Atwell Island Restoration Project Activities
2000 - 2010
Central Valley Project Improvement Act Land Retirement Demonstration Project

U.S. Department of the Interior
Interagency Land Retirement Team
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Cover Photos:

Upper: Atwell Island restoration field: Spring 2010, five years after planting

Lower left: Swale in restoration field: Spring 2010, planted in Fall 2007 – Alkali Daisy (*Lasthenia ferrisiae*) is the dominant plant

Lower Center: Planting Atwell Island restoration field: Fall 2007

Lower right: Atwell Island restoration field: Spring 2010

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Table of Contents

List of Tables

List of Figures

Chapter 1. Executive Summary

The Central Valley Project Improvement Act (CVPIA) of 1992 authorized the Federal government to retire drainage-impaired lands by purchasing them from willing sellers (US Congress 1992). Retired lands have been restored with native plant communities to enhance wildlife resources. The Land Retirement Demonstration Project (LRDP), through the guidance and management of the Bureau of Land Management (BLM), and cooperation with Bureau of Reclamation (USBR) and Fish and Wildlife Service (FWS), evaluated re-vegetation strategies to determine effective methods for restoring retired agricultural lands within the Atwell Water District.

Significant challenges to successful restoration included:

- *Limited existing reference sites to guide restoration efforts*
- *Altered hydrology*
- *Effects of past agricultural activities (e.g., depleted native seed bank)*
- *Competitive pressure from non-native invasive species due to large amount of weed seed in seed bank*
- *Low mean annual precipitation and extremely variable precipitation patterns*
- *Constraining site conditions such as variable soil salinity, highly motile silty soils, fine sand inclusions and low topographic variability*

From 2000 to 2009, BLM planted 67 restoration sites for a total of 3100 acres. Currently 400 acres are being planted each year. Monitoring in the spring of 2010 showed the restoration sites with an average native plant cover of 35.1%; exceeding the 15% native cover performance criterion. Of the 65 sites for which both monitoring and planting data are available, ten sites (15.4%) met the total native cover criterion, but not the shrub cover criterion; five sites (7.7%) met the shrub cover criterion, but not the total native cover criterion; 46 sites (70.8%) met both performance criteria and only four sites (6.2%) met neither criterion.

The following are the most important recommendations for successful restoration efforts in the Tulare Basin:

- *Fresh locally collected seed is important to restoration success*
- *Moderate to high seeding rates (25 pounds per acre or more) should be used. Use enough seed so the native plants you are planting will dominate the site and suppress the weed species*
- *Develop planting designs based on soil type*
- *Plant in fall prior to first heavy late fall rains*
- *Use standard agricultural site preparation and planting techniques. The following sequences have yielded the best restoration success:*
    - *Fallow fields are burned and planted with a range drill*
    - *Agricultural fields are disked several times and planted with the Trillion broadcast seeder.*

- *Irrigate the restoration planting only if the rainfall totals for the year are more than 20% below average. Irrigation may help the native plantings, but it will also encourage the weed species.*
- *Use existing local reference sites to define success criteria for restoration.*

Chapter 2. Introduction

Successful habitat restoration necessitates the establishment of self-sustaining, native plant communities with desirable values for wildlife habitat, site stabilization and weed suppression. The lands on the Atwell Island Restoration ProjectAtwell Island Restoration Project targeted for retirement and habitat restoration present significant restoration challenges. This document presents a summary of the restoration activities from 2000 to 2010 at the Atwell Island Restoration Project near Alpaugh, Tulare County, California. In addition to describing completed restoration activities, we present the results of monitoring activities and conclude with recommendations for future restoration efforts. For abbreviations and acronyms see Appendix 1.

Atwell Island Restoration Project Management Goals and Objectives

The primary focus of Bureau of Land Management's (BLM) Atwell Island Restoration Project (Project) is to restore marginal farmland to native upland habitat. As BLM has strived to increase the acreage of restored habitat, viable methods for upland habitat restoration have been developed and showcased in a way that creates a model for future restoration projects both on and off the site.

BLM has four primary goals for upland habitat restoration at the Atwell Island Restoration Project:

1. *Restore lands with potential for native forb and grass dominance to a minimum of 15% native grass and forb cover.*
2. *Re-establish native shrub communities.*
3. *Restore a functioning, sustainable ecosystem supporting native wildlife species.*
4. *Restore 300 or more acres (122 ha) per year using suitable species assemblages for each soil type.*

Wetland and riparian habitats at the BLM Atwell Island Restoration Project are very limited in area, but are important components of the project. The focus of the Project's wetland restoration and management is to restore habitats used by migratory and breeding birds and special-status species. The goals of the Project's riparian restoration and management are to recreate riparian zones along canals, create riparian vegetation near wetlands and sloughs and to increase diversity of vegetation.

When these goals are met, the Project will meet the desired future habitat conditions, with 70% of the Project acreage in restored uplands, 5% in wildlife-friendly farming, 5% in wetlands and riparian areas and 20% in potential flood-control/management areas. Management goals and objectives, as with any on-the-ground project, may be altered as adaptive management is applied. Upland and wetland habitat restoration will benefit native species, including special-status species, while providing environmental and economic sustainability. Wetlands and canals on the Project contribute to the chain of wetlands from Pixley National Wildlife Refuge (NWR) to Kern NWR.

Program Background

Agriculture has been a significant feature of the central California landscape for over 150 years. To meet growing water demands, the federal government constructed the Central Valley Project (CVP), and began delivery of northern California water to more than 1,000,000 acres on the west side of the southern San Joaquin Valley in 1968. In the 1970's, as the perched water table reached the crop root zone, capillary action carried water close to the soil surface, where it left a salt residue. Crop production declined as the salt content of soil and irrigation water increased. To combat this problem, construction of the San Luis Drain was authorized to transfer drainage water to the Sacramento-San Joaquin Delta. By 1975, the US Bureau of Reclamation (USBR) had completed 85 miles of the main San Luis Drain and 120 miles (193 km) of collector drains. Kesterson Reservoir was the target area for the first phase of drain water disposal. Within a few years, deformities and deaths of aquatic birds due to selenium poisoning were discovered at the site. Kesterson Reservoir was closed in 1983 and the drain system was abandoned.

In 1990, a joint federal and state Drainage Report (USDI 1990) concluded that an estimated 460,000 to 554,000 acres (187,755 to 226,122 ha) of irrigated agricultural land might be abandoned by landowners by 2040 if no further action was taken to control drainage problems. In the Tulare Basin, the report recommended selective retirement of 75,000 acres (30,612 ha) of marginal irrigated farmlands characterized by low productivity, poor drainage and high selenium concentrations in the shallow groundwater. In 1992, in response to the Drainage Report, Congress enacted the Central Valley Project Improvement Act (CVPIA) as Public Law 102-575, Title XXXIV. CVPIA goals were to reduce agricultural drainage, enhance fish and wildlife resources and acquire water for CVPIA purposes, as outlined in Section 3402 of the Act (U.S. Congress, 102nd Session, October 30, 1992). Under this legislation, restoration and mitigation of fish and wildlife in California's Central Valley take an equal priority with irrigation and domestic uses. This legislation also authorized a Land Retirement Program (LRP), (Section 3408(h)) to take land permanently out of irrigated agricultural production. The LRP authorized the purchase of land, water and other property interests from willing sellers on lands that have a CVP water allocation.

USBR, in partnership with the US Fish and Wildlife Service (FWS) and the BLM, formed the CVPIA Interagency Land Retirement Team (LRT). The LRT authorized a 15,000-acre (6,122 ha) project at two sites in drainage-impaired basins: Tranquility in Fresno County and Atwell Island in Kings and Tulare counties. In 2001, BLM began restoring the 8,000-acre (3,265 ha) Atwell Island Restoration Project with native shrubs, grasses and forbs. As irrigation has been reduced on the Project site, the amount of agricultural drainage has also been reduced, and the depth to the shallow perched saline groundwater table has increased. The restored agricultural lands provide upland habitat, in conjunction with wetland habitats, for declining wildlife populations and special status species. The Project contributes to larger, landscape scale conservation goals for connectivity via wildlife corridors and integration of project land with surrounding protected lands. The Project lies between Pixley NWR and Kern NWR and is adjacent to other existing native habitats (e.g., Sand Ridge and Allensworth Ecological Reserve) (Figure 2.1)**.**

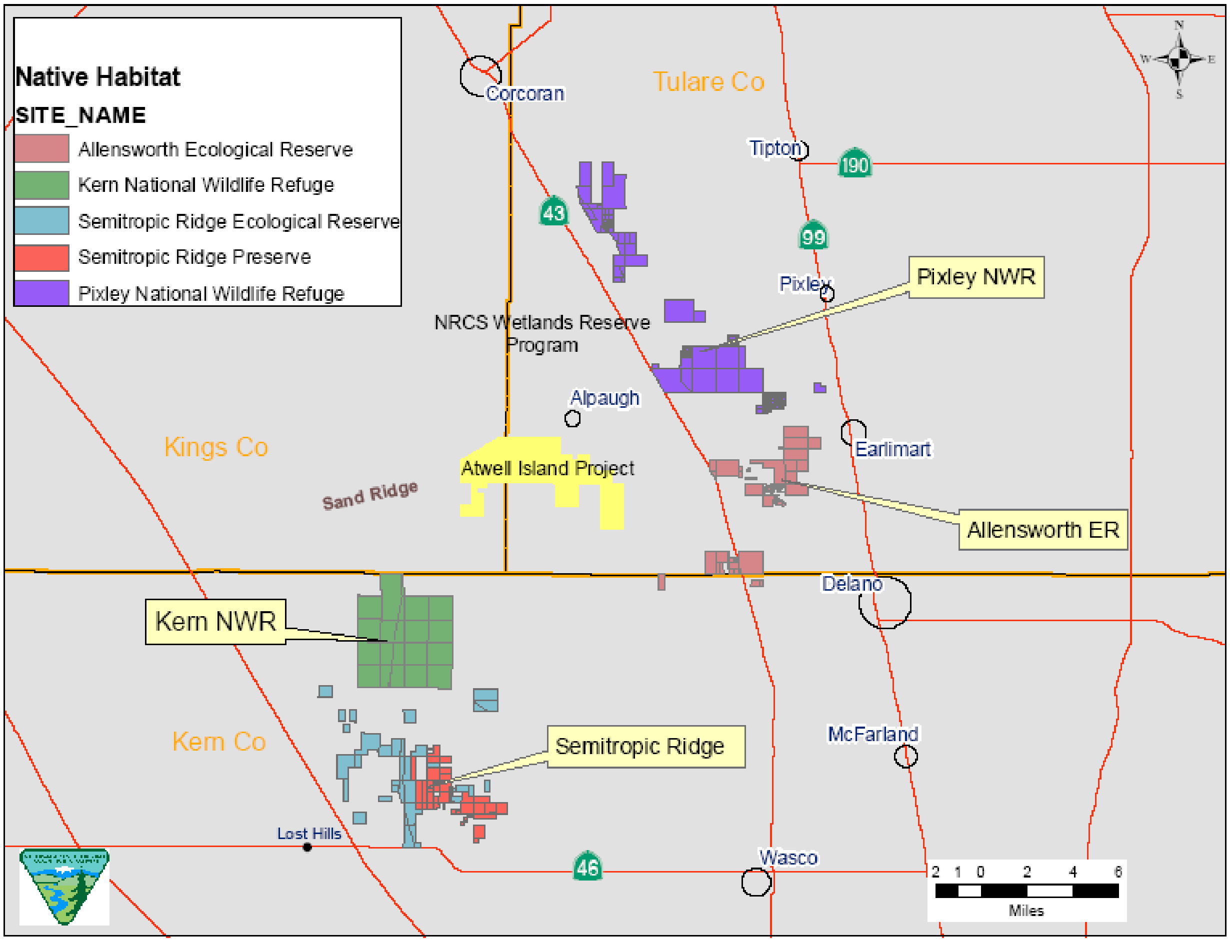

Figure 2-1: Atwell Island Restoration and the surrounding protected lands.

Chapter 3. Project Area Background Information

The Atwell Island Restoration Project is located in the Tulare Basin in the southern third of California's Central Valley, in southwestern Tulare and southeastern Kings counties, one mile (1.6 km) south of the town of Alpaugh (Figure 3-1). The Project is named for Atwell Island, the sandy ridge that separated historic Tulare Lake from historic Ton Tache Lake (Figure 3-2). Tulare Lake, fed by the Kings, Kaweah, Kern and Tule rivers, once averaged approximately 800 square miles (2,072 km^2) in surface area, with a maximum depth of 30 feet (9.1 m). As recently as 100 years ago, it was the largest freshwater lake west of the Mississippi River. Ton Tache Lake was a continuous shallow tule (*Schoenoplectus acutus* var *occidentalis)* marsh that lay between present day Alpaugh and Allensworth, and was fed by Deer Creek, White River and Poso Creek. The highest portion of Atwell Island was never submerged, even during major flood events.

Atwell Island Area History

Tulare Lake and Ton Tache Lake – Early Accounts

In the Atwell Island area, prehistoric Clovis points are among the Native American artifacts found that attest to 11,000 to 14,000 years of continuous human occupancy (Wilke 1991). By AD 400, Yokuts occupied nearly all of the San Joaquin Valley and adjacent foothills, and moved between several villages throughout the year as different resources became available (Preston 1981). The Yokut communities were highly mobile, since the lakeshore fluctuated frequently due to the shallow lake depth and flat ground: winds could occasionally shift the shoreline by up to a mile. Most settlements around the lake were established on small rises to protect them from flooding, and near sloughs where ready supplies of water and more food resources were available. The Yokuts economy was based upon the tule marshes along the river, where tules grew 20 feet (6 m) high, with stems 2-3 inches (5-8 cm) in diameter (Mayfield 1929). In the 1850s, many of the Yokuts were forced onto the reservations (Hurtado 1988). The Yokuts population decreased dramatically from the late 18th century to the early 20th century (Preston 1981). By 1910 approximately 1-5% of the original Indian population remained (Kroeber 1951).

History of Farming Activities

Tulare Lake was at the center of the first economic activity in the region. In 1880, people reported catching three-foot-long (1 m) trout in the lake, weighing over 20 pounds (9 kg) (Latta 1999). Commercial fishermen laid huge nets that brought in over 3,000 pounds (908-1,362 kg) of fish at one time. Western pond turtles (*Clemmys marmorata*) were caught in large numbers to meet the demand in San Francisco restaurants. Other successful businesses included transporting supplies to lakeshore residents and recreational sailing (Mitchell 1949).

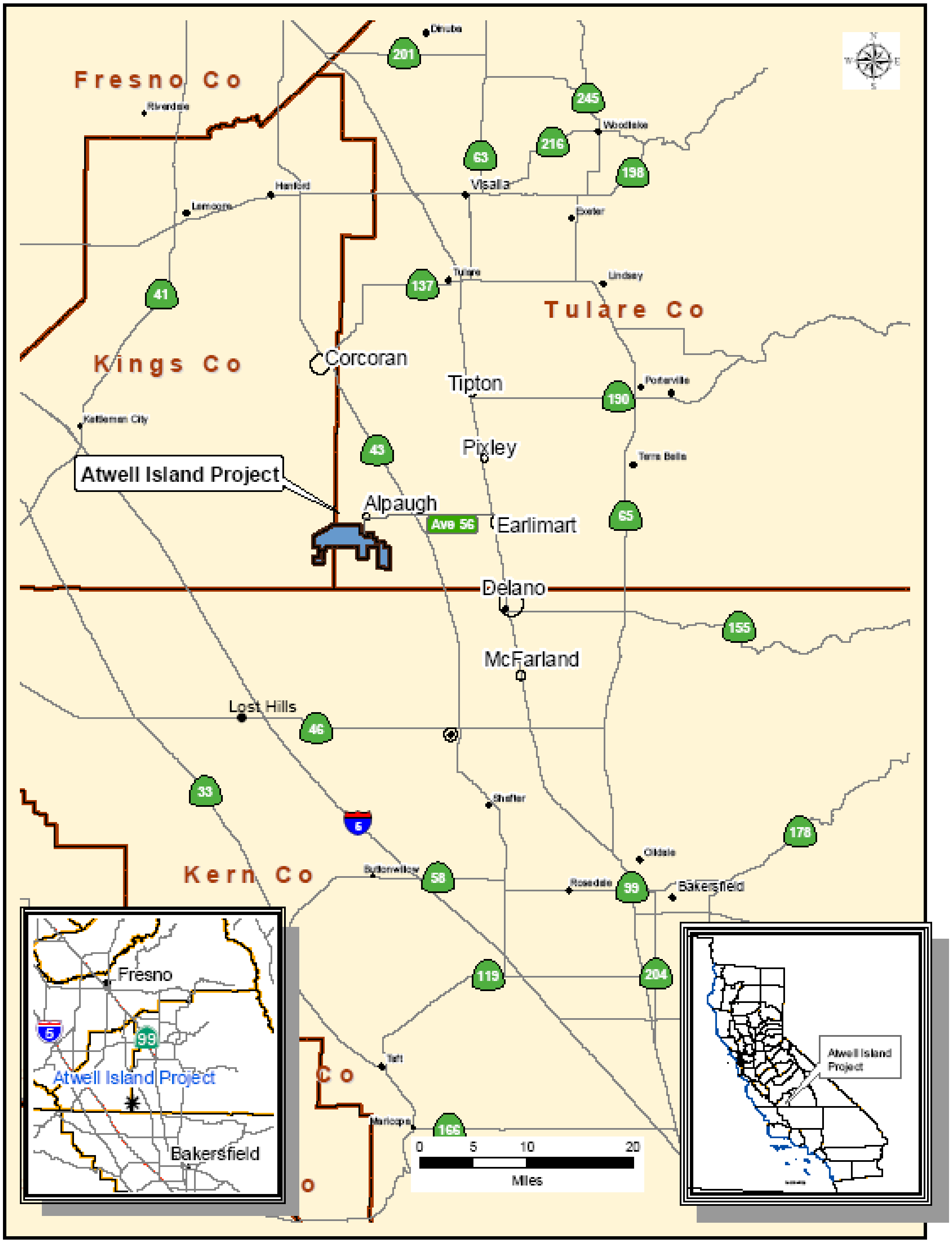

Figure 3-1: Location of Atwell Island Restoration Project

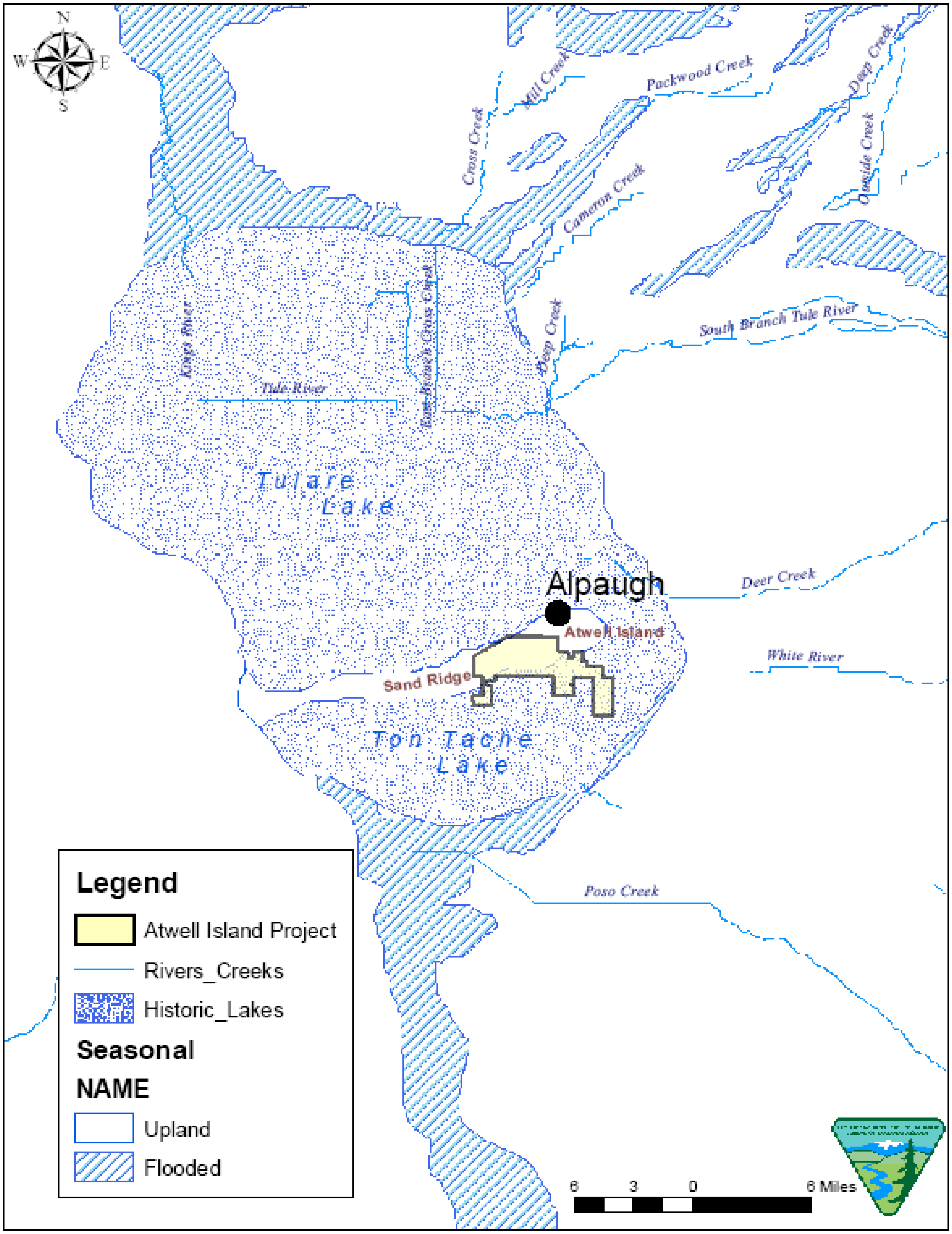

Figure 3-2: Location of the Atwell Island Restoration Project in relation to Tulare Lake and historic Tulare Basin wetlands.

Irrigated agriculture in the lake bottom began as early as 1873. Farmers waited for floodwaters to recede, then built levees and cultivated the rich alluvial soils. Historical records show that the lake was constantly above the 200-foot level until 1880's. Observations of a shrinking lake were recorded as early as 1883, and the lake went dry for the first time in 1900. By the 1920's, all the river water that previously fed Tulare Lake had been diverted for agriculture (Hendrixova 1993).

Early 20th century crop production focused on corn, Sudan grass, sugar beets and squash (Holton 1915). By the 1950s and 1960s, cotton dominated the landscape, until the 1990's when foreign competition made cotton farming unprofitable. Cotton is an intensively managed crop requiring extensive soil preparation, herbicide and pesticide applications, defoliant spraying prior to harvesting, post-harvest tillage and 3-4 acre-feet of irrigation water annually. With the first farmers Alfalfa was an important crop, but became dominant as dairies moved into Tulare County (Mitchell 2006). Dairies first appeared in the Alpaugh area with founding of the Sevilla Colony, circa 1890, and the colony then became the largest dairy in the state (Mitchell pers. com. 2007). Trees and orchards were not grown in the area, because once their roots came in contact with the shallow saline-perched water table, the trees died.

When Alpaugh was founded in 1906, a water system was not established. The first wells drilled in the early 1900s were artesian wells. In 1915, the Alpaugh Irrigation District (AID) was formed under the Wright Act. Like other water districts in the region, AID faced bankruptcy several times over the years. The Atwell Island Water District (AIWD) was formed in 1977 in order to connect to the proposed Cross Valley Canal, which would have run between the Friant Kern Canal and the California Aqueduct, but a connection was ultimately never built. AIWD purchased Class I CVP water until it sold that allocation to the Hill Valley WD, but AIWD is still a contractor to receive Class II CVP water when it is available (Mitchell pers. com. 2007).

Because the Project land lies along the historic Tulare Lake shore, where areas flooded and evaporated over thousands of years, soils are naturally alkaline. Over the past 100 years, farmland reclamation methods were employed including applications of soil amendments, deep tillage and leaching. To address the problem that the perched water table caused to agricultural production, subsurface tile-drain systems were installed in some fields on the western half of the Project to reduce water levels. Drain water was historically evaporated or blended and reused for irrigation. These subsurface tile drain systems have not been operated since 2000.

Recent Atwell Island Land Use

The Atwell Island Restoration Project lands were acquired by BLM and consisted mostly of laser-leveled agricultural fields. One exception is a 360-acre (146 ha) parcel with native habitat that had never been cultivated or leveled. Another 1,000 acres (405 ha) on the western side of the Project, between Poso Canal and Dairy Avenue, has now been out of agricultural production for 30 years and was never leveled, but for several years it was cultivated with grain crops (USDI 1999).

In 2000, when the USBR and BLM began to acquire land for the Project, 4,040 acres (1,649 ha) were being farmed and irrigated (Figure 3-3). More than half (63%) of this irrigated land has been retired over the past 13 years. Today, approximately 1,485 acres (606 ha) is being farmed, primarily with alfalfa (1,295 acres, 529 ha) and oats (*Avena sativa*) (190 acres, 78 ha). Restoration activities have exceeded the 300 acre per year goal and are currently proceeding at approximately 400 acres (163 ha) per year.

