Environmental Factors Correlated with Changes in Riparian Plant Composition along the Santa Clara River Floodplain, California

by
Brian E. Holly

A Master's Project Presented to the DEL MEM
Faculty of the Nicholas School of the Environment
Duke University
Spring 2011

In Partial Fulfillment
of the Requirements for the Degree of
Master of Environmental Management
With a Focus in
Ecosystem Science and Management

Approved by:

Norm Christensen, PhD., Research Professor and Founding Dean (Advisor) Date

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ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Norm Christensen for his technical assistance with study design and data analyses as well as encouragement. My sincere thanks go to all of the people who have contributed to this project in its various stages. Thanks to the California Department of Fish and Game and U.S. Fish and Wildlife Service for supporting this study and providing technical information and guidance. In addition, thank you to the City of Santa Paula for providing historical information, maps and local knowledge of the study area. And lastly, thanks to my boss Carl Thelander for his support and guidance.

A special thanks to my wife Camille and my parents, Rich and Carol, for their endless support and encouragement.

The project team included Steve Jones (Botanist, Team Leader), Cedrick Villasenor (Botanist), Katie Chess (Botanist), Seth Sutherland (GIS Specialist) and I as the project manager, with project direction and technical input from Norm Christensen and Carl Thelander. Steve and Cedrick were instrumental in data collection while Katie and Cedrick were responsible for data tabulation/organization. Steve and Cedrick conducted research as well as assisted in data analyses. Seth performed GIS analyses and produced maps and photographic logs. Data collection, background research, study design, analyses and written synthesis were completed by me. Norm Christensen provided technical review of this thesis.

ABSTRACT

Riparian habitat supports a diverse array of species and is maintained by complex environmental processes. Changes in habitat composition can be an indicator of the health of an ecosystem, which is based on the assumption that an ecosystem, with a diverse suite of plant communities, can support a diverse set of animal species because of the complexity of microhabitats created by the layering of trees, shrubs, and herbaceous and aquatic vegetation (Nautilus Environmental 2005).

The aim of this study was to provide an analysis of habitat conditions and vegetation dynamics in relation to environmental factors and invasive species establishment to discern what changes, if any, occur to a nine-acre southern willow scrub riparian community as a result of the cessation 2.5 million GPD of wastewater. The study began in January of 2009 and ended in February of 2011. Cessation of treated effluent water occurred in May, 2010.

A total of 119 plant species of 82 genera was observed. Absolute percent cover values for each species were collected at 19 plots over 16 events. Willow (*Salix* spp.), giant reed (*Arundo donax*) and mulefat (*B. salicifolia*) were the most abundant and dominant species. Change in mean absolute percent cover values for dominant species was analyzed for overall and seasonal trends. Overall willow percent cover values declined sharply during the post cessation study while overall variation with other plants occurred more or less sporadically. Species richness declined and variation in percent cover and nativity occurred at several plots.

Ordination techniques as non-metric multidimensional scaling (NMS) and canonical correspondence analysis (CCA) were used to examine the relationship between changes in vegetation and environmental parameters. CCA analysis revealed that axis 1 is strongly correlated with willow percent cover while axis 2 is strongly correlated with Arundo percent cover. These gradients were closely related to the first 2 canonical axes and accounted for approximately 30% of the species-environment relationship in the study plots. The results suggest that variation in species composition is related to percent cover change in willow and Arundo. Other environmental variables that were correlated included distance of the study site to the center of effluent channel and the presence or absence of surface water. Understanding relationships between environmental variables and vegetation dynamics is helpful in applying these findings to management and conservation of southern California riparian ecosystems.

1.0 INTRODUCTION

The City of Santa Paula's wastewater treatment plant was discharging treated wastewater effluent to the Santa Clara River for approximately 71 years (Fig. 1). The plant had been upgraded several times since it was built in 1938, however it operated poorly as a result of outdated infrastructure and technology. In addition, a growing population put higher demand on the already overworked system.

In 2006, the Environmental Protection Agency (EPA) began to study the effluent water quality standards and determined in 2007 that the City must construct a new wastewater treatment facility and stop discharging to the Santa Clara River. As a result, the City began construction of a new wastewater treatment plant in 2009 with updated technology and infrastructure to address EPA wastewater treatment standards and meet the demands of the City's forecasted 2020 population. The new design eliminated the need to discharge treated effluent directly into the Santa Clara River as treated effluent will percolate through a series of settling ponds.

1.1 Project Purpose

Despite the improvement in water quality that the new plant will help to achieve, state and federal wildlife conservation agencies have determined that significant habitat loss and "incidental take"[1] of endangered and threatened species are likely to occur. As wastewater treatment facilities are known to play an important role in maintaining stream flows in dammed, diverted and compromised riverine systems (Faber and Holland 1996), it was determined that the cessation of treated effluent could significantly impact up to nine acres of pristine southern willow scrub riparian habitat immediately downstream of the discharge. This was likely to occur

[1]Non-federal entities undertaking otherwise lawful projects that might result in the death of/or destruction of habitat for an endangered or threatened species.

as a result of surface and groundwater reduction that contribute to the vigor and biomass of this community. Consequently, a number of species that are the focus of regulatory concern could also be impacted.

Several private organizations and public agencies such as the Nature Conservancy have recognized the precarious status of riparian habitats and have risen to their defense. These include private groups concerned with fisheries, waterfowl, wildlife, recreation and conservation (Faber and Holland 1996). The riparian ecosystem analyzed in this study has been identified as targeted conservation area (Fig. 4.4) and is particularly important because it provides active nesting sites for the federal and state endangered least Bell's vireo (*Vireo bellii pusillus*), the federal and state endangered southwestern willow flycatcher (*Empidonax traillii extimus*) (BioResource Consultants, Inc. 2008) as well as a recently discovered population of southwestern pond turtle (*Actinemys marmorata pallida*) (Holly and Schade 2010), which is a California species of special concern.

1.2 Southern California Riparian Ecosystems

Riparian ecosystems are important both as ecotones between terrestrial and aquatic systems and as corridors across regions (Naiman et al. 1993). Riparian habitat supports a diverse array of species and is maintained by complex environmental processes. Southern California riparian habitat includes the trees, other vegetation and the physical features normally found on the banks and floodplains of rivers, streams, and other bodies of fresh water. Although riparian areas typically occupy a very small part of the total land area of California, they support a tremendous number of fish and wildlife species. Over 225 species of bird, mammals, reptiles, and amphibians depend upon California's riparian habitats (Knopf et al. 1988). Many large coastal southern California rivers (i.e., the Los Angeles, Santa Ana and San Gabriel Rivers) have been confined to

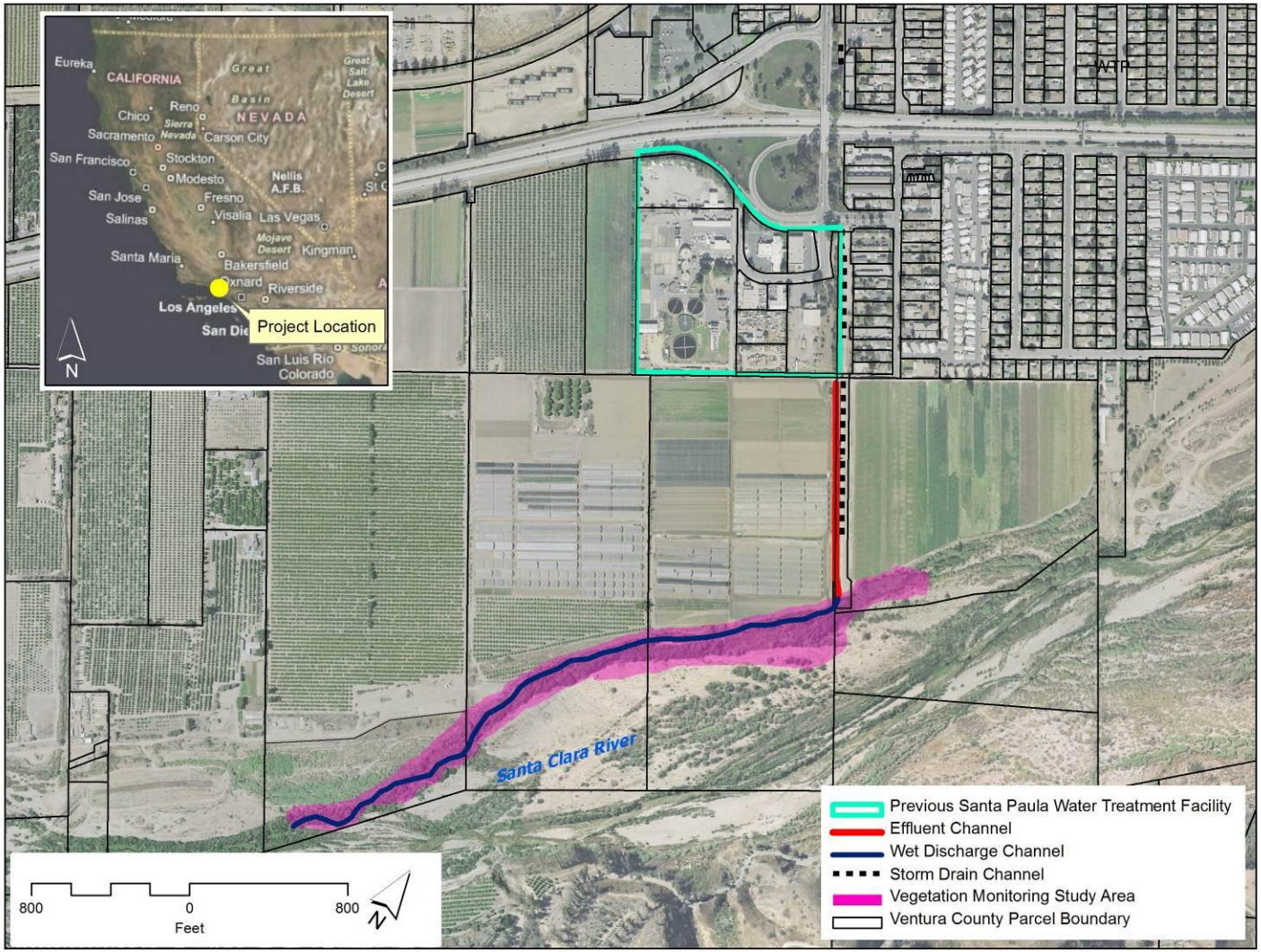
concrete channels in their lower reaches to provide flood protection for surrounding urban areas, dramatically reducing (or eliminating) riparian vegetation and fluvial geomorphic processes that maintains a functioning river corridor ecological system (Stillwater 2007). Approximately 70% of the riparian habitat in the United States has already been lost due to development, agriculture, livestock and damming (Brinson 1981). In southern California, the loss is even greater, estimated at 95% (Bell 1993).

1.2.1 Limiting Factors of Functioning Riparian Ecosystems

Flooding and Introduction of Invasive Plant Species

Southern California riparian ecosystems are dynamic and undergo a predictable sequence of revegetation following flood events. Succession from exposed alluvial soil to mature riparian forest or woodland may take 50 to 75 years or more (Faber and Keller, 1985). This relatively slow rate of re-growth is partially why exotic species are so successful at out-competing riparian herbaceous and woody species in Southern California riparian ecosystems because they establish after floods before native species can take hold. Once established, exotic species tend to use more water and out-compete native species. Additionally, the lack of decomposed sequestered nutrients from a diversity of species causes a positive feedback loop where less biomass is available during each seasonal cycle.

Figure 1. Location of the City of Santa Paula's wastewater treatment plant (retired May 2010), effluent outfall and study area, south of Highway 126 near Santa Paula, California.



1.2.2 Invasive Plant Species and Giant Reed

Worldwide, the threat of invasive species to biological diversity is second only to direct habitat loss and fragmentation (Scott and Wilcove 1998). Rare species appear to be particularly vulnerable to the changes wrought by non-native invaders (Randall and Hoshovsky 2000). California's invasive plant problems are widespread and severe. The state's varied topography, geology, and climates have helped give rise to the state's extraordinary native biological diversity and high levels of endemism. However, these varied conditions also provide suitable habitat for a wide variety of non-native species, many of which are already well established and rapidly spreading in the state.

Origins of Giant Reed

One of the most prolific invasive species impacting southern California riparian ecosystems is giant reed (*Arundo donax*), which was likely introduced into California in the early 1800's (Bell 1993). Giant reed is endemic to freshwaters of eastern Asia, specifically northern India and southern Nepal (Polunin and Huxley 1987). Approximately 2,000 years ago, giant reed was introduced around the Mediterranean Basin for use in erosion control, for reeds for musical instruments and for construction of roofs, ceilings, fences and baskets (Perdue 1958). It has been introduced to most tropical and warm temperate regions worldwide. In southern California, giant reed was prevalent along the Los Angeles River as early as the 1820s and often planted for erosion control along streams and windbreaks (Robins et al. 1951). Currently, giant reed is rapidly invading rivers and streams throughout California. On the Santa Clara River, it grows in large stands or monocultures along floodplains and terraces and has invaded most riparian vegetation types (Sillwater Sciences and URS 2007).

Giant Reed and Ecological Interactions

In California, giant reed is known to increase the risk of flooding, create fire hazards, out-compete indigenous species for scarce water resources, and reduce the value of riparian habitat for wildlife (Bell 1994, Bell 1997, DiTomaso 1998). As giant reed replaces riparian vegetation in semi-arid zones, it reduces habitat and food supply, particularly insect populations, for several special-status species. Changes in habitat composition over time can be an indicator of the health of an ecosystem. The federally endangered least Bell's vireo (*Vireo bellii pusillus*) and other riparian birds require structural diversity provided by riparian scrub and mature forest communities for breeding (Zembal 1990, Bell 1994, Bell 1997). When natural riparian vegetation types are replaced by thick stands of giant reed, bird species abundance and other native wildlife have been found to decline (Bell 1994, Bell 1997, Herrera and Dudley 2003, Kisner 2004, Labinger and Greaves 2001).

2.0 OBJECTIVE

This two-year riparian vegetation monitoring study was designed to assess habitat conditions and vegetation dynamics in relation to environmental factors and invasive species establishment (particularly *A. donax*) to discern what changes, if any, occur to this nine-acre southern willow scrub riparian community as a result of the cessation of effluent discharge. The first year being the baseline study, was conducted in 2009 and completed in February of 2010. The effluent channel was permanently shut down and the new plant was brought into operation on May 15, 2010. By monitoring this habitat, the study aimed to determine how lack of surface and ground water impacts specific plant species as well as which exotic plant species are most prolific after native plant loss. The results are beneficial for restoration techniques, as well as for

better understanding willow riparian habitat, which is highly degraded in many streams and rivers in southern California.

Changes in habitat composition can be an indicator of the health of an ecosystem. This study objective is based on the assumption that an ecosystem, with a diverse suite of plant communities, can support a diverse set of animal species because of the complexity of microhabitats created by the layering of trees, shrubs, and herbaceous and aquatic vegetation. Since plants are sensitive to changes in salinity and hydrologic regimes, as well as substrate, analysis of plant communities should provide an indication of changes in habitat within the study area over time. Such changes could be due to modifications of flow dynamics related to upstream channel alteration, reduction of overall flows, elimination of habitat as land is reclaimed, alteration in water quality and changes in the frequency of erosional and depositional events (Nautilus Environmental 2005).

Predictions

As a result of the cessation of effluent water, it is expected that the loss of nutrient rich water could impact native vegetation, however, it is not known which species will be effected and how quickly. It is also expected that certain surface water dependent herbaceous plants will potentially die off first, followed by some understory riparian plants. Some willow shrub species (*Salix exigua* or *S. laevigata*) with shallow tap roots might be initially impacted, while larger willow trees (*S. interior* or *S. lasiolepis*) with deeper tap roots may not be impacted. It is expected that there will be some seasonal changes with biomass and canopy density, but ultimately, the lack of high nitrate nutrient-rich effluent water could cause significant changes to this habitat. This study aims to track those changes and determine the causality.

In addition, giant reed (*Arundo donax*), an extremely prolific invasive species in southern California riparian ecosystems dominates the east and west sides of the study area. It is expected that as native vegetation dies off, giant reed will quickly replace barren areas. Documenting the stages of giant reed infestation will be helpful for understanding ways to control its spreading during the successional stages of riparian ecosystem regeneration.

