Red-winged Blackbird	Agelaius	phoeniceus	9525	235
Sandhill Crane	Grus	canadensis	170	1
Sanderling	Calidris	alba	1	1
Say's Phoebe	Sayornis	saya	3	3
Savannah Sparrow	Passerculus	sandwichensis	1363	78
Semipalmated Plover	Charadrius	semipalmatus	106	7
Snowy Egret	Egretta	thula	331	51
Snow Goose	Chen	caerulescens	1	1
Sora	Porzana	carolina	24	5
Solitary Sandpiper	Tringa	solitaria	3	1
Song Sparrow	Melospiza	melodia	1047	231
Spotted Sandpiper	Actitis	macularia	10	8
Spotted Towhee	Pipilo	maculatus	219	33
Sharp-shinned Hawk	Accipiter	striatus	2	2
Swainson's Hawk	Buteo	swainsoni	12	9
Swainson's Thrush	Calathrus	ustulatus	2	1
Townsend's Warbler	Dendroica	townsendi	2	2
Tricolored Blackbird	Agelaius	tricolor	9	2
Tree Swallow	Tachycineta	bicolor	3915	114

Turkey Vulture	Cathartes	aura	259	49
Unidentified Blackbird	Icteridae		51	11
Unidentified Duck	Anatidae		8	5
Unidentified Swallow	Hirundinidae		107	7
Vaux's Swift	Chaetura	vauxi	4	2
Violet-green Swallow	Tachycineta	thalassina	1	1
Virginia Rail	Rallus	limicola	27	16
Unknown Waterbird (duck or grebe)			0	1
Warbling Vireo	Vireo	gilvus	9	4
White-breasted Nuthatch	Sitta	carolinensis	5	4
White-crowned Sparrow	Zonotrichia	leucophrys	1953	49
Western Bluebird	Sialia	mexicana	11	7
Western Grebe	Aechmophorus	occidentalis	3	3
Western Kingbird	Tyrannus	verticalis	625	162
Western Meadowlark	Sturnella	neglecta	584	183
Western Sandpiper	Calidris	mauri	2177	12
Western Scrubjay	Aphelocoma	californica	46	26
Western Tanager	Piranga	ludoviciana	8	6
Western Wood-Pewee	Contopus	sordidulus	80	25
White-faced Ibis	Plegadis	chihi	5562	51
Whimbrel	Numenius	phaeopus	80	4
Wilson's Phalarope	Phalaropus	tricolor	8	3
Wilson's Snipe	Gallinago	delicata	10	5
Wild Turkey	Meleagris	gallopavo	7	5
Wilson's Warbler	Wilsonia	pusilla	20	8
Western/Least Sandpiper	Calidris		31	1
Wood Duck	Aix	sponsa	140	35
Wrentit	Chamaea	fasciata	6	5
White-tailed Kite	Elanus	leucurus	36	23
White-throated Swift	Aeronautes	saxatalis	1	1
unknown dabbling duck	Anas		15	2
unknown peep (western or least)	Calidris	manuri/minutilla	189	3
Unknown Anas species	Anas	sp	5	1
Empidonax unknown species	Empidonax		1	1
Unknown goldfinch	Carduelis		2	1
Unidentified Hummingbird	Trochilidae		18	9
Unidentified Sandpiper	Scolopacidae		102	3
Unidentified Scaup	Aythya		3	1
Unknown warbler	Parulidae		1	1
Unknown woodpecker	Picidae		3	1
Unidentified Bird	Aves		0	1
Yellow-breasted Chat	Icteria	virens	1	1
Yellow-billed Cuckoo	Coccyzus	americanus	3	1
Yellow-billed Magpie	Pica	nuttalli	3	2
Yellow-headed Blackbird	Xanthocephalus	xanthocephalus	1016	19
Yellow-rumped Warbler	Dendroica	coronata	138	20
Yellow Warbler	Dendroica	petechia	11	7