The historic cropping pattern in the Project area involved the production of various field and row crops. Cotton was once the major crop, with other fields planted to alfalfa, oats, wheat and safflower; however cotton has not been grown on site since the Project began in 2000. Currently, crops grown on the Project include alfalfa, oats, and a small amount of safflower.

Alfalfa is a perennial crop which is re-seeded every three to five years. Monthly aerial pesticide applications are made for butterfly and moth larvae from June through September, and there is a pesticide application in January to control alfalfa weevil. Alfalfa requires 5-6 acre-feet of irrigation per year. Oats are an annual crop that is seeded in November or December, and in wet years can be grown without irrigation. In dry years, one or two irrigations are required. Oats are harvested in May, the stubble is rough-disked in June, and the soil lays bare for five months until November. No herbicide or pesticide applications are required on oats. Safflower is an annual crop grown on the Project. Fields are pre-irrigated in January, seeded in February, and harvested in July or August. Irrigation requires 1-2 acre-feet per year. The safflower stubble is left until late fall when it is incorporated through tillage.

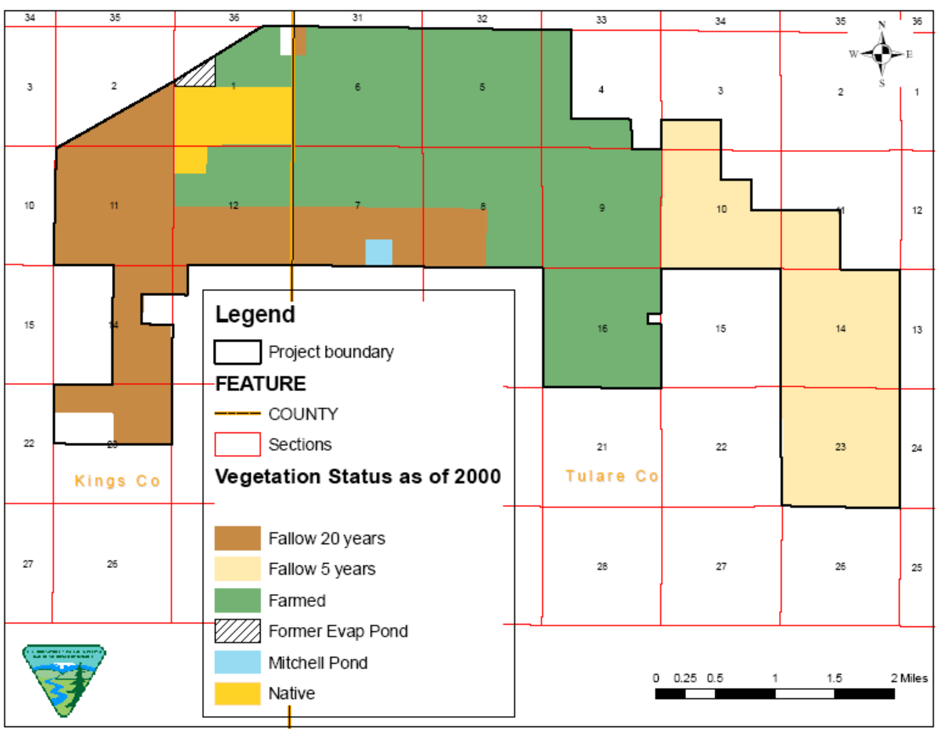

Figure 3-3. Atwell Island Restoration Project land-use patterns at project initiation in 2000.

Project Site Characteristics

The Atwell Island Restoration Project is located in the center of the Tulare Basin. This region has a Mediterranean climate with annual precipitation of 7 inches/year, classifying it as a desert. In addition to the climate constraints, there are numerous other environmental factors typical of arid ecological regions - including geology, hydrology, soils and invasive plant species – that provide several challenges to the restoration practitioner.

Climate

The Meditteranean climate of the Atwell Island region is characterized by low rainfall, falling primarily between November and April; long hot summers with high temperatures in the 90s and 100s; and cool winters - often with persistent tule fog and sometimes with low temperatures below freezing. Weather data for the area comes from a variety of sources. In Alpaugh, resident George Pryse collected rainfall data from 1953 to 1990. Precipitation, temperature, and wind data have been collected at the National Weather Service station #42, located near Wasco, approximately 20 miles (32 km) southeast of the Project from 1948 to the present. Weather data was collected at Angiola, approximately six miles north of Alpaugh, from 1948 to 1980. In July 2006, a California Irrigation Management Information System (CIMIS) weather station was established on the Project near the Mitchell Farm Headquarters (USDI 2005). The data from the Wasco and Angiola stations are available on the Western Region Climate Information website at http://www.wrcc.dri.edu.

Analysis of the 62 years worth of available weather data for the Project shows that the average rainfall for the area is 7.27 inches, with an all-time high of 17.53 inches in 1997-98 and an all-time low of 2.36 in 2006-07. (Figure 3-4) As is typical in California, the Project has more years with below average rainfall than above, with 36 years (58%) below average and 26 years (42%) above average. Precipitation has been below average for six of the 10 years of the Project (2000 to 2010), near normal in two years, and above normal in two years.

In addition to overall low precipitation levels, the rainfall pattern over the rainy season is unpredictable, with even the wettest years having dry periods of a month or more. Annual rainfall patterns show that January is the wettest month, followed in descending order by February, March, December, November, April, October, May, and September. June, July and August average less than 0.10 inches of rainfall, and July is the driest month (Figure 3-5).

The average yearly temperature at the Project CIMIS station (installed in 2006) is 61.1^{o} F (16.2^{o} C). In January, the average high temperature is 58.2^{o} F (14.6^{o} C) and the average low is 29.0^{o} F (-1.7^{o} C). In July, the average high temperature is 98.0^{o} F (36.7^{o} C) and the average low is 61.9^{o} F (16.6^{o} C). The area has an extremely high evapotranspiration (ET) deficit. Over the past three years ET has averaged 59.7 inches (151.6 cm) while precipitation has averaged 3.42 inches (8.7 cm).

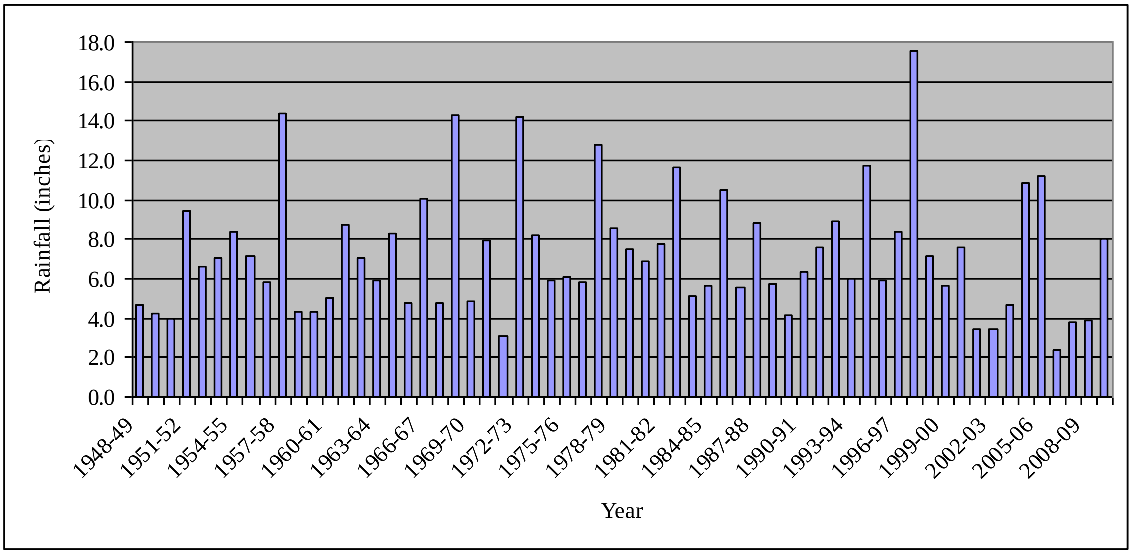

Figure 3-4. Yearly variation in rainfall at Atwell Island: 1948 – 2010.

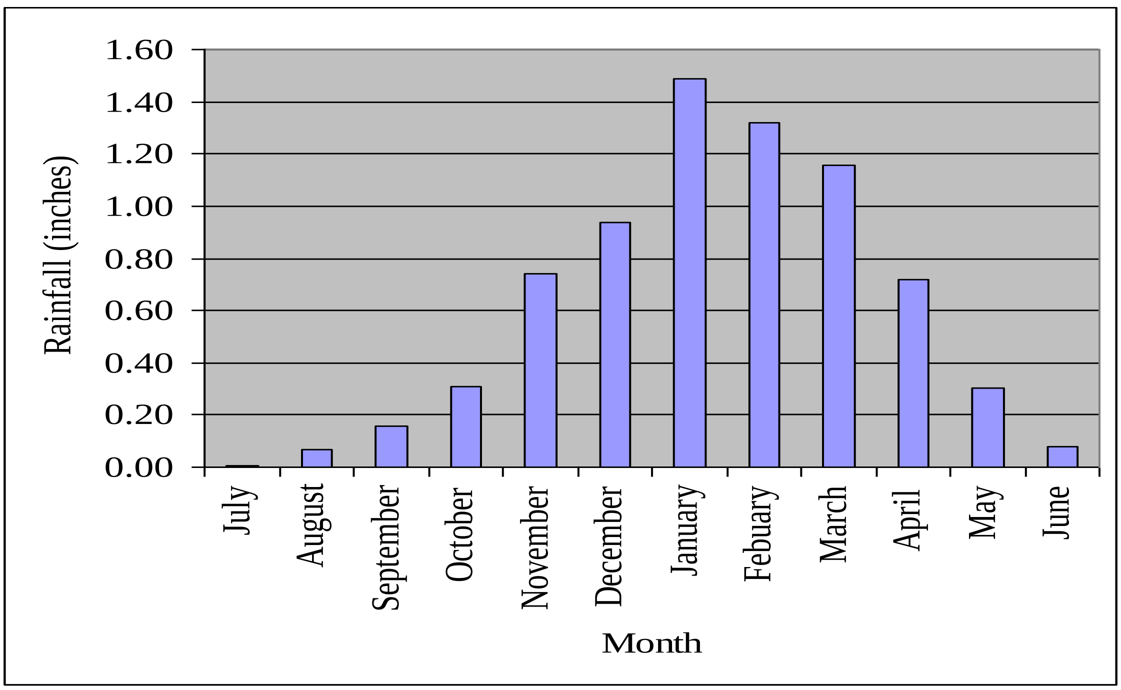

Figure 3-5. Atwell Island average monthly rainfall.

From a restoration standpoint, the variations in temperature on the Project do not appear to be as critical to successful plant establishment as annual variations in precipitation. The relative small amount of rainfall received requires the selection of native species that are extremely tolerant of variable, low-moisture conditions.

Geology

The Atwell Island Restoration Project is situated in the Tulare Basin, on the southeastern margin of the Tulare Lake bed, the dominant geologic feature in the region (Figure 3-2). The Tehachapi Mountains form the southern Tulare Basin boundary, while coalescing alluvial fans from Los Gatos Creek and the Kings River form the northern boundary. The Basin is a subsidence basin characterized by a broad structural trough on its west and south sides. Lakebed and marsh deposits in excess of 3,600 feet (1,088 m) underlay the site and are derived from the Coast Ranges and the Sierra Nevada sediments, primarily of clay and silt, with some sand (Page 1986). The historic lakebed dates back 2,000,000 years or more, and fluctuated dramatically in size, once occupying most of the San Joaquin Valley. The natural drainage in the Project is generally to the southeast with ground surface elevations ranging from about 203 feet (63 m) above mean sea level (msl) in the southeast portion of the site to about 217 feet (67 m) above msl in the northwestern portion of the site. The pronounced sand ridge, at 208 to 217 feet (63-66 m) elevation, traverses the center of the Project site in a northeasterly to southwesterly orientation. It became an island during years of above-normal precipitation, and formed the southeastern shore of Tulare Lake and the northwestern shore of Ton Tache Lake at lower lake levels. The elevation of the maximum water level of Tulare Lake in historic times was approximately 208 feet (63 m) above sea level. At present, all the hydrologic influence on the Project originates in the Sierra Nevada.

The Project area is underlain by Corcoran clay, a lake bed deposit of fine textured, low permeability clay ranging from 15 to 900 feet (5 to 272 m) below the soil surface, dividing the groundwater flow system into an upper semi-confined aquifer and a lower confined aquifer. The semi-confined aquifer in the Tulare Basin contains four distinct hydrogeologic units: coast ranges alluvium, Sierran sand, flood basin deposits, and Tulare Lake bed deposits in the center of the basin. These units all differ in texture, hydrologic properties and oxidation state. The unique Sand Ridge on the site is a fine-grained, wind-blown relict sand dune deposit up to 10 feet (3.3 m) in depth, derived from the former shoreline of the Tulare Lake bed (USDI 1999).

Groundwater Resources

Depth to useable groundwater in the Project area is extremely variable, standing at approximately 200 feet (60 m) below land surface in wet years at the beginning of the irrigation season, and at 400 feet (120 m) below land surface at the end of the growing season in dry years. Wells are typically dug to 1,200 feet (363 m), with perforation between 800 to 1,200 feet (242 to 363 m), and generally produce between 200 and 400 gallons per minute (757-1,514 L min^{-1}) (Smith 2001). Ground water quality and quantity are better as one proceeds east and south on the Project. The northwestern portion of the project has no reachable aquifers, as evidenced by several dry wells recently drilled just north of the western portion of the Project.

Perched Groundwater Levels

When water enters the upper aquifer faster than it percolates through the underlying Corcoran clay, it forms a perched water table. This occurs during flood events and when multiple applications of irrigation water are made. Areas in the Tulare Basin with a perched water table within 5 feet (1.8 m) of the land surface expanded from 119,000 acres (48,571 ha) in 1991 to 301,000 acres (122,857 ha) in 1997. By ceasing irrigation, the primary source of recharge to the shallow aquifer system is terminated and the water table declines (USDI 1999). The water table is generally nearest to the land surface in the northwest portion of the Project and becomes deeper to the southeast. The perched groundwater underlying the Project site is moderately saline in nature and is a result of irrigation leaching the saline soil profile (USDI 2005).

Retiring land from irrigated agriculture has proven successful at lowering the perched water table. Where irrigation has ceased, the shallow water table has declined in response. Project seasonal high water levels measured during 2002 dropped to 7 to 8 feet (2.5-2.9 m) below land surface, a decline of 2-3 feet (about 1 m). Irrigation of high water use crops such as alfalfa is being phased out as restoration of native upland vegetation progresses (USDI 2005).

Surface Water

Surface watercourses within the Project consist primarily of irrigation supply canals and irrigation return flow ditches. Shallow ephemeral surface water ponds may form on low-lying portions of the site due to localized sheet flow run-off during prolonged winter storm events. The areas surrounding the Project site receive periodic unregulated winter storm flows from Deer Creek, Poso Creek, and White River. The central portion of the site (i.e., Sand Ridge) is not subject to long-term flooding, due to its higher topographic position. Although no flooding has been observed on the eastern portion of the site during this study, these lands are subject to periodic flooding due to topography and proximity to Poso and Deer Creeks (USDI 2005).

Soils

Soils are the basis for the formation of plant communities and restoration activities. Soil texture, structure and chemistry dictate the selection of appropriate plant species for restoration. Project soils range from fine, windblown sand to those with high clay content. The majority of Project acreage consists primarily of silt and sandy loams surface textures, formed from alluvium derived from igneous and sedimentary rocks. Silty clay loam soils are also present in the southeast portion of the site. The primary U.S. Department of Agriculture soil mapping units are: Excelsior, Houser, and Lethent fine sandy loams; Lethent, Nahrub, Posochanet, and Westcamp silt loams; Sandridge loamy fine sand; Excelsior sandy loam, and Westcamp loam (USDI 2005; USDA 2002) (Figure 3-6, Table 3-1).

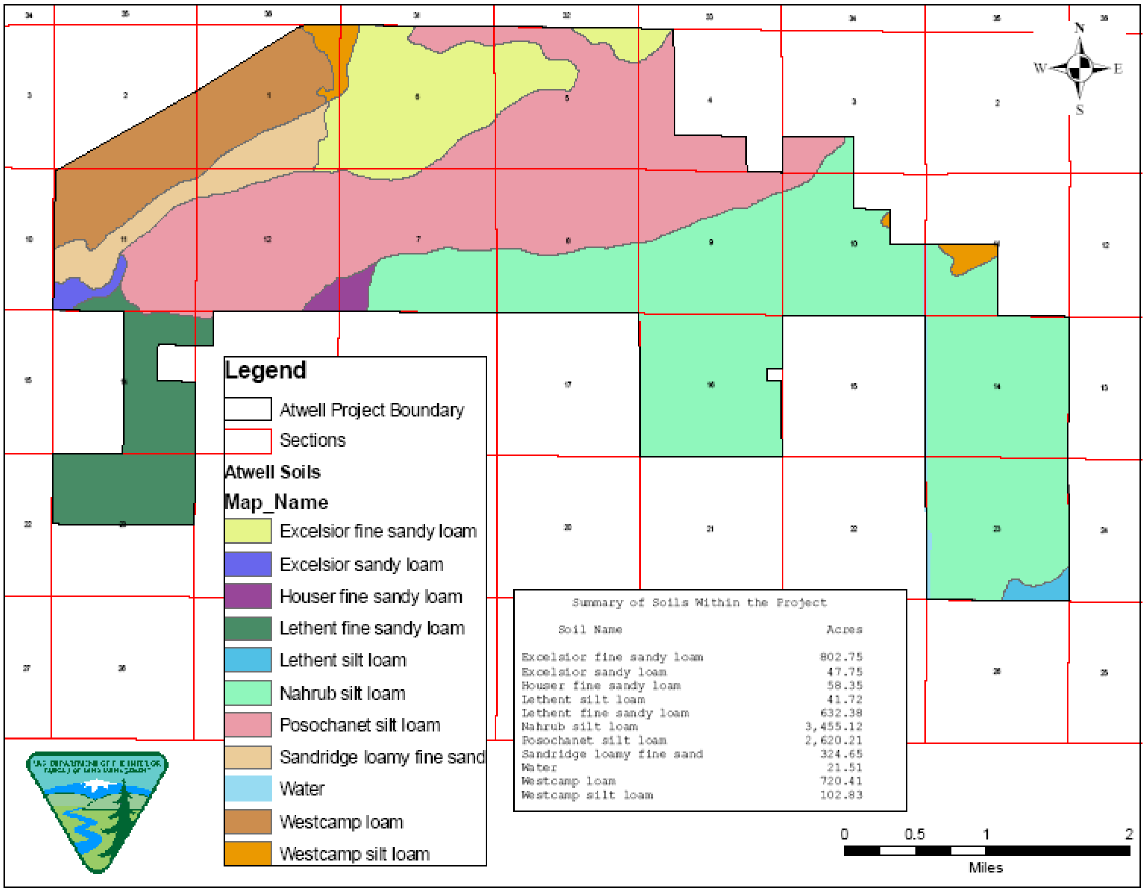

Figure 3-6. Atwell Island Restoration Project soil map.

The arid soils on the west side of the Tulare Basin contain substantial amounts of naturally occurring soluble salts. Additional buildup of salts in the soil from irrigated agriculture can adversely affect plant productivity. Soil chemistry data from the Project indicate that the surface soils (0-12 inch [0 to 30 cm] depth) are moderately to highly saline. Soil selenium concentrations are relatively low for both soluble and total selenium (USDI 2005). Moderate concentrations of boron have been detected within the first 12 inches (30 cm) from the soil surface, but increase sharply below that depth, at 2-3 feet (0.6-1.0 m) depth reaching concentrations that may be phytotoxic to most crop plants, especially cotton. Native species chosen for restoration need to tolerate both boron and soil salinity. A declining perched water table in response to land retirement will lessen the likelihood of future salinization of surface soils. Winter precipitation gradually leaches out excess salts in the 0 to 30-inch (0-76 cm) active root zone if the water table is lowered to more than 12 feet (3.7 m) (USDI 2005).

Table 3-1: Generalized series descriptions for primary soils within the Atwell Island Restoration Project area (USDA 2002).

Soil Type	Characteristics	Acres in Project	Salinity Ranges (dS m^{-1})	Permeability /Erosion Potential
Excelsior fine sandy loam	Very deep, fine sandy loam alkaline soils.	803	0-8 upper, 2-16 lower	Well drained, moderately rapid permeability, very slow runoff, high potential for wind erosion when sparsely vegetated.
Excelsior sandy loam	Very deep, sandy loam alkaline soils, well drained.	48	0-8	Well drained, moderate to slow permeability
Houser fine sandy loam	Fine sandy loam or silty clay; alkaline and sodic	58	> 16	Moderately drained.
Lethent fine sandy loam	Saline, alkaline, very deep	632	> 16	Moderately well drained, slow permeability.
Lethent silt loam	Saline, alkaline, very deep	42	> 16	Moderately well drained, slow permeability.
Nahrub silt loam	Mixed alluvium from granitic rocks. Very deep.	3,445	1-16 upper, 8-30 lower	Somewhat poorly drained, very slow permeability, slow surface runoff.
Posochanet silt loam	Saline, alkaline, very deep. Silty clay loam & silty clay.	2,620	4-8 upper portion, 4-30 lower	Moderately well-drained, slow permeability, slow surface runoff.
Sandridge loamy fine sand	Loamy fine sand, loamy sand, or sand on basin rim	325	Slightly acid to strongly alkaline	Excessively drained soils formed in wind-blown deposits, very slow runoff, moderately rapid permeability.
Westcamp loam	Saline, alkaline, very deep with perched water table	720	2-16	Somewhat poorly drained, very slow permeability
Westcamp silt loam	Saline, alkaline, very deep with perched water table	103	2-16	Somewhat poorly drained, very slow permeability.

Invasive Species

Atwell Island Restoration Project restoration sites are former agricultural fields that were farmed for 50 to 100 years. Whenever farming activities cease, annual weeds quickly colonize the site during the next growing season. Weeds are a major problem for restoration efforts, and can out compete native plant species for water, nutrients and sunlight. Efforts are being made to minimize the total, long-term weed control workload, to limit new infestations and to contain the spread of plants with expanding ranges.

Weed species that can immediately encroach upon restoration sites are:

- annual broadleaf weeds (e.g., five-hook bassia (*Bassia hyssopifolia*), mustards (*Brassica spp.),* non-native Atriplex spp. and Russian thistle (*Salsola tragus*))
- annual grasses (e.g., *Bromus, Avena, Phalaris and Vulpia spp.*)
- perennial grasses (e.g., Bermuda grass (*Cynodon dactylon*))

Weed species are dependent upon the previous field crop history. Alfalfa fields are colonized initially by Bermuda grass and non-native forbs (broadleaf herbs). Grain fields typically are colonized by five-hook bassia and a variety of non-native annual grasses (e.g., red brome (*Bromus madritensis* ssp. *rubens*), ripgut brome (*Bromus diandrus*) and oats (*Avena* spp.)). If native species are not quickly established, these grasses can become predominant.

Herbaceous broadleaf annuals such as five-hook bassia and Russian thistle can form dense stands on some sites. Some of these annuals, especially Russian thistle, become "tumbleweeds" that break off from their base as they begin to senesce, and distribute their seeds as they are blown across the landscape. These plants do not degrade easily and can form a dense cover of stems of the previous year's plants that limit other species' germination.

Targeted Habitats

Prior to agriculture, the upland portions of the Project would have consisted of habitat series dominated by herbaceous plants and shrubs. When BLM acquired the Project site, most of the area was laser-leveled agricultural fields. A few parcels were native lands that had never been cultivated or leveled, including a 360-acre parcel (150 ha) in Section 1 (Figure 3-3) known as the "Pasture". Approximately 1,000 acres (408 ha) on the western side of the Project between Poso Canal and Dairy Avenue were enrolled in the Conservation Reserve Program in 1988 and had not been farmed for 20 years prior to acquisition by the Project (now 30 years). This area was previously cultivated with grain crops, but had not been leveled (USDI 1999).

The Project's long–term management goal for upland habitats, after establishment of native vegetation on restoration sites, is to maintain ecosystem health, native grassland and shrub communities, an open habitat structure for special status species and suitable vegetation structure using low intensity management techniques.

Plant Communities at Atwell Island

In its current state, the lands at the Project are dominated by five upland habitat series, two wetland habitat series, and one agricultural habitat series. The five upland habitat series are those described by Sawyer and Keeler-Wolf (1997) and currently utilized by California Department of Fish and Game for their Conceptual Area Project Plans and Tulare Basin Wildlife Partners in the Sand Ridge Tulare Lake Conservation Plan (2006). The agricultural and wetland series are those described by Holland (1986). Each of these habitats and their occurrence within the project are shown on Figure 3-7.