3.0 STUDY SITE

3.1 The Santa Clara River Floodplain

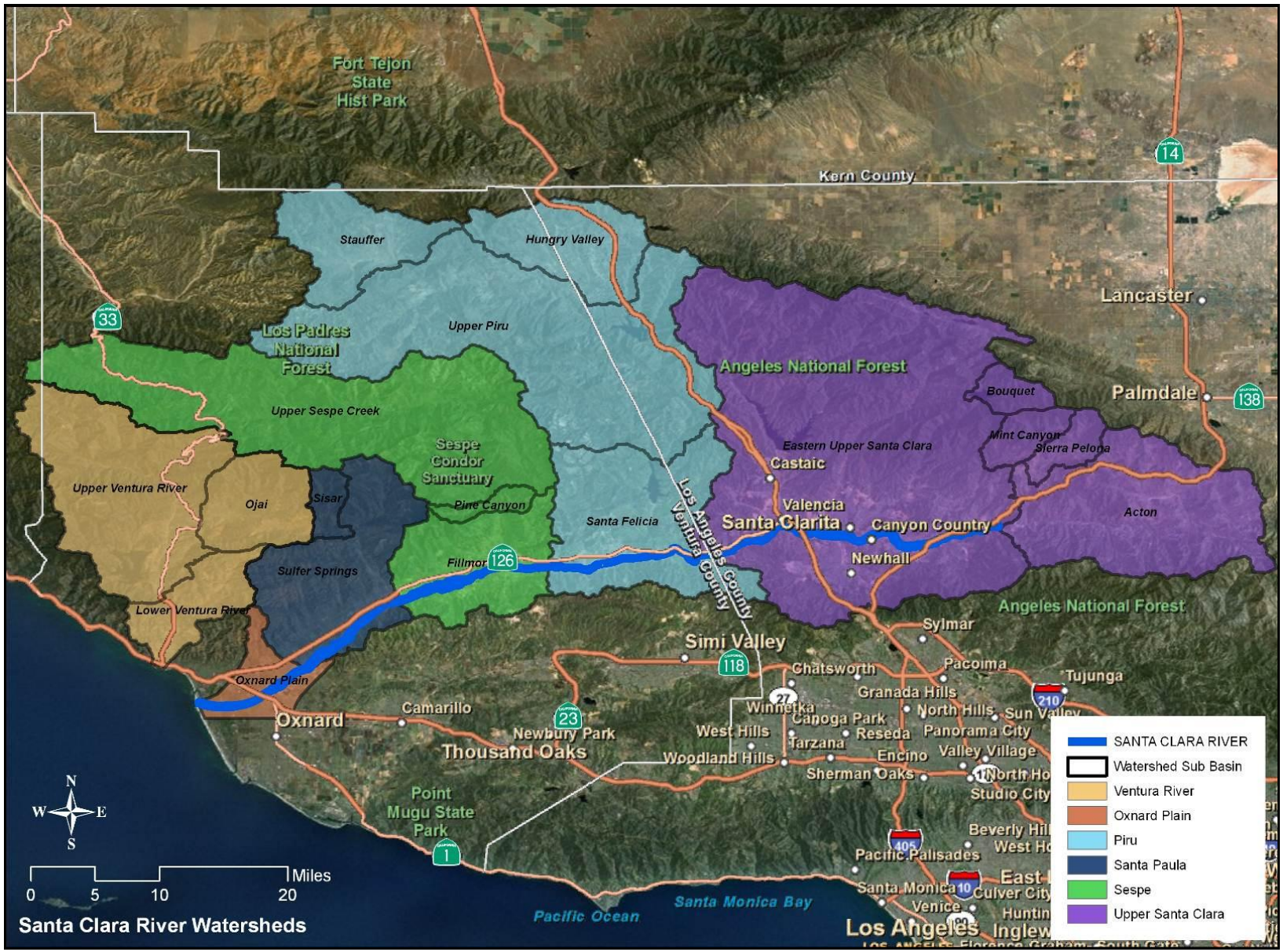
The 116-mile long Santa Clara River flows in a westerly direction from the headwaters on the northern slopes of the San Gabriel Mountains in Los Angeles County through the Santa Clara River Valley and the Oxnard Plain in Ventura County and finally empties into the Pacific Ocean near the City of Ventura (Stillwater Sciences 2007) (Fig. 3). The Santa Clara is one of the largest watersheds on the southern California coast, and it is significant to the region because it retains many natural attributes no longer exhibited by many coastal rivers that have been impacted by urban development. The present-day Santa Clara River is a dynamic semi-arid ecological system driven primarily by periodic short duration, high intensity flood events (Stillwater 2005). The channel varies between meandering and braided river forms, as defined by the gradient discharge, and bed material. Although the Santa Clara River is relatively intact compared to other southern California river systems, flood protection infrastructure, diversion, roads, agriculture and urbanization have constrained or disrupted natural processes, causing riparian and aquatic habitat degradation (Stillwater 2007).

3.2 Historical Context

The first European activity to affect California riparian habitats undoubtedly was livestock grazing, farming and resource extraction (Faber and Holland 1996). Early twentieth century farmers and settlers along the Santa Clara floodplain regularly caught large rainbow trout or steelhead in the annually flowing river. In addition, these farmers harvested large amounts of wood for heating or building. They had to depend entirely on wood for fuel until coal became more readily available. The abundance of natural resources at that time appeared limitless, but this resource rich condition quickly dissipated as development of infrastructure and farming began to put pressure on the natural ecosystems.

The diversity of habitats associated with the Santa Clara River has historically supported a wide variety of plant and animal species. However, as the sizes of these habitats have diminished over time, the abundance and distribution of many endemic species have also declined (Nautilus Environmental 2005). Human population growth, alongside increasing groundwater extraction due to development, long periods of drought and the introduction of non-native species have caused significant impacts to the Santa Clara River watershed and other southern California riparian ecosystems. Many creeks and tributaries to the Santa Clara that once flowed year-round have become ephemeral washes remaining dry much of the year. This lack of surface water, coupled with loss of habitat, has pushed the southern steelhead trout as well as several other sensitive species to near extinction.

Figure 3. Location of the Santa Clara River watershed in Ventura and Los Angeles Counties, California.



3.3 Existing Natural Setting at the Study Site

The field research was conducted adjacent to the Santa Clara River, 0.5 miles south of Peck Road, southwest of the City of Santa Paula, Ventura County, California (Fig. 1). The predominant natural plant community at the study site is best described as Riparian Woodland, more specifically classified as Arroyo willow series or southern willow scrub (Sawyer, Keeler-Wolf, 1995).

This study area is particularly unique to the Santa Clara floodplain because flood events have not impacted much of the habitat due to its alignment with the river system (Fig. 4), leaving it relatively intact and not degraded by invasive plants such as giant reed. In addition, the nutrient-rich effluent water that was flowing for the past 75 years has likely contributed to the overall biomass and rigidity of the system within the floodplain. This is true because 3-7 foot stream banks have formed which have protected the system from flooding and scouring.

Dominant tree and plant species include Arroyo willow (*Salix lasiolepis*), red willow (*Salix laevigata*), narrowleaf willow (*Salix exigua*), mulefat (*Baccharis salicifolia*), coyote brush (*Baccharis pilularis*) and mugwort (*Artemisia douglasiana*). To the north, agricultural fields, ruderal habitat and wastewater treatment plant works make up the dominant landscape.

The southern willow scrub forms a closed canopy within a linear or ribbon shaped community that follows the path of water availability from the effluent channel. Outside of the variable-width bands of mulefat and/or willow to the east, toward the main channel of the Santa Clara River, a river wash herbaceous community exists. This community is on sandy stream-terraces within the flood plain of the braided river channel. These terraces appear to be formed from sediment deposition after storm events and are generally dry most of the year. The communities are dominated by upland species including significant weedy species, with sporadic occurrences of riparian species.

Site Hydrology

Apart from seasonal rains, surface water and occasional flooding/scouring, several wells on the adjacent farms appear to play a significant role in the site's hydrologic regime (Appendix A). Groundwater is discharged to the surface at several locations throughout the year, probably to meet the annual acre-feet allocation budget, which is based on a "use it or lose it" groundwater law.

4.0 METHODS

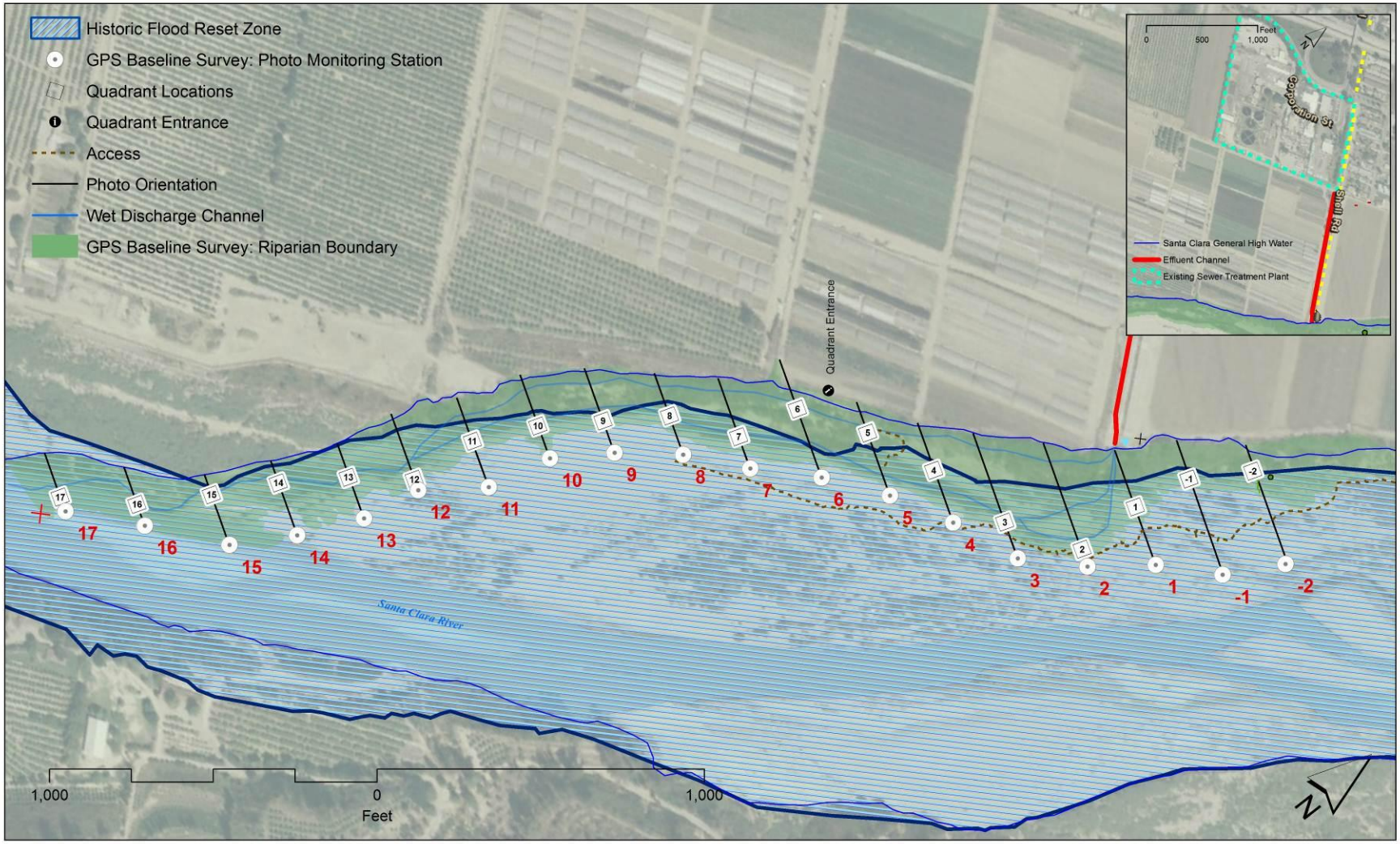
4.1 Field Study Methods

This experiment presented a unique opportunity to investigate community response by comparing the study site conditions before and after the effluent discharge was shut off. Monitoring began approximately one year prior to cessation of the effluent discharge, and continued for approximately nine months after. Sampling occurred above and below the discharge point in order to detect changes after the effluent flows stopped, as well as differentiate downstream changes from normal temporal trends upstream.

The upstream monitoring area extended above the discharge point to 400 feet. The downstream monitoring area extended to 3,200 feet downstream from the discharge point.

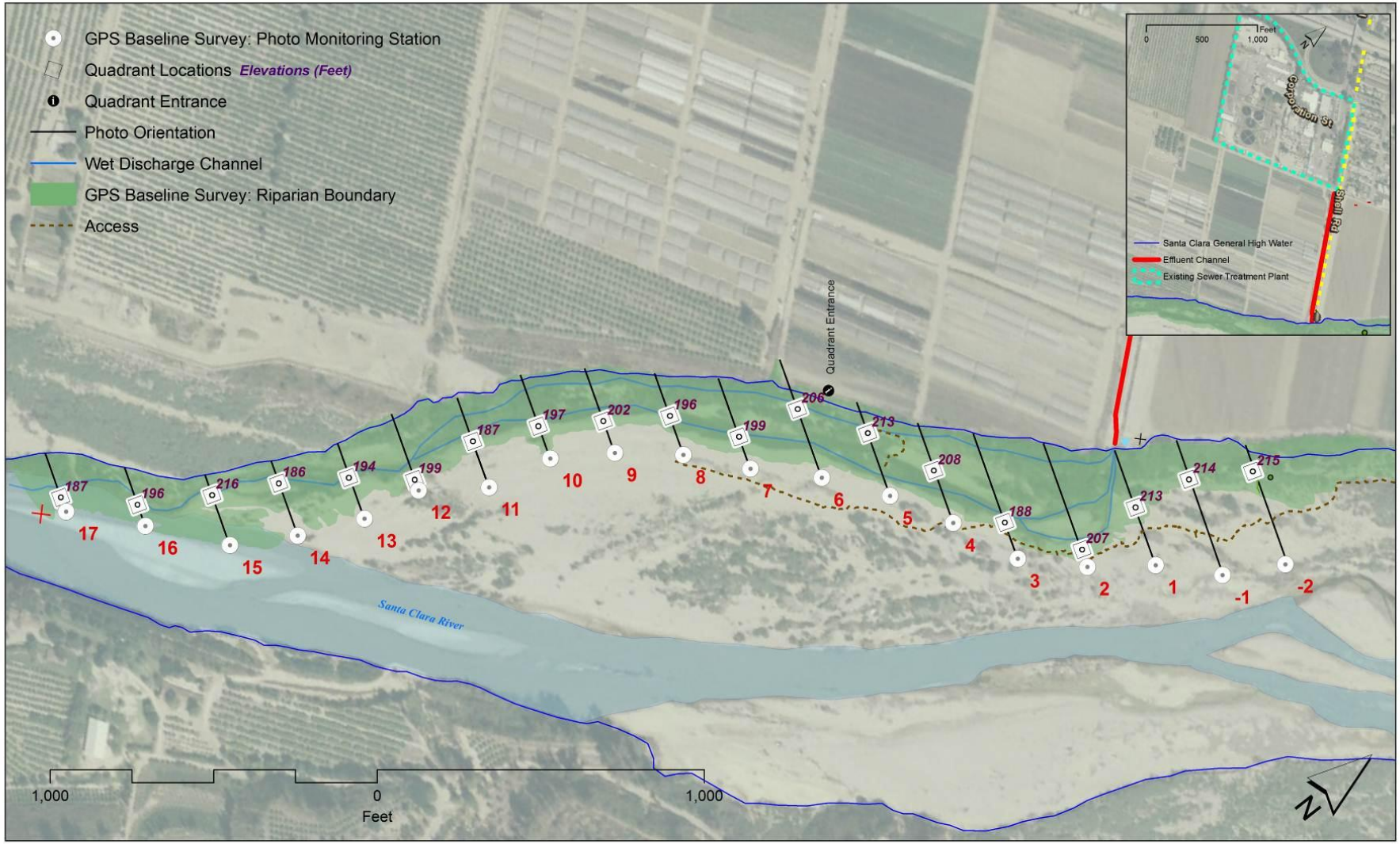
Transects were established within both monitoring areas at 200-foot intervals. Transects were identified by a sequential number; downstream a positive number 1 through 17 and upstream -1 through -2 (Fig. 4.1). Each permanent transect was located by GPS (Trimble GEO Explorer—GEO XH), assigned a photographic station and marked by a wooden stake. Each stake was identified with a photo station number and transect number (ie; photo station 1, transect 1). A 10 X 10 meter permanent sampling plot was centered on a randomly selected point along each transect. Plant cover and habitat characteristics were measured in each of these plots.

Figure 4. Study site with 100-year historical flood reset zone shown in shaded blue.



Historical hydrologic data provided by Stillwater Sciences, 2011

Figure 4.1. Study site including transects -2 through 17 and associated study area plots (white boxes). Elevation (in feet) at the center of each plot is also shown below.



4.1.1 Monitoring Frequency

The repeated visit linear transect method was used for approximately two years, with the first year baseline data study completed prior to the effluent discharge cessation in 2009. Data were gathered across all 19 plots, 16 times during this two-year study. Each collection event lasted 2-3 days, depending on environmental and weather conditions. The first sampling event occurred in late March 2009 (sample events summarized in Table 4 below). Nine sample events were conducted during the pre-cessation baseline study between March 2009 and February 2010.

Beginning in early June 2010 (after cessation of the effluent water), the remainder of this vegetation monitoring study continued over seven more sampling events (February 2011). Multiple sampling events occurred within a calendar year in order to capture seasonal variation. Three sampling events occurred in the spring in order to assess natural new growth of species associated with spring reproduction after the rainy season.

Three sampling events occurred in the summer and fall in order to assess the vegetation during the period of the year when riparian plants typically exhibit drought stress due to reduced water availability. One sampling event occurred in the winter.

Table 4. Sampling event schedule.

Sampling Event	Sampling Period	Year
1	March 30-31	2009
2	April 22-23	2009
3	May 14, 18-19	2009
4	June 19, 22-23	2009
5	July 16-17	2009
6	August 19, 24-25	2009
7	September 29-30	2009
8	November 18-19	2009
9	February 3-4	2010
CESSATION		
10	June 10-11	2010
11	July 15-16	2010
12	August 23-24	2010
13	September 20-21	2010
14	November 15-16	2010
15	January 13-14	2011
16	February 10-11	2011

4.1.2 Qualitative Assessment

The downstream and upstream habitat was monitored qualitatively through photographic record. The photographic record provided a broad qualitative assessment of the entire area from which a comparative analysis could be drawn. Photographic stations were established in alignment with each transect. At these stations, a photograph was taken looking west along the transect alignment. The center point of the sampling plot was established as a photographic station. At the center point station, a photograph was taken in each direction of the cardinal points of the compass. In addition, a representative photograph of the sample quadrant location was taken. Each

photograph was identified by a number and briefly described and recorded on a standardized data collection form (Fig. 4.2). An overall description of plant health, drought stress and habitat conditions was recorded in association with the photograph. The photographs were organized by sampling event and transect number. All photographs have been archived for reference (see Fig. 4.3 for a representative photo log of Transect/Plot (or Quadrant) 1 from sampling event 2).

Figure 4.2. Example study site field data collection form.