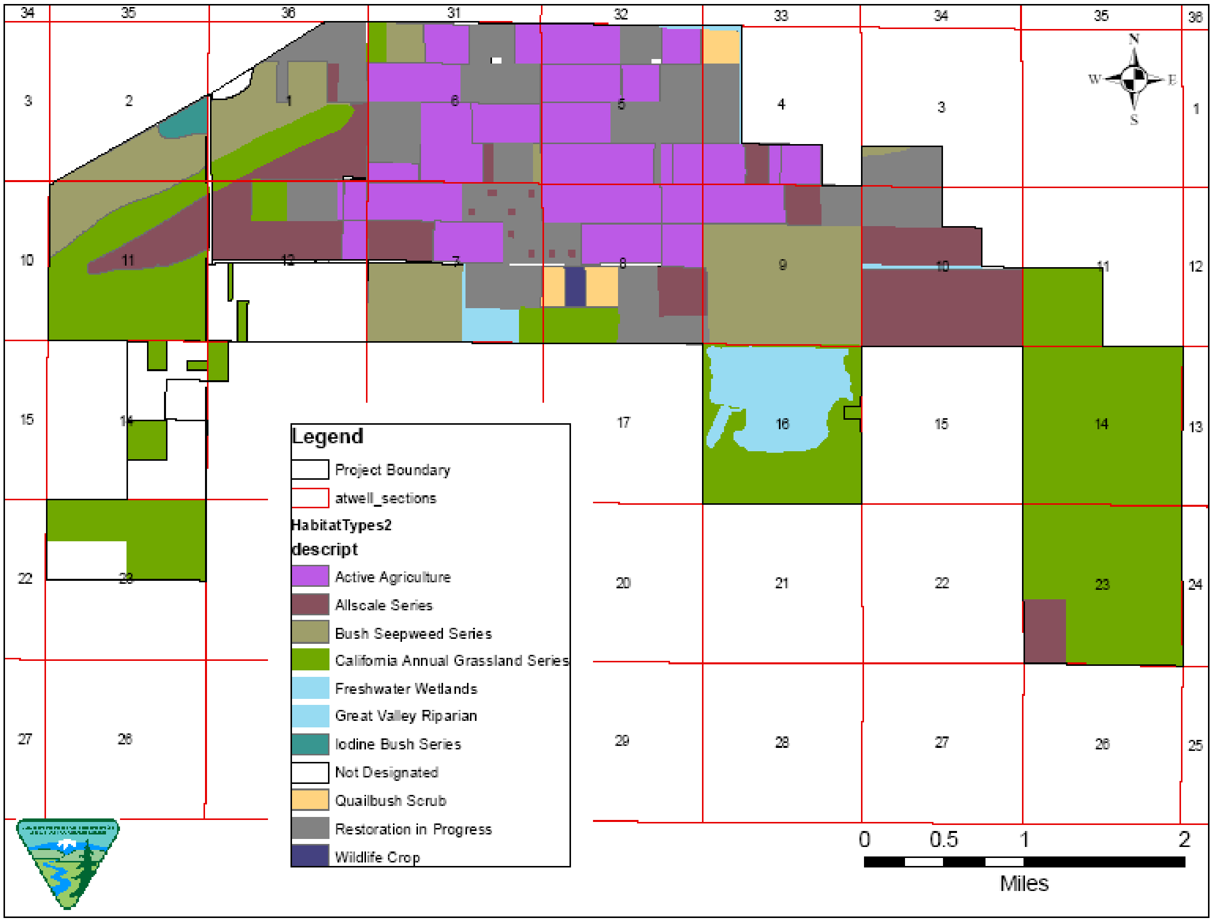

Figure 3-7. Existing habitats on Atwell Island Restoration Project in 2010.

Upland Habitat Association

Upland habitats are currently composed of sites (Figure 3-3) that:

- *Have never been farmed (approximately 360 acres; 150 ha)*
- *Have not been farmed for 20 to 30 years (approximately 3,000 acres; 1,225 ha)*
- *Have undergone restoration during the past eight years (approximately 3,088 acres; 980 ha)*
- *Are currently being farmed (approximately 1,600 acres; 653 ha)*

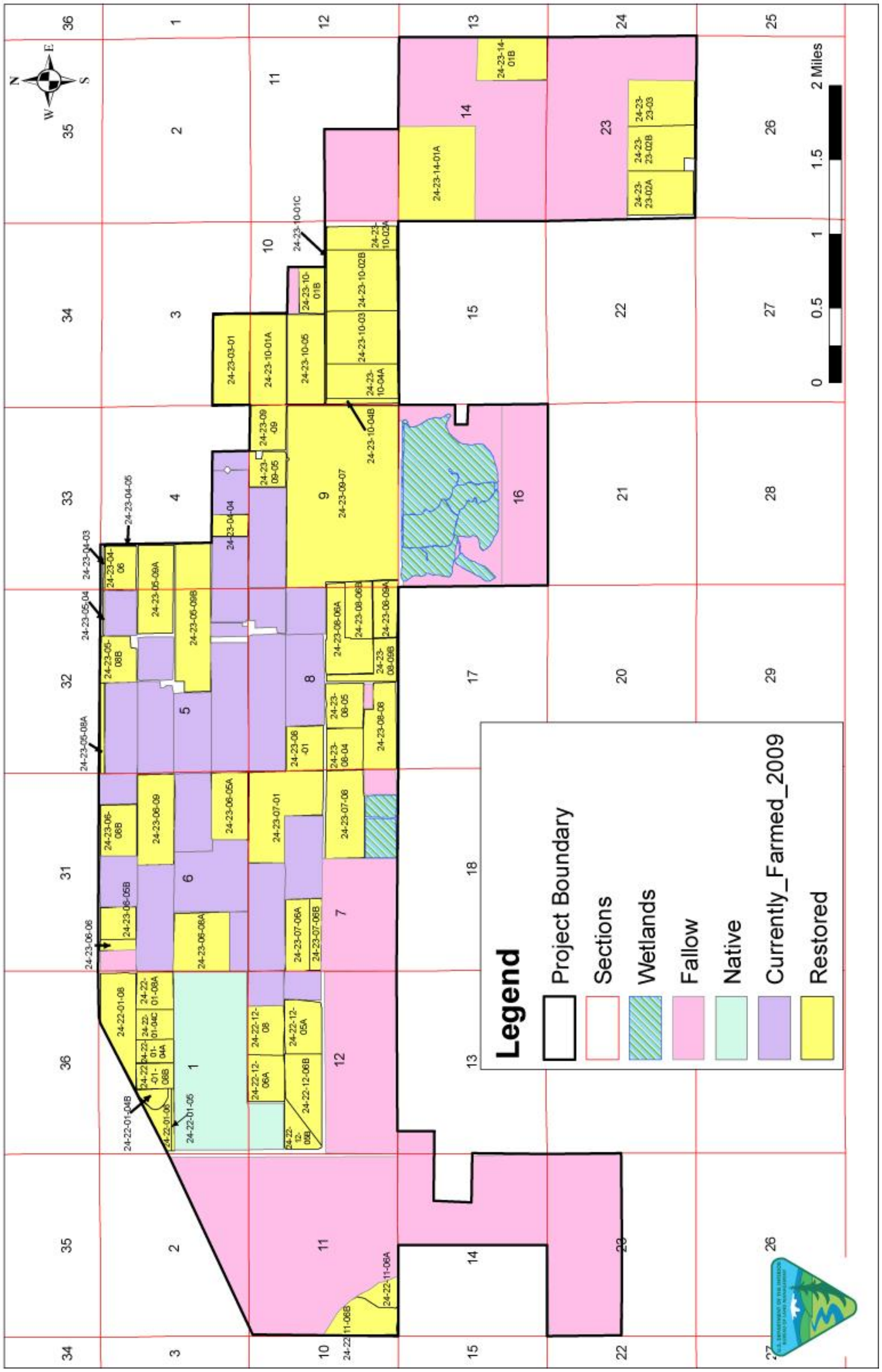

Figure 3-8. Restoration sites, farmed areas, and fallow sites on Atwell Island Restoration Project Summer 2010.

The primary upland habitat series on the Project are described below. Scientific and common names utilized in this report are from the 1993 version of The Jepson Manual (Hickman 1993).

California Annual Grassland

This upland habitat covers much of the unfarmed and unrestored areas on the Project. Its condition varies from field to field, with some fields having a substantial proportion of native vegetation, and others with almost no native vegetation. The dominant plants are a mix of native and introduced annual grasses and herbs: ripgut brome, red brome (*Bromus madritensis* ssp. *rubens*), soft chess (*Bromus hordeaceus*), slender wild oat (*Avena barbata*), wild oats (*Avena fatua*), hairy rattail fescue (*Vulpia myuros* var. *hirsuta*), California goldfields (*Lasthenia californica*), broadleaf filaree (*Erodium botrys*), California poppy (*Eschscholzia californica*) and purple owl's-clover (*Castilleja exserta*). Grasses are typically less than 2 feet in height, and the canopy is continuous to open. Restoration of this series is difficult because of the highly competitive ability of the non-native annual species. The quality of degraded habitat in this series for targeted state and federally-listed Threatened and Endangered (T and E) wildlife recovery species [i.e.: blunt-nosed leopard lizard (*Gambelia sila*), Tipton kangaroo rat (*Dipodomys nitratoides* ssp. *nitratoides*) and San Joaquin kit fox (*Vulpes macrotis mutica*)] can be improved by using a combination of proper grazing and prescribed burning treatments.

Saltbush Scrub

Allscale Series

This series is an upland habitat on old beach and lake deposits, alluvial fans and rolling hills where the soil is carbonate-rich or sandy. These sites are dominated by allscale (*Atriplex polycarpa*), bladderpod (*Isomeris arborea*), alkali goldenbush (*Isocoma acradenia*) and saltgrass (*Distichlis spicata)*. Shrubs are less than 6 feet (2 m) in height and have a continuous to open canopy. Stands of this series are located on the Project only where they have been successfully reintroduced. This habitat is relatively easily restored and restoration techniques have been developed that succeed under most conditions. There is ample opportunity for significant restoration of this habitat on the Project.

Quailbush Series

This series is dominated by quailbush (*Atriplex lentiformis*). There are a few existing stands of this habitat on the Project. The canopy is less than 9 feet (3 m) in height and generally found in small stands at the borders of managed fields and intermittently flooded wetlands, usually in association with annual grasses and non-native herbs. Restoration techniques for this habitat type are well understood and the opportunities for restoration along the water distribution channels in developed wetland areas are great.

Alkali Sink

Seepweed Series

This series is a wetland habitat that is intermittently flooded or saturated with saline water, and is generally found on old lakebeds or playas. These habitat sites are dominated by bush seepweed (Suaeda moquinii), alkali heath (Frankenia salina), alkali sacaton (Sporobolus airoides), allscale, spiny saltbush (Atriplex spinifera) and iodinebush (Allenrolfea occidentalis). Shrubs are less than 4.5 feet (1.5 m) in height and generally have an open canopy. Significant patches of Seepweed are on the Project, and this habitat is relatively easy to restore. Tipton kangaroo rats and California horned lizards (*Phrynosoma coronatum frontale*) have colonized restoration sites having this habitat within a year of restoration seeding. Many opportunities for restoration of this habitat are located within the Project area.

Iodinebush Series
This wetland habitat is intermittently flooded or saturated with hyper-saline water. It is found in dry lakebeds, lake margins, hummocks and seeps. Several existing stands of this habitat remain on the Project. Iodinebush, alkali heath, alkali sacaton, seepweed and saltgrass dominate these sites. The shrubs are less than 4.5 feet (1.5 m) in height and have a continuous to open canopy. Restoration techniques for this habitat type are being developed with some success. Iodinebush appears to only reproduce when this habitat is flooded during the appropriate season.

Active Agriculture

This habitat does not occur naturally, but consists of fields with cultivated agricultural crops, such as irrigated alfalfa or dryland grain.

Fallow Agriculture

This habitat occurs on formerly cultivated, often laser-leveled, agricultural fields that are currently in a weedy fallowed condition. As fields are taken out of production on the Project, efforts are made to restore the land and not allow a field to fallow.

Existing Reference Sites

There are few places remaining in the Tulare Basin where the historic upland ecosystems are intact and can be used as reference sites. The best reference sites for the Atwell Island Restoration Project are the following:

On-Site Project Areas
The 360-acre (150 ha) pasture in Section 1 that has never been farmed. This site has areas of California Annual Grassland Series, Allscale Series and Seepweed Series habitats (Figure 3.7).

Off-Site Project Areas
Center for Natural Lands Management's (CNLM) Semitropic Ridge Preserve; California Department of Fish & Game's Allensworth and Semitropic Ecological Reserves; and FWS's Pixley and Kern National Wildlife Refuges. The same habitat series are found on these sites with the addition of fresh water wetlands (Figure 3-9).

None of these sites, with the exception of the 360-acre pasture located within the Atwell Island Restoration Project, are in an identical setting to restoration sites on the Project area.

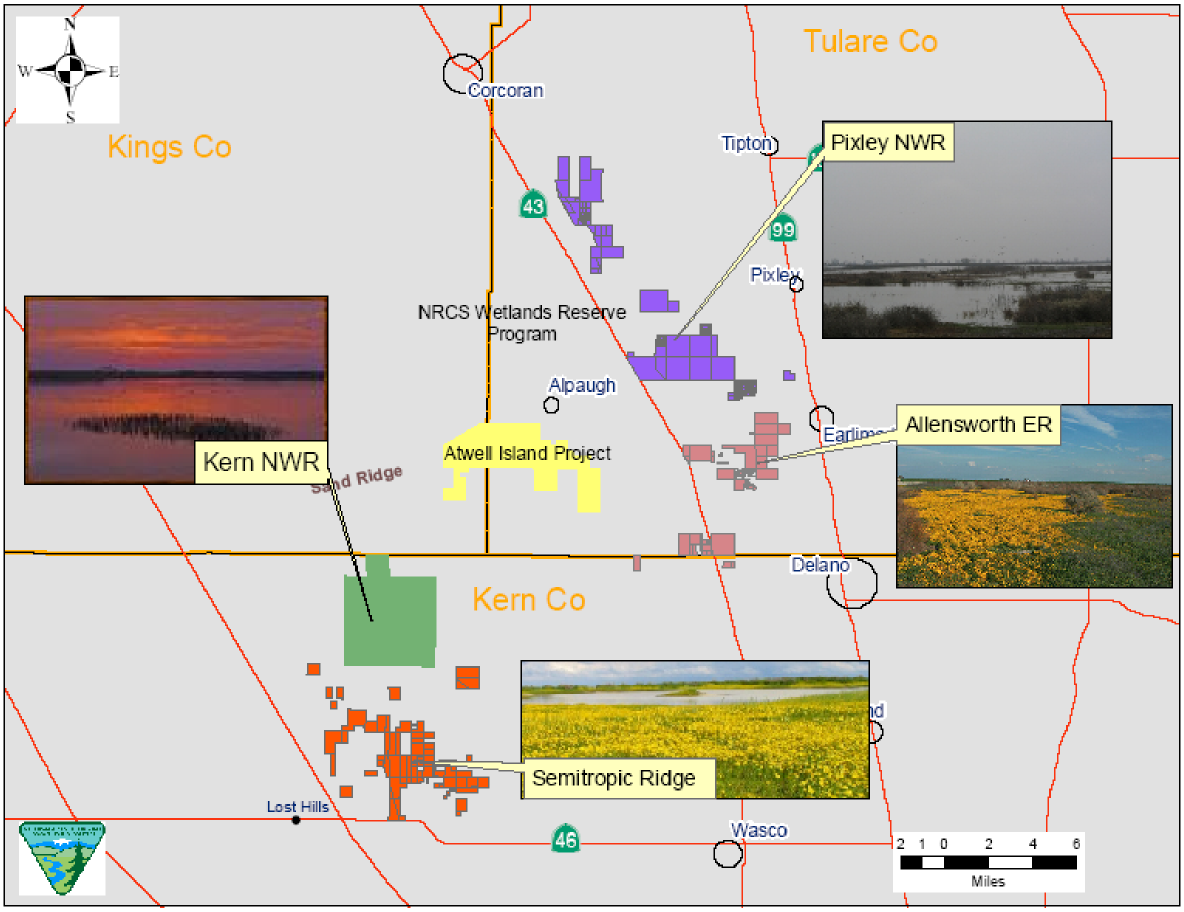

Figure 3-9. Atwell Island Restoration Project habitat reference sites.

Chapter 4. Upland Restoration Implementation

Atwell Island Restoration Studies and Experiments (Planted 2000-2003)

Habitat Restoration Study (HRS) Plots (Planted 2000, Monitored Through 2006)

This initial restoration study was implemented at Atwell Island by the California State University Stanislaus Endangered Species Recovery Program (ESRP), in cooperation with the Land Retirement Program. The experiment was designed to test the effects of seeding, micro-topographic relief (small berms, approximately 18 inches in height) and a combination of the two techniques. Three 160-acre study blocks were established and within each block there were 16 two-acre plots for a total of 48 study plots. Thirty-six plots received one of three treatments (12 plots for each treatment) and there were also 12 control plots. Treatments were as follows:

- 12 plots - seeded with no berms (NR)
- 12 plots - seeded with berms (CR)
- 12 plots - not seeded with berms (CN)
- 12 plots – control with no seed or berms (NN)

In order to isolate the study plots, buffers consisting of sterile barley were planted around the plots. The seed planted was commercially available and was purchased from S&S Seed Company. Only two species were of San Joaquin Valley origin, the remaining species were from outside the Tulare Basin, primarily from Riverside County. The seeded plots were planted using an imprinter in December 2000 with a seeding rate of 16.6 pounds/acre (lbs/acre). The seeding mix was:

- Iodine bush (*Allenrolfea occidentalis*) – 2 lbs/acre
- Allscale (*Atriplex polycarpa*) – 2 lbs/acre
- Spiny saltbush (*Atriplex spinifera*) – 1.5 lbs/acre
- California brome (*Bromus carinatus*) – 3 lbs/acre
- Alkali heath (*Frankenia salina*) – 0.5 lbs/acre
- Alkali heliotrope (*Heliotropium curassavicum*) – 0.5 lbs/acre
- Spikeweed (*Hemizonia pungens*) – 0.1 lbs/acre
- Goldenbush (*Isocoma acradenia*) – 1 lbs/acre
- Goldfields (*Lasthenia californica*) – 0.5 lbs/acre
- Creeping wildrye (*Leymus triticoides*) – 2 lbs/acre
- Alkali sacaton (*Sporobolus airoides*) – 1 lbs/acre
- Bush seepweed (*Suaeda moquinii*) – 0.5 lbs/acre

- Pacific fescue (*Vulpia microstachys*) – 2 lbs/acre

Each plot was monitored at 12 randomly chosen locations using a Daubenmire frame each spring from 2001 to 2002 by ESRP and 2003 to 2006 by BLM. The results of the ESRP monitoring are presented in ESRP reports (Uptain et. al. 2002 and Uptain et. al. 2004). The results presented in this report are from spring 2003 through spring 2006.

In 2003 monitoring, plots on Blocks 2 and 3 had very little native vegetation. There were no shrubs established on any of these study plots. The only deliberately planted native species found was goldfields (*Lasthenia californica*), which was found only at very low density (five of 16 plots in Block 2 and two of 16 plots in Block 3). Native forbs that were not planted, Rancher's fireweed (*Amsinkia menziesii*) and California mustard (*Guillenia lasiophylla*), were recorded on Block 3 in good numbers (16 of 16 plots and 15 of 16 plots respectively). In Block 2, these species were also found, but in much reduced numbers, with rancher's fireweed on 6 of 16 plots and California mustard on two of 16 plots. Blocks 2 and 3 were only monitored through 2003 because of the lack of response to restoration plantings.

In Block 1, monitoring was continued on the plots through spring 2006. Several patterns emerged from the monitoring data. Most importantly, native shrubs and forbs were only found on the eight plots that were planted and none were found on the eight control plots. This demonstrated how only small amounts of native seed remained in the seed bank, and showed that seeding is necessary if sites are to be restored within a reasonable timeframe (Figure 4-1 and Figure 4-2).

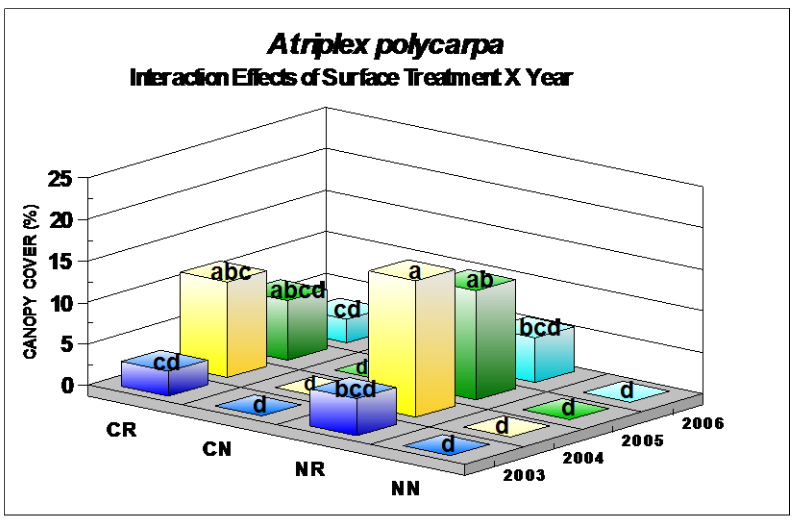

Figure 4-1. Example of a shrub, allscale (Atriplex polycarpa), found only on seeded plots (NR & CR). CR is contoured and seeded, CN is contoured and not seeded, NR is not contoured and seeded and NN is control and is not contoured or seeded. Letters a, b, c, and d refer to data that is not discussed in this report and should be ignored.

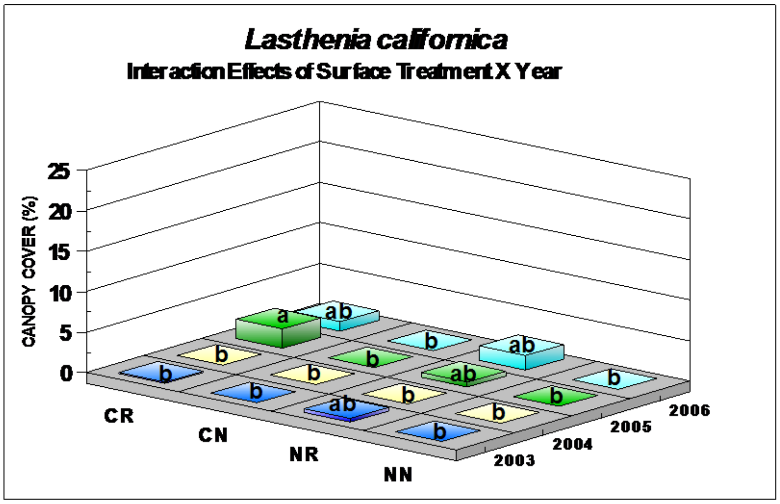

Figure 4-2. Example of a forb, California goldfields (*Lasthenia californica),* found only on seeded plots (NR & CR). CR is contoured and seeded, CN is contoured and not seeded, NR is not contoured and seeded and NN is control and is not contoured or seeded. Letters a, b, c, and d refer to data that is not discussed in this report and should be ignored.

Additional patterns demonstrated that weed pressure and weed species differed from year to year. In 2003, prickly lettuce (*Lactuca serriola*) was fairly common, but was nearly absent from the sites during 2004, only to return in higher density during 2005 and 2006 (Figure 4-3). Furthermore, London rocket (*Sisymbrium irio*) was at very low density on the site from 2003 to 2005, but was the dominant plant during 2006 (Figure 4-4).

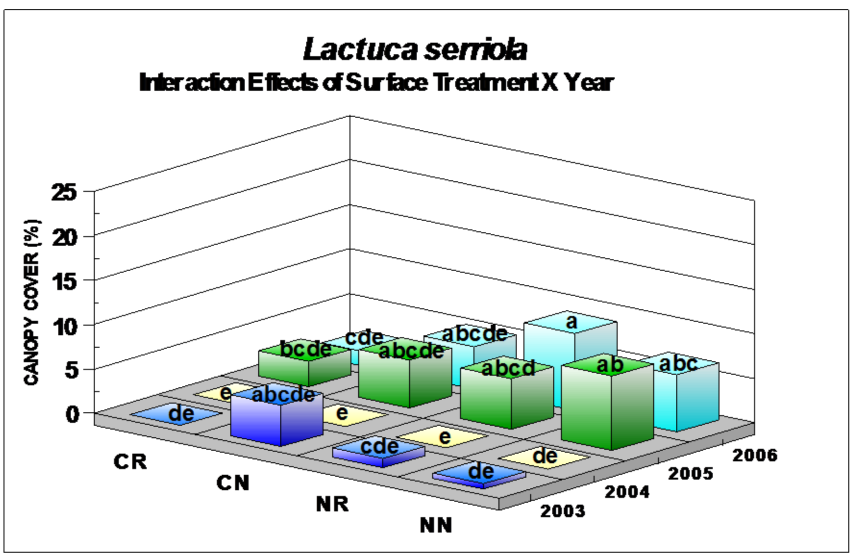

Figure 4-3. Yearly differences in prickly lettuce (*Lactuca serriola*) on HRS plots.
CR is contoured and seeded, CN is contoured and not seeded, NR is not contoured and seeded and NN is control and is not contoured or seeded. Letters a, b, c, and d refer to data that is not discussed in this report and should be ignored.

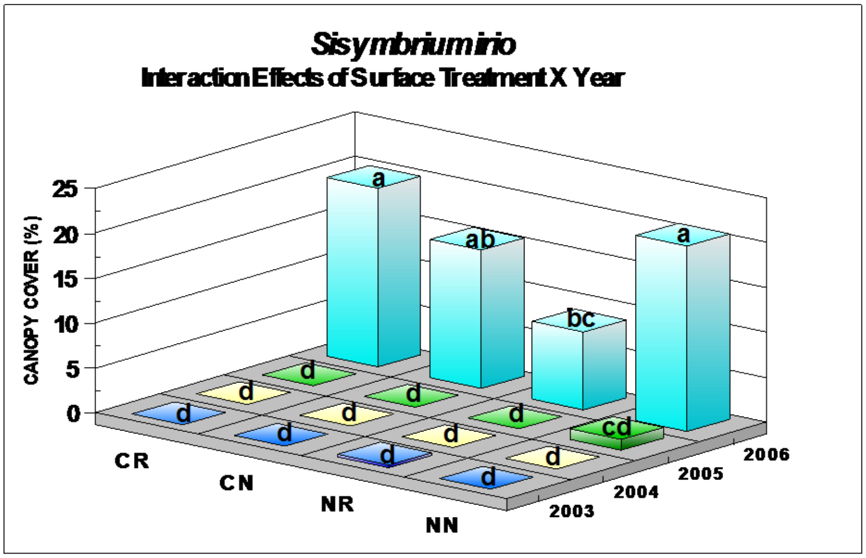

Figure 4-4. Yearly differences in London rocket (*Sisymbrium irio*) on HRS plots.
CR is contoured and seeded, CN is contoured and not seeded, NR is not contoured and seeded and NN is control and is not contoured or seeded. Letters a, b, c, and d refer to data that is not discussed in this report and should be ignored.

Of the 13 species in the planting mix seven species (spiny saltbush, California brome, alkali heliotrope, goldenbush, creeping wildrye, alkali sacaton, and Pacific fescue) were not detected during monitoring of the HRS plots. Creeping wildrye and alkali sacaton only occur in moister areas in the Tulare Basin and were not good choices for the seed mix. Spiny saltbush and alkali heliotrope often have low viability and are not easily reestablished. Of the seven species that were not detected, only goldenbush has since proven to be a useful restoration species in this study area.

Six species (iodine bush, allscale, alkali heath, spikeweed, goldfields and bush seepweed) of the 13 species planted on the plots were detected on the HRS plots during monitoring. Iodine bush was found on only one of eight seeded plots, and was detected only during (2004). Alkali heath was detected on two of eight plots, but was only found during 2004. The remaining four species were more successfully established. California goldfields were found on four to six plots, depending on the year (six plots during 2003 and 2006, five plots during 2004 and four plots during 2005). Spikeweed, another forb, was found on six plots during 2005, two plots during 2003 and 2006 and was not found at all in 2004. Bush seepweed was found on from three to eight plots, depending on the year (three plots during 2006, six plots during 2003, and eight plots during 2004 and 2005). Of the 13 species in the seeding mix, Allscale was the most consistent species, and was detected on seven of the eight plots each year.

An additional factor this study tested was the importance of micro-contouring of a restoration site prior to planting. In this study, dozens of small berms approximately 18” in height were created on eight plots. There were no differences detected in native species establishment or abundance on contoured sites vs. non-contoured sites.

This experimental study (HRS) was designed prior to gaining sufficient knowledge of the ecological system through preliminary studies and exploratory data analysis, and therefore, the questions asked by the HRS study were not necessarily the most important questions to consider when designing successful restoration projects. The main findings from the HRS project are:

- *Planting natives is necessary because there are little to no viable seeds remaining in the seed bank.*
- *Small, 18-inch micro-topographic berms do not aid in restoration. Larger scale earth moving, where hummocks are created three feet above grade and the depressions created three feet below grade, may have positive impacts on establishment of some native species.*
- *The seeding rate utilized may not have been high enough to get good establishment of native species.*
- *Heavy clay soils on the east side of the project provide very difficult conditions for successfully restoring native vegetation.*
- *Sandy loam soils in the center of the project are the best soils for reestablishing native species.*

2000 – 2002 Plantings

During January 2001, 160 acres of heavy clay soils (Nahrub silt loam) in Section 23 east of the Alpaugh canal was planted with a commercial seed mix. The seed mix consisted of 11 species and was planted using an imprinter and a Truax Range Drill at a rate of 11.8 pounds per acre and included the following species:

- Dove weed – 1.77 lbs/acre
- Alkali sacaton – 0.76 lbs/acre
- Alkali heath – 0.51 lbs/acre
- Spikeweed – 0.76 lbs/acre
- California goldfields – 0.38 lbs/acre
- Allscale – 2.28 lbs/acre
- Spiny saltbush – 2.28 lbs/acre
- Pacific fescue – 0.76 lbs/acre
- Birds-eye gilia – 0.76 lbs/acre
- Bush seepweed – 0.76 lbs/acre
- Goldenbush – 0.76 lbs/acre

There was no soil preparation done on this site, and the seed was planted directly into the dry non-native grasses and forbs. Rainfall was slightly above average, with nearly 6 inches in January and February. The site grew lush with non-natives including red brome and sour clover (*Melilotus indica*) and non-planted native such as ranchers' fireweed. Very little native vegetation germinated, and no shrubs became established on the site. Within a year, the site was totally dominated by non-natives and it was impossible to determine that the site had been planted with a seed mix.

Small Test Plots

During November 2001, BLM established an array of 456 test plots of 1/1000-acre (6ft 7in x 6ft 7in) in the southwest quarter of Section 23. Seed from 29 different species of shrubs, forbs and grasses were planted in the study plots. Four types of site preparation were used: (1) scraping the surface, (2) disking to eight inches, (3) harrowing to four inches and (4) no preparation. This study was conducted on heavy clay soils (Nahrub silt loam) in Section 23 east of Alpaugh Canal.

A standard seeding rate of 40 pounds/acre was used on the plots for each site preparation. On the scraped area, in addition to the 40 pounds/acre seeding rate, three plots with different seeding rates were established: 10 pounds/acre, 80 pounds/acre, and 160 pounds/acre. On the disked area, plots with added nutrients were established. Bone meal was used to increase soil phosphorus content and blood meal was used to increase soil nitrogen content. Rates of 500 and 1,000 pounds/acre effectively doubled and tripled the available soil phosphorus and nitrogen in the soil. An additional treatment of 500 pounds/acre of both blood and bone meal was used.

The test plots were used as a screening technique to look for broad effects and were the first step of a tiered approach; searching for interesting trends and helping to focus future, more in-depth, research. Shrub species planted included: bush seepweed (*Suaeda moquinii*) (local); spiny saltbush (A*triplex spinifera*) (local); alkali heath (*Frankenia salina*) (local and commercial); iodine bush (*Allenrolfea occidentalis*) (commercial); goldenbush (*Isocoma acradenia*) (local); quail bush (*Atriplex lentiformis*) (commercial) and allscale (*Atriplex polycarpa*) (commercial). Grass species planted included: alkali sacaton (*Sporobolus ariodes*) (local and commercial); few-flowered fescue (*Vulpia microstachys*) (local and commercial); slender-hair grass (*Deschampsia danthonioides*) (local); nodding needlegrass (*Nassella cernua*) (commercial); creeping wildrye (*Leymus triticoides*) (commercial) and Arizona brome (*Bromus arizonicus*) (commercial). Forb species planted included: spikeweed (*Hemizonia pungens*) (local); alkali mallow (*Malvella leprosa*) (local); alkali heliotrope (*Heliotropium curassavicum*) (local); Jimson weed (*Datura wrightii*) (local); goldfields (*Lasthenia californica*) (local and commercial); purple owl's clover (*Castilleja exserta*) (commercial); slender-leaf milkweed (*Asclepias fascicularis*) (local); common sunflower (*Helianthus annuus*) (local); California poppy (*Eschscholzia californica*) (commercial); gumplant (*Grindelia camporum*) (commercial); dove weed (*Eremocarpus setigerus*) (commercial); telegraph weed (*Heterotheca grandiflora*) (local); mustang clover (*Lotus purshianus*) (commercial); sky lupine (*Lupinus nanus*) (commercial); caterpillar phacelia (*Phacelia tanacetifolia*) (commercial) and tomcat clover (*Trifolium wildenovii*) (commercial).

The test plots were monitored on 7 January and 20 February 2002. Rainfall for the Project area during the winter 2001-2002 was very low, with only 2.8 inches falling between 13 November 2001 and 25 March 2002. No seedlings were found for any of the seven shrub species during the monitoring period. Of the six grass species, none were found on January 7, 2002. On February 20, 2002, a few seedlings of alkali sacaton, few-flowered fescue, and slender-hair grass were found. These species were found primarily in the disked area. Of the 16 forb species, goldfields, purple owl's clover, California poppy, mustang clover, caterpillar phacelia, and tomcat clover were found on January 7, 2002. Only goldfields and tomcat clover showed more than 10% coverage on January 7, 2002. On February 20, 2002, only five species of forbs were found. Goldfields and the caterpillar phacelia had the best coverage, with over 20%. Spikeweed, poppy, and tomcat clover seedlings were also found. At this visit, the phacelia was beginning to die from lack of water and only the goldfields appeared healthy. The locally collected goldfields seed did not germinate as well as the commercial goldfields seed. However, the commercial goldfields plants died without blooming or setting seed, while the local plants bloomed and set seed. Broad trends showed that higher seeding rates led to better germination and establishment. The 10 pound/acre seeding had very few plants, while the higher seeding rates had many more. The phacelia did best in the plowed plots, while the goldfield did best in the scraped plots. Very few plants of any species were found in the untreated control indicating very poor germination and survival of native plants in areas with heavy competition. There were no obvious trends in the amended plots.

The plots were monitored again on 28 January and 27 February in the spring 2003 on. This was another dry year with only 2.24 inches of rainfall between November and February. Again, no shrubs seedlings were detected. During the January check, seven species were detected: spikeweed (max 1% cover), alkali sacaton (max 2% cover), goldfields (max 10% cover), Pacific fescue (max 10% cover), California poppy (max 1% cover), sky lupine (max 4% cover), caterpillar phacelia (max 90% cover) and tomcat clover (max 5% cover). During the February check, five species were detected: goldfields (max 15% cover), Pacific fescue (max 3% cover), sky lupine (max 2% cover), caterpillar phacelia (max 95% cover) and tomcat clover (max 3% cover). Plots that were seeded at higher density had more cover. For example, the locally collected goldfields had 12% cover on the 160 lbs/ac seeding, 8% cover on the 80 lbs seeding, 3% on the 40 lbs seeding and <1% cover on the 10 lbs seeding.

In subsequent years, only goldfields were detected on any of the plots and only on the plots seeded with native seed. In spring 2010, no species that had been planted were detected and it was not possible to determine a difference in vegetation between plots and unplanted areas.

Alfalfa Study

In November 2003, an array of small study plots was established in a field with Posochanet silt loam soils that had been planted to alfalfa for several years. The objectives of this study were to explore native species selection, planting methods and need for soil amendments on recently retired alfalfa fields. Eight species were planted: allscale, spikeweed, alkali goldenbush, goldfields, Sierra white layia, Great Valley phacelia, alkali sacaton, and seepweed. Four planting methods were used: (1) a deep-furrow plot drill, (2) herbicide followed by Truax Flex II range drill, (3) disked followed by Truax Flex II range drill, and (4) disked followed by Truax Trillion broadcast seeder. Two soil augmentations were used: super treble phosphate fertilizer at 40 pounds per acre and HydraHume at 100 pounds per acre along with the 40 pound per acre application of phosphate. Plots with no soil augmentation were also planted to act as a control. This design yielded a total of 1,024 plots.

All species with the exception of alkali sacaton became established on the plots. Disked plots planted with the range drill or broadcast seeder, had clearly superior establishment of native plant species when compared to herbicide application with no tillage or deep furrows plantings. Neither of the soil amendments was shown to improve plant establishment. The annuals on these small plots were, over time, dominated by non-native grasses. However, it was determined that plots seeded into wider alfalfa strips, as was done the next year west of the BLM Project Headquarters, did not become dominated by non-natives and have persisted over time (Lair 2006).

Lessons Learned from Early Restoration Projects

Several important findings came from the study trials and plantings conducted during the first three years of the project. These observations have provided guidance and experience in conducting restoration work over the past eight years. Some of the important observations results are listed below:

- *It is important to use locally collected native seed. Local genotypes are adapted to the hot, dry climate of the Tulare Basin. The year to year variation in rainfall and the intermittent nature of rainfall events, even in wet years, is a challenge that cannot be overcome by seed from outside the Tulare Basin.*
- *Most native species are not suitable for use in restoration projects. Only a few species can form sufficient cover in the first year after planting to compete with non-native weedy species.*
- *Site preparation and weed control are important steps in the restoration process. Planting native seed without proper site preparation can lead to project failure.*
- *Seeding rate is extremely important and the early studies and plantings, in an attempt to save money, were planted with too little seed.*
- *After many years of farming there is little or no native seed in the seed bank.*
- *Heavy clay soils are very difficult to establish native species on, and weed competition on these sites is very high.*

Revegetation Site Characteristics and Challenges

The Tulare Basin presents a complex array of environmental constraints typical of arid areas. These factors present the restoration worker with imposing severe limitations on revegetation strategies, technologies and plant materials. Constraints include:

- *Variable surface soil textures ranging from clay loam to fine sand.*
- *Low and unpredictable rainfall totals, which are variable both within and between years.*
- *Intense pressure from aggressive non-native weed seeds.*
- *Inadequate knowledge of the basic biology of many target native plant species.*
- *Inadequate supply of local native seed for some desirable species.*
- *Lack of knowledge of plant species and soil type interactions.*
- *Extensive landscape alterations introducing high levels of disturbance and hydrologic alteration.*
- *Influence of often unknown past agricultural practices on weed seed load.*

Native seed collected on the Project and in the surrounding area provides species adapted to the local soil and climatic conditions. Where soil salinity is moderate to moderately high (electrical conductivity, EC > 4,000 $\mu S\ cm^{-1}$), restoration plantings are limited to salt-tolerant species.

Measuring Success

Reconstruction of complete plant communities that match the historic condition of a site is beyond the scope of most restoration projects. Ideally, however, restoration projects can move beyond the establishment of just a few generalist native species. Based on soil type and climatic conditions, restored native plant communities at Atwell Island will consist predominately of shrubs and forbs, with native grasses as a minor component. From early historical descriptions, this likely mimics the historic condition. These communities reflect the realistic habitat restoration capabilities of these formerly irrigated farm fields. The Atwell Island plant composition is expected to be similar to reference habitats within the Tulare Basin (e.g., Allensworth and Semitropic Ecological Reserves; Kern and Pixley National Wildlife Refuges). These reference sites have the desired habitat qualities for targeted animal species (Threatened and Endangered species, as well as other, more common components of the fauna), site stability and weed suppression.

Early in the restoration process at Atwell Island, we struggled to develop criteria that would determine whether or not our restoration effots had been successful. We finally turned to high quality native habitat managed by BLM in the Lokern (Kern County) and Carrizo Plain (San Luis Obispo County) areas. Using existing vegetation survey data, we determined that the best habitats averaged about 15% native cover, with a native shrub component greater than 1%. The remaining 85% was covered with either non-native vegetation or bare ground. We adopted these measurements as our yardstick of success for the Atwell Island Restoration Project; sites that maintained 15% native cover with a native shrub component were deemed successful.

Selection of Species for Restoration

BLM guidelines for habitat restoration require that seed be collected at a similar elevation and within a fifty-mile radius of the project. Experience from our preliminary restoration projects led us to several native plant species that work well in restoration plantings in the Tulare Basin. Shrub species included: allscale, bush seepweed and goldenbush. Forb species included: several species of goldfields (*Lasthenia californica*, *L. ferrisiae*, and *L. minor*), spikeweed and Great Valley phacelia (*Phacelia ciliata*). Several important restoration species, bladderpod (*Isomeris arborea*) and Sierra white layia (*Layia pentachaeta* ssp. *albida*), were added as our restoration efforts progressed. Several other shrub species are also regularly put in the seed mix, including: iodine bush, spiny saltbush and alkali heath, even though they have been only marginally successful at establishment to date. It is believed that seed of these species is viable for many years and that they may germinate and become established some years in the future when weather conditions are optimum. Many species planted in the first few years of the Project have been discontinued because they demonstrated consistently low rates of establishment. Some of these (e.g., quail bush, gumplant and creeping wildrye) are now only used where supplemental water is available, as they do not persist in upland situations. Rancher's fireweed is not planted because it is often the only native species remaining in the seed bank and becomes established on sites whether or not it is planted.

The Project has continually refined species selection and mixture formulations. Numerous species have been collected, evaluated and discarded as potential restoration species. Of the 455 species of native plants growing in the Tulare Basin, only 10 to 20 species have characteristics making them suitable for upland habitat restoration on the Project. Desirable restoration species have the following traits:

- *Native to the Tulare Basin.*
- *Availability of seed for collection.*
- *Ease of seed harvest, cleaning, conditioning and storage.*
- *Good response to standard site preparation and seeding methods.*
- *Good establishment on restoration sites including high germination rate and seedling vigor.*
- *Good sustainability and reproductive success.*
- *Suppression of, and resistance to, weed competition.*

Seed Acquisition

The Atwell Island restoration work follows BLM's restoration guidelines requiring seed of native species be used, and seed be collected within 50 miles (80 km) of the Project. In addition to this protocol, seed is collected only from sites at a similar elevation to the Project site (100 to 300 feet [30-90 m] above sea level). Seed has been collected through service contracts with professional native seed collectors. These contracts specify that BLM must approve the time, place and method of seed harvest. BLM personnel have also collected some small lots of seed. Currently, 12,000 pounds of seed is collected each year for the project. For further detail on seed collection, see Table 4-1.

Seed increase and growout has been performed on several species of native grasses and forbs for which insufficient amounts can be collected from existing wild populations. Currently, one acre of alkali sacaton seed is being grown under contract with a farmer in the Tulare Basin.

Seed Viability Testing

Samples for all large seed collections are submitted for purity and viability testing by the seed collection contractor. The Atwell Island Restoration Project is currently using the Ransom Seed Laboratory in Carpinteria, CA. Results of the tests include: species purity (%), growth chamber germination (%), dormant (%), TZ viable (%), number of live seeds per pound and a composite determination of pure live seed (%). To date, 92 seed reports have been received on 29 species. Three or more seed reports have been received on 13 species (Table 4-2).

Table 4-1: Seed collecting information including month, method, plant disturbance, and cost per pound.

Species	Collection Month	Collection Method	Plant Disturbance	Collection Cost/Pound
Allenrolfea occidentalis	Dec	Tennis Racquet	Low	$5.15
Atriplex lentiformis	Dec	Tennis Racquet	Low	$3.95
Atriplex polycarpa	Dec	Tennis Racquet	Low	$2.45
Atriplex spinifera	June	Tennis Racquet	Low	$4.25
Eremalche parryi	Mar/Apr	Hand	N/A	$11.90
Frankenia salina	Sept	Hand	Medium	$4.95
Grindelia camporum	Sept	Hand	Low	$4.80
Hemizonia pungens	June/Sept	Hand	N/A	$6.95
Isocoma acradenia	Oct	Tennis Racquet	Low	$9.95
Isomeris arborea	June	Hand	Low	$8.80
Lasthenia californica	Mar/Apr	Hand/Mower	N/A	$12.45
Lasthenia ferrisiae	Mar/Apr	Hand/Mower	N/A	$11.90
Layia pentachaeta ssp. *alba*	Mar/Apr	Hand	N/A	$14.25
Malacothrix coulteri	Mar/Apr	Hand	N/A	$9.95
Phacelia ciliata	Mar/Apr	Hand	N/A	$12.45
Suaeda moquinii	Sept/Oct	Tennis Racquet	Medium	$6.90
Vulpia microstachys	Mar/Apr	Hand/Mower	N/A	$15.00

Table 4-2: Seed test results on selected restoration species for the Atwell Island Restoration Project.

Species	No of Tests	Average Purity (%)	Range of Purity (%)	Average TZ Viability (%)	Range of TZ Viability (%)
Allenrolfea occidentalis	7	51.0	20.0 – 93.2	57.9	34 – 86
Atriplex lentiformis	5	89.0	80.9 – 94.2	63.2	54 – 69
Atriplex polycarpa	6	70.7	55.1 – 80.1	40.7	18 – 52
Atriplex spinifera	5	88.3	79.9 – 93.5	13.4	1 – 36
Frankenia salina	7	5.0	1.0 – 11.3	83.3	60 – 94
Hemizonia pungens	4	9.2	5.8 – 14.1	67.3	61 – 78
Isocoma acradenia	7	27.4	9.2 – 62.9	26.4	10 – 65
Lasthenia californica	6	30.0	6.9 – 55.6	54.0	26 – 79
Lasthenia ferrisiae	3	39.9	32.0 - 46.8	74.3	55 - 90
Layia pentachaeta ssp. albida	5	23.0	14.9 – 28.8	56.6	44 – 73
Phacelia ciliata	4	69.8	37.1 – 94.4	93.9	85 – 98
Suaeda moquinii	7	37.3	26.8 – 46.5	21.6	8 - 38
Vulpia microstachys	4	67.5	40.5 – 98.5	94.3	87 - 98

Seed Mixtures

Seeding trials and field-level applications included both multi-species mixtures and individual species, as appropriate. Seed mixtures for each restoration site are chosen based on the goals for that site and the soil type. Seed mixes are generally limited to two to three shrub species and two to four grass and forb species (for examples see Appendix 2).

In general, for clay soils on alkaline sites, iodinebush and seepweed are the dominant shrubs seeded; while on sandy soils, alkali goldenbush and saltbush are the dominant shrubs seeded. On soils of intermediate texture, a broader palette incorporating all shrub species may be seeded. Quailbush is reserved for areas that have additional water (i.e. canal banks and pond edges). Seed mixes for each of the Project's major soil types are given in Appendix 2.

Restoration Site Preparation Methods

Numerous techniques have been used to prepare Project sites for restoration. These techniques function both as stand-alone strategies, or in combination with other strategies.

Fallowing

Fields can be fallowed after farming is ended for one or more years prior to restoration. This strategy serves to increase soil compaction which discourages many early successional annual weed species after years of intensive cultivation and disturbance. Potential disadvantages of fallowing include a potential buildup of secondary successional weeds and weed seed in the seed bank. When this method is used, the fallow period must be followed by a hot controlled burn, and possibly herbicide or propane flaming treatment, prior to seeding. On the Project, 63% (41 of 65) of the sites have been fallowed for two or more years prior to planting and 32% have been fallowed for five or more years.

Controlled Burns

Controlled burns are used prior to seeding, especially on fallowed lands. An early season (May to June) burn on sites dominated by non-native annual grasses is ideal, as the burn typically consumes grass and weed seed. On sites dominated by five-hook bassia, the ideal burn time is late fall (November), after the bassia has senesced and desiccated. On the Project, 31% (20 of 65) of the sites have been control burned prior to planting.

Propane Flaming

Propane flaming using an alfalfa flamer is effective in years with early fall precipitation. The technique is used after weed seeds start to germinate but before seed of native species have been planted. This technique is expensive, due to the high cost of propane, but has the advantage of not disturbing the soil surface and thus exacerbating weed growth. Only small areas of less than 10 acres have been treated with this method.

Micro-topography Creation

Several techniques have been used to create micro-topographic relief on restoration sites. While the project area is naturally flat with little topographic relief, the agricultural fields on which restoration is occurring have been laser-leveled to maximize surface irrigation efficiency. Micro-topography is implemented in two ways: a) by creating swales and hummocks using a bulldozer blade; and b) by creating hedgerows using a tractor-mounted rear blade. If locations of old surface flow channels can be determined, the flow channels will be re-created or approximated to the extent feasible. On the Project, 17% (11 of 65) of the sites have had some type of micro-topographic work prior to planting. The micro-topographic relief created on the HRS plots proved to have little effect on either native plant or animal establishment. Therefore, deeper swales and larger hummocks have recently been implemented (up to 4 feet below and above grade).

Disking

Disking reduces soil compaction and reduces or incorporates plant residues (live and senesced) to approximately 6-8 inches depth below the soil surface. This technique is used for weed control prior to seeding native species after fall precipitation has germinated the weed seeds. It will also be used as seedbed preparation on sites that are being restored as they are coming out of alfalfa production. To date, 43% (28 of 65) of the sites have been disked prior to planting.

Harrowing

Harrowing is used as an alternative technique for controlling weeds that have germinated prior to seeding native species, disturbing the soil surface to about four inches below the surface. To date, 5% (3 of 65) of the sites have been harrowed prior to planting.

Scraping

Six of 65 sites (9%) have been scraped using a rear blade on a tractor or a bulldozer.