Station: Transect:		
Date:	Time:	Surveyor(s):
Temperature:	Cloud Cover:	Wind:

Photographic Documentation
Qualitative Assessment

	Roll/Card#	Overall Assessment- overall plant health-drought stress-canopy cover
Station Photo (facing West)		
Quadrant Photo 1 (facing West)		
Quadrant Photo 2 (facing North)		
Quadrant Photo 3 (facing East)		
Quadrant Photo 4 (exit photo)		

Note: exit photo (#4) taken from: E center point

Quantitative Assessment

Hydrology (at center of Quadrant)	Canopy (at center of Quadrant)
Inundation: Yes☐ No☐ **Surface Water Yes☐ No☐** **Surface Water Depth:** **Water Marks Yes☐ No☐** **Sediment Deposits Yes☐ No☐** **Previous Event tree heights** **Ambros @ center: 1'** **SALE @ tallest: 29'**	**Species:** **Height @ center:** **Height @ tallest:** **Cover-Densitometer Reading:** **W N E S**

Field Data Form Continued

Species	Previous Event Absolute	Previous Event Relative	Absolute Cover ≤ or ≥ 100%					Relative Cover = 100%				
			nw	ne	sw	se	T	nw	ne	sw	se	T
Dead Willow												
Total Vegetation												
Surface Water												
Debris												
Bare Ground/Litter												
TOTAL												

Percent of Total Vegetative Cover:
Percent of Vegetative Cover of Dominant Species - 20% or higher:
Additional Comments:

Figure 4.3. Representative photo log of Transect/Plot 1 from monitoring event 2 (March, 2009).

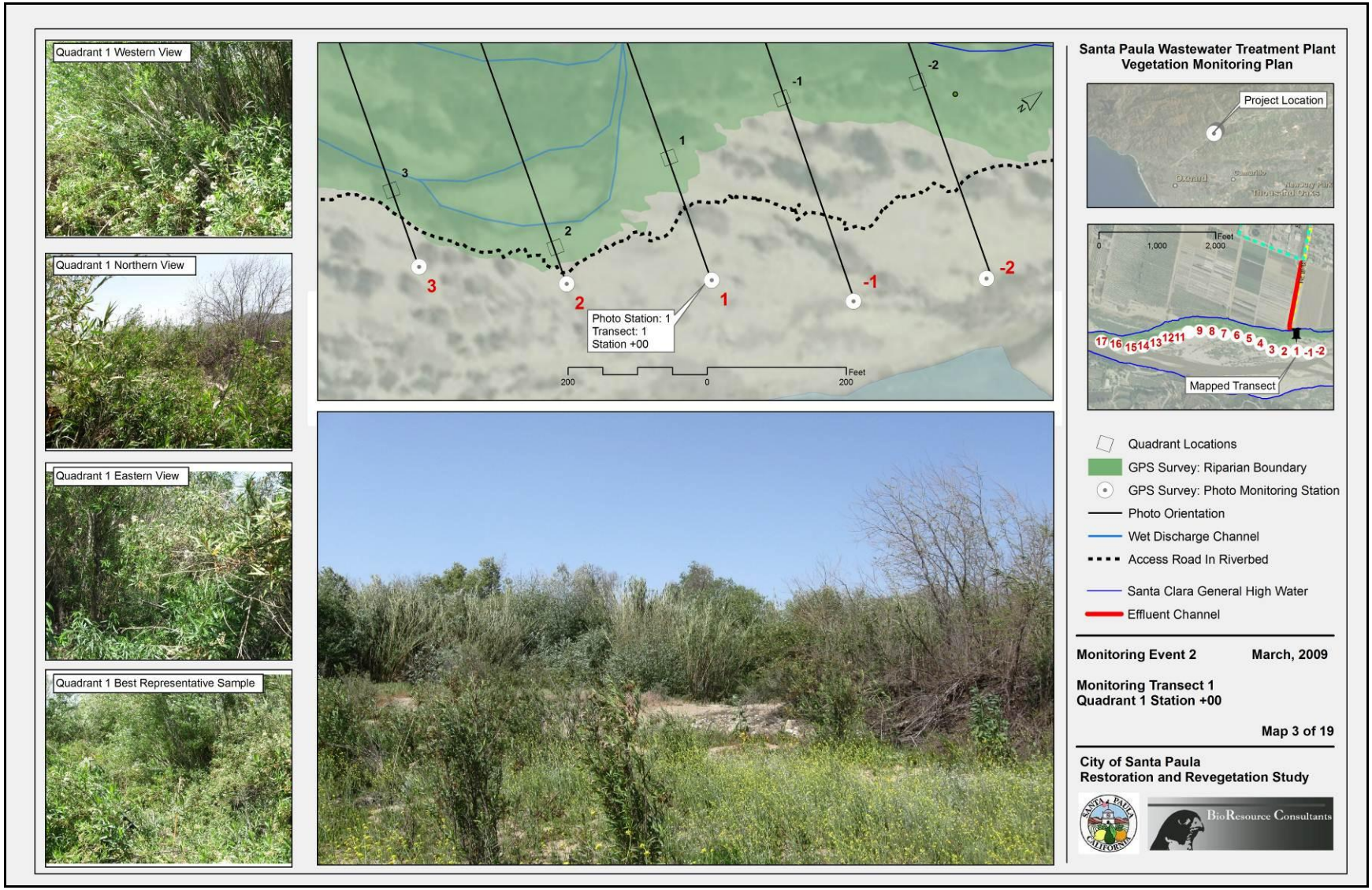
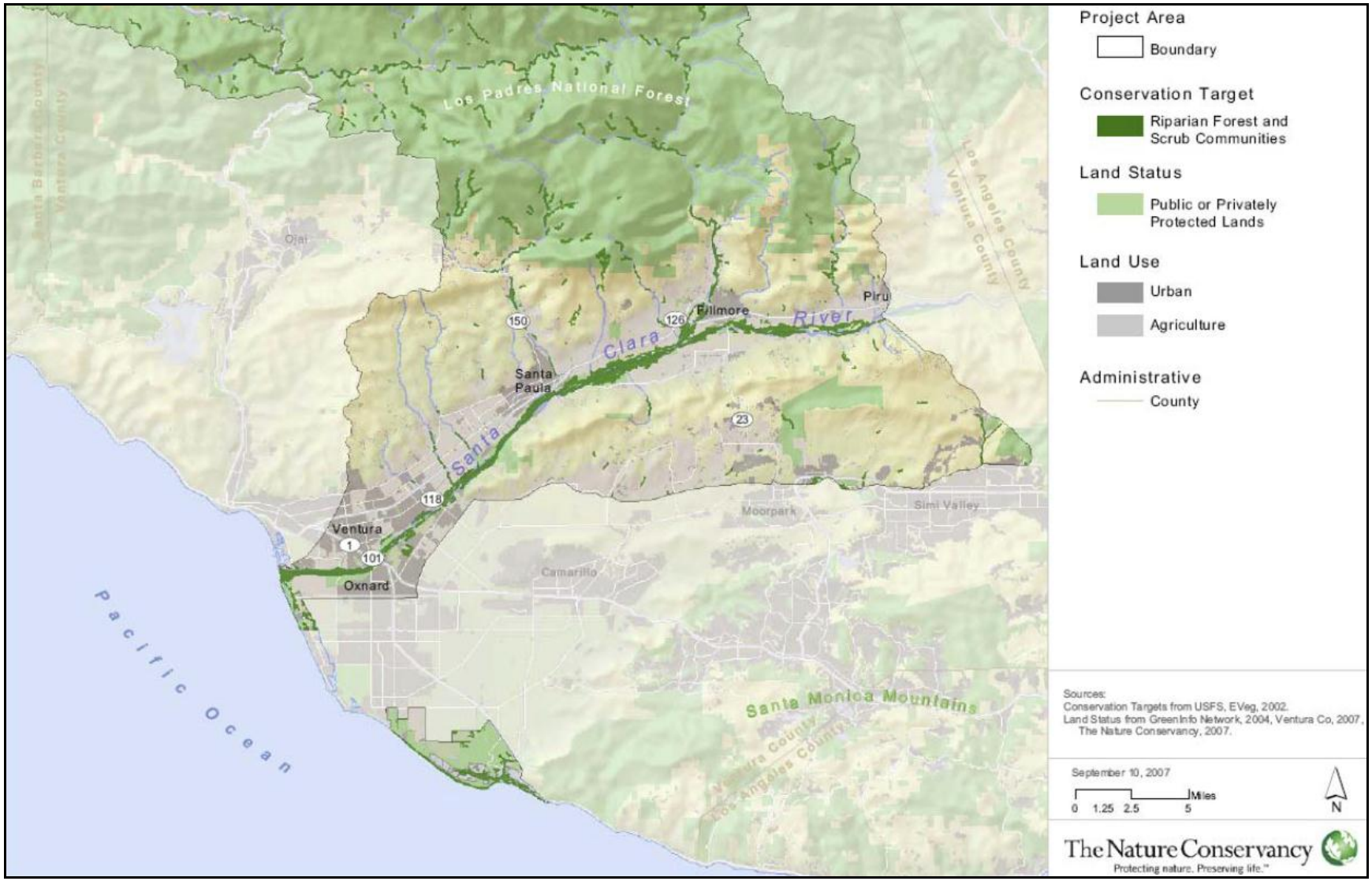


Figure 4.4. The Nature Conservancy riparian forest and scrub community conservation target areas, which includes the riparian area analyzed in this study.

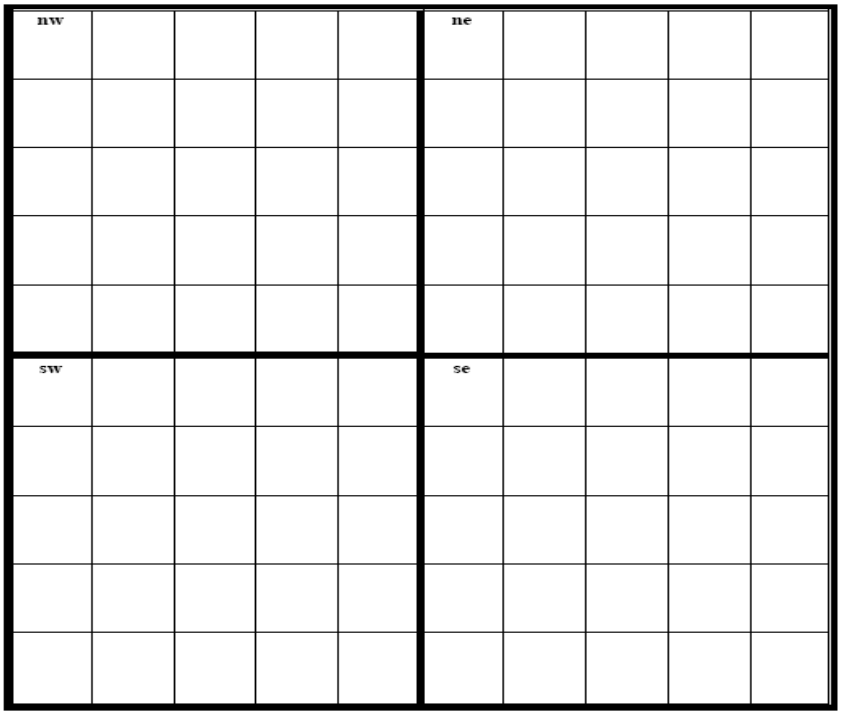


4.1.3 Quantitative Assessment

The vegetation in both upstream and downstream locations was quantitatively monitored in order to assess changes in the southern willow scrub vegetation community. Hydrology, species composition, percent of vegetative cover, canopy cover and canopy height were collected at the sampling quadrants to provide a quantitative assessment of the vigor and biomass of the southern willow scrub immediately upstream and downstream of the discharge location.

Ocular estimates of foliar cover were conducted by dividing the plot into four equal squares, which were divided into 1 X 1 meter Quadrats (Fig. 4.5 below). Canopy foliage, shrub, and herbaceous layers were included in the estimates. Relative and absolute percent cover was estimated during each sampling event.

Figure 4.5. Study quadrant and sub quadrat percent cover map.



Numerous summaries and basic statistics of plot data were calculated. Summaries included total species richness (number of plant species seen at each plot), total percent cover by plants (Total Vegetation Cover), total percent cover by substrate, total percent cover by dominant species and a breakdown of totals for three nativity categories. For cover values of "<1," the value 0.25 was used for summarizing purposes. Occasionally, 0.75 or 0.5 was used for specific species that were closer to 1% cover than 0.25%.

Dominant Species as Indicators of Ecosystem Functionality

A very common goal in community ecology analysis is to detect and describe the value of different species for indicating environmental conditions (McCune and Grace 2002). Willows and mulefat are riparian and or wetland indicator species that are dependent on surface and or groundwater and are not drought tolerant. Arroyo willow, the dominant tree species in the study area, is an obligate (OBL) species. OBL wetland or riparian species occur almost always (99%) under natural conditions in riparian or wetland conditions. Red willow, narrowleaf willow and mulefat are facultative wetland (FACW) species. FACW species usually occur in wetlands or riparian conditions (67% to 99%) but are occasionally found in non-wetland or riparian conditions. Giant reed is also a FACW species but can tolerate drier conditions and is found in wetland, riparian and sometimes in upland conditions.

Dominant (indicator) species were defined as those having 20% or greater cover and dominant occurrence throughout all study plots which was used to contrast performance of species across multiple sample events.

Percent Nativity as an Indicator of Ecosystem Functionality

The breakdown of native verses non-native species present, as well as the cover they provide, can be an indicator of overall ecological conditions at the site. In addition, the dominant tree, shrub cover and structure are important indicators of ecological health. Therefore, the nativity status of the taxa observed across the study site was summarized. Some plants could not be identified to species, but were identified to the genus level. The nativity status of these taxa is unknown. Thus, the three categories native, non-native and unknown were used to quantify nativity. Estimated cover values were totaled for nativity and dominant trees and shrubs observed during each sample event.

Types of data statistically summarized:

- Species richness
- Total vegetation cover
- Percent dominant vegetation
- Total percent substrate
- Total percent cover by natives
- Total percent cover by non-natives
- Total percent cover by unknown nativity
- Percent native plant cover of total vegetation cover
- Percent non-native plant cover of total vegetation cover
- Percent unknown nativity plant cover of total vegetation cover
- Percent willow cover of total vegetation cover
- Percent mulefat cover of total vegetation cover
- Percent giant reed cover of total vegetation cover

4.1.4 Hydrology

Hydrologic parameters were recorded at each plot to evaluate seasonal and human manipulated moisture regimes in relation to available surface water, groundwater for plants, plant health and habitat value. Hydrologic parameters were observed visually and included inundation, presence of surface water, surface water depth, presence of water marks, drift

patterns and sediment deposits. Ventura County rainfall data provided additional information on hydrologic variations among sampling events.

4.1.5 Canopy Cover

Canopy cover is a useful parameter to evaluate the overall health of the habitat and can be used to measure growth of the tree as the canopy fills in over time. Canopy cover was measured using a spherical densitometer, with the measurement taken from the center of each plot. The densitometer reading was recorded on a field data form for each transect and plot.

4.1.6 Canopy/Tree Height

Tree height measured over time is an important indicator of water availability and health. This parameter allows for comparisons to be made between the two areas and different species within each area and how they respond to a changing water regime differently. Canopy height was measured at each quadrant and recorded on a field data form for that transect and quadrant.

4.2 Statistical Analysis Methods

4.2.1 Ordination

I used nonmetric multidimensional scaling (NMS) in PC-ORD, Version 5 (McCune and Mefford 2006) to investigate patterns of species composition through time. The data were analyzed by comparing pre and post cessation mean absolute percent cover of each plant species. In addition, three seasonal absolute percent cover averages for each plant species were analyzed (spring, summer and fall).

NMS was used as an ordination technique due to its suitability to ecological data analysis; it makes no assumptions regarding data linearity or underlying models of species-environmental relationships. NMS iteratively searches for an ordering of samples in

multidimensional space that minimizes the stress and number of dimensions in the solution. Stress is the inverse of goodness-of-fit (high stress = poor fit) between the original dissimilarity matrix of sample data and the selected configuration of samples (McCune and Grace 2002).

For all ordinations, a specified preliminary run with a maximum of 200 iterations was established. The Monte Carlo test was used to determine whether or not NMS was extracting stronger axes than expected by chance.

4.2.2 Canonical Correspondence Analysis

A second data matrix containing environmental variables was compared with the NMS matrix using canonical correspondence (CCA) analysis in PC-ORD v. 5 to evaluate the strongest correlations in species compositional patterns with environmental parameters. Correlations among species mean absolute percent cover and physical site variables were assessed together. The environmental variables used in this assessment are listed below.

Environmental variables with analysis abbreviations

- Presence/absence of ponded water at the study plot during at least two collection events (H20pa)
- Willow (all spp.) percent cover (Sal%cv)
- Giant reed (*A. donax*) percent cover (Aru%cv)
- Elevation (Elev)
- Presence/absence of bark beetle (Barbtlpa)
- Distance from the center of the effluent channel (Distfrmec)

5.0 RESULTS AND TRENDS

5.1 General Observations and Environmental Conditions by Plot

The following section provides a discussion of survey observations, qualitative and quantitative assessments, for each transect plot, pre and post cessation of wastewater to the study area. Only those collection events that could be directly compared on pre and post cessation analyses are discussed. The 12 collection events analyzed for these summaries are as follows:

	Jun	Jul	Aug	Sep	Nov	Feb
Pre	2009	2009	2009	2009	2009	2010
Post	2010	2010	2010	2010	2010	2011

Monitoring data from the 16 collection events, including all the field-recorded cover values for all plant taxa observed, as well as calculated totals and statistics are presented at:

Pre Cessation http://www.biorc.com/Vegstudy/MasterDataTable-PreCessation.pdf

Post Cessation http://www.biorc.com/Vegstudy/MasterDataTable-PostCessation.pdf

A list of all plant species (common and scientific names) observed during the study is presented at:

http://www.biorc.com/Vegstudy/FINAL_Species_Observed.pdf

Overall Study Area Trends and Data Results (Section 5.2), analyzes the data from all 16 events.

The plot descriptions below emphasize dominant plant indicator species that contribute significantly to the habitat structure. A discussion of species richness, the nativity (native, non-native) status, unique qualities or unusual observed patterns is also provided. Weedy species defined by California Invasive Plant Council as having high levels of concern are also discussed.

5.1.1 Transect -2

General Description of Plot

One of two control plots, plot -2 is located in a mixed arroyo willow (*Salix lasiolepis*) and giant reed (*Arundo donax)* stand, located on a sandy terrace associated with the braided Santa Clara River channel. Surface water was not present within the plot throughout the study and the plot is not immediately adjacent to the effluent channel. Elevation is approximately 215 feet.

Trends

Dominant Species

As a dominant indicator species, overall willow (all spp.) mean absolute percent cover (mean of means) increased 5% during the post cessation data collection events (range 40-51%) (Table 5). Giant reed percent cover was generally 2-5% lower during post-cessation data collection, with the exception of the February 2011 event, but roughly the same mean percent cover (44% pre and 43% post) for both years.

Regarding the dominant willows and giant reed at this site, both species followed an expected pattern of growth or increase during spring and summer and a decline in fall and winter. Giant reed percent cover stayed roughly the same. A slight increase in willow percent cover and a general trend towards an increase in the richness of native plants was observed.

Species Richness

The total number of plant taxa seen in this plot was 15, with a minimum of 8 and a maximum of 12 observed during any one sample event. Overall mean species richness decreased by one species.

Nativity

The mean of means (overall mean) percent native species increased 9% (range 55-78%) while non-native species decreased 9% (range 22-45%). Overall mean absolute percent cover for native species increased 2% (range 48-58%) and decreased 2% for non-natives (range 42-52%).

Invasive Species of Concern

This plot has a significant infestation of black mustard (*Brassica nigra*) in less than 50% of the plot area. Giant reed, black mustard and smilo grass (*Piptatherum miliaceum*) are weedy species of particular concern at this plot.

Hydrology

No permanent or intermittent water flow was observed at this transect plot.

Table 5.

Transect/Plot -2		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	11	8	8	9	9	12	10
	Post	9	9	9	8	9	8	9
% Native Species	Pre	55	75	75	67	67	58	66
	Post	78	78	67	75	78	75	75
% Non-Native Species	Pre	45	25	25	33	33	42	34
	Post	22	22	22	25	22	25	23
Cover								
Total Absolute Vegetation Cover	Pre	99	96	93	79	79	82	88
	Post	115	112	98	91	85	73	92
Native % Mean Absolute Cover	Pre	50	51	52	52	50	49	51
	Post	48	50	49	54	58	58	53
Non-native % Mean Absolute Cover	Pre	50	49	48	48	50	51	49
	Post	52	50	51	46	42	42	47
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	40	42	43	44	44	40	42
	Post	44	46	46	50	47	51	47
Dead Willow % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0.3	0
Mulefat % Mean Absolute Cover	Pre	6	6	6	5	4	4	5
	Post	1	1	1	1	1	0	1
Giant Reed % Mean Absolute Cover	Pre	45	45	44	46	44	39	44
	Post	40	41	43	46	41	41	43

Note: Values rounded to whole numbers. For instances where values were less than 0.5 the actual value is shown. Those greater than 0.5 and less than 1 were rounded up to "1." Occasionally the total sums of relative or absolute nativity group covers do not add up to 100 due to rounding values up or down.

5.1.2 Transect -1

General Description of Plot

The second of two control plots, plot -1 is located in a more open mixed arroyo willow and giant reed stand located in a sandy depression which is part of the braided riverbed terrace system. Surface water was not present within the plot throughout the sampling year and the plot is not immediately adjacent to the effluent channel. Elevation is approximately 214 feet.

Trends

Dominant Species

A significant dieback of willows occurred during the pre-cessation collection events, particularly in the late spring and summer of 2009. Giant reed percent cover was significantly higher during post-cessation data collection with overall mean percent cover 12% higher (range 6-34%). Significant dieback of willows was observed during the pre-cessation collection events, with 6% live cover in March 2009 and 1% by February 2010, followed by a large increase in giant reed percent cover in 2010/11 (Fig. 5) presents photographic representation of this willow dieback).

Species Richness

The total number of plant taxa seen in this plot was 27, with a minimum of 16 and a maximum of 21 observed during any one sample event. Overall mean species richness dropped by one species.

Nativity

Overall mean percent native species represented in the plot increased 3% (range 26-41%) while non-native species decreased 4% (range 53-74%). Mean absolute percent cover for native species decreased 12% (range 18-40%) and significantly increased 48% for non-natives (range 16-81%) which is partially attributed to a large increase in giant reed cover. As a dominant indicator species, willow mean percent absolute cover (all spp.) increased 2% during the post cessation data collection events (range 1-8%) (Table 5.1).

Invasive Species of Concern

This plot has a significant infestation of mustards, black mustard and shortpod mustard (*Hirschfeldia incana*). Mustard absolute cover ranged from 2% to 26%, making it a seasonal dominant at this plot. The next most common non-native plant was giant reed,

followed by red brome (*Bromus madritensis*) and the noxious poison hemlock (*Conium maculatum*). Along with these four invasives, additional high priority invasive plants seen at this plot included shortpod mustard, castorbean (*Ricinus communis*), fennel (*Foeniculum vulgare*), Italian thistle (*Carduus pycnocephalus*), soft chess (*Bromus hordeceus*), annual rabbits foot grass (*Polypogon monspeliensis*) and smilo grass.

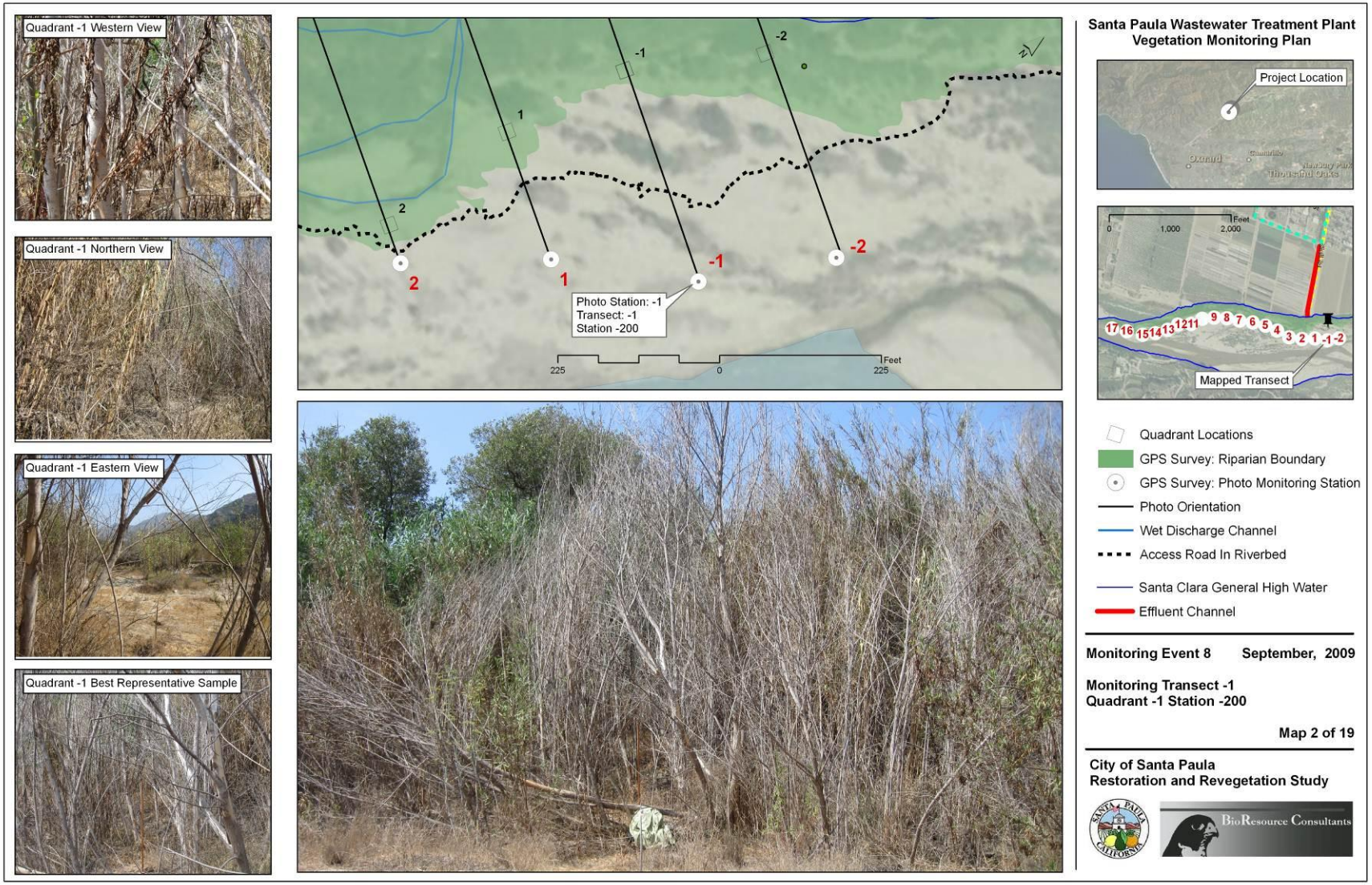
Hydrology

No permanent or intermittent water flow was observed at this transect plot. Although this plot is located up river from where the effluent stream enters the riverbed, evidence of significant water flow due to winter storms was observed at this site during February 2010. Resulting sediment deposits contributed to most of the bare ground/litter (substrate) recorded that month.

Table 5.1

Transect/Plot -1		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	20	17	21	18	20	19	19
	Post	17	21	19	19	16	17	18
% Native Species	Pre	35	41	33	39	35	26	35
	Post	29	38	32	32	38	29	32
% Non-Native Species	Pre	65	59	67	61	65	74	65
	Post	71	57	53	53	56	65	61
Cover								
Total Absolute Vegetation Cover	Pre	69	62	60	49	57	85	64
	Post	122	134	138	83	110	87	109
Native % Mean Absolute Cover	Pre	40	37	36	33	33	38	36
	Post	22	26	28	18	19	29	24
Non-native % Mean Absolute Cover	Pre	29	25	24	16	24	46	27
	Post	77	74	72	81	81	71	75
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	3	3	3	2	2	1	2
	Post	8	7	8	3	2	1	4
Dead Willow % Mean Absolute Cover	Pre	33	37	38	49	42	28	38
	Post	3	2	2	9	7	8	6
Mulefat % Mean Absolute Cover	Pre	10	11	10	8	7	6	9
	Post	7	7	8	7	9	11	9
Giant Reed % Mean Absolute Cover	Pre	16	16	15	14	12	6	13
	Post	22	21	23	34	25	20	25

Figure 5. Photographic representation taken from Photo Station -1 and the center of Plot -1 during the September 2009 collection event. Significant dieback of willow (spp.) occurred during the summer and fall. The light green vegetation at the back of the plot is giant reed (*A. donax*).



5.1.3 Transect 1

General Description of Plot

Plot 1 is located in a stand dominated by mulefat with only two arroyo willow trees, on an undulating sandy area, approximately 200 feet to the east of the effluent channel outfall. Plot 1 captures the edge of an area of sparse willow trees. Elevation is approximately 213 feet.

Trends

Dominant Species

Mulefat was the dominant species within the tree and shrub layers with an absolute percent cover ranging from 56% to 69%. Overall giant reed mean absolute percent cover increased by 6% (range 1-10%). As an indicator species, willow percent cover (all spp.) decreased 16% during the post cessation data collection events (range 4-29%) (Table 5.2).

Species Richness

The total number of plant taxa seen in this plot was 17, with a minimum of 8 and a maximum of 15 observed during any one sample event. Overall mean species richness increased by 3 species.

Nativity

Overall mean percent native species represented in the plot decreased 24% (range 27-67%) while non-native species increased 30% (range 33-73). Mean absolute percent cover for native species decreased 17% (range 74-97%) and increased 9% for non-native species (range 4-19%).

Invasive Species of Concern

This plot has slight infestations of several weedy species of particular concern, including giant reed, castorbean and perennial pepperweed (*Lepidium latifoilium*).

Hydrology

Significant vegetation changes and sediment movement were observed throughout the plot during February 2010, following the winter storms. Evidence of scour or sediment deposit covered the whole plot. Surface water was not present within the plot throughout the pre and post cessation collection events.

Table 5.2

Transect/Plot 1		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	10	9	9	9	8	8	9
	Post	14	14	15	12	10	10	12
% Native Species	Pre	60	56	67	56	50	50	57
	Post	29	29	27	33	40	30	33
% Non-Native Species	Pre	40	40	33	33	38	38	37
	Post	71	71	73	67	60	70	67
Cover								
Total Absolute Vegetation Cover	Pre	104	97	85	75	90	73	87
	Post	89	91	88	66	84	78	82
Native % Mean Absolute Cover	Pre	92	94	97	96	91	94	94
	Post	74	75	78	78	75	80	77
Non-native % Mean Absolute Cover	Pre	7	7	4	4	9	6	6
	Post	15	15	13	14	19	15	15
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	24	21	20	24	25	29	24
	Post	4	7	7	10	10	9	8
Dead Willow % Mean Absolute Cover	Pre	0	5	4	4	3	4	3
	Post	0	0	0	3	2	1	1
Mulefat % Mean Absolute Cover	Pre	53	57	63	57	54	53	56
	Post	70	68	71	68	65	71	69
Giant Reed % Mean Absolute Cover	Pre	2	2	1	1	2	3	2
	Post	9	9	8	10	7	7	8

5.1.4 Transect 2

General Description of Plot

Plot 2 is located in a mixed arroyo willow and giant reed stand, located adjacent to the effluent channel willow riparian ecosystem. Giant reed cover was generally low with willows being the dominant species. This is the only plot where the non-native garden nasturtium (*Tropaeolum majus*) and the riparian native Fremont's cottonwood (*Populus fremontii*) (one tree) were observed, both with low percent cover. Elevation is approximately 207 feet.

Trends

Dominant Species

Willows are the dominant species in this plot, however, giant reed mean absolute percent cover increased significantly during the post cessation data collection events with an overall cover 21% higher (range 19-52%). As a dominant indicator species, overall willow mean absolute percent cover (all spp.) decreased 29% during the post cessation data collection events (range 0-74%). The "zero" value in the range is attributed to a significant dieback of willows occupying the plot, which was observed during the February 2011 collection event. Note that 46% dead willow mean absolute cover accounts for the sharp decline (Table 5.3).

Species Richness

The total number of plant taxa observed was 31 with a minimum of 9 and a maximum of 21 observed during any one sample event. Mean species richness increased by 3 species, which is attributed to an increase in non-native plants in the plot.

Nativity

Overall mean percent native species represented in this plot decreased 13% (range 14-44%) while non-native species increased 18% (range 38-76%). Overall mean absolute percent cover for native species decreased significantly by 26% (range 4-71%) and increased 17% for non-native species (range 26-63%).

Invasive Species of Concern

Giant reed, annual rabbit's foot grass and smilo grass are the weedy species of particular concern at this plot. This plot has a significant seasonal infestation of willow weed (*Polygonum lapathifolium*). This non-native species is nearly always associated with the edge of the stream and was seen in several plots.

Hydrology

During February 2010, following the winter storms, significant sediment flow and deposits were observed throughout lower portions of the plot.

Table 5.3

Transect/Plot 2		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	21	13	10	10	9	9	12
	Post	15	15	16	11	15	21	15
% Native Species	Pre	38	38	40	40	44	44	41
	Post	33	33	31	27	33	14	28
% Non-Native Species	Pre	38	46	50	50	44	44	45
	Post	60	60	50	64	60	76	63
Cover								
Total Absolute Vegetation Cover	Pre	134	119	113	102	107	93	111
	Post	82	80	70	73	54	67	69
Native % Mean Absolute Cover	Pre	60	69	70	70	73	71	69
	Post	62	61	58	62	45	4	43
Non-native % Mean Absolute Cover	Pre	37	30	30	30	26	29	30
	Post	38	39	41	38	55	63	47
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	56	67	69	74	71	70	68
	Post	59	58	57	61	41	0	39
Dead Willow % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	46	15
Mulefat % Mean Absolute Cover	Pre	0.2	0.3	0.3	0.3	0	0.3	0
	Post	0.3	0.3	0.4	0.3	0.5	1	1
Giant Reed % Mean Absolute Cover	Pre	19	21	22	24	22	28	23
	Post	35	35	38	35	44	52	44

5.1.5 Transect 3

General Description of Plot

Plot 3 is located in a mixed arroyo willow and giant reed stand, located alongside the effluent channel in southern willow scrub habitat, in a bowl-shaped swale due to streamside erosion. Elevation is approximately 188 feet.

Trends

Dominant Species

Willow (spp.) trees and shrubs make up the dominant canopy structure of this plot with a mean absolute percent cover ranging from 64% to 76%. As a dominant indicator species, willow mean absolute percent cover (all spp.) decreased slightly (4 %) during the post cessation data collection events. Giant reed mean absolute percent cover decreased slightly by 1% (range 13%-19%). Regarding the dominant willows and giant reed at this plot, willows fluctuated slightly and grew or increased during spring and summer and declined in fall and winter. No significant dieback of willows was observed during the pre or post collection events.

Species Richness

The total number of plant taxa observed was 7 with a minimum of 4 and a maximum of 7 observed during any one sample event. Mean species richness decreased by one species.

Nativity

Overall mean percent native species represented in this plot decreased 4% (range 60-83%), while invasive species increased 10%. Mean absolute percent cover for native species remained the same (85%) (range 81-87%) while non-native cover slightly declined by 1% (range 13-19%) (Table 5.4).

Invasive Species of Concern

Giant reed is the only invasive species of particular concern at this plot.

Hydrology

Permanent water flow was observed at this transect plot, with an average absolute cover of 34% (in the substrate section, see Appendix B). Significant sediment erosion and deposits were observed across 50% to 60% of the plot during February 2010, following the winter storms.