No Site Preparation

Early restoration efforts on the Project attempted to plant directly into existing weedy grass fields (20%; 13 of 65). This method led to very low success at native plant establishment and is no longer used.

Grazing

Grazing with cattle, sheep, or goats is used to reduce the thatch prior to seeding. To date, this method has not been used on the project. Potential future applications of this method are discussed in Chapter 6.

Crop Selection Prior to Restoration

Implementing restoration following alfalfa production has proven to be a viable technique and will be actively pursued in future restoration on the Project. The weeds in alfalfa fields are adapted to frequent irrigation (60 inches [152 cm] per year or more), while native species seeded during restoration are adapted to low precipitation (6-10 inches [15-25 cm] per year). Weed competition has proven to be much less severe on alfalfa fields when compared to annually cropped oat, barley, safflower, or fallow fields. To date, 15% (10 of 65) of the fields have been planted to alfalfa prior to restoration.

Seeding Methods

The Project staff has developed seeding designs for each restoration site. The optimum seeding method or combination of methods is determined for each site based on soil type, pre-seeding treatment and restoration goals for the site (for examples of seed mixes see Appendix 2). Seeding design, including site preparation, seeding method, seed mixture and applied micro-topography, is determined for each site prior to seeding. We recommend a combination of techniques on each site, to avoid the use of a single technique that may not be compatible with yearly environmental conditions and could lead to failure of the year's plantings.

A Truax Flex II Range Drill (or similar seed drill), which minimizes ground disturbance, is used to plant seed mixes on sites that have been fallowed, usually following a controlled burn. This drill should not be used on sites that have been disked or harrowed unless they have been treated with a float or cultipacker. The Truax Trillion Broadcast Seeder™ (or similar broadcast-type drill), which spreads the seed in a uniform broadcast application and then compacts it into the soil with paired cultipackers (ring-rollers), is used to plant on sites that have prepared with disking and/or harrowing. An imprinter, which creates an indentation in the soil and then broadcasts the seed, was used in the first three years of the project. The majority of sites (54%, 35 of 65) have been planted with range drill, while 37% (23 of 65) were planted with a broadcast seeder, and 11% (seven of 65) were planted with an imprinter.

Seeding Timing

Restoration sites have been planted as early as October and as late as February. Sites that have been planted in October and November have tended to be more successful than those planted in January and February. Currently, planting is scheduled for October and November prior to the first major fall rainfall event and all planting is completed before 1 January. Whenever possible, planting is done just prior to a major rain event.

Irrigation

Irrigation of restoration plantings is avoided, if possible. If needed, irrigation is applied in the initial seeding year to establish perennial plants, especially in years of below-normal precipitation. Most of the fields targeted for restoration are equipped with alfalfa valves and can be irrigated as needed. Shrubs are monitored for water stress throughout the first growing season and irrigated as needed. In dry years, a maximum of one acre-feet of water is applied in two, one-half acre-feet applications. Shrubs requiring more water to become established are likely not adapted to site conditions and should not be seeded. A minimum amount of water should be applied to keep the target species out of drought stress without creating an unnecessary weed load. To date, 23% (15 of 65) of the sites have been irrigated. Three sites were irrigated three times, seven sites were irrigated twice and five sites were irrigated once.

Cooperative Agreements

BLM uses Cooperative Agreements with farmers to conduct farming activities and practices on Project lands. As a part of these agreements, farmers perform activities necessary to restore lands to upland wildlife habitat. Cooperating farmers use their own farm equipment to plant wildlife-friendly crops, reshape appropriate micro-topography for restoration, and perform irrigation operations and maintenance of the irrigation system and roads. In return, they are permitted to grow alfalfa and grain crops on those units not yet scheduled for restoration activities.

Monitoring

Restoration sites were monitored in the spring of 2008, 2009 and 2010 by making an ocular estimate of the percent cover of each native and non-native species encountered during two to four transects (approximately 200 m. each) on each restoration site. Transects were completed each year during March and April. The establishment and expansion of shrub cover occurs over several years and is not always obvious in the first year. Several years may elapse before the extent of shrub establishment is detected. Sites that appear to be failures in April can look very different in September as the shrubs become more apparent.

Chapter 5. Results of Upland Habitat Restoration

Since 2000, BLM has planted 67 restoration sites for a total of 3,100 acres. After the initial planting of the HRS plots in 2000 (480 acres, 120 acres with native seed and 360 acres with sterile barley) between 103 to 240 acres were planted yearly for the next four years, while learning which restoration techniques proved successful and which did not. In 2005, as BLM staff gained more confidence in their methodology, 298 acres were planted. In subsequent years, BLM has exceeded 380 acres of plantings each year (Figure 5-1; Figure 3-8; Appendix 3).

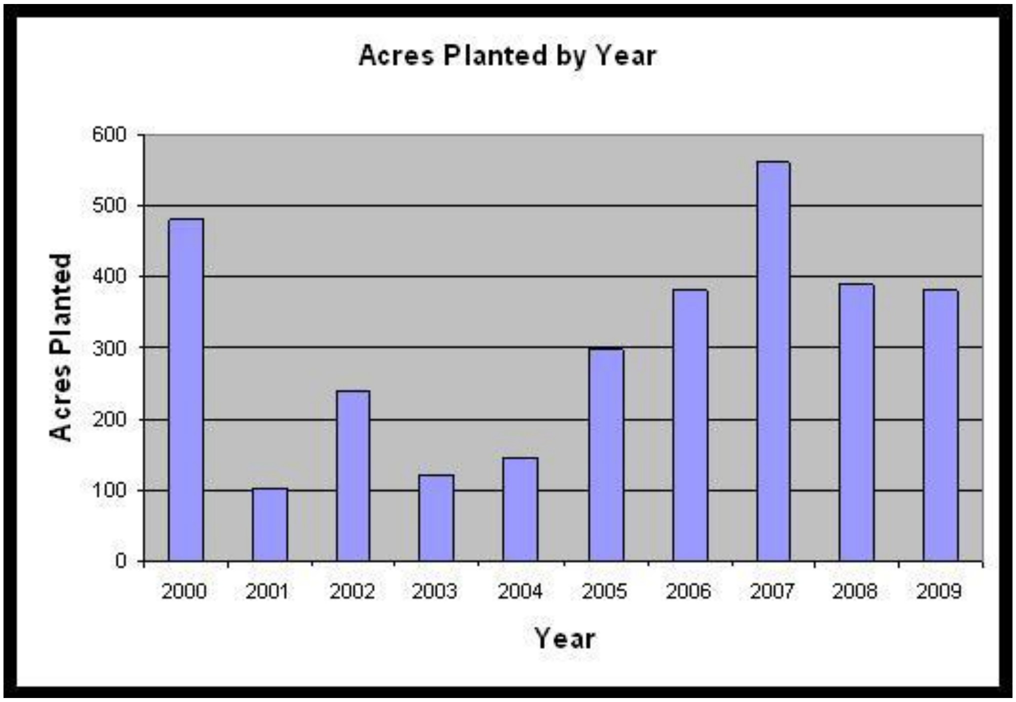

Figure 5-1. Acreage of restoration plantings per year at Atwell Island Restoration Project.

Restoration Success

Sites were monitored in the springs of 2008, 2009 and 2010. The winters of 2007-2008 and 2008-2009 were drought years, so the most interesting monitoring results came from the spring 2010 data, after a winter of slightly above average rainfall (Appendix 4). Early in the restoration process, success criteria had been defined: sites with 15% native cover and 1% native shrub cover would be considered successful. Restoration sites were judged against this standard. The 67 restoration sites had an average native plant cover of 35.1%, with a range from 0 to 100% during the spring of 2010. A large majority of sites (54 sites, 80.6% of sites) had more than 15% native plant cover and met that performance criterion (Figure 5-2). Native shrub cover averaged 11.4% and ranged from 0 to 90%. A majority of sites (51 sites, 79.7% of sites) had 1% or more shrub cover and met that performance criterion (Figure 5-3).

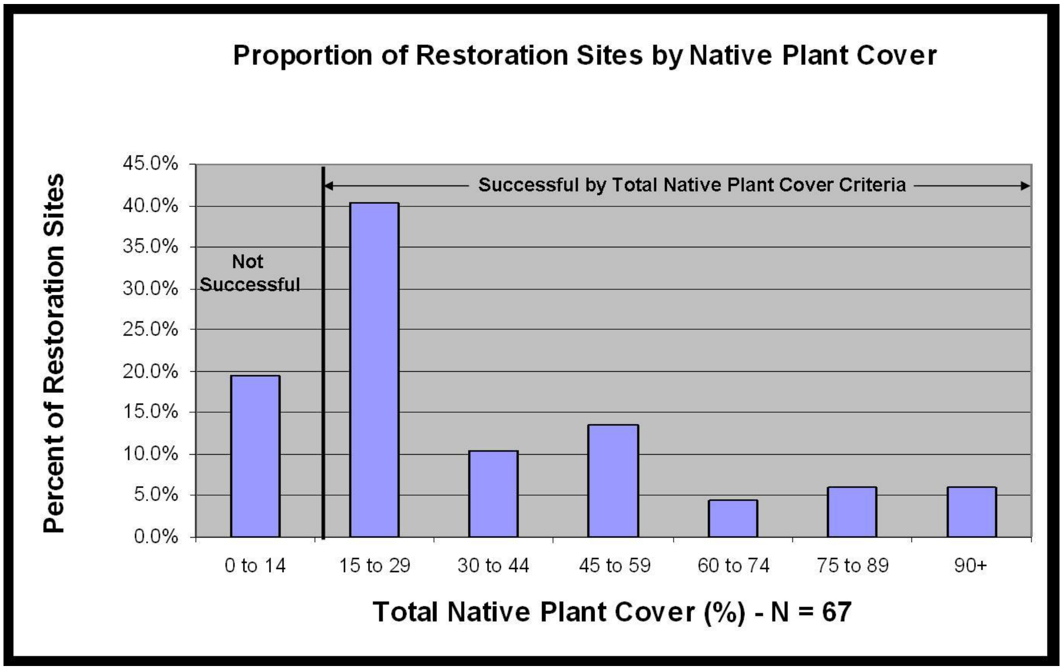

Figure 5-2. Successful and unsuccessful restoration sites based on the total native plant cover criteria: sites with greater than 15% native plant cover are considered successful.

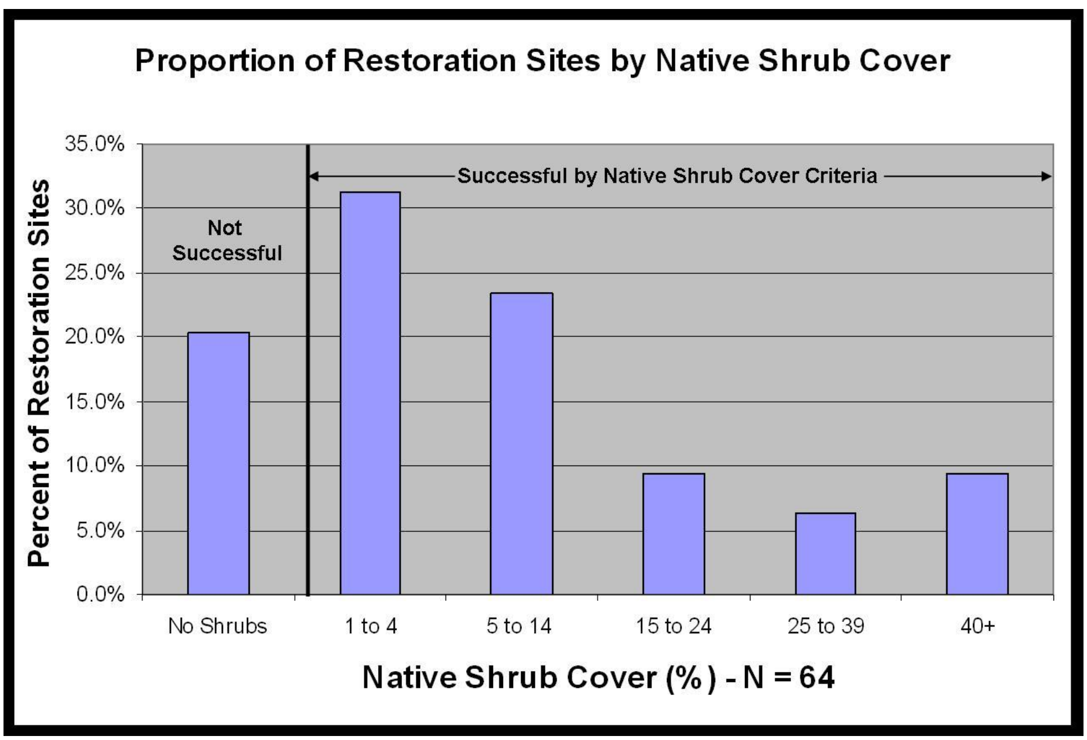

Figure 5-3. Successful and unsuccessful restoration sites based on the native shrub cover criteria: sites with greater than 1% native shrub cover are considered successful.

Of the 65 restoration sites for which both monitoring data and planting data are available, 46 sites (70.8%) met both performance criteria and only four sites (6.2%) met neither criterion. Ten sites (15.4%) met the total native cover criterion, but not the shrub cover criterion and five sites (7.7%) met the shrub cover criterion, but not the total native cover criterion (Figure 5-4).

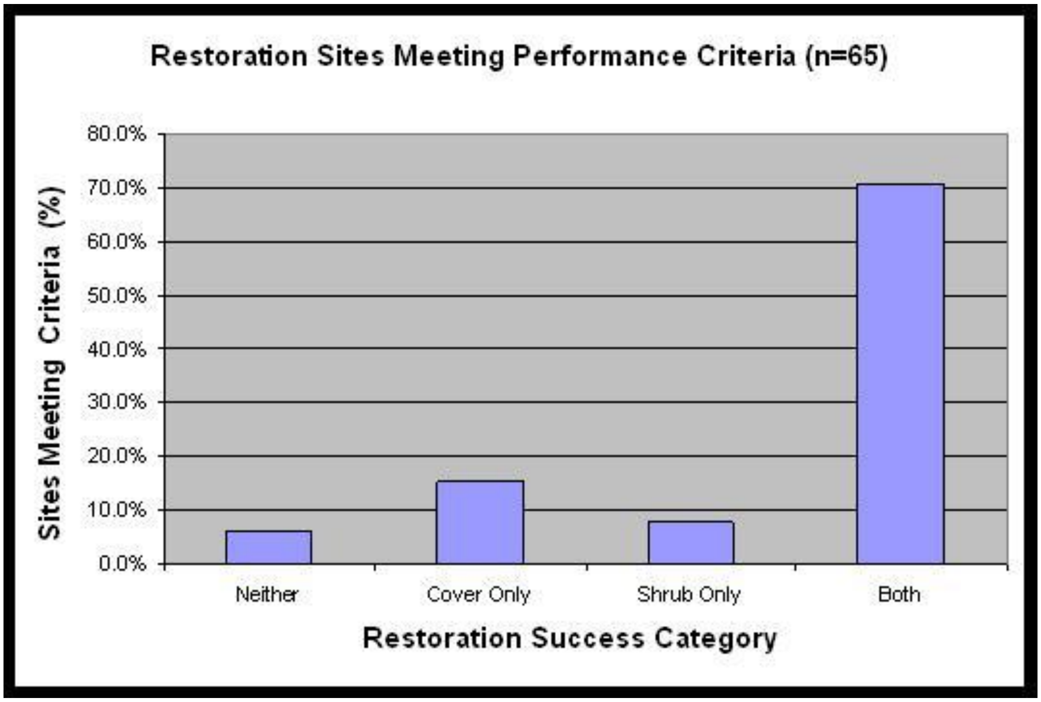

Figure 5-4. Percent of restoration sites meeting performance criteria: a minimum of 1% shrub cover for scrub cover criteria and a minimum of 15% native plant cover for the native plant cover criteria.

Soil Type and Effects on Restoration Success

Soil type was expected to have an effect on the resulting native plant cover and the success of the restoration sites. Excelsior and Sandridge soils were combined under the Sandridge heading for this analysis because of similar properties. If two soils were found under one general heading (i.e., Westcamp) they were also combined (e.g., Westcamp loam and Westcamp silt loam were combined). Nearly half of the early restoration sites (31 sites) were planted on Nahrub soils, which have heavy clay content. Posochanet soil (19 sites) was the second most commonly represented, while fewer sites were on Sandridge and Westcamp soils (ten and four sites respectively). For total native plant cover, Posochanet soils (48.8% cover) and Sandridge soils (43.3% cover) had significantly higher percent cover than either Nahrub or Westcamp soils (25.7% and 19.5 % cover respectively) (Figure 5-5 and Table 5-1).

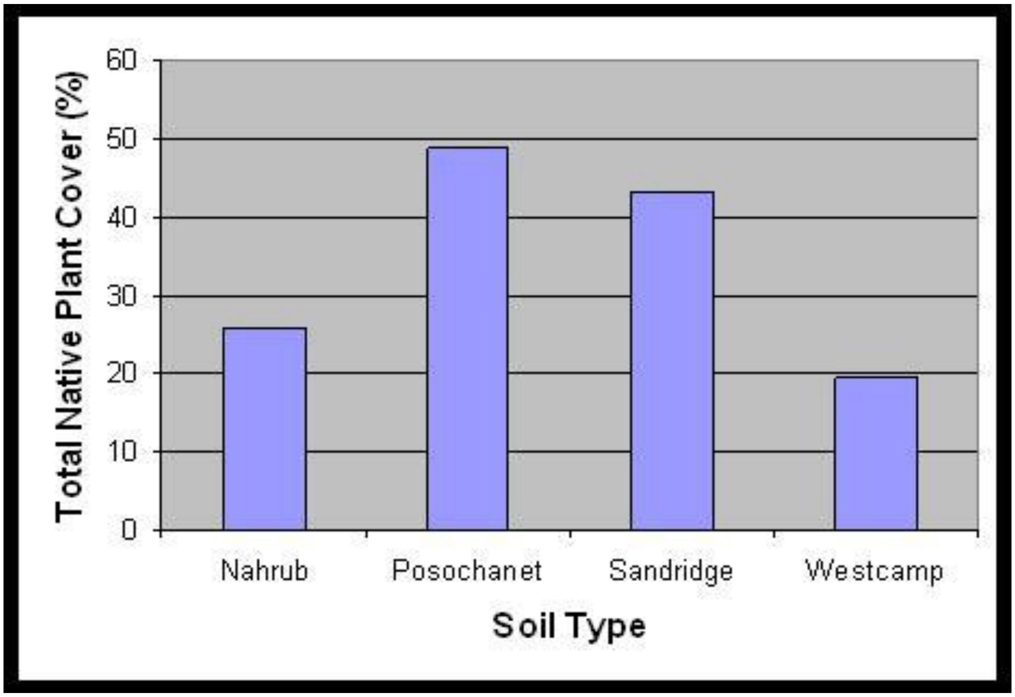

Figure 5-5. Total native plant cover established on the four dominant soil types at Atwell Island Restoration Project.

Table 5-1: Statistical tests comparing total native cover on the four dominant soil types at Atwell Island Project.

Comparison	t-value	p value
Posochanet vs. Sandridge	0.68	0.68
Posochanet vs. Nahrub	**2.92**	**0.01**
Posochanet vs. Westcamp	**3.02**	**0.00**
Nahrub vs. Sandridge	**2.21**	**0.03**
Nahrub vs. Westcamp	1.36	0.18
Sandridge vs. Westcamp	**2.96**	**0.01**

No statistically significant differences were found for native forb cover between the four soil types. However, sites with Posochanet soils had the highest percentage, with 32.2% native forb cover, and Westcamp soils were the lowest at 11.8%. Nahrub and Sandridge soils were intermediate in native forb cover at 22.0% and 20.9% respectively (Figure 5-6).

Nahrub soils had the lowest shrub cover, with a 3.8% average over 31 restoration sites. The shrub cover on Nahrub soils was significantly lower than on Posochanet, Sandridge, and Westcamp soil types (16.7%, 22.2%, and 17.5% respectively) (Figure 5-7; Table 5-2).

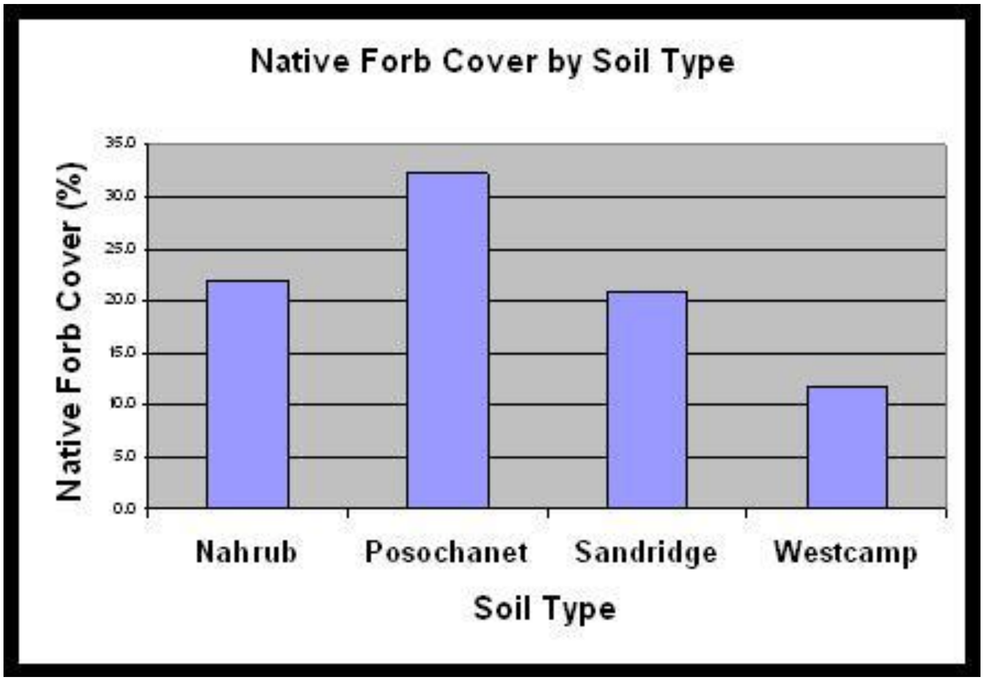

Figure 5-6. Native forb cover established on the four dominant soil types at Atwell Island Restoration Project.

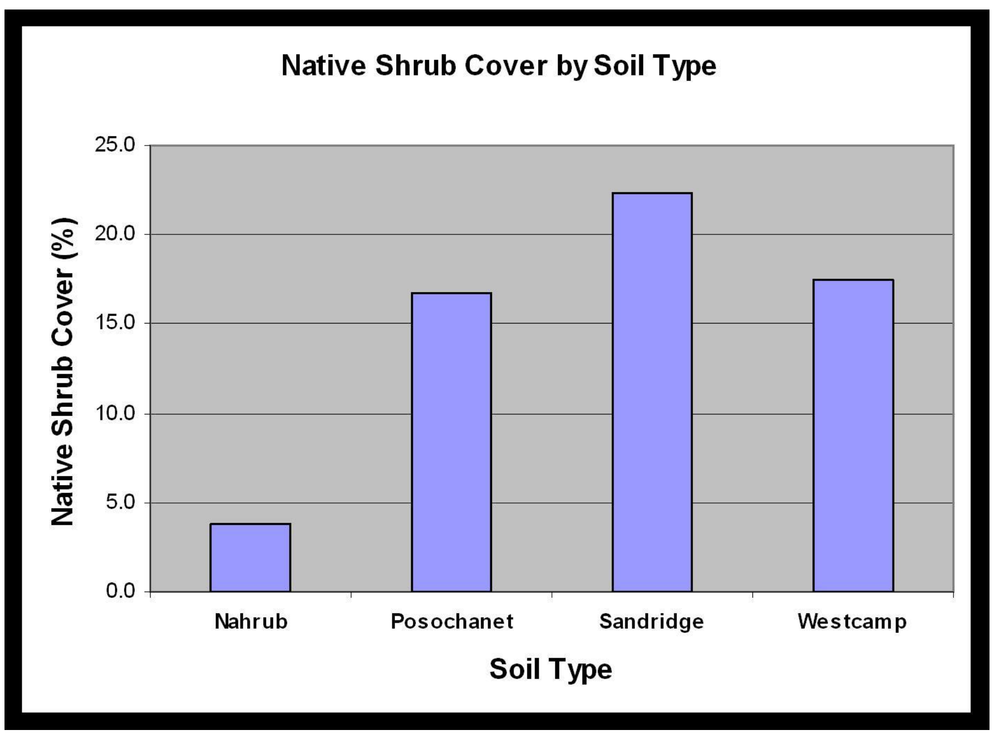

Figure 5-7. Native shrub cover established on the four dominant soil types at Atwell Island Restoration Project.

Table 5-2: Statistical tests comparing native shrub cover on the four dominant soil types at Atwell Island Restoration Project.