Table 5.4

Transect/Plot 3		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	7	5	6	5	4	5	5
	Post	4	4	5	5	4	4	4
% Native Species	Pre	71	80	83	80	75	60	75
	Post	75	75	60	60	75	75	71
% Non-Native Species	Pre	14	20	17	20	25	20	19
	Post	25	25	40	40	25	25	29
Cover								
Total Absolute Vegetation Cover	Pre	108	106	105	101	99	81	100
	Post	159	163	164	133	125	113	138
Native % Mean Absolute Cover	Pre	81	86	86	85	85	84	85
	Post	87	86	86	83	84	84	85
Non-native % Mean Absolute Cover	Pre	19	14	14	15	15	16	16
	Post	13	14	14	17	16	16	15
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	70	74	76	76	76	74	74
	Post	75	75	74	68	67	64	70
Dead Willow % Mean Absolute Cover	Pre							
	Post	0	0	0	0	0	0.4	0
Mulefat % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0	0
Giant Reed % Mean Absolute Cover	Pre	19	14	14	15	15	16	16
	Post	13	14	13	17	16	16	15

5.1.6 Transect 4

General Description of Plot

Plot 4 is located in a mixed red willow, arroyo willow and narrowleaf willow (*Salix exigua*) stand adjacent to the effluent channel, in southern willow scrub habitat. Elevation is approximately 208 feet.

Trends

Dominant Species

Willows were dominant plant species in this plot with a mean absolute percent cover ranging from 61% to 94%. As a dominant indicator species, overall willow mean absolute percent cover (all spp.) increased significantly by 31%. On average, willow coverage was approximately 30% higher during each of the post cessation data collection events. Mulefat cover was low at this site, with absolute cover averaging less than 1% and reaching a maximum of 1%.

Species Richness

The total number of plant taxa observed was 24 with a minimum of 13 and a maximum of 21 observed during any one sample event. Overall mean species richness decreased by 2 species.

Nativity

Overall mean percent native species represented in this plot decreased 6% (range 40-60%) while non-native species increased 4% (range 33-47%). Overall mean absolute percent cover for native species increased 6% (range 89-98%) while non-native cover decreased 6% (range 2-11%) (Table 5.5). During most post cessation collection events, non-native cover was 2-9% lower, on average.

Invasive Species of Concern

Poison hemlock was the noxious species with the highest cover in this plot, ranging from 0.25% to 2% absolute cover. Black mustard, Italian thistle and annual rabbit's foot grass are the other weedy species of particular concern at this plot, although they all have low absolute cover of 0.25%.

Hydrology

During February 2010, following the winter storms, significant sediment flow and deposits were observed in the lower, westernmost-part of plot; sediment, debris flow and deposit covered about 67% of the plot. Surface water was observed at this plot during all post cessation collection events with the exception of events 6 and 7.

Table 5.5

Transect/Plot 4		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	21	18	18	15	15	16	17
	Post	13	15	17	17	15	15	15
% Native Species	Pre	48	50	56	53	60	44	52
	Post	54	47	47	41	40	47	46
% Non-Native Species	Pre	43	44	44	40	33	44	41
	Post	38	47	47	41	47	47	45
Cover								
Total Absolute Vegetation Cover	Pre	94	93	95	89	80	69	87
	Post	107	107	104	99	96	88	98
Native % Mean Absolute Cover	Pre	90	93	89	89	94	93	91
	Post	98	98	98	97	97	96	97
Non-native % Mean Absolute Cover	Pre	10	7	11	11	5	6	8
	Post	2	2	2	2	2	4	2
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	62	63	61	61	64	62	62
	Post	91	90	93	94	94	92	93
Dead Willow % Mean Absolute Cover	Pre							
	Post	0	0	0	0	0	0.3	0
Mulefat % Mean Absolute Cover	Pre	1	1	0.3	0.3	0.4	0.4	1
	Post	1	1	1	1	1	0.3	1
Giant Reed % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0	0

5.1.7 Transect 5

General Description of Plot

Plot 5 is located on a giant reed dominated elevated, dry stream terrace, along the edge of southern willow scrub and upslope from the effluent channel. A unique feature of plot 5 is that it is the only plot where only one willow tree, in this case an older red willow, is captured in the plot; it is actually rooted outside the plot, but most of its structure leans into the plot. General drought stress and willow stress was observed during the summer months of the post cessation collection events. Elevation is approximately 213 feet.

Trends

Dominant Species

Giant reed canopy remained a dominant feature in this plot, with a mean percent absolute cover ranging from 43% to 73%. Overall giant reed mean absolute percent cover increased by 15% during the post cessation events. The second most dominant canopy cover was willow (spp.), which increased by 1% during the post cessation study (range 23-36%). Mulefat cover was low at this site, with absolute cover averaging less than 1% and reaching a maximum of 1%.

Species Richness

The total number of plant taxa observed was 10 with a minimum of 5 and a maximum of 9 observed during any one sample event. Overall mean species richness decreased by one species.

Nativity

Overall mean percent native species represented in this plot decreased by 2% (range 33-50%), while non-native species increased 4% (range 50-67%). Overall mean absolute

percent cover for native species increased 1% (range 18-43%) while non-native cover decreased 1% (range 57-75%) (Table 5.6).

Invasive Species of Concern

Giant reed, black mustard, Italian thistle and red brome are the weedy species of particular concern at this plot, although Italian thistle and red brome cover never exceeded 1% absolute cover.

Hydrology

No intermittent water or evidence of water or sediment flow was observed at this site.

Table 5.6

Transect/Plot 5		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	9	5	5	5	7	8	7
	Post	6	7	6	6	6	6	6
% Native Species	Pre	33	40	40	40	43	50	41
	Post	33	43	33	33	33	50	39
% Non-Native Species	Pre	56	60	60	60	57	50	57
	Post	67	57	67	67	67	50	61
Cover								
Total Absolute Vegetation Cover	Pre	96	89	81	68	68	60	77
	Post	104	82	75	71	70	54	74
Native % Mean Absolute Cover	Pre	29	31	38	43	35	18	32
	Post	31	36	34	34	36	25	33
Non-native % Mean Absolute Cover	Pre	70	69	62	57	65	82	68
	Post	69	68	66	66	64	75	67
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	28	31	37	43	34	17	32
	Post	31	35	33	34	36	23	33
Dead Willow % Mean Absolute Cover	Pre							
	Post	0	0	0	0	0	0	0
Mulefat % Mean Absolute Cover	Pre	1.0	0.3	0.3	0.4	0.4	0.4	0
	Post	1	0.3	0.3	0.4	0	0	0
Giant Reed % Mean Absolute Cover	Pre	44	44	43	44	47	56	46
	Post	51	60	63	62	60	73	61

5.1.8 Transect 6

General Description of Plot

Plot 6 is located along the edge of southern willow scrub on an elevated, dry stream terrace within a dense but variable giant reed stand, upslope from the effluent channel and associated willows. Surface water was not present within the plot throughout the study and the plot is not immediately adjacent to the effluent channel. The 10 x 10 meter plot captures the edge of the willow stand and an area within the dense giant reed stand. Drought stress was noted during events 6 and 7 of the post cessation study. Elevation at the center of plot is approximately 206 feet.

Trends

Dominant Species

The plot is dominated by mulefat and black mustard. Mulefat percent cover decreased significantly during the post cessation collection events, averaging 10-20% lower during each event and ranged from 23% to 52% over the 12 events. Giant reed cover increased 1% (range 8-11 %). Willow percent cover significantly increased during the post cessation collection events, averaging 10-15% higher per event (range 7-26%).

Species Richness

The total number of plant taxa seen in this plot was 18, with a minimum of 9 and a maximum of 17 seen during any one sample event. Overall mean species richness decreased by 4 species.

Nativity

Overall mean percent native species represented in this plot increased by 17% (range 33-65%), while non-native species decreased 17% (range 21-46%). Mean percent absolute

cover for native species increased 6% (range 54-79%) while non-native cover decreased 6% (range 21-46%) (Table 5.7).

Invasive Species of Concern

Weedy species of particular concern at this plot include black mustard, giant reed, wild radish (*Raphanus* sp.), Italian thistle, charlock mustard (*Sinapis arvensis* ssp. *arvensis*), London rocket (*Sisymbrium irio*) and smilo grass.

Hydrology

No intermittent water or evidence of water or sediment flow was observed at this site.

Table 5.7

Transect/Plot 6		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	17	15	14	12	14	14	14
	Post	11	10	10	10	9	10	10
% Native Species	Pre	35	40	50	42	43	43	42
	Post	55	60	60	60	56	60	59
% Non-Native Species	Pre	65	60	50	58	57	57	58
	Post	45	40	40	40	44	40	41
Cover								
Total Absolute Vegetation Cover	Pre	103	95	93	72	85	90	90
	Post	137	141	115	108	100	90	111
Native % Mean Absolute Cover	Pre	54	61	67	79	71	66	66
	Post	70	67	71	72	74	73	72
Non-native % Mean Absolute Cover	Pre	46	39	33	21	29	34	34
	Post	30	33	29	28	26	27	28
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	7	8	12	15	12	7	10
	Post	18	18	23	24	26	24	23
Dead Willow % Mean Absolute Cover	Pre	0	0	0	0	2	2	1
	Post	0	0	0	0	0	0.6	0
Mulefat % Mean Absolute Cover	Pre	39	44	43	52	47	45	45
	Post	23	23	29	30	33	31	29
Giant Reed % Mean Absolute Cover	Pre	10	11	10	8	9	9	10
	Post	15	14	9	10	10	11	11

5.1.9 Transect 7

General Description of Plot

Plot 7 is located in a mixed willow and mulefat stand adjacent to the effluent channel in southern willow scrub habitat. During November 2009, a small amount of dead willow cover (2% absolute) was recorded. Elevation is approximately 199 feet.

Trends

Dominant Species

Arroyo willow was the most dominant species at this plot, with a mean absolute percent cover ranging from 75% to 88% and an overall increase of 6% cover. Mulefat was the next most dominant species with cover ranging from 10% to 20% and an overall decrease by 6% cover. Willows fluctuated slightly and grew or increased during spring and summer and declined in fall and winter. No significant dieback of willows was observed during the pre or post collection events.

Species Richness

The total number of plant taxa seen in this plot was 21, with a minimum of 10 and a maximum of 19 seen during any one sample event. Overall mean species richness decreased by 2 species.

Nativity

Native plants occupy approximately 50% of this plot. Overall mean percent native species represented in this plot increased by 5% (range 43-57%), while non-native species decreased by 7% (range 27-50%). Overall mean absolute percent cover for native species stayed the same at 98% (range 96-99%), as well as for non-natives (2%) (range 21-46%) (Table 5.8).

Invasive Species of Concern

No giant reed was observed in this plot. Weedy species of particular concern at this plot include black mustard, red brome, Italian thistle, annual rabbit's foot grass and smilo grass, although all of these had low cover values of 1% or less.

Hydrology

Evidence of flooding and sediment deposits were observed across 55% to 60% of the plot during February 2010, following the winter storms. Ponded surface water was observed during all post cessation collection events.

Table 5.8

Transect/Plot 7		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	19	16	14	12	10	14	14
	Post	13	15	14	10	12	11	12
% Native Species	Pre	47	50	50	50	50	43	48
	Post	54	53	57	50	50	55	53
% Non-Native Species	Pre	42	38	50	50	40	50	45
	Post	46	27	29	50	42	36	38
Cover								
Total Absolute Vegetation Cover	Pre	103	101	100	94	93	84	96
	Post	92	107	106	98	98	91	97
Native % Mean Absolute Cover	Pre	96	98	98	98	99	97	98
	Post	98	99	99	98	97	97	98
Non-native % Mean Absolute Cover	Pre	4	2	2	2	1	2	2
	Post	2	1	1	2	3	2	2
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	75	77	77	81	81	75	78
	Post	79	81	83	88	85	85	84
Dead Willow % Mean Absolute Cover	Pre	0	0	0	0	2	2	1
	Post	0	0	0	0	0	1	0
Mulefat % Mean Absolute Cover	Pre	19	20	20	17	17	19	19
	Post	19	16	14	10	11	12	13
Giant Reed % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0	0

5.1.10 Transect 8

General Description of Plot

Plot 8, like plot 7, is located in a mixed willow and mulefat stand, near the effluent channel in southern willow scrub habitat. Dead willows (with low cover values of 2% to 4%) were observed in this plot beginning August 2009. Elevation is approximately 196 feet.

Trends

Dominant Species

Arroyo willow was the most dominant species, with a mean absolute percent cover ranging from 64% to 92% with an overall decrease of 12% during the post cessation collection events. Mulefat was the next most dominant species with an absolute percent cover from 4% to 19%; overall mean percent cover decreased slightly (1%). Expected patterns of growth occurred; willows fluctuated slightly and grew or increased during spring and summer and declined in fall and winter. No significant dieback of willows was observed during the pre or post collection events.

Species Richness

The total number of plant taxa seen in this plot was 29, with a minimum of 13 and a maximum of 25 seen during any one sample event. Overall mean species richness decreased by 3 species.

Nativity

Overall mean percent native species represented in this plot increased by 12% (range 28-54%), while non-native species decreased 12% (range 46-68%). Overall mean absolute percent cover for native species decreased by 12% (range 80-97%) while non-native species increased 12% (range 3-20%) (Table 5.9).

Invasive Species of Concern

No giant reed was observed in this plot. Weedy species of particular concern at this plot include black mustard, poison hemlock, red brome, Italian thistle, milk thistle, perennial pepperweed, annual rabbits foot grass and smilo grass, although all of these had low cover values of 1% or less except black mustard which had a maximum absolute cover of 3%.

Hydrology

During February 2010, following the winter storms, evidence of significant flooding and sediment deposits were observed in the lower portions of the plot. Sediment, debris flow and deposits covered about 90% of the plot. Ponded surface water was observed during the first four collection events but was not present during events 5-7.

Table 5.9

Transect/Plot 8		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	25	21	19	14	17	18	19
	Post	18	16	17	14	20	13	16
% Native Species	Pre	28	33	32	29	41	39	34
	Post	33	38	41	50	40	54	46
% Non-Native Species	Pre	68	57	68	64	65	67	65
	Post	67	56	59	50	60	46	53
Cover								
Total Absolute Vegetation Cover	Pre	104	91	93	102	106	96	99
	Post	122	125	126	132	137	115	124
Native % Mean Absolute Cover	Pre	93	95	97	96	96	97	96
	Post	86	86	87	83	80	85	84
Non-native % Mean Absolute Cover	Pre	7	4	3	4	4	3	4
	Post	14	14	13	17	20	15	16
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	72	83	85	92	86	76	82
	Post	73	72	72	68	64	70	70
Dead Willow % Mean Absolute Cover	Pre	0	0	4	3	3	3	2
	Post	0	0	0	0	0	0.4	0
Mulefat % Mean Absolute Cover	Pre	19	11	11	4	9	19	12
	Post	11	10	11	11	11	12	11
Giant Reed % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	11	10	10	15	13	13	12

5.1.11 Transect 9

General Description of Plot

Plot 9 is located in a mixed willow and mulefat stand, near the effluent channel in southern willow scrub habitat. Elevation at the center of plot is approximately 202 feet.

Trends

Dominant Species

Willows made up the dominant vegetative cover with a percent absolute cover ranging from 28% to 61%. During the post collection events, willow cover was significantly lower during most collection events from 10-20% lower. Overall mean absolute percent cover for willows decreased 23%. Mulefat was the next most dominant species with a cover ranging from 28% to 46% and an overall increase in cover of 13%. Giant reed cover was lower than 0.5 percent cover during each of the collection events.

Species Richness

The total number of plant taxa seen in this plot was 35, with a minimum of 16 and a maximum of 26 seen during any one sample event. Overall mean species richness increased by one species.

Nativity

Overall mean percent native species represented in this plot decreased by 3% (range 26-46%), while non-native species increased by 8% (range 54-78%). Overall mean absolute percent cover for native species decreased by 10% (range 68-93%) while non-native cover increased 10% (range 7-32%) (Table 5.10).

Invasive Species of Concern

Weedy species of particular concern at this plot include black mustard, shortpod mustard, red brome, tocalote (*Centaurea melitensis*), Italian thistle, milk thistle, bur clover

(*Medicago polymorpha*), London rocket, rip-gut brome (*Bromus diandrus*), bristly oxtongue (*Picris echioides*), perennial pepperweed, giant reed, annual rabbit's foot grass and smilo grass, although most of these had low cover values of 1% or less. Black and shortpod mustards were seasonally co-dominant species with combined absolute cover between 5 and 30%.

Hydrology

Surface water was not present within the plot throughout the sampling year. Evidence of flooding and sediment deposits were observed across 20% of the plot during February 2010, following winter storms.

Table 5.10

Transect/Plot 9		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	23	17	20	13	23	22	20
	Post	16	18	19	18	23	26	21
% Native Species	Pre	30	41	35	46	30	23	34
	Post	38	33	37	33	26	27	31
% Non-Native Species	Pre	65	59	60	54	65	73	63
	Post	63	67	74	67	78	73	71
Cover								
Total Absolute Vegetation Cover	Pre	131	120	119	100	108	100	113
	Post	149	146	132	123	128	125	132
Native % Mean Absolute Cover	Pre	85	93	92	92	83	83	88
	Post	68	73	80	82	81	82	78
Non-native % Mean Absolute Cover	Pre	15	7	8	8	16	17	12
	Post	32	27	20	18	19	18	22
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	53	59	60	61	55	47	56
	Post	28	30	33	37	36	34	33
Dead Willow % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0	0
Mulefat % Mean Absolute Cover	Pre	30	33	31	30	28	35	31
	Post	40	42	46	45	44	46	44
Giant Reed % Mean Absolute Cover	Pre	0.2	0.2	0.2	0	0.2	0	0
	Post	0.2	0.2	0.2	0.2	0.2	0.2	0

5.1.12 Transect 10

General Description of Plot

Plot 10 is located in a mixed willow and mulefat stand, near the effluent channel in southern willow scrub habitat. Dead willows (with low cover values of 2 to 4%) were observed in this plot beginning August 2009. General drought stress was noted during most of the post cessation collection events. Elevation at the center of plot is approximately 197 feet.