Comparison	t-value	p value
Posochanet vs. Sandridge	0.66	0.51
Posochanet vs. Nahrub	***3.57***	***0.00***
Posochanet vs. Westcamp	0.08	0.93
Nahrub vs. Sandridge	***3.35***	***0.00***
Nahrub vs. Westcamp	***3.34***	***0.00***
Sandridge vs. Westcamp	0.75	0.33

As anticipated, soil type had a great effect on native plant establishment and restoration success. The heavy Nahrub soils that make up nearly half of the project area have proven very difficult for restoration efforts, especially for the establishment of native shrub communities. These soils were originally lake bottom substrates and are more suited for wetland restoration than they are for upland shrubs and forbs.

Seeding Rate and Effects on Restoration Success

Data from the small test plots showed higher percent cover for some species on plots with higher seeding rates, and a similar result on the restoration sites. However, there was little effect found in total native cover on the restoration sites in relation to seeding rate. Most sites (56.7% - 33 of 58 sites) were planted at a medium seeding rate between 20 and 39 pounds/acre. 15 sites (25.9%) were planted at a low rate of less than 20 pounds/acre and 10 sites (17.2%) were planted with a high rate of greater than 40 pounds/acre. No statistical difference in native plant cover was found between these three seeding levels. Additional trials to determine the optimum seeding rate will be carried out, but until those are completed BLM will use a medium seeding rate between 25 and 35 pound per acre on future plantings.

Month of Planting and Effects on Restoration Success

From our observations over the past nine years, we expected to find a higher native plant establishment and success rate on sites that were planted earlier in the season. We planted restoration sites from October until February and found no significant differences in native plant cover, forb cover or shrub cover as a result of the month of planting. Despite this result, we recommend that sites be planted in the fall before the first heavy rains. This avoids the stress of trying to plant between rain events, and gives the seeds the best opportunity to germinate with the early rains. In reality, each year is different, with varying rainfall and temperature patterns; and the optimum time for planting each species probably also differs. The overall optimal time to plant is immediately before the first heavy late fall or early winter rain, but the timing of significant rainfall in the Tulare Basin is unpredictable. Sites planted too early may have some or much of the seed eaten by insects, rodents and birds.

Previous Land Use and Effects on Restoration Success

All of the sites planted had been farmed prior to restoration. The three primary crops grown on these sites are small grains (oats or barley; 44 sites, 74.6%), alfalfa (10 sites, 17.0%) and safflower (5 sites, 8.5%). The data shows no significant differences between restoration success and total native cover on sites planted following these three crops. It is likely that alfalfa will prove to be the best crop to precede restoration plantings. Weeds in alfalfa fields are adapted to frequent irrigations and these weed species should not prove to be problematic on restoration sites because they are not irrigated.

A regression analysis between the number of years that a field had been fallow and the percent of shrub, forb and total native cover showed the strongest relationship for native forbs; fields that had been fallow longer resulted in higher native forb cover (R^2 = 10.2%). Relationships for shrubs and total native cover had much weaker relationships (R^2 < 2%). The native forb cover is higher on the sites that have been fallow longer, because these sites have had an opportunity to be re-colonized by some native species (e.g., rancher's fireweed). A major disadvantage to fallowing fields for several years prior to restoration is that invasive grass species may also have an opportunity to colonize the field and these species do not respond well to controlled burns prior to planting.

Site Preparation and Effects on Restoration Success

Sites that were burned had higher cover of native shrubs, native forbs and total native cover than disked or not treated sites. The difference for total native cover was statistically significant (t = 2.09; p = 0.04) (Figure 5-8). Burning is a very good technique on sites that have been out of production for several years and have a build up of weeds. Most sites are not suitable for burning since they are just coming out of agricultural production and there is nothing to burn.

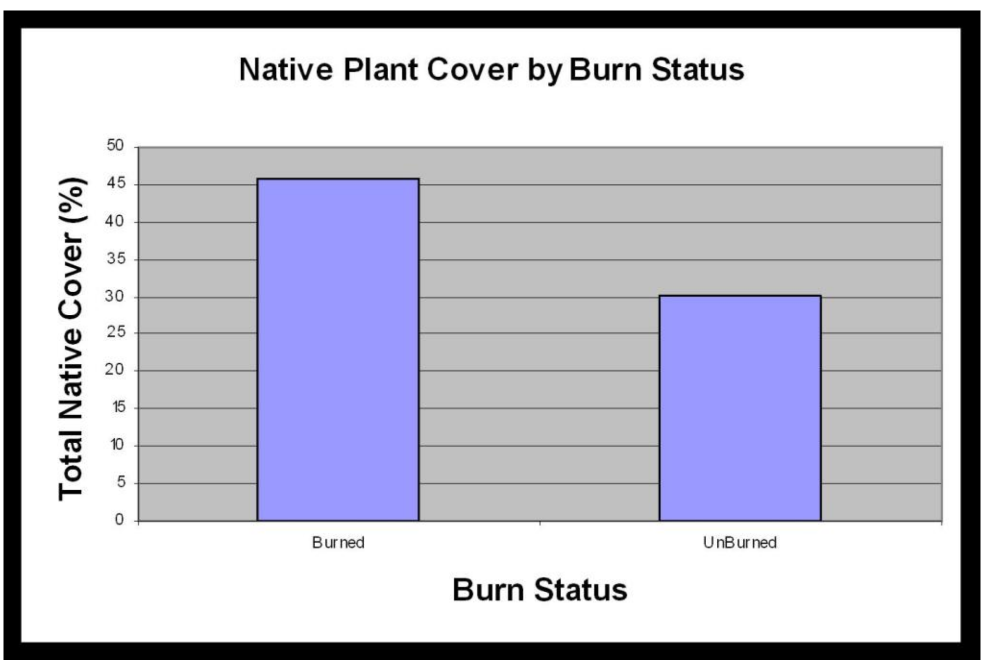

Figure 5-8. A comparison of total native cover on restoration sites that were and were not burned prior to planting.

Seed Source and Effects on Restoration Success

Results from the small test plots indicated that it was very important to use seed from locally collected sources. Since 2003, all 52 restoration sites were planted with locally collected seed. No significant difference was found between total native plant cover between the nine sites planted with commercial seed, much with origins outside of the Tulare Basin, and those sites planted with locally collected seed. The sites planted with native seed had more native shrub cover (12.5% vs. 2.3%) and the difference was close to being statistically significant ($p=0.09$, $t=1.71$). At Atwell Island, BLM will continue to use locally collected seed because the cost is less than 50% of commercial seed and BLM can control the source location.

Seeding Method and Effects on Restoration Success

Most fields have been planted with a Truax Range Drill (33 sites, 51.6%) and Truax Trillion broadcast seeder (24 sites, 37.5%). Seven sites in the first three years were planted with an imprinter, but this planting method was discontinued when it became clear that it was not as effective for shrub establishment. In terms of total native plant cover the results of all three planting methods are essentially the same. However, for shrubs, both the broadcast seeder and the range drill are better than the imprinter with 12.3% and 12.7%, respectively for the first two seeders and only 1.6% cover for the imprinter. The difference between the broadcast seeder and the imprinter was nearly significant ($t = 1.74$, $p = 0.09$).

Successful Native Plant Species

During the 2010 monitoring season 21 native species were found. Of these, 14 were species that were included in the seed mix and seven were species that had not been seeded. The five most successful planted species and the most important for restoration efforts were *Layia pentachaeta* spp. *albida* (53 sites, 6% average cover), *Lasthenia* spp. (L. minor and L. californica; 40 sites, 2.7% average cover), *Phacelia ciliata* (38 sites, 3.3% average cover), *Atriplex polycarpa* (37 sites, 3.7% average cover), and *Suaeda moquinii* (24 sites, 2.9% average cover) (Table 5-3). Additionally, *Hemizonia pungens* (14 sites, 0.5% average cover), *Isocoma acradenia* (12 sites, 0.6% average cover), *Malacothrix coulteri* (8 sites, 0.1% average cover), and *Isomeris arborea* (7 sites, 0.2% average cover) are also important restoration species (Table 5-3). *Isomeris* is especially interesting because it persists in heavy clay soil and provides a nectar source for insects throughout the summer. *Isocoma* is an early fall blooming species that works well on lighter soils like Posochanet and Sandridge soil types.

Seven native species that had not been planted were found during the 2010 monitoring season (Table 5-4). The most common was *Amsinkia menziesii*, which was found on 41 sites (63%) and provided 7.3% average cover - more than any of the planted species. *Lepidium* spp. and *Spergularia* sp. were found primarily on the very alkaline Westcamp soils and *Guillenia lasiophylla* was fairly common at some of the sites with Nahrub soils. This latter species may hold promise as a more important restoration species.

Table 5-3: Native species planted on Atwell Island Restoration Project restoration sites - 2000 to 2010.

Species	Number of Sites	Average Cover (%)	Range (%)
Layia pentachaeta ssp. *albida*	53	6.0%	0 to 50%
Lasthenia spp.	40	2.7%	0 to 50%
Phacelia ciliata	38	3.3%	0 to 30%
Atriplex polycarpa	37	3.7%	0 to 25%
Suaeda moquinii	24	2.9%	0 to 40%
Hemizonia pungens	14	0.5%	0 to 9%
Isocoma acradenia	12	0.6%	0 to 15%
Atriplex lentiformis	8	2.1%	0 to 60%
Malacothrix coulteri	8	0.1%	0 to 1%
Isomeris arborea	7	0.2%	0 to 4%
Frankenia salina	5	0.1%	0 to 3%
Allenrolfea occidentalis	3	0.1%	0 to 2%
Atriplex spinifera	3	0.0%	0 to 1%
Eremalche parryi	2	0.0%	0 to 1%

Table 5-4: Native species found on restoration sites during 2010 monitoring that were not planted.

Species	Number of Sites	Average Cover (%)	Range (%)
Amsinkia menziesii	41	7.3%	0 to 65%
Lepidium spp.	14	0.8%	0 to 15%
Guillenia lasiophylla	12	0.3%	0 to 5%
Spergularia sp.	7	0.4%	0 to 8%
Castilleja brevistyla	6	0.1%	0 to 1%
Plagiobothrys spp.	4	0.1%	0 to 2%
Cressa truxillensis	3	0.0%	0 to 1%

Problematic Weed Species

The most problematic weed species on the restoration sites are non-native grasses. These were not monitored by species, but were lumped together as a unit. This group provided the dominant cover on the restoration plots (Mean = 40.7%, range 0% to 85%) and were found on all but one site (64 of 65 sites) (Table 5-5). Other weed species on average covered 17.5% of the restoration sites (range 0% to 62%). Eight weed species were encountered during the site monitoring. Non-native mustards were the second most common group encountered and were found on 80% of the sites (52 of 65 sites) providing 8.8% of the average cover. Clovers, *Erodium cicutarium* and *Bassia hyssopifolia* were the third and fourth most common weed species (Table 5-5).

Table 5-5: Weed species encountered on 65 restoration sites during 2010 monitoring

Species	Number of Sites	Average Cover (%)	Range (%)
Non-native grasses spp	64	40.7%	0 to 85%
Mustard spp.	52	8.8%	0 to 65%
Clover spp.	20	4.1%	0 to 50%
Erodium cicutarium	19	2.5%	0 to 25%
Bassia hyssopifolia	12	0.6%	0 to 10%
Cynodon dactylon	2	0.1%	0 to 5%
Malva parviflora	1	0.0%	0 to 1%
Acroptilon repens	1	0.0%	0 to 1%

Chapter 6. Summary and Recommendations for Upland Habitat Restoration and Long-term Management

A very high proportion of the restoration sites met the project performance criteria for successful restoration. The performance criteria were developed from the habitat needs of the San Joaquin Valley special status species, as determined by the sites where they have non-declining populations. Restoration sites at Atwell Island averaged 35.1% cover from native vegetation, which exceeded the average percent cover for Carrizo Plain National Monument and Lokern Natural Area where the project performance criteria was originally developed. Restoration techniques used at Atwell Island have resulted in successful native plant establishment. These techniques will be continued to complete the restoration work at Atwell Island and can be used at other sites throughout the Tulare Basin (Figure 6-1). Long-term management strategies for these restoration sites need to be developed to insure the continued, sustained success of the restoration efforts at Atwell Island.

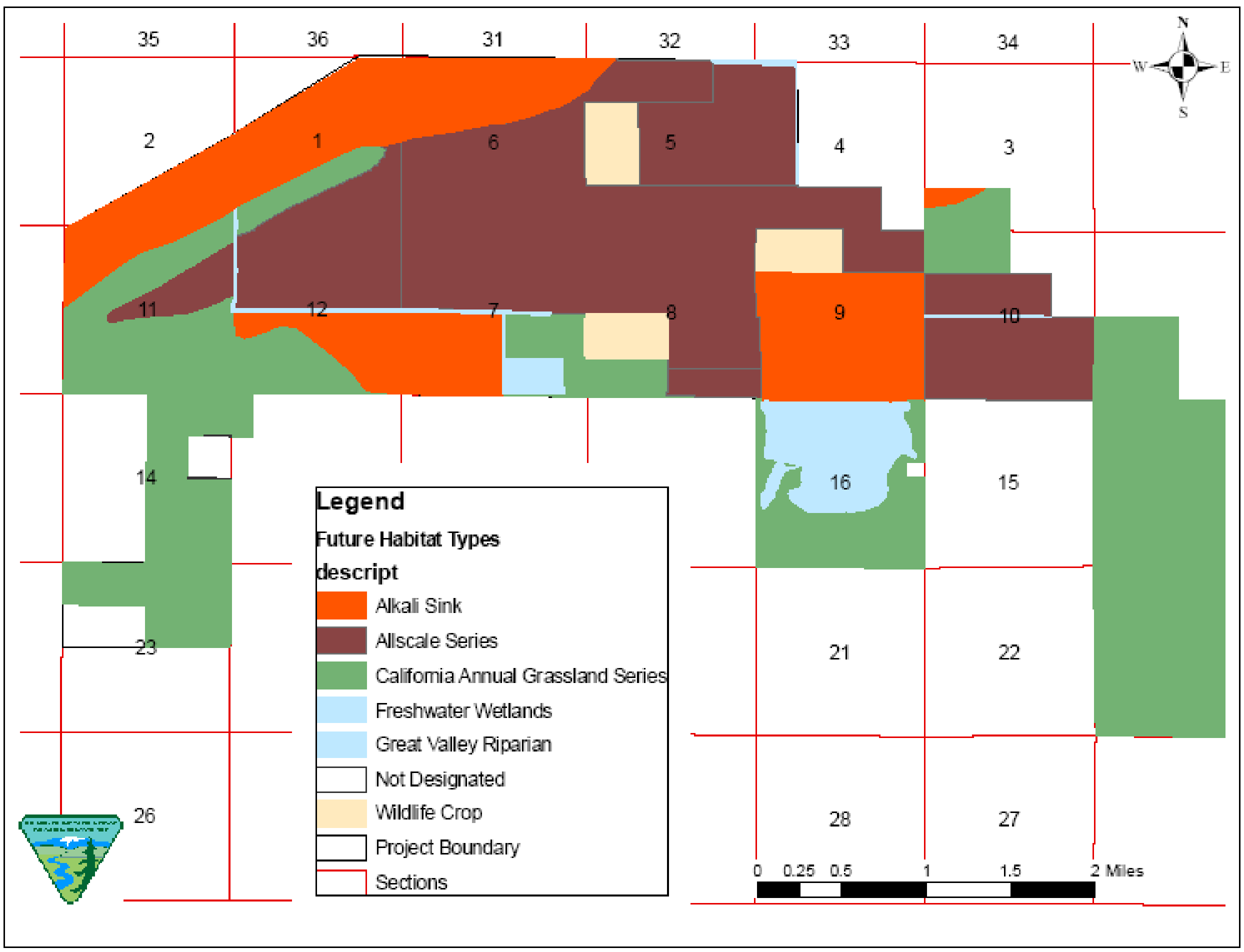

Figure 6-1. Future Vision of Habitats at Atwell Island upon Completion of Restoration Activities.

Restoration Recommendations

The following are the most important recommendations for successful habitat restoration in the Tulare Basin (also see Appendix 5):

1. *Always use fresh locally collected seed in restoration plantings.*
2. *Don't try to save money by planting at low seeding rates (under 25 pounds per acre). Use enough seed so the native plants you are planting will dominate the site and suppress the weed species.*
3. *Develop planting designs based on soil type; don't try to grow species that are not adapted to site conditions. See Appendix 2 for recommended seed mixes.*
4. *Plant in fall - October and November - prior to first heavy late-fall rains.*
5. *Use standard agricultural site preparation and planting techniques. To date, the best restoration success has occurred utilizing these two sequences:*
    - *If field is fallow, then burn it before planting with a range drill.*
    - *If field is immediately out of production, disk several times and plant with the Trillion broadcast seeder.*
6. *Irrigate the restoration planting only if the rainfall totals for the year are more than 20% below average. Irrigation may help the native plantings, but it will also encourage the weed species.*
7. *Use existing local reference sites to define success criteria for restoration.*

Cost Effectiveness

The largest single cost for restoration planting is for native seed. Seed costs at Atwell Island have been approximately $200 per acre. Other costs include equipment and labor for site preparation and planting, resulting in an additional cost of approximately $200 per acre depending on the necessary treatments. Total planting costs are approximately $400 per acre. A one-time half acre-foot irrigation application, if necessary, could be an additional $50 to $100 per acre. These cost estimates do not include staffing (e.g., restoration project management, research or monitoring).

Persistence of Restoration Sites

The common opinion among land managers in the Tulare Basin is that native vegetation on restoration sites will decline over time and the site will eventually be reclaimed by non-native grasses and forbs. However, this does not appear to be happening on the Project sites where a native forb and shrub component has been established. As an example, one 40-acre site (24-22-12-05A) planted on Posochanet soils in fall 2005 had 71% native cover, with 32% shrub cover and 39% forb cover in the spring of 2010. These results show that, at least in the mid-term, native vegetation is able to maintain itself over time. It appears that if native vegetation in the first year after planting is able to dominate the annual weeds and sufficient seed is set, native vegetation on the site will persist indefinitely.

Long-term Management Needs and Techniques

Management actions utilize adaptive management strategies, whereby the results of treatments are monitored and this information is used to alter or refine treatments for additional areas.

Long-term management challenges for this habitat are three-fold:

- *Maintenance of native forbs and shrubs on the restoration site.*
- *Maintenance of an open habitat structure for threatened and endangered species populations.*
- *The control of invasive plant species such as Russian thistle, five-hook bassia and Russian knapweed.*

Long-term management is a balancing act between keeping the habitat open and maintaining native vegetation without weed invasion. This requires frequent monitoring to determine results of grazing and other treatments.

Vegetation Management Using Livestock

The management goal for the restoration sites is to maintain an open habitat structure for the benefit of upland, special status wildlife species (e.g., San Joaquin Valley kit fox, Tipton kangaroo rat, blunt-nosed leopard lizard, and coast horned lizard). Selective, rotational grazing has proven to be an important tool for maintaining the health and biological diversity of upland grassland and shrub communities in some locations**.** Grazing perscriptions need to be developed and tested on restoration sites at Atwell Island. Grazing, timed for late spring (after native forbs have set seed and before non-native grasses have dropped their seed) may prove useful to:

- *Reduce mulch and thatch layer.*
- *Lessen fire potential by reducing the amount of vegetative fuel loading.*
- *Control invasive species propagation and spread.*
- *Control the height and density of exotic annual grasses.*

A typical applied stocking rate is 2-3 animal-unit-months (AUM's) per acre. The Residual Dry Matter (RDM) target is 700 pounds per acre, depending upon precipitation. A successful grazing treatment program will be flexible enough to respond quickly to changes on restoration sites. Grazing treatments are developed to meet the habitat goals of individual sites in order to maintain desired plant vigor and diversity. One possible draw back to grazing is the continuing potential of introducing new weed species. This issue needs to be addressed as a grazing plan is developed.

Vegetation Management Using Fire

Fire can be used as a tool for managing native grasslands by reducing RDM, increasing light and water penetration to the soil, controlling weeds by consuming foliage and seeds and providing native plants with better conditions to germinate and grow. One drawback to using fire for vegetation management is that it has the potential to reduce or destroy the shrub component, especially for the *Atriplex* species. Low intensity spring burns that consume the grasses and forbs, but do not kill the shrubs are likely the best uses of fire for vegetation management on the Project. These burn prescriptions have not yet been developed.

One potential drawback to using fire is air pollution. The surrounding community has been supportive of the BLM's burning projects to date, being accustomed to on-going agricultural burning in the area. The San Joaquin Air Pollution Control District (Air District), which regulates air quality and burn permitting, has also been supportive of the BLM's burn program. BLM coordinates with the Air District to ensure that burns take place when meteorological conditions allow for good dispersion of smoke. To date, BLM's site preparation fires have been quick-burning fall burns which produce relatively short periods of smoke emissions that disperse quickly. Burns to manage restoration sites would need to be slow and would likely produce more emissions. Controlled burns in successive years can have additional benefits of favoring native perennial grass and annual forbs over invasive exotic grasses, as observed at the Herbert Preserve (Kamansky pers. com. 2007).

Chapter 7. Wetland and Riparian Habitat Restoration

Tulare Lake once occupied approximately 500 square miles in the southern San Joaquin Valley, consisting of permanent wetlands, sloughs, ponds, marshes and seasonal wetlands. Millions of migratory ducks, geese and swans used this area as their major wintering grounds in California. Tulare Lake is now only a memory, as agricultural development and water diversion have altered and destroyed entire natural habitats. As a result, the Tulare Lake Basin has had the largest percent loss of wetlands in any portion of California.

Despite the substantial loss of wetland habitats, the area is recognized in the Central Valley Joint Venture (CVJV) and the *North American Waterfowl Management Plan* (NAWMP) for its international importance in sustaining the life cycle of many species of migratory waterfowl and shorebirds of North America's Pacific Flyway (USFWS 2004). The CVJV has targeted the Tulare Basin as its highest priority for wetland restoration.

Targeted wetland and riparian associations for restoration and/or enhancement purposes include:

Freshwater Wetlands

This wetland habitat is permanently or seasonally flooded with fresh to hyper-saline water. This series is found on ditch banks, sloughs, lakes and ponds. Dominant plants are broadleaf cattail (*Typha latifolia*), narrowleaf cattail (*Typha angustifolia*), California bulrush (*Scirpus californicus*), common three-square (*Schoenoplectus pungens*), tule (*Schoenoplectus acutus* var. *occidentalis*), saltgrass, cosmopolitan bulrush (*Schoenoplectus maritimus*) and tall flatsedge (*Cyperus eragrostis)*. Plants are generally less than 12 feet (4 m) in height.

Great Valley Mixed Riparian

This wetland habitat is seasonally flooded or saturated with fresh water, and occurs along river, stream, pond and slough edges. This series is found along the Alpaugh Canal in Sections 4 and 5; along the Poso Canal in Sec. 1, 2, 11, and 12; and along a canal in Section 10. Goodding's black willow (*Salix gooddingii*), Fremont cottonwood (*Populus fremontii*), Mexican elderberry (*Sambucus nigra* ssp. *caeruleas*), mule fat (*Baccharis salicifolia*), red willow (*Salix laevigata*), and white alder (*Alnus rhombifolia*) dominate this series. Trees are generally less than 90 feet (30 m) in height with a continuous canopy. Shrubs are sparse under the canopy, and ground cover is variable. Arroyo willow (*Salix lasiolepis*), California wild grape (*Vitis californica*) and narrowleaf willow (*Salix exigua*) may also be present in the shrub layer. Shrubs are generally less than 12 feet (4 m) in height with a continuous canopy. Exotic annual grasses, creeping wildrye (*Leymus triticoides*) and non-native forbs dominate the herbaceous layer. Alkali sacaton, saltgrass, spikerush (*Eleocharis spp*.) and California loosestrife (*Lythrum californicum*) may also be present. Grasses and forbs are generally less than three feet (1 m) in height. Restoration techniques for this habitat type are well understood along the water distribution channels in developed wetland areas.

Existing Reference Sites

Existing wetland and riparian reference sites for the Tulare Basin are found along Deer Creek, Poso Creek, Tule River and the Kern and Pixley NWR.

Wetland and Riparian Management Objectives

The goals for wetland restoration and management include:

- *Restoring historic wetlands for migratory birds.*
- *Restoring wetlands for breeding water birds.*
- *Establishing habitat for special-status species such as fulvous whistling duck (Dendrocygna bicolor), southwestern pond turtle (Actinemys marmorata) and giant garter snake (Thamnophis gigas).*

General wetland restoration and management strategies employ the following techniques:

- *Creation of wetland topography and infrastructure for water delivery.*
- *Application of initial irrigation to promote the re-establishment of wetland species.*
- *Planting of desired wetland species, including native grasses.*
- *Seasonal irrigations for targeted waterfowl and shorebird requirements.*
- *Wetland maintenance requiring annual mowing and disking (every three to four years) to maintain desired vegetation structure.*
- *Re-contouring canal banks to a slope of no more than 50% (i.e., 2:1) and re-vegetating canal banks with native grasses, shrubs and trees.*

Atwell Island Restoration Project Wetlands

The Atwell Island Restoration Project currently has 30 acres (12.2 ha) of existing wetlands and is in the process of creating an additional 269-acre of wetland habitat.

Mitchell Seasonal Wetland

Mitchell Seasonal Wetland is a 20-acre (8.2 ha) pond that was created on the Project 30 years ago in Section 7 as an evaporation pond mitigation (Figure 7-1), with the farm owner using it for waterfowl hunting. Currently the pond is managed as a seasonal wetland for wintering birds and is flooded annually from September to March. Seasonal wetlands are managed to grow moist-soil plants (e.g., swamp timothy (*Crypsis schoenoides*), watergrass (*Echinochloa crus-galli*) and smart weed (*Polygonum* spp.)), which provide forage for wintering waterfowl. Dominant emergent vegetation in the pond includes broadleaf cattails and tule. In order to reduce the density of cattails in the pond, mowing is performed annually prior to inundation. To promote the regeneration of moist-soil plant species, periodic disking is performed every 3-4 years.

Mitchell Reverse-Cycle Wetland

In 2005, Mitchell Reverse Cycle Wetland, a 10-acre (4.1 ha) brood pond was created to the east of and adjacent to the Mitchell Seasonal Wetland. Reverse-cycle ponds are flooded only spring and summer (March to September), creating nesting vegetation and an abundant supply of aquatic invertebrates for nesting birds. The dominant emergent vegetation found in this pond is cattails.

NRCS Wetland Easement - Ton Tache Wetland

The NRCS Wetland Reserve Program Easement (herein referred to as Ton Tache Wetland) located in Section 16, provided an opportunity to create five additional wetland impoundments totaling 269 acres (Figures 7-1, 7-2). Three different management scenarios for these areas include seasonal wetlands, reverse-cycle wetlands and permanent wetlands.

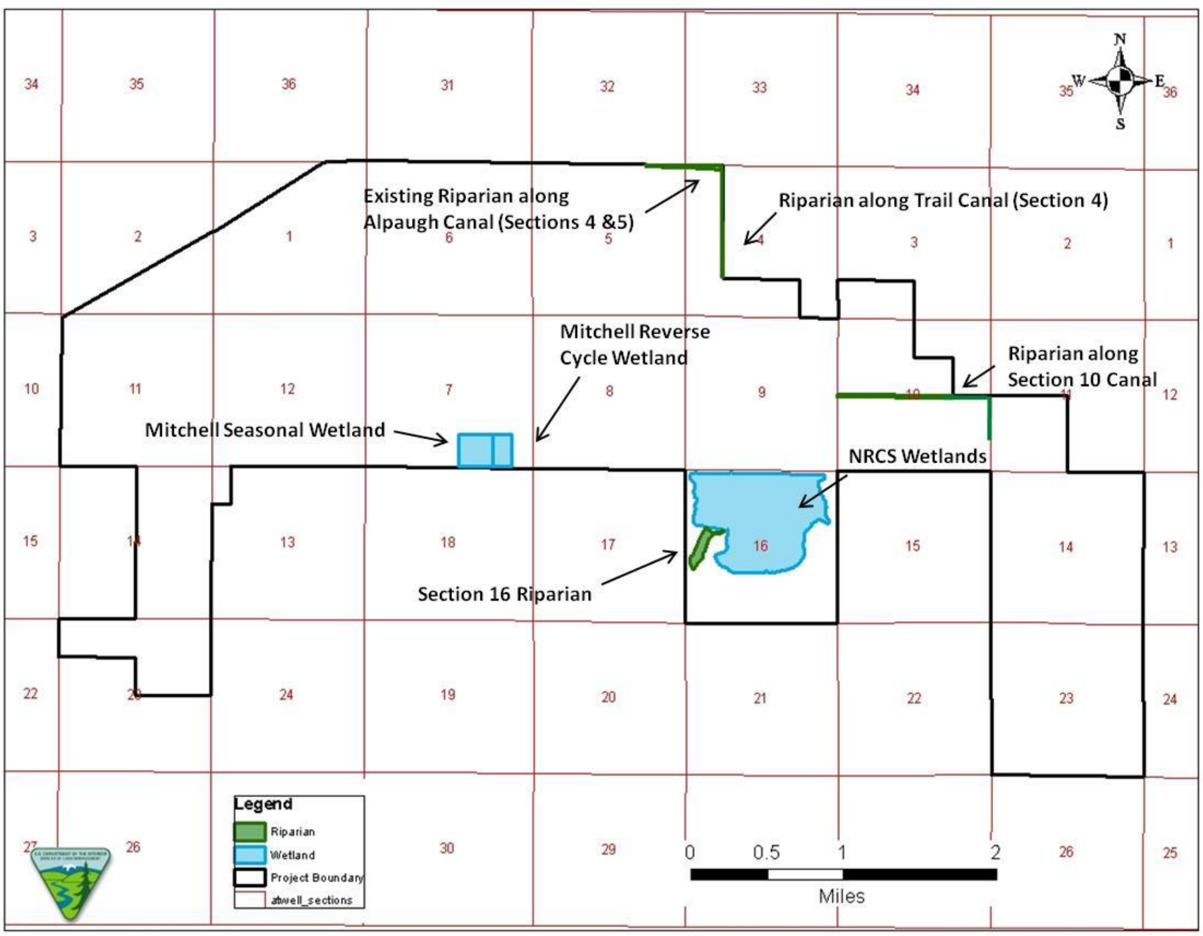

Figure 7-1. Atwell Island Restoration Project wetland and riparian habitats.

NRCS Seasonal Wetland

Three ponds in cells 1, 2, and 3 (Figure 7-2) consist of 198 acres (80.6 ha) and will be managed as seasonal wetlands for wintering waterfowl and flooded from September through March. Prior to the first inundation, levees and some islands will be vegetated (e.g., quailbush, Great Valley gumweed (*Grindelia camporum*), mugwort (*Artemisia douglasiana*) and creeping wildrye)), and pond areas will be mechanically disturbed via tillage, harrowing or scraping to promote the colonization of desired moist-soil plants. Once the ponds are flooded, tule bulrush will be transplanted and water levels with a depth of 4-10 inches (10-25 cm) will be maintained for foraging waterfowl. Summer irrigations will be conducted to enhance stand density of moist-soil plants other than cattails. Mowing will be performed annually prior to inundation to selectively reduce the density of cattails. Periodic disking every 3-5 years will be needed to promote regeneration of moist-soil plants.

NRCS Reverse-Cycle Wetland

Management of cell 5 (37 acres; 15.1 ha) focuses on breeding birds and will be flooded from March to September. As with the seasonal wetland ponds, levees and some islands will be vegetated with similar seeding composition prior to the first inundation. Once flooded, tules will be transplanted to create nesting habitat for songbirds and water birds. Riparian trees and shrubs will be planted along the levees and some of the islands to create nesting habitat for songbirds. To reduce the density of cattails, mowing may likely be required annually prior to inundation.

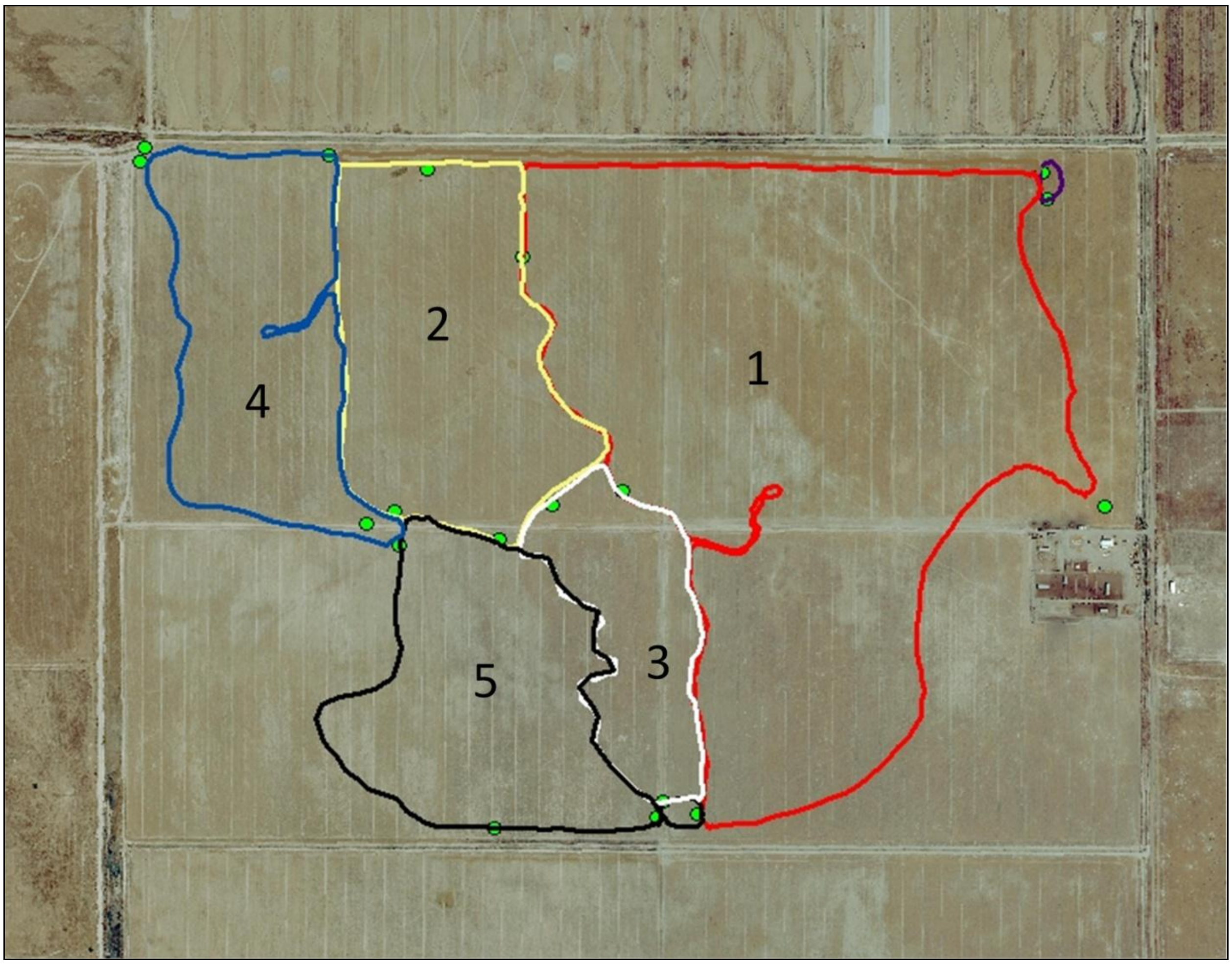

Figure 7-2. NRCS Wetland Reserve Program easement developments for wetland habitat for the Atwell Island Restoration Project.

NRCS Permanent Wetland

Management of cell 4 (34 acres; 14.1 ha) will focus on establishment of a permanent wetland (i.e., remain flooded all year). The permanent marsh habitat can support highly diverse and beneficial vegetation (e.g., grasses, sedges, rushes, tule, willows (*Salix* spp.) and cottonwoods (*Populus* spp.)) for wildlife species. Although not as productive as seasonal and reverse-cycle wetlands in terms of invertebrate abundance and moist-soil plant biomass, permanent marshes provide habitat for wildlife year round. As with the seasonal and reverse-cycle wetlands, levees and islands were vegetated with composition similar to the former applications. After the area was first flooded, tule bulrush were transplanted, while 50 Fremont cottonwood, 30 narrowleaf willow, 135 mule fat and 235 arroyo willow saplings were planted along the levees and some of the islands. To augment these efforts, additional riparian restoration is planned for this pond. In the future, this wetland may require drainage and landscaping maintenance (mowing and disking) in order to reduce the density of cattails.

Water Sources, Conveyance, and Delivery Systems

Water supply for the wetlands is derived from several sources. Floodwater can be obtained in some years, and the wetlands in return can provide flood control to local farmlands and nearby communities. The wetland construction was designed so surface water could be accessed from both the Homeland and Alpaugh Irrigation District canals. Additionally, three deep wells are available for groundwater pumping. When fully flooded, seasonal wetlands will require 792 acre-feet of water (four acre-feet/acre/year). Reverse-cycle wetlands will require 270 acre-feet of water (five acre-feet/acre/year), and the permanent wetland will require 272 acre-feet of water (eight acre-feet/acre/year). The total annual water requirement is approximately 1,249 acre-feet of water. The cost of the water supply averages approximately $65 per acre-foot (ranging from $5to $120 per acre-foot, depending upon demand and predominant source(s) of supply).

Riparian Restoration and Management

Historically, riparian vegetation followed the creeks from the foothills into the Tulare Basin, forming extensive oak woodlands and willow thickets. Riparian habitat is vitally important for many wildlife species as it provides spatial and structural diversity to an otherwise uniform landscape. The goals for riparian restoration and management include:

- *Restore and create riparian zones along canals for Neotropical migratory birds.*
- *Create riparian vegetation adjacent to, or in desired juxtaposition with, selected wetland areas.*
- *Create backwater sloughs where more extensive riparian vegetation can be planted.*
- *Provide habitat for special-status species (e.g., Buena Vista lake shrew (Sorex ornatus relictus, Swainson's hawk (Buteo swainsoni)).*
- *Increase diversity of habitat types on the Project.*

Riparian Habitat Area Along Alpaugh Canal (Sections 4 & 5)

The riparian habitat along Alpaugh Canal (Sections 4 and 5) extends for approximately 0.5 miles (0.8 km) in length and is forested with cottonwood and willow (Figure 7-1). The BLM has planted additional riparian vegetation, (e.g., mule fat, California wildrose (*Rosa californica*), box elder (*Acer negundo*), Goodding's black willow, Oregon ash (*Fraxinus latifolia*) and common buttonbush (*Cephalanthus occidentalis*)) along the Alpaugh canal to increase species diversity.

Riparian Habitat Along Trail Canal (Section 5)

The riparian habitat along Trail Canal (Section 5) extends for approximately 0.75 miles (1.2 km) in length and stretches from the Alpaugh Canal in the north to Avenue 42 in the south (Figure 7-1). The Trail Canal is maintained as a delivery ditch and only the western bank of the canal has been re-vegetated. BLM has planted several hundred trees and shrubs along this canal (mule fat, cottonwood, California rose, box elder, narrowleaf willow, Goodding's black willow, Oregon ash, common buttonbush and arroyo willow), and creeping wildrye has been seeded on the western bank. Much of the understory and ground-cover vegetation is also native and was planted. Creeping wildrye has successfully established along the ditch banks and sapling survival along the Trail Canal is around 70%.

Riparian Habitat Along Section 10 Canal

The riparian habitat along Section 10 Canal is located at the junction of Avenue 48 and Road 40, extending east for one mile (1.6 km) to the Alpaugh Irrigation Canal Road. This area has been planted by BLM with 1,800 Goodding's black willow cuttings and seeded with creeping wildrye. Cuttings were planted on both sides of the canal because this canal is no longer used to transport water. Creeping wildrye has successfully established along the ditch banks and survivorship of willow cuttings has been approximately 20%.

Ton Tache Wetland Riparian Habitat (Section 16)

The riparian habitat of Ton Tache Wetland is 11 acres (4.5 ha) in size, and is located adjacent to the NRCS permanent wetland impoundment (Figure 7-1). Orchard-style planting techniques were employed to create a forest that contains tall groves of trees, shrub clusters, and a dense herbaceous understory. The following species were planted in the spring of 2009: 50 box elder, 200 California rose, 200 Fremont cottonwood, 300 narrowleaf willow, 265 mule fat, 120 red willow, 85 arroyo willow, and 30 common buttonbush. Creeping wildrye, mugwort and Great Valley gumplant were seeded between planting rows. Plantings were irrigated every month from March to the end of September with irrigations averaging 15 acre-feet of water per month. Preliminary results indicate that survival of plantings is less than 20%, with non-native grasses dominating the understory. Of all the woody species planted, mule fat seems to have the highest survivorship. Low survivorship is most likely caused by harsh soil conditions, which can be described as salty-heavy-clay soils. Monthly irrigations caused salt accumulation in the topsoil, which most likely inhibited plant growth. In the future, this area will still receive summer irrigations but less frequently.

Riparian Restoration Implications

Riparian habitat re-vegetation should only occur along canals and wetlands where plantings are continuously inundated with fresh water. Orchard-style planting designs that receive flood irrigations and cause salt accumulation in the topsoil should be discontinued and no longer be implemented. Section 5 and 10 Canals should be kept charged with freshwater from February through October. Past efforts focused on determining which species seemed most adapted to handle dry salty soils. Mule fat and Goodding's black willow proved to be very drought and salt tolerant species. Based on the Atwell Island studies, greater efforts should be spent on creating structure from local cuttings and less on increasing species diversity with potted-stock from outside the Tulare Basin.

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APPENDICES

Appendix 1: Acronyms and Abbreviations

ac	acres
AID	Alpaugh Irrigation District
AIWD	Atwell Island Water District
BLM	Bureau of Land Management
CIMIS	California Irrigation Management Information System
cm	centimeters
CVJC	Central Valley Joint Venture
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
EC	Electrical Conductivity
EPA	Environmental Protection Agency
ESRP	Endangered Species Recovery Program
ET	Evapotranspiration
FWS	U.S. Fish and Wildlife Service
ha	hectares
HRS	Habitat Restoration Study
in	inches
kg	kilogram
km	kilometers
LRDP	Land Retirement Demonstration Project
LRP	Land Retirement Program
LRT	Land Retirement Team
m	meters
mi	miles
$\mu S\ cm^{-1}$	micro Siemens per centimeter
NAWMP	North American Waterfowl Management Plan
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge
p value	Probability of Statistical Significance
R^2	Percent Explained Variance
spp.	Species not Known
t value	Statistic showing confidence interval around mean
TZ	Chemical seed viability test
USBR	US Bureau of Reclamation
USDA	U.S. Department of Agriculture

Appendix 2: Recommended Seed Mixes for Dominant Project Soil Types

Soil Type: Posochanet Silt Loam
Soil Texture & Salinity: Upper – silt loam, salinity 4-8 ds/m, SAR 2-13; Lower – silty clay loam, salinity 4-30 ds/m, SAR 13-50
Drainage: Moderately well drained, slow permeability

Species	**Pounds/Acre**
Shrubs	
Allscale (*Atriplex polycarpa*)	5
Iodine bush (*Allenrolfea occidentalis*)	2
Goldenbush (*Isocoma acradenia*)	4
Bush seepweed (*Suaeda moquinii*)	3
Bladderpod (*Isomeris arborea*)	2
Alkali heath (*Frankenia salina*)	2
Forbs	
Goldfields (*Lasthenia californica* & *L. minor*)	6
Sierra white layia (*Layia pentachaeta* ssp. *albida*)	6
Great Valley phacelia (*Phacelia ciliata*)	2
Spikeweed (*Hemizonia pungens*)	2
Total	**34**

Soil Type: Houser Fine Sandy Loam
Soil Texture & Salinity: Alkaline and sodic, salinity >16 ds/m
Drainage: Moderately drained

Species	**Pounds/Acre**
Shrubs	
Allscale (*Atriplex polycarpa*)	4
Iodine bush (*Allenrolfea occidentalis*)	2
Goldenbush (*Isocoma acradenia*)	4
Bush seepweed (*Suaeda moquinii*)	4
Bladderpod (*Isomeris arborea*)	1
Alkali heath (*Frankenia salina*)	2
Forbs	
Goldfields (*Lasthenia californica* & *L. minor*)	5
Sierra white layia (*Layia pentachaeta* ssp. *albida*)	5
Great Valley phacelia (*Phacelia ciliata*)	2
Spikeweed (*Hemizonia pungens*)	3
Total	**32**

Soil Type: Sandridge Loamy Fine Sand
Soil Texture & Salinity: Loamy sand to sand, slightly acid to strongly alkaline
Drainage: Excessively drained soil, moderately rapid permeability

Species	**Pounds/Acre**
Shrubs	
Allscale (*Atriplex polycarpa*)	6
Iodine bush (*Allenrolfea occidentalis*)	1
Goldenbush (*Isocoma acradenia*)	6
Bush seepweed (*Suaeda moquinii*)	1
Alkali heath (*Frankenia salina*)	2
Forbs	
Goldfields (*Lasthenia californica* & *L. minor*)	4
Sierra white layia (*Layia pentachaeta ssp. albida*)	4
Great Valley phacelia (*Phacelia ciliata*)	1
Spikeweed (*Hemizonia pungens*)	5
Total	**30**

Soil Type: Nahrub Silt Loam
Soil Texture & Salinity: Upper – salinity 1-16 ds/m; Lower – salinity 8-30 ds/m
Drainage: Somewhat poorly drained, very slow permeability

Species	**Pounds/Acre**
Shrubs	
Allscale (*Atriplex polycarpa*)	6
Iodine bush (*Allenrolfea occidentalis*)	1
Goldenbush (*Isocoma acradenia*)	2
Bush seepweed (*Suaeda moquinii*)	2
Bladderpod (*Isomeris arborea*)	2
Alkali heath (*Frankenia salina*)	4
Forbs	
Goldfields (*Lasthenia californica* & *L. minor*)	6
Sierra white layia (*Layia pentachaeta* ssp. *albida*)	1
Great Valley phacelia (*Phacelia ciliata*)	1
Spikeweed (*Hemizonia pungens*)	6
Total	**31**

Soil Type: Westcamp Silt Loam
Soil Texture & Salinity: Saline & alkaline; salinity 2-16 ds/m
Drainage: Somewhat poorly drained, slow permeability

Species	**Pounds/Acre**
Shrubs	
Allscale (*Atriplex polycarpa*)	1
Spiny saltbush (*Atriplex spinifera*)	4
Iodine bush (*Allenrolfea occidentalis*)	4
Goldenbush (*Isocoma acradenia*)	1
Bush seepweed (*Suaeda moquinii*)	6
Alkali heath (*Frankenia salina*)	2
Forbs	
Goldfields (*Lasthenia californica* & *L. minor*)	6
Sierra white Layia (*Layia pentachaeta* ssp. *albida*)	3
Great Valley phacelia (*Phacelia ciliata*)	1
Spikeweed (*Hemizonia pungens*)	1
Total	**29**

Soil Type: Lethent Fine Sandy Loam
Soil Texture & Salinity: Saline & alkaline; salinity >16 ds/m
Drainage: Moderately well drained, slow permeability

Species	**Pounds/Acre**
Shrubs	
Allscale (*Atriplex polycarpa*)	4
Iodine bush (*Allenrolfea occidentalis*)	2
Goldenbush (*Isocoma acradenia*)	4
Bush seepweed (*Suaeda moquinii*)	4
Alkali heath (*Frankenia salina*)	2
Forbs	
Goldfields (*Lasthenia californica* & *L. minor*)	5
Sierra white layia (*Layia pentachaeta* ssp. *albida*)	5
Great Valley phacelia (*Phacelia ciliata*)	2
Spikeweed (*Hemizonia pungens*)	4
Total	**32**

Appendix 3: Plot history for Atwell Island Project restoration sites

Field	Acres	Soil Type	Type	Last Crop	Years Fallow	Burn	Mechanical	Date Planted	Planter	Rate	Source
24-22-01-04A	16	West Camp	Field Planting	Oats	2	No	Disked	Nov-03	Broadcast Seeder	86	Local/Native
24-22-01-04B	7	West Camp	Sump Planting	Sump		No	No	Oct-03	Range Drill	64	Local/Native
24-22-01-04C	24	West Camp	Hedgerows	Oats	2	No	Disked	Nov-03	Broadcast Seeder	63	Local/Native
24-22-01-05	7	West Camp	Sump Planting	Sump		No	No	Oct-04	Range Drill	17	Local/Native
24-22-01-06	14	West Camp	Sump-2nd Planting		5	No	No	Oct-05	Range Drill	19	Local/Native
24-22-01-07	65	West Camp	Field Planting	Oats	5	Yes	Harrowed - 4"	Nov-07	Broadcast Seeder	30	Local/Native
24-22-11-06A	26	Excelsior	Field Planting	Oats	20	Jan-06	No	Jan-06	Range Drill	10	Local/Native
24-22-11-06B	52	Sand Ridge	Field Planting	Oats	52	Jul-07	No	Jan-06	Range Drill	15	Local/Native
24-22-12-05A	40	West Haven	Field Planting	Safflower	5	Nov-04	No	Nov-04	Range Drill	26	Local/Native
24-22-12-05B	40	West Haven	Field Planting	Oats	0	No	Disked	Dec-04	Broadcast Seeder	42	Local/Native
24-22-12-06A	40	Sand Ridge	Interplanting Fallow Field	Alfalfa	1	No	No	Oct-05	Range Drill	6	Local/Native
24-22-12-06B	70	West Haven	Field Planting	Safflower	6	Nov-05	No	Nov-05	Range Drill	19	Local/Native
24-22-12-07	50	West Haven	Field Planting	Alfalfa	2	Yes	No	Jan-08	Range Drill	30	Local/Native
24-23-03-01	80	West Haven	ESRP Plots	Oats	4	No	Disked & Contoured	Jan-01	Imprinter	12	S&S Seed Mix
24-23-04-03	2	Sand Ridge	Hedgerow	Oats	2	No	Disked	Dec-02	Range Drill	75	Local/Native