Trends

Dominant Species

Willows made up the dominant vegetative cover with a mean absolute percent cover ranging from 17% to 52%. During the post collection events, willow cover was slightly lower during most collection events from 2-15% lower. Overall mean percent cover for willows decreased 3%. Mulefat was the next most dominant species with a cover ranging from 31% to 52% with an overall decrease in cover of 12%.

Species Richness

The total number of plant taxa seen in this plot was 35, with a minimum of 12 and a maximum of 24 seen during any one sample event. Overall mean species richness increased by 2 species. Despite the relative evenness in species richness for native and non-native plants at this plot, native species cover is significantly higher than non-native partially because the majority of the non-native taxa are understory herbaceous plants, each with low absolute cover.

Nativity

Overall mean percent native species represented in the plot decreased 8% (range 29-60%) while non-native species increased 11% (range 42-71%). Overall mean absolute percent cover for native species decreased 12% (range 71-98%) and increased 12% for non-native species (range 2-29%) (Table 5.11).

Invasive Species of Concern

Although giant reed cover was minimal at this plot, it showed an increase from an average of 0.2 percent cover during the pre-cessation study to 2% during the post-cessation study. Weedy species of particular concern at this plot include wild radish, charlock mustard, black mustard, shortpod mustard, giant reed, red brome, tocalote, Italian thistle, milk thistle, annual rabbits foot grass and smilo grass, although several of these had low cover values of 1% or less. Wild radish had higher absolute covers of 0.25 to 24% and 0.25 to 6%, respectively.

Hydrology

Evidence of flooding and sediment deposits were observed during February 2010, across about 30% of the plot, following the winter storms. Ponded surface water was observed during the first post cessation collection event and it did not occur for the remainder of the study.

Table 5.11

Transect/Plot 10		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	19	15	15	12	16	20	16
	Post	16	15	15	18	20	24	18
% Native Species	Pre	53	53	47	58	50	40	50
	Post	44	40	60	39	35	29	42
% Non-Native Species	Pre	47	47	53	42	44	60	49
	Post	56	60	53	61	65	71	60
Cover								
Total Absolute Vegetation Cover	Pre	105	98	90	81	101	103	96
	Post	102	96	91	77	96	101	94
Native % Mean Absolute Cover	Pre	95	96	98	98	83	71	90
	Post	73	78	79	81	79	75	78
Non-native % Mean Absolute Cover	Pre	5	4	2	2	17	29	10
	Post	27	22	21	19	21	25	22
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	40	44	48	52	43	17	41
	Post	38	42	43	39	36	33	38
Dead Willow % Mean Absolute Cover	Pre	0	0	4	2	2	2	2
	Post	0	0	0	0	0	0	0
Mulefat % Mean Absolute Cover	Pre	52	51	44	43	36	49	46
	Post	33	31	31	35	36	36	34
Giant Reed % Mean Absolute Cover	Pre	0.2	0.3	0.3	0.3	0.2	0.2	0
	Post	2	2	2	3	2	1	2

5.1.13 Transect 11

General Description of Plot

Plot 11 is located in a mixed willow and mulefat stand, near the effluent channel in southern willow scrub habitat. Surface water was not present within the plot throughout the study. Elevation is approximately 187 feet.

Trends

Dominant Species

Willow, the most dominant species, had a mean absolute percent cover ranging from 52% to 64% and an overall increase of 6% during the post cessation study. Willow cover at this plot had minor fluctuations throughout the year. Mulefat was the next most dominant species with an absolute cover ranging from 29% to 47%, however an overall decrease in cover of 8%.

Species Richness

The total number of plant taxa seen in this plot was 30, with a minimum of 16 and a maximum of 20 seen during any one sample event. Overall mean species richness stayed the same (19).

Nativity

Native plants made up approximately 50% of the total species richness; they covered well over 80% of the plot, with absolute cover by natives ranging from 91% to 98%. A slight decrease in percent cover (2%) occurred for native species. Non-native percent cover increased 2% (Table 5.12).

Invasive Species of Concern

Giant reed cover was 0.2 percent cover or less during each of the collection events. Weedy species of particular concern at this plot include black mustard, shortpod mustard, wild mustard; red brome, tocalote, bur clover, giant reed, and annual rabbit's foot grass. Most of these had low cover values of 1% or less. Black and shortpod mustards had a combined maximum absolute cover of 5%.

Hydrology

During February 2010, following the winter storms, evidence of slight flooding and sediment/debris deposits were observed in the lower portions (10%) of the plot. Surface water was not present during any collection event of the post cessation study.

Table 5.12

Transect/Plot 11		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	20	19	18	17	20	19	19
	Post	16	21	20	20	19	18	19
% Native Species	Pre	40	53	50	47	50	53	49
	Post	50	52	45	45	47	56	49
% Non-Native Species	Pre	50	42	44	41	45	47	45
	Post	50	48	55	55	53	44	51
Cover								
Total Absolute Vegetation Cover	Pre	119	120	114	105	107	107	112
	Post	113	124	119	113	122	128	120
Native % Mean Absolute Cover	Pre	95	98	96	98	94	94	96
	Post	94	95	94	95	95	91	94
Non-native % Mean Absolute Cover	Pre	5	2	3	2	5	6	4
	Post	6	5	6	5	5	9	6
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	52	56	56	56	52	46	53
	Post	64	61	59	60	57	53	59
Dead Willow % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	1	0
Mulefat % Mean Absolute Cover	Pre	42	42	39	41	40	47	42
	Post	29	32	34	34	36	35	34
Giant Reed % Mean Absolute Cover	Pre	0	0.2	0.2	0.2	0.2	0.2	0
	Post	0	0	0	0	0	0	0

5.1.14 Transect 12

General Description of Plot

Plot 12 is located in a mixed willow and mulefat stand, near the flowing effluent channel in southern willow scrub. Dead willows (with low cover values of 0.25%) were observed in this plot beginning February 2010. Significant damage to willow trees caused by woodpeckers and bark beetle was noted during the post cessation collection events. Elevation is approximately 199 feet.

Trends

Dominant Species

Willows were the most dominant species with a mean absolute percent cover ranging from 70% to 87% and an overall decrease of 5% during the post cessation study. Willow cover at this plot had minor fluctuations throughout both pre and post studies; on average, percent cover was 5-10% less during each post cessation collection event. Mulefat mean absolute percent cover was low during the first year (1%) and increased significantly during the post cessation study (6%). No significant dieback of willows was observed during the pre or post collection events.

Species Richness

The total number of plant taxa seen in this plot was 31, with a minimum of 14 and a maximum of 23 seen during any one sample event. Overall mean species richness increased by 3 species. Despite the relative evenness in species richness for native and non-native plants at this plot, native species cover is significantly higher than non-native partially because the majority of the non-native taxa are understory herbaceous plants, each with low absolute cover.

Nativity

Native plants made up approximately 68% of the total species richness during the pre-cessation study and covered 95% of the plot. Overall mean percent native species represented in the plot decreased 24% (range 33-93%) while non-native species increased 4% (range 36-78%). Overall mean absolute percent cover for native species decreased 6% (range 87-96%) and increased 6% for non-native species (range 4-13%) (Table 5.13), which is partly attributed to an increase in giant reed cover (see *Invasive Species of Concern* discussion below).

Invasive Species of Concern

Giant reed was not present at this plot during the pre-cessation baseline study collection events. By June, 2010, giant reed cover reached 6% and had an overall average of 3% for the post cessation study. Weedy species of particular concern at this plot include tree tobacco, shortpod mustard, castorbean, red brome, milk thistle and annual rabbit's foot grass. Most of these had low cover values of 1% or less. Tree tobacco (*Nicotiana glauca*) and shortpod mustard had higher absolute covers that did not exceed 3%.

Hydrology

Following the winter storms, during February 2010, evidence of flooding and sediment/debris deposits were observed in the lower portions of the plot. Ponded surface water was observed during the first post cessation collection event and it did not occur for the remainder of the study.

Table 5.13

Transect/Plot 12		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	20	16	15	14	18	18	17
	Post	21	21	19	21	16	23	20
% Native Species	Pre	55	56	87	93	72	44	68
	Post	43	43	47	33	50	48	44
% Non-Native Species	Pre	40	38	40	36	78	39	45
	Post	52	43	42	57	44	48	49
Cover								
Total Absolute Vegetation Cover	Pre	109	109	103	92	93	80	98
	Post	102	100	93	82	82	85	90
Native % Mean Absolute Cover	Pre	96	96	96	96	94	90	95
	Post	87	88	89	89	91	89	89
Non-native % Mean Absolute Cover	Pre	4	4	4	4	6	9	5
	Post	13	11	11	11	9	11	11
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	76	77	81	87	84	74	80
	Post	70	71	72	77	79	76	75
Dead Willow % Mean Absolute Cover	Pre	0	0	0	0	0	0.3	0
	Post	1	0	0	0	0	0	0
Mulefat % Mean Absolute Cover	Pre	1	1	1	1	1	1	1
	Post	5	5	6	6	6	6	6
Giant Reed % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	6	4	4	4	3	1	3

5.1.15 Transect 13

General Description of Plot

Plot 13 is located in a mixed willow stand with a significant amount of giant reed and stinging nettle (*Urtica dioica*), near effluent channel in southern willow scrub habitat. Some willow dieback occurred and was first observed in July, 2009. An undocumented

population of southwestern pond turtle was first observed in the effluent channel near this plot in April of 2009. Elevation is approximately 194 feet.

Trends

Dominant Species

Willows were the most dominant species with a mean absolute percent cover ranging from 59% to 82% and a significant overall increase of 14% during the post cessation study. Willow cover at this plot had minor fluctuations throughout both pre and post studies; on average, percent cover was 5-10% greater during each post cessation collection event. Dead willows with 5% cover values were first observed in this plot beginning in July, 2009 and reached 10% cover by February 2011.

Species Richness

The total number of plant taxa seen in this plot was 24, with a minimum of 8 and a maximum of 18 seen during any one sample event. Overall mean species richness decreased by 6 species.

Nativity

Overall mean percent native species represented in the plot increased 9% (range 56-78%) while non-native species decreased 10% (range 22-44%). Overall mean absolute percent cover for native species increased 6% (range 69-90%) while non-native species percent cover increased 11% (range 12-30%) (Table 5.14).

Invasive Species of Concern

Giant reed had absolute cover ranging from 9% to 17%. Weedy species of particular concern at this plot include giant reed, tree tobacco, black mustard, castorbean and poison hemlock. Most of these had low cover values of 1% or less.

Hydrology

Following the winter storms, evidence of significant flooding and sediment deposits were observed during February 2010, in the lower portions of plot; sediment and debris flow and deposit covered about 80% to 90% of the plot. Surface water was not observed during any of the post cessation collection events.

Table 5.14

Transect/Plot 13		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	18	14	17	14	15	9	15
	Post	11	11	9	10	9	8	9
% Native Species	Pre	56	57	59	71	60	78	64
	Post	73	73	78	70	78	63	73
% Non-Native Species	Pre	44	43	41	29	40	22	37
	Post	27	27	22	30	22	38	27
Cover								
Total Absolute Vegetation Cover	Pre	110	107	104	91	93	59	94
	Post	80	84	82	82	83	68	79
Native % Mean Absolute Cover	Pre	77	78	86	88	86	69	81
	Post	89	90	90	85	86	85	87
Non-native % Mean Absolute Cover	Pre	14	13	14	12	14	17	14
	Post	19	20	20	30	27	29	25
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	64	61	66	66	61	59	63
	Post	77	75	76	74	74	82	77
Dead Willow % Mean Absolute Cover	Pre	0	5	5	6	5	8	5
	Post	6	6	6	7	7	10	8
Mulefat % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0	0
Giant Reed % Mean Absolute Cover	Pre	11	11	13	11	13	17	13
	Post	9	10	10	15	13	14	12

5.1.16 Transect 14

General Description of Plot

Plot 14 is located in a mixed willow stand, near the effluent channel in southern willow scrub habitat. Dead willows (with cover values of 3 to 5%) were observed in this plot beginning August 2009. Elevation is approximately 186 feet.

Trends

Dominant Species

Willows (all spp.), the most dominant species in the plot, had a mean absolute percent cover ranging from 55% to 85% with an overall mean percent cover decrease of 22%. During November 2009, several willow trees near this plot were apparently blown over during a major wind event. Most of these trees were outside of the plot, except for the tree that marked the southeast corner. By February 2010 more trees had been blown down, including several smaller trees in the plot which accounts for the increase in dead willow percent cover during this event (Table 5.15).

Species Richness

The total number of plant taxa seen in this plot was 29, with a minimum of 16 and a maximum of 19 seen during any one sample event. Overall mean species richness stayed the same over for both the pre and post cessation collection events (17).

Nativity

Native plants made up over 50% of the total species richness and their absolute percent cover ranged from 64% to 98%. Total native plant mean absolute percent cover decreased significantly during the post cessation collection events, 23% on average. Non-native plants accounted for approximately 30% of the total species richness and this did not significantly change during the study (1% decrease). Total non-native plant mean absolute

percent cover increased from 5% to 17% (range 2-21%) which is mostly attributed to an increase in giant reed cover (see below)

Invasive Species of Concern

Giant reed and black mustard are the weedy species of particular concern at this plot. Giant reed mean absolute percent cover increased significantly during the post cessation collection events at 9-15%, on average. This increase appears to be correlated to the willow dieback that occurred.

Hydrology

Evidence of significant flooding and sediment/debris deposits were observed during February 2010 across 100% of this relatively flat plot. Surface water was not observed during any of the post cessation study events.

Table 5.15

Transect/Plot 14		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	18	18	17	18	16	13	17
	Post	19	18	18	17	17	16	17
% Native Species	Pre	61	61	65	61	69	62	63
	Post	58	56	67	71	71	69	66
% Non-Native Species	Pre	33	28	29	33	25	31	30
	Post	32	33	28	24	29	31	29
Cover								
Total Absolute Vegetation Cover	Pre	115	117	105	73	73	55	90
	Post	91	100	103	95	93	76	92
Native % Mean Absolute Cover	Pre	94	95	93	93	94	98	95
	Post	73	71	75	74	74	64	72
Non-native % Mean Absolute Cover	Pre	6	5	6	7	4	2	5
	Post	19	21	18	17	17	12	17
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	85	85	80	80	77	82	82
	Post	57	55	61	60	65	56	60
Dead Willow % Mean Absolute Cover	Pre	0	0	4	5	7	9	4
	Post	7	6	6	8	9	24	10
Mulefat % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	2	2	0.2	0.3	0.3	0.3	1
Giant Reed % Mean Absolute Cover	Pre	0.2	0.2	0.2	0.3	0.3	0.5	0
	Post	14	15	15	15	15	10	14

5.1.17 Transect 15

General Description of Plot

Plot 15 is located in a mixed arroyo and red willow stand with a small coverage of mulefat, located adjacent to the effluent channel in southern willow scrub habitat. This is the only plot where an even and dense willow canopy covers the entire plot. There is a slight slope connecting the larger flat portion of this plot to the effluent channel. Significant stress and damage caused by bark beetle and woodpeckers was observed during events 6 and 7 of the post cessation collection events. Elevation is approximately 216 feet.

Trends

Dominant Species

Willows (spp.), by far the most dominant plant species at this plot, had a mean absolute percent cover ranging from 89% to 99% and saw an overall mean increase of 1% after the post cessation collection events. Willow cover at this plot increased between March and April 2009, stayed relatively constant during the summer and fall of 2010, and increased to 99% cover by February 2011. Giant reed is not present at the site.

Species Richness

The total number of plant taxa seen in this plot was 23, with a minimum of 4 and a maximum of 16 seen during any one sample event. Overall mean species richness decreased by 2 species from 10 to 8.

Nativity

Native plants made up approximately 60% of the total species richness, but their absolute cover ranged from 98% to 100%. Overall mean absolute percent cover for native plants decreased from 59 to 58%. Overall mean percent non-native species ranged from 29-50% and increased 7% after the post cessation collection events (Table 5.16).

Invasive Species of Concern

Fennel and smilo grass are the only noxious weedy species of particular concern at this plot and cover was always less than 1% for both.

Hydrology

The plot encompasses a small portion of the effluent channel, recorded as 5% surface water cover during the pre-cessation collection events. During February 2010, following the winter storms, evidence of significant flooding and sediment/debris deposits were observed across the entire plot. In this case, the sediment deposits resembled a mud-flow that had flowed evenly across most of the plot.

Table 5.16

Transect/Plot 15		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	16	8	12	7	10	4	10
	Post	10	10	8	8	8	6	8
% Native Species	Pre	56	50	42	71	60	75	59
	Post	70	60	63	57	50	50	58
% Non-Native Species	Pre	31	38	50	29	20	50	36
	Post	30	30	38	57	50	50	43
Cover								
Total Absolute Vegetation Cover	Pre	114	111	108	111	109	102	109
	Post	116	114	104	100	102	86	102
Native % Mean Absolute Cover	Pre	98	99	98	100	99	100	99
	Post	99	99	99	99	99	99	99
Non-native % Mean Absolute Cover	Pre	1	1	1	0.5	0.5	0.5	1
	Post	1	1	1	1	1	1	1
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	92	94	95	95	95	97	95
	Post	89	91	98	98	98	99	96
Dead Willow % Mean Absolute Cover	Pre	0	0	0	1	1	1	1
	Post	0	0	0	0	0	0	0
Mulefat % Mean Absolute Cover	Pre	4	4	3	3	3	2	3
	Post	9	7	0.2	0.3	0.2	0	2
Giant Reed % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0.3	0

5.1.18 Transect 16

General Description of Plot

Plot 16, unlike all the other plots, is located in a mulefat stand, near the effluent channel in mulefat scrub habitat. A small amount of willow, relative to other plots, is captured in this plot. Elevation is approximately 196 feet.

Trends

Dominant Species

Mulefat, the most dominant species, had an overall mean absolute percent cover ranging from 63% to 81% with an overall decrease in cover of 10% during the post cessation collection events. Arroyo willow, the second most dominant species, had an overall mean absolute percent cover ranging from 2% to 20% with an overall increase in cover of 14%.

Species Richness

The total number of plant taxa seen in this plot was only 8, the lowest observed in any plot, with a minimum of 4 and a maximum of 8 seen during any one sample event. Overall mean species richness stayed the same (5).

Nativity

Native plants made up approximately ¾ of the total species richness with absolute cover between 98% and 100%. This plot saw a large increase in cover by stinging nettle during the spring and fall of 2009. Overall mean absolute percent cover for native plants increased from 98% to 100%. Overall mean percent non-native species ranged from 0.2-2% and decreased to 0% after the post cessation collection events (Table 5.17).

Invasive Species of Concern

Pink tamarix (*Tamarix ramosissima*) and black mustard are the weedy species of particular concern at this plot. Both species had low absolute covers of 2% or less and had significantly lower cover during the post cessation collection events.

Hydrology

Very much like the pattern seen at plot 15, evidence of significant flooding and sediment/debris deposits resembling a mud-flow were observed across the entire plot during February 2010. Ponded surface water was observed during the first post cessation collection event and it did not occur for the remainder of the study.

Table 5.17

Transect/Plot 16		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	8	4	5	4	4	4	5
	Post	5	5	5	5	5	5	5
% Native Species	Pre	63	75	80	75	75	75	74
	Post	80	75	75	75	75	75	76
% Non-Native Species	Pre	38	25	20	25	25	25	26
	Post	20	25	25	25	25	25	24
Cover								
Total Absolute Vegetation Cover	Pre	116	111	119	120	122	117	118
	Post	125	127	131	130	134	115	126
Native % Mean Absolute Cover	Pre	98	98	98	98	98	100	98
	Post	100	100	99	99	99	100	100
Non-native % Mean Absolute Cover	Pre	2	2	2	2	2	0.2	2
	Post	0.4	0.4	0.6	0.6	0.6	0.2	0
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	4	5	4	4	4	2	4
	Post	20	20	20	18	19	11	18
Dead Willow % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0	0
Mulefat % Mean Absolute Cover	Pre	78	81	80	76	74	77	78
	Post	63	66	66	68	67	75	68
Giant Reed % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0	0

5.1.19 Transect 17

General Description of Plot

Plot 17 is located at the westernmost section of the study area, on the downstream edge of where the southern willow scrub habitat crosses the effluent channel at its confluence with the main channel of the Santa Clara River. It captures the edge of a mixed mulefat and arroyo willow stand, a portion of the flowing effluent channel, and some open ground next to the channel and the woody willow scrub dominants. Elevation is approximately 187 feet.

Trends

Dominant Species

Mulefat, the most dominant species, had mean absolute cover between 38% and 67% and saw an overall mean absolute cover decrease of 5%. Arroyo willow was the next most dominant species with absolute cover ranging from 19% to 81% and a significant overall mean absolute cover increase (47%). Vegetation patterns observed at this plot were more dynamic than at most other plots. Apparent increased growth rates resulted in relatively fast increases in cover of certain native and non-native annual and perennial herbs. Several hydrophytic plants grew significantly larger in the open sun, than they did under the willow canopy sampled in other plots. Fringed willowherb (*Epilobium ciliatum*) and whitestem hedgenettle (*Stachys alba*) are native examples of this.

Species Richness

The total number of plant taxa seen in this plot was 31, with a minimum of 10 and a maximum of 19 seen during any one sample event. Overall mean species richness decreased by 4 species.

Nativity

Native plants made up approximately half of the plot with an absolute cover ranging 74% to 94% and an overall increase in cover of 13% occurred. Non-native absolute cover ranged from 6% to 26% and a significant drop in overall cover occurred during the post cessation collection events (14%) (Table 5.18).

Invasive Species of Concern

Tree tobacco, castorbean, black mustard and giant reed are the weedy species of particular concern at this plot, although mustard and giant reed cover never exceeded 2 or 3% absolute cover, respectively.

Hydrology

Unlike all the other plots, evidence of two significant flooding events was observed at this site. During November 2009, following the first rain of the season, we observed that clay sediment deposits had evenly flowed across the lower parts of the ground surface. During February 2010, evidence of significant flooding and sediment/debris deposits were observed across the entire plot, even the higher-ground areas. Ponded surface water was observed during the first post cessation collection event and it did not occur for the remainder of the study.

Table 5.18

Transect/Plot 17		Sample Events						
Nativity		**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Feb**	**Mean**
Species Richness	Pre	19	19	17	15	17	10	16
	Post	13	16	14	10	13	10	12
% Native Species	Pre	42	47	41	40	47	70	48
	Post	62	63	57	60	54	50	57
% Non-Native Species	Pre	53	47	53	53	47	30	47
	Post	38	25	29	30	38	50	36
Cover								
Total Absolute Vegetation Cover	Pre	111	115	115	119	108	88	109
	Post	99	91	91	81	83	87	87
Native % Mean Absolute Cover	Pre	80	77	75	74	76	83	78
	Post	88	94	93	91	91	93	91
Non-native % Mean Absolute Cover	Pre	20	23	23	26	24	17	22
	Post	12	6	6	8	8	7	8
Important Species Cover								
Willow Mean % Absolute Cover (all Spp.)	Pre	19	19	23	24	23	20	21
	Post	64	69	71	81	80	40	68
Dead Willow % Mean Absolute Cover	Pre	0	0	0	0	0	0	0
	Post	0	0	0	0	0	0	0
Mulefat % Mean Absolute Cover	Pre	56	55	48	48	53	64	46
	Post	47	49	49	38	39	67	41
Giant Reed % Mean Absolute Cover	Pre	1	2	3	3	3	3	3
	Post	4	4	4	7	7	5	10

5.2 Overall Study Area Trends

A total of 119 plant species of 82 genera were observed. Absolute percent cover values for each species were collected over 16 events. Willow (*Salix* spp.), giant reed (*Arundo donax*) and mulefat (*B. salicifolia*) were the most abundant and dominant species. Change in mean absolute percent cover values for dominant species was analyzed for overall and seasonal trends. Willow percent cover values declined sharply during the post cessation study while other compositional variation in percent cover happened more or less sporadically.

Following is summary of overall study area mean absolute percent cover trends observed for the pre and post data sets across space and time. Specifically, these results summarize total vegetative cover, nativity (native vs. non-native plant cover), dominant species cover and non-native plant species (giant reed as a dominant) cover. Standard error of mean (SEM) was calculated (estimated) by dividing the square root of the sample size (*n*) by the standard deviation. Given the sample size, SEM approximates a 95% confidence interval.

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

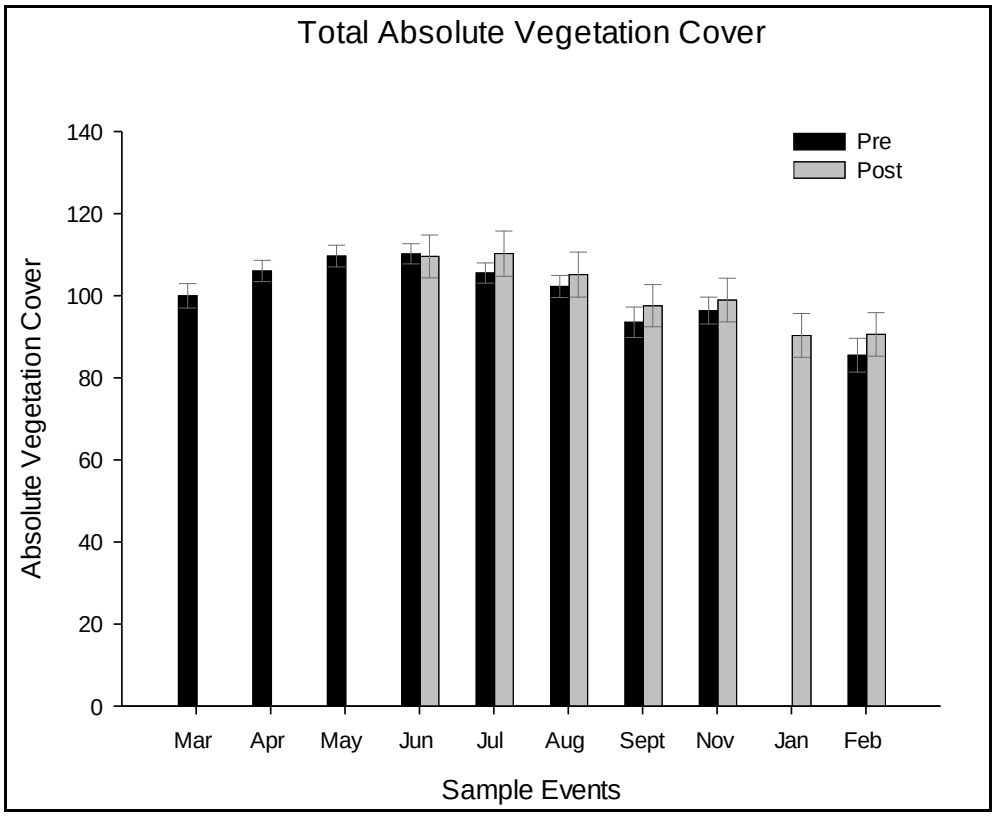
Note that the data for Control Plots -1 and -2 are not included in these analyses as the sample size is markedly smaller than plots 1-17. Significant species compositional changes at plot -1 (such as the willow die-off summarized in the plot-by-plot analysis) influenced the overall average of both plots combined. To address this problem, a larger control site should have been designed in order to more accurately analyze temporal conditions with the study site conditions.

5.2.1 Total Vegetative Percent Cover

Overall study area trends (Plots 1-17) were analyzed for both the pre and post data sets with respect to overall mean absolute percent cover for all species. Expected seasonal fluctuations occurred, with a general increase in percent cover in the spring and summer months, followed by a reduction in the winter (Fig. 5.1).

Given the overlapping of error bars represented graphically below, there appears to be no significance between the pre and post data sets.

Figure 5.1. Mean absolute percent cover for all plant species with calculated SEM.

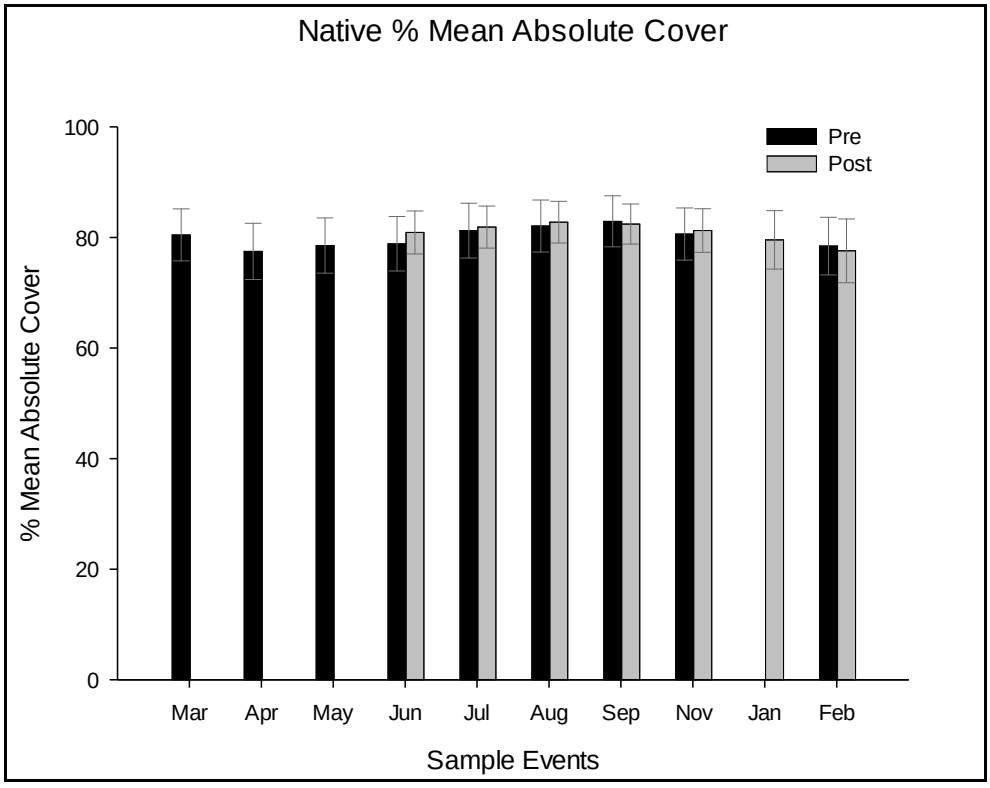


5.2.2 Nativity

Native Plant Percent Cover

Mean absolute percent cover for all native species varied between 75 and 80% during the study period. Some seasonal fluctuation occurred, with a general increase in percent cover in the spring and summer months, followed by a reduction in the winter. Given the overlapping of error bars represented in Figure 5.2, there appears to be no significant difference between the pre and post data sets.

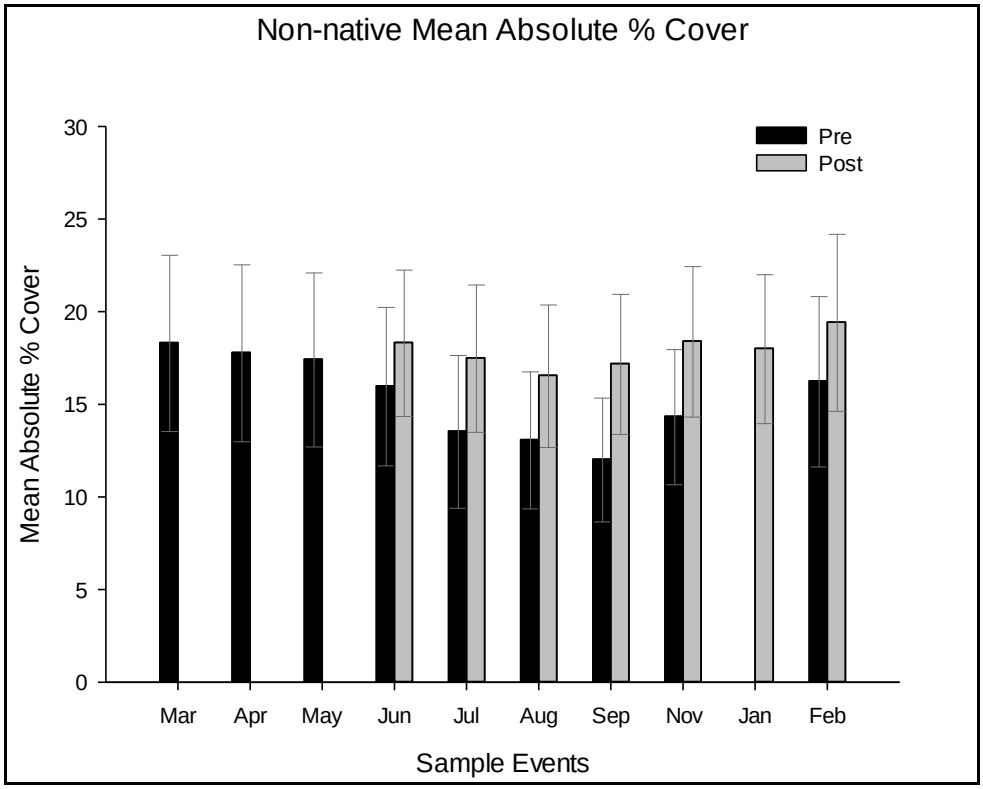
Figure 5.2. Mean absolute percent cover for all native plant species with calculated SEM.



Non-native Plant Percent Cover

Overall study area trends were analyzed for both the pre and post data sets with respect to overall mean absolute percent cover for all non-native plant species. Some seasonal fluctuation occurred, with a general increase in percent cover in the spring and summer months, followed by a reduction in the fall and winter. This is partially attributed to a significant number of annual invasives such as mustard. Given the overlapping of error bars with respect to SEM represented in Figure 5.3, there appears to be low statistical significance between the pre and post data sets, however a general trend shows a mean absolute percent cover of ca. 12-20% and a general increase in overall percent coverage.

Figure 5.3. Mean absolute percent cover for all non-native plant species with calculated SEM.

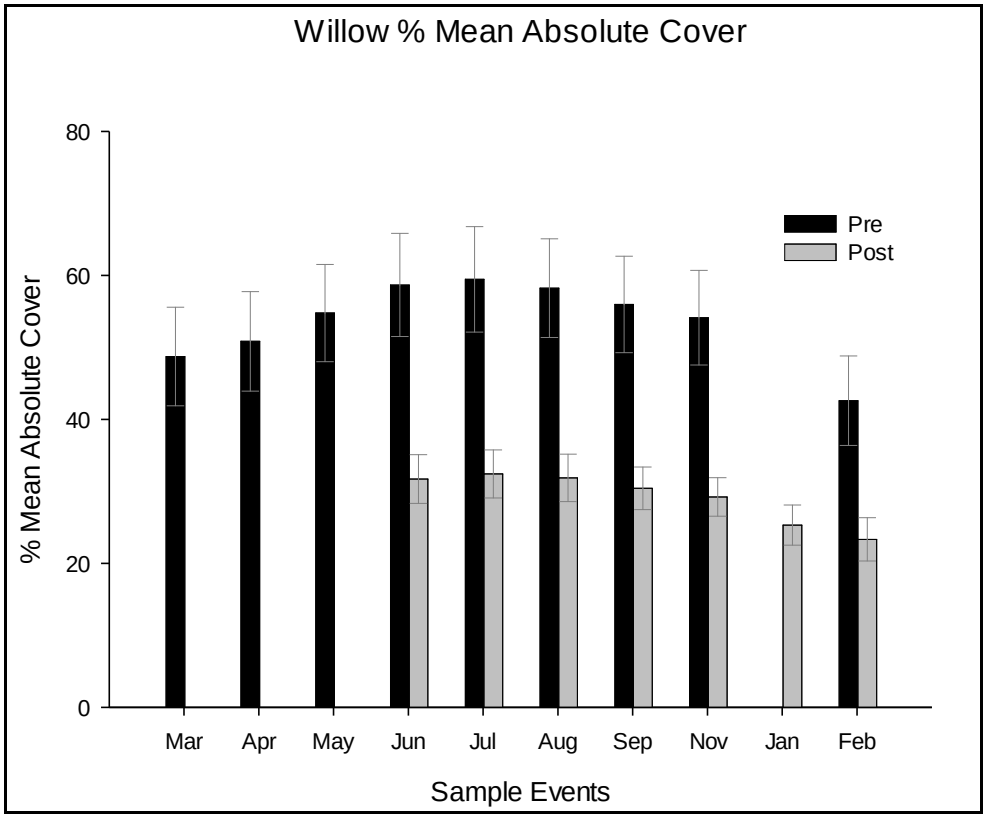


5.2.3 Indicator Species

Willow Percent Cover

Overall study area trends were analyzed for both the pre and post data sets with respect to overall mean absolute percent cover for all species of willow. Expected seasonal fluctuations occurred, with a general increase in percent cover in the spring and summer months, followed by a reduction in the winter. Statistically significant differences are noted between the pre and post data sets, clearly showing a trend towards reduction in willow mean absolute percent cover over time (Fig. 5.4).