Field	Acres	Soil Type	Type	Last Crop	Years Fallow	Burn	Mechanical	Date Planted	Planter	Rate	Source
24-23-04-04	20	West Haven	Alfalfa Test Plots	Alfalfa	5	No	Disk/Herbicide	Nov-03	Various		Local/Native
24-23-04-05	1	West Haven	Canal Planting	none		No	Scraped	Feb-05	Broadcast Seeder	10	Hedgerow Farms
24-23-04-06	16	West Haven	Field Planting	Oats	0	No	Disked	Jan-06	Broadcast Seeder	13	Local/Native
24-23-05-04	2	Sand Ridge	Hedgerows	Oats	3	No	Disked	Dec-03	Range Drill	30	Local/Native
24-23-06-05A	40	West Haven	Field Planting	Oats	2	No	Disked	Feb-05	Broadcast Seeder	40	Local/Native
24-23-06-05B	40	Sand Ridge	Field Planting	Oats	0	Yes	Disked	Jan-05	Broadcast Seeder	44	Local/Native
24-23-06-06	12	Sand Ridge	Field Planting	Oats	3	No	Disked	Jan-06	Broadcast Seeder	38	Local/Native
24-23-07-01	120	West Haven	ESRP Plots	Barley	1	No	Disked & Contoured	Jan-01	Imprinter	12	S&S Seed Mix
24-23-07-06A	40	West Haven	Field Planting	Alfalfa	2	Nov-05	No	Dec-05	Range Drill	27	Local/Native
24-23-07-06B	15	West Haven	Field Planting	Alfalfa	2	Nov-05	No	Dec-05	Range Drill	23	Local/Native
24-23-08-01	40	West Haven	ESRP Plots	Barley	1	No	Disked & Contoured	Jan-01	Imprinter	12	S&S Seed Mix
24-23-08-04	20	Nahrub	Field Planting	Oats	4	No	Disked	Feb-04	Broadcast Seeder	20	Local/Native
24-23-08-05	20	Nahrub	Field Planting	Oats	5	No	Disked	Feb-05	Broadcast Seeder	20	Local/Native
24-23-08-06A	49	Nahrub	Field Planting	Oats	1	Nov-05	No	Dec-05	Range Drill	23	Local/Native
24-23-08-06B	46	Nahrub	Field Planting	Oats	1	Nov-05	No	Dec-05	Range Drill	16	Local/Native
24-23-09-05	30	West Haven	Field Planting	Alfalfa	0	No	Disked	Nov-04	Range Drill & Broadcast	31	Local/Native
24-23-09-07A	56	Nahrub	Hedgerows	Oats	1	Nov-06	Rear blade	Nov-06	Range Drill	19	Local/Native

Field	Acres	Soil Type	Type	Last Crop	Years Fallow	Burn	Mechanical	Date Planted	Planter	Rate	Source
24-23-09-07B	66	Nahrub	Disked Shrub Strip	Oats	1	Nov-06	Disked	Nov-06	Broadcast Seeder	31	Local/Native
24-23-09-07C	150	Nahrub	Flat not Disked	Oats	1	Nov-06	No	Nov-06	Range Drill	24	Local/Native
24-23-09-07D	37.5	Nahrub	Flats in Hedgerow E 1/4	Oats	1	Nov-06	Harrowed - 4"	Dec-06	Broadcast Seeder	27	Local/Native
24-23-09-07E	112.5	Nahrub	Flats in Hedgerow W 3/4	Oats	1	Nov-06	Harrowed - 4"	Dec-06	Broadcast Seeder	31	Local/Native
24-23-09-07F	25	Nahrub	Depressions in Hedgerows	Oats	1	Nov-06	Bulldozed	Dec-06	Broadcast Seeder	23	Local/Native
24-23-10-01A	80	Nahrub	ESRP Plots	Oats	4	No	Disked & Contoured	Jan-01	Imprinter	12	S&S Seed Mix
24-23-10-01B	20	Nahrub	Hedgerow	Oats	4	No	Hedgerow Prep	Jan-01	Range Drill	10	S&S Seed Mix
24-23-10-01C	3	Nahrub	Canal Planting	none		No	Scraped	Jan-01	Broadcast by Hand	10	Hedgerow Farms
24-23-10-01C	3	Nahrub	Canal Planting	None		No	Scraped	Jan-04	Broadcast by Hand	50	Hedgerow Farms
24-23-10-02A	20	Nahrub	Hedgerow	Safflower	2	No	Hedgerow Prep	Feb-02	Range Drill	18	S&S Seed Mix
24-23-10-02B	140	Nahrub	Hedgerow	Safflower	2	No	Hedgerow Prep	Feb-02	Range Drill	35	Local/Native
24-23-10-03	50	Nahrub	Hedgerow	Safflower	2	No	Hedgerow Prep	Jan-03	Range Drill	30	Local/Native
24-23-10-04A	40	Nahrub	Hedgerows	Oats	5	No	Scraped	Nov-03	Range Drill	30	Local/Native
24-23-10-04B	6	Nahrub	Field Planting	Oats	5	No	No	Jan-04	Range Drill	87	Local/Native
24-23-10-05	80	Nahrub	Hedgerows	Oats	5	No	Hedgerow	Nov-04	Range Drill	36	Local/Native
24-23-14-01A	160	Nahrub	ESRP Plots	Oats	4	No	Disked & Contoured	Jan-01	Imprinter	12	S&S Seed Mix
24-23-14-01B	80	Nahrub	Field Planting	Oats	4	No	No	Jan-01	Range Drill	11	S&S Seed Mix

Field	Acres	Soil Type	Type	Last Crop	Years Fallow	Burn	Mechanical	Date Planted	Planter	Rate	Source
24-23-23-02A	40	Nahrub	Field Planting	Oats	5	No	No	Nov-01	Imprinter	11	S&S Seed Mix
24-23-23-02B	40	Nahrub	Field Planting	Oats	5	No	No	Dec-01	Imprinter & Range Drill	27	Local/Native
24-23-23-03	70	Nahrub	Field Planting	Oats	5	No	No	Dec-02	Range Drill	19	Local/Native
24-23-01-08A	40	Sand Ridge	Field Planting	Oats	5	Yes	No	Nov-08	Range Drill 8'	31	Local/Native
24-23-06-08A	60	Sandridge	Field Planting	Alfalfa	5	no	disk	Jan-09	Broadcast Seeder	33	Local/Native
24-23-05-08A	15	Posochanet	Field Planting	Alfalfa	10	Yes	No	Nov-09	Range Drill 8'	30	Local/Native
24-23-07-08	80	Nahrub	Field Planting	Oats	9	No	Disk	Dec-09	Broadcast Seeder	29	Local/Native
24-23-08-08	80	Nahrub	Field Planting	Oats	10	No	No	Dec-09	Range Drill 8'	12	Local/Native
24-23-06-08B	30	Posochanet	Field Planting	Garden	1	Yes	No	Dec-09	Range Drill 16'	34	Local/Native
24-23-05-08B	40	Sandridge	Field Planting	Alfalfa	0	No	Disk	Oct-09	Broadcast Seeder	30	Local/Native
24-23-08-08B	30	Nahrub	Field Planting	Oats	4	No	Disk	Oct-09	Broadcast Seeder	28	Local/Native
24-23-05-09A	80	Posochanet	Field Planting	Oats	1	No	Disk	Oct-09	Range Drill 16'	27	Local/Native
24-23-05-09B	120	Posochanet	Field Planting	Oats	1	No	Disk	Oct-09	Range Drill 16'	27	Local/Native
24-23-09-09	40	Posochanet	Field Planting	Oats	4	No	Disk	Oct-09	Broadcast Seeder	30	Local/Native
24-23-06-09	80	Sandridge	Field Planting	Alfalfa	1	No	Disk	Oct-09	Broadcast Seeder	80	Local/Native
24-23-08-09A	30	Nahrub	Field Planting	Oats	8	No	Disk	Oct-09	Broadcast Seeder	27	Local/Native
24-23-08-09B	30	Nahrub	Field Planting	Oats	8	No	No	Oct-09	Range Drill 16'	25	Local/Native

Appendix 4: Restoration Monitoring Outcome on Restoration Sites in 2010

Outcome 2010 Field	Bare %	Grass %	Tot Shrub%	Nat Forbs%	Tot Native%	Tot Weed%
24-22-01-04A	0	76	12	10	22	78
24-22-01-04B	68	0	22	5	27	5
24-22-01-04C	0	48	26	24	50	50
24-22-01-07	2	78	10	8	18	80
24-22-11-06A	1	11	0	73	73	26
24-22-11-06B	3	26	4	50	54	46
24-22-12-05A	2	20	32	39	71	27
24-22-12-05B	0	19	7	49	56	44
24-22-12-06A	0	61	2	35	37	63
24-22-12-06B	0	8	20	70	90	10
24-22-12-07	0	51	4	43	47	53
24-23-03-01	20	48	0	7	7	73
24-23-04-03	0	10	90	0	90	10
24-23-04-04	1	82	11	4	15	84
24-23-04-05	0	5	53	91	144	6
24-23-04-06	0	15	40	0	40	60
24-23-05-04	0	55	20	0	20	80
24-23-06-05A	0	35	2	14	16	97
24-23-06-05B	1	17	50	44	94	18
24-23-06-06	15	20	20	20	40	42
24-23-07-01	0	41	6	38	44	55
24-23-07-04	10	20	0	49	49	41
24-23-07-06A	1	62	15	12	27	72
24-23-07-06B	0	13	53	34	87	13
24-23-08-01	0	24	4	52	56	44
24-23-08-04	1	25	8	2	10	30
24-23-08-05	2	48	3	45	48	50
24-23-08-06A	2	58	5	11	16	82
24-23-08-06B	3	56	2	21	23	74
24-23-09-05	0	62	19	17	36	64
24-23-09-07A	5	15	42	8	50	45
24-23-09-07B	0	81	10	2	12	88
24-23-09-07C	0	85	1	2	3	97
24-23-09-07D	0	77	0	1	1	100
24-23-09-07E	0	83	1	7	7	93
24-23-09-07F	15	15	10	55	65	20
24-23-10-01A	2	26	0	25	25	73
24-23-10-01B	2	75	2	2	4	94
24-23-10-01C	10	15	5	80	85	17
24-23-10-02A	0	65	0	25	25	75
24-23-10-02B	1	41	3	15	18	81
24-23-10-03A	2	70	8	5	13	85
24-23-10-04A	3	61	3	26	29	68

Outcome 2010 Field	Bare %	Grass %	Tot Shrub%	Nat Forbs%	Tot Native%	Tot Weed%
24-23-10-04B	1	71	0	1	1	98
24-23-10-05	4	35	5	12	17	79
24-23-14-01A	0	25	1	17	18	81
24-23-14-01B	2	25	0	17	17	81
24-23-23-02A	2	40	5	18	23	75
24-23-23-02B	1	20	1	37	38	60
24-23-23-03	5	25	0	27	27	68
24-22-01-08B	5	45	0	15	15	80
24-22-01-08A	4	67	2	17	19	77
24-23-06-08A	0	70	5	19	24	75
24-23-05-08A	2	20	36	44	80	20
24-23-07-08	1	65	0	22	22	78
24-23-08-08	4	55	0	26	26	70
24-23-06-08B	2	12	14	65	79	22
24-23-05-08B	0	52	30	3	33	67
24-23-08-08B	5	20	1	29	29	66
24-23-05-09A	2	76	1	11	11	87
24-23-05-09B	4	67	1	18	19	77
24-23-09-09	1	50	0	3	3	96
24-23-06-09	1	61	1	21	22	77
24-23-08-09A	4	20	0	59	59	39
24-23-08-09B	3	42	1	22	23	74
Average Cover	3.3	40.7	10.7	23.9	34.5	58.2
N of Sites	41	64	51	64	65	65

Outcome 2010 Field	Native Shrubs ALOC%	ATPO%	ATSP%	ATLE %	FRSA%	ISAC%	ISAR %	SUMO %
24-22-01-04A	0	10	0	0	0	0	0	2
24-22-01-04B	2	0	0	0	0	0	0	20
24-22-01-04C	0	20	1	0	0	0	0	5
24-22-01-07	0	2	0	3	0	0	0	5
24-22-11-06A	0	0	0	0	0	0	0	0
24-22-11-06B	1	2	0	0	0	0	0	1
24-22-12-05A	0	15	0	0	2	0	0	15
24-22-12-05B	0	7	0	0	0	0	0	0
24-22-12-06A	0	0	0	0	0	2	0	0
24-22-12-06B	0	20	0	0	0	0	0	0
24-22-12-07	0	3	0	0	0	1	0	0
24-23-03-01	0	0	0	0	0	0	0	0
24-23-04-03	0	15	0	60	0	15	0	0
24-23-04-04	0	7	0	0	0	2	0	2
24-23-04-05	0	0	0	0	0	0	0	0
24-23-04-06	0	0	0	40	0	0	0	0
24-23-05-04	0	20	0	0	0	0	0	0
24-23-06-05A	0	1	0	0	0	1	0	0
24-23-06-05B	0	7	0	0	0	3	1	40
24-23-06-06	0	0	0	0	0	0	0	20
24-23-07-01	1	5	1	0	0	0	0	0
24-23-07-04	0	0	0	0	0	0	0	0
24-23-07-06A	0	13	0	0	0	0	0	2
24-23-07-06B	0	25	0	0	0	0	0	10
24-23-08-01	0	4	0	0	0	0	0	0
24-23-08-04	0	7	0	1	0	0	0	0
24-23-08-05	0	3	0	0	0	0	0	0
24-23-08-06A	0	3	0	0	0	0	1	1
24-23-08-06B	0	1	0	0	0	1	1	0
24-23-09-05	0	2	0	0	3	9	4	1
24-23-09-07A	0	10	0	30	0	0	2	0
24-23-09-07B	0	3	0	2	0	0	0	5
24-23-09-07C	0	0	0	0	0	0	0	1
24-23-09-07D	0	0	0	0	0	0	0	0
24-23-09-07E	0	1	0	0	0	0	0	1
24-23-09-07F	0	0	0	0	0	0	0	10
24-23-10-01A	0	0	0	0	0	0	0	0
24-23-10-01B	0	2	0	0	0	0	0	0
24-23-10-01C	0	0	0	0	0	0	0	0
24-23-10-02A	0	0	0	0	0	0	0	0
24-23-10-02B	0	3	0	0	0	0	0	0
24-23-10-03A	0	8	0	0	0	0	1	0
24-23-10-04A	0	2	0	0	0	0	0	0
24-23-10-04B	0	0	0	0	0	0	0	0
24-23-10-05	0	4	0	0	0	0	1	0
24-23-14-01A	0	0	0	0	1	0	0	0
24-23-14-01B	0	0	0	0	0	0	0	0

Outcome 2010 Field	Native Shrubs ALOC%	ATPO%	ATSP%	ATLE %	FRSA%	ISAC%	ISAR %	SUMO %
24-23-23-02A	0	3	0	0	2	0	0	0
24-23-23-02B	0	0	1	0	0	0	0	0
24-23-23-03	0	0	0	0	0	0	0	0
24-22-01-08B	0	0	0	0	0	0	0	0
24-22-01-08A	0	0	0	0	0	0	0	2
24-23-06-08A	0	5	0	0	0	1	0	0
24-23-05-08A	0	1	0	0	0	0	0	35
24-23-07-08	0	0	0	0	0	0	0	0
24-23-08-08	0	0	0	0	0	0	0	0
24-23-06-08B	0	7	0	1	0	3	0	3
24-23-05-08B	0	10	0	5	0	0	0	15
24-23-08-08B	0	1	0	0	0	1	0	0
24-23-05-09A	0	0	0	0	0	0	0	1
24-23-05-09B	0	1	0	0	0	1	0	1
24-23-09-09	0	0	0	0	0	0	0	0
24-23-06-09	0	0	0	0	0	0	0	1
24-23-08-09A	0	0	0	0	0	0	0	0
24-23-08-09B	0	0	0	0	1	0	0	0
Average Cover	0.1	3.7	0.0	2.1	0.1	0.6	0.2	2.9
N of Sites	3	37	3	8	5	12	7	24

ALOC = *Allenrolfea occidentalis*
ATPO = *Atriplex polycarpa*
ATSP = *Atriplex spinifera*
ATLE = *Atriplex lentiformes*
FRSA = *Frankenia salina*
ISAC = *Isocoma acradinia*
ISAR = *Isomeris arborea*
SUMO = *Suaeda moquinii*

Outcome 2010 Field	Native Forbs LACA%	LAPE%	HEPU%	PHCI%	AMME%	GULA%	MACO%	Lepidium%
24-22-01-04A	0	10	0	0	0	0	0	0
24-22-01-04B	0	0	0	0	0	0	0	5
24-22-01-04C	1	20	0	1	2	0	0	0
24-22-01-07	1	4	0	3	0	0	0	0
24-22-11-06A	3	1	2	1	65	1	1	0
24-22-11-06B	2	1	2	0	45	0	1	0
24-22-12-05A	20	10	0	5	4	0	0	0
24-22-12-05B	3	15	0	5	25	0	0	0
24-22-12-06A	0	5	0	0	30	0	0	0
24-22-12-06B	0	50	3	10	5	0	0	0
24-22-12-07	0	3	0	0	40	0	0	0
24-23-03-01	1	1	0	0	1	0	0	5
24-23-04-03	0	0	0	0	0	0	0	0
24-23-04-04	1	1	0	1	1	0	0	0
24-23-04-05	0	0	0	0	0	0	0	0
24-23-04-06	0	0	0	0	0	0	0	0
24-23-05-04	0	0	0	0	0	0	0	0
24-23-06-05A	1	2	0	8	2	0	1	0
24-23-06-05B	35	3	1	1	5	1	1	0
24-23-06-06	1	1	9	0	2	1	1	15
24-23-07-01	3	30	0	5	0	0	0	0
24-23-07-04	0	0	0	0	1	0	0	1
24-23-07-06A	2	5	0	5	0	0	0	0
24-23-07-06B	2	30	0	2	0	0	0	0
24-23-08-01	2	20	0	30	0	0	0	0
24-23-08-04	1	1	0	0	0	0	0	0
24-23-08-05	5	20	0	0	20	0	0	0
24-23-08-06A	1	1	1	3	5	0	1	1
24-23-08-06B	2	3	1	10	5	0	0	1
24-23-09-05	1	3	0	8	3	2	0	0
24-23-09-07A	1	5	0	3	0	0	0	0
24-23-09-07B	0	1	0	1	0	0	0	0
24-23-09-07C	0	1	0	1	0	0	0	0
24-23-09-07D	0	1	0	1	0	0	0	0
24-23-09-07E	1	1	0	5	1	0	0	0
24-23-09-07F	50	1	0	3	0	0	0	0
24-23-10-01A	0	1	0	0	25	0	0	0
24-23-10-01B	0	0	0	0	2	0	0	0
24-23-10-01C	0	0	0	0	0	0	0	0
24-23-10-02A	0	0	0	0	25	0	0	0
24-23-10-02B	0	1	0	0	15	0	0	0
24-23-10-03A	0	1	0	0	5	1	0	0
24-23-10-04A	1	15	0	3	6	1	0	0
24-23-10-04B	1	1	0	1	0	0	0	0
24-23-10-05	0	1	1	0	10	0	0	0
24-23-14-01A	0	1	0	0	11	5	0	2
24-23-14-01B	0	0	0	0	15	0	0	2
24-23-23-02A	0	0	1	0	15	1	0	1

Outcome 2010 Field	Native Forbs LACA%	LAPE%	HEPU%	PHCI%	AMME%	GULA%	MACO%	Lepidium%
24-23-23-02B	1	1	2	0	30	1	1	5
24-23-23-03	0	0	2	0	20	2	0	3
24-22-01-08B	1	10	0	3	2	0	0	0
24-22-01-08A	1	8	0	1	2	0	0	5
24-23-06-08A	1	5	0	4	10	0	0	0
24-23-05-08A	4	30	0	10	0	0	0	0
24-23-07-08	1	10	0	10	1	0	0	0
24-23-08-08	1	5	0	0	15	0	0	5
24-23-06-08B	15	25	0	15	5	0	0	0
24-23-05-08B	1	1	0	1	0	0	0	0
24-23-08-08B	1	3	1	15	10	0	0	0
24-23-05-09A	1	3	0	4	0	0	0	0
24-23-05-09B	2	3	1	4	0	1	0	0
24-23-09-09	1	1	0	1	0	0	0	0
24-23-06-09	3	5	5	2	1	0	1	0
24-23-08-09A	10	25	0	20	3	1	0	0
24-23-08-09B	0	2	0	15	4	0	0	4
Average Cover	2.7	6.0	0.5	3.3	7.3	0.3	0.1	0.8
N of Sites	40	53	14	38	41	12	8	14

LACA = *Lasthenia californica*
LAPE = *Layia pentachaeta ssp. albida*
HEPU = *Hemizonia pungens*
PHCI = *Phacelia ciliata*
AMME = *Amsinkia menziesii*
GULA = *Guillenia lasiophylla*
MACO = *Malacothrix coulteri*
Lepidium = primarily *Lepidium dictyotium*

Outcome 2010 Field	Invasive Shrubs & Forbs BAHY%	Mustard %	ERCI%	Clover%
24-22-01-04A	0	2	0	0
24-22-01-04B	5	0	0	0
24-22-01-04C	0	2	0	0
24-22-01-07	0	2	0	0
24-22-11-06A	0	0	15	0
24-22-11-06B	0	0	20	0
24-22-12-05A	0	7	0	0
24-22-12-05B	0	25	0	0
24-22-12-06A	0	2	0	0
24-22-12-06B	0	2	0	0
24-22-12-07	0	2	0	0
24-23-03-01	1	3	10	10
24-23-04-03	0	0	0	0
24-23-04-04	0	2	0	0
24-23-04-05	0	1	0	0
24-23-04-06	10	35	0	0
24-23-05-04	0	25	0	0
24-23-06-05A	5	65	1	0
24-23-06-05B	0	1	0	0
24-23-06-06	2	23	0	0
24-23-07-01	0	15	0	0
24-23-07-04	1	5	0	15
24-23-07-06A	5	5	0	0
24-23-07-06B	0	0	0	0
24-23-08-01	0	20	0	0
24-23-08-04	0	5	0	0
24-23-08-05	0	2	0	0
24-23-08-06A	0	15	0	5
24-23-08-06B	0	5	3	5
24-23-09-05	0	2	0	0
24-23-09-07A	0	30	0	0
24-23-09-07B	0	5	0	2
24-23-09-07C	0	10	0	0
24-23-09-07D	0	3	0	5
24-23-09-07E	0	5	0	5
24-23-09-07F	0	0	0	0
24-23-10-01A	0	2	25	20
24-23-10-01B	2	10	5	2
24-23-10-01C	2	0	0	0
24-23-10-02A	0	5	5	0
24-23-10-02B	0	30	10	0
24-23-10-03A	0	10	5	0
24-23-10-04A	0	2	5	0
24-23-10-04B	2	0	15	10
24-23-10-05	0	10	15	19
24-23-14-01A	0	1	5	50
24-23-14-01B	0	1	20	35

Outcome 2010 Field	Invasive Shrubs & Forbs BAHY%	Mustard %	ERCI%	Clover%
24-23-23-02A	0	0	5	30
24-23-23-02B	0	0	5	35
24-23-23-03	0	0	0	0
24-22-01-08B	0	35	0	0
24-22-01-08A	0	10	0	0
24-23-06-08A	3	2	0	0
24-23-05-08A	0	0	0	0
24-23-07-08	0	10	0	3
24-23-08-08	0	0	0	15
24-23-06-08B	0	5	0	0
24-23-05-08B	0	15	0	0
24-23-08-08B	0	22	2	2
24-23-05-09A	1	10	0	0
24-23-05-09B	0	10	0	0
24-23-09-09	0	46	0	0
24-23-06-09	0	15	0	0
24-23-08-09A	0	3	1	5
24-23-08-09B	0	20	0	4
Average Cover	0.6	8.8	2.5	4.1
N of Sites	12	52	19	20

BAHY = *Bassia hyssopifolia*
Mustard = *Brassica nigra, Sisymbrium iro, etc.*
ERCI = *Erodium cicutarium*
Clover = primarily *Melilotus indica*

Appendix 5: Restoration Site Implementation Recommendations

BLM's recommendations for restoration implementation in the Tulare Basin are as follows:

Step 1. Select site and determine restoration goal for site.

Step 2. Determine soil type(s) from USDA Soil Survey Maps.

Step 3. Determine condition of field:

- If field is being actively farmed disk field several times follow with a cultipacker and float if needed.
- If field is fallow do hot controlled burn if weedy or disk and cultipack if dominate by non-native grasses.

Step 4. Select seed mix based on soil type – consult Appendix 2 to help determine seed mix that is most likely to succeed.

Step 5. Plant field in mid-fall prior to first heavy fall rains:

- If soil is undisturbed (not disked) plant with Truax Range Drill or similar equipment.
- If site is disked plant with plant with Truax Trillion broadcast seeder or similar equipment.

Step 6. If rainfall is 20% or more below normal use supplementary irrigation to bring the rainfall totals up to approximately 20% above normal.