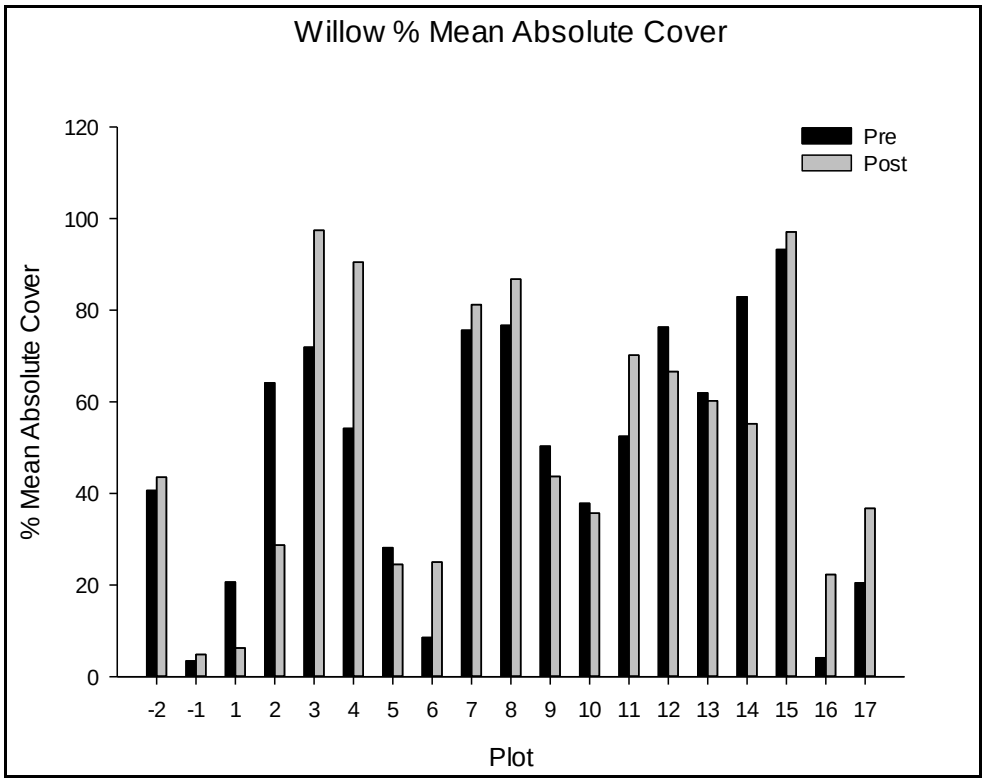
Figure 5.4. Mean absolute percent cover for all willow species with calculated SEM.



Willow Percent Cover by Plot

Willow cover varies significantly by plot. At some plots, willow cover increased, while at others, it decreased significantly; a general trend towards a reduction in overall mean absolute percent cover was observed during the post cessation collection events (5.4.1).

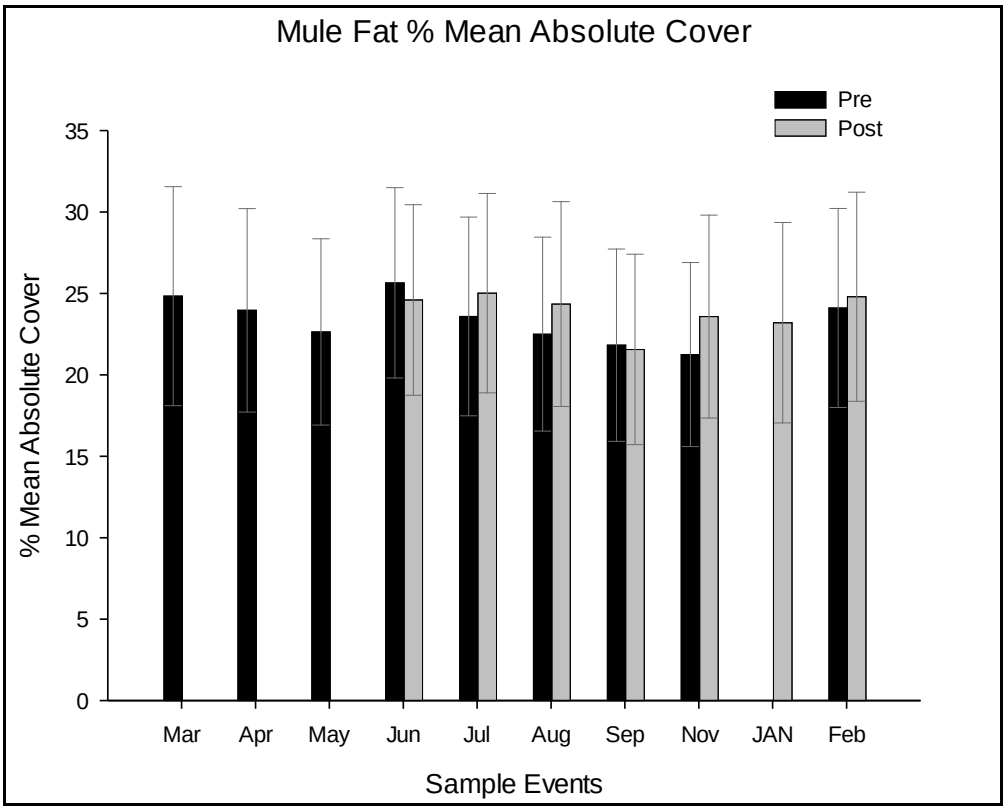
Figure 5.4.1. Mean absolute percent cover for all willow species by plot.



Mulefat (B. salicifolia) Percent Cover

Overall study area trends were analyzed for both the pre and post data sets with respect to overall mean absolute percent cover for mulefat (*B. salicifolia*). Expected seasonal fluctuations occurred, with a general increase in percent cover in the spring and summer months, followed by a reduction in the winter. Given the overlapping of error bars represented in Figure 5.5, there appears to be no significant difference between the pre and post data sets.

Figure 5.5. Mean absolute percent cover for mulefat with calculated SEM.

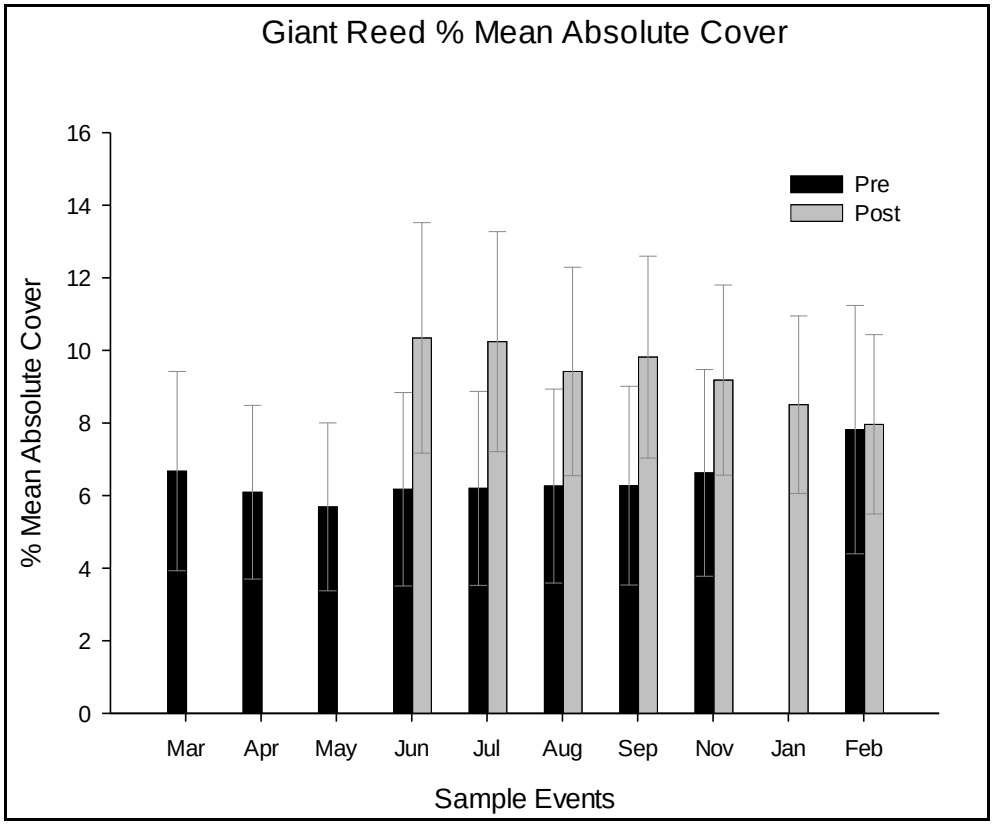


5.2.4 Dominant Invasive Species

Giant Reed Percent Cover

Overall study area trends were analyzed for both the pre and post data sets with respect to overall mean absolute percent cover for the invasive giant reed (*A. donax*). A general trend towards an increase in giant reed can be observed in Figure 5.6. Less significant seasonal trends are noted in vegetative cover as giant reed is a perennial evergreen that is less impacted by seasonal changes in weather. Given the overlapping of error bars, there appears to be no significant difference between the pre and post data sets.

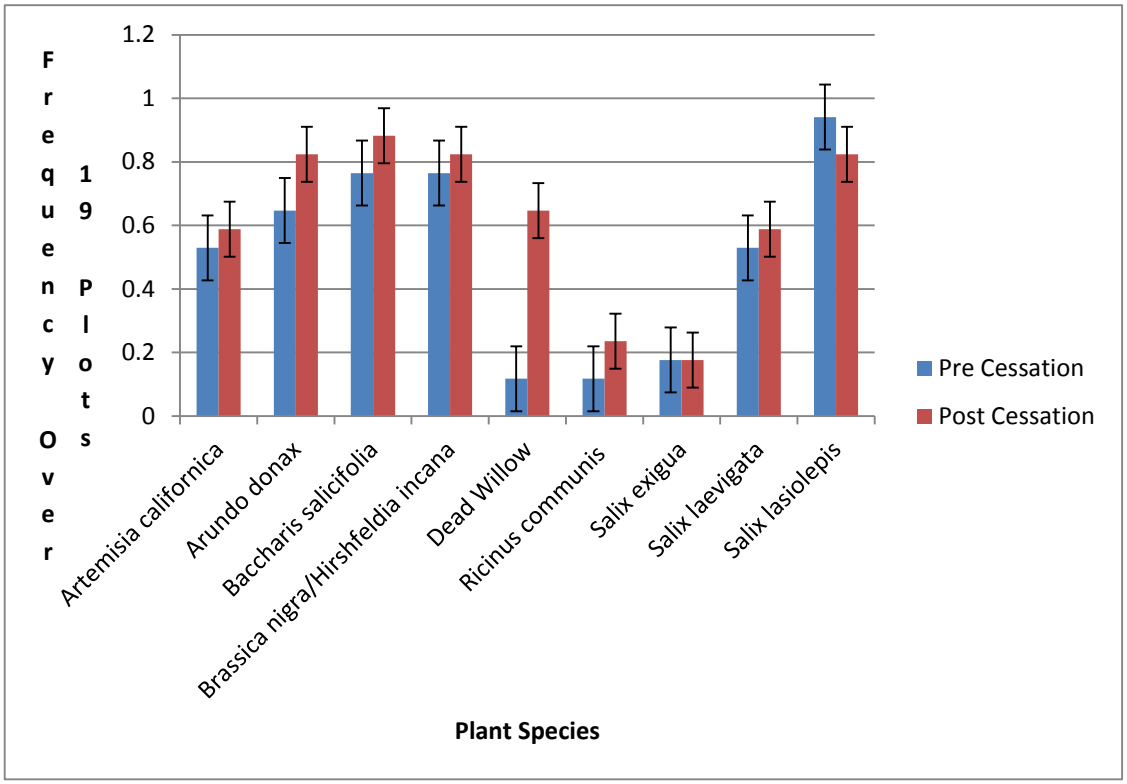
Figure 5.6. Mean percent absolute cover for giant reed with calculated SEM.



5.2.5 Frequency of Dominant Plant Species

Overall study area trends were analyzed for both the pre and post data sets with respect to eight of the most frequently occurring plant species. Giant reed increased in frequency during the post cessation study. Dead willow was significantly more frequent during the post cessation study which is correlated to the overall decline in willow percent cover.

Figure 5.7. Pre and post cessation frequency of the eight most abundant species over 16 collection events and 19 plots.



Plant Species	Pre Cessation	Post Cessation
Artemisia californica	0.53	0.59
Arundo donax	0.65	0.82
Baccharis salicifolia	0.76	0.88
Brassica nigra/Hirshfeldia incana	0.76	0.82
Dead Willow	0.12	0.65
Ricinus communis	0.12	0.24
Salix exigua	0.18	0.18
Salix laevigata	0.53	0.59
Salix lasiolepis	0.94	0.82

5.3 Multivariate Statistical Results

5.3.1 NMS

Plant species occurring in less than three of the study plots have been shown to result in instability in CCA (Tausch *et al.* 1995) and were removed from the NMS analysis. The NMS main matrix included 38 pre and post averages (rows) and 78 species (columns). The Sorensen distance measure was used for all analyses with a random starting configuration of time of day. The number of runs with real data was 200. The total number of axes was 3 with a reduction in dimensionality at each cycle of one. The final stress for 3-dimentional solution was 6.84184 with 104 iterations.

5.3.2 CCA

The final CCA run included the NMS matrix with a second matrix containing 38 pre and post averages (rows) with 7 environmental variables (columns). Data were centered and standardized to unit variance while ordination axes were scaled to optimize representation of the pre and post plots (McCune and Grace 2002). Eigenvalues indicate the amount of variation in the vegetation data that is captured in an ordination axis. With this analysis, 36.7% of the variation with mean absolute percent cover data is represented by the 3 ordination axes generated from the CCA (Table 5.19).

Table 5.19. Axis Summary Statistics.
Number of canonical axes: 3
Total variance ("inertia") in the species data: 2.2747

	Axis 1	**Axis 2**	**Axis 3**
Eigenvalue	0.432	0.292	0.111
Variance in species data			
% of variance explained	19.0	12.8	4.9
Cumulative % explained	**19.0**	**31.8**	**36.7**
Pearson Correlation, Spp-Envt*	0.990	0.935	0.815
Kendall (Rank) Corr., Spp-Envt	0.858	0.752	0.570

CCA assigns each of the 38 pre and post plot averages an axis score or position related to how well change in mean absolute percent cover and physical site data are correlated to each axis (Table 5.20). In this case, willow percent cover is strongly correlated with axis 1 and to a lesser degree, axis 2 while Arundo percent cover is strongly correlated with axis 2. Distance from center of study plot to center of the effluent channel is also correlated to axis 2.

Table 5.20. CCA correlations and biplot scores for seven physical site variables in relation to change in species mean absolute percent cover at each of the 19 plots (n=38).

	Correlations			Biplot Scores		
Variable	**Axis 1**	**Axis 2**	**Axis 3**	**Axis 1**	**Axis 2**	**Axis 3**
1 Elev	0.009	-0.518	-0.203	0.006	-0.280	-0.068
2 H20pa	-0.164	0.642	0.439	-0.108	0.347	0.146
3 **Aru%cv**	-0.352	**-0.924**	0.084	-0.231	**-0.499**	0.028
4 **Sal%cv**	**-0.831**	0.527	0.015	**-0.546**	0.285	0.005
5 **Disfrmec**	-0.085	**-0.506**	-0.390	-0.056	**-0.274**	-0.130
6 Barbtlpa	-0.164	0.139	-0.495	-0.108	0.075	-0.165
7 Deadsal	-0.257	-0.161	-0.756	-0.169	-0.087	-0.252

*Bold indicates physical site variables most strongly correlated with axes 1, 2.

The 38 pre and post plots are broadly distributed along axes 1 and 2, based on the CCA scores derived for each plot (Fig. 5.7). Successional vectors indicate shifts in mean absolute percent cover for plant species at each plot and generally these patterns appear to be random. Plots 4, 7, 8, 12, 13, and 14 are shifting in the same general direction (down axis 2) and are strongly correlated to willow percent cover, indicating that changes in species percent cover at these plots is correlated with willow percent cover. Plot-by-plot analysis (Section 5.1) indicates that these plots saw significant increases or decreases in willow percent cover after the post cessation events (6-30%). Plots -2, 2 and 5 are shifting in different directions and are strongly correlated to Arundo percent cover. Arundo cover at

Plot -2 decreased slightly but remained a dominant feature. It increased sharply at plots 2 and 5 (21% and 15%, respectively). Plots in the upper left corner of the graph are shifting in different directions and compositional changes in plant percent cover at these plots appear to have low correlation to the environmental variables.

Figure 5.8. CCA biplot of 19 pre and post plots distributed along ordination axes 1 and 2. Successional vectors (blue arrows) indicate compositional shifts through time in mean absolute percent cover values for 78 of the most frequently occurring species. Red arrows represent environmental variables with the greatest correlation to the axes; arrow direction indicates the maximum correlation while arrow length is related to the strength of the correlation.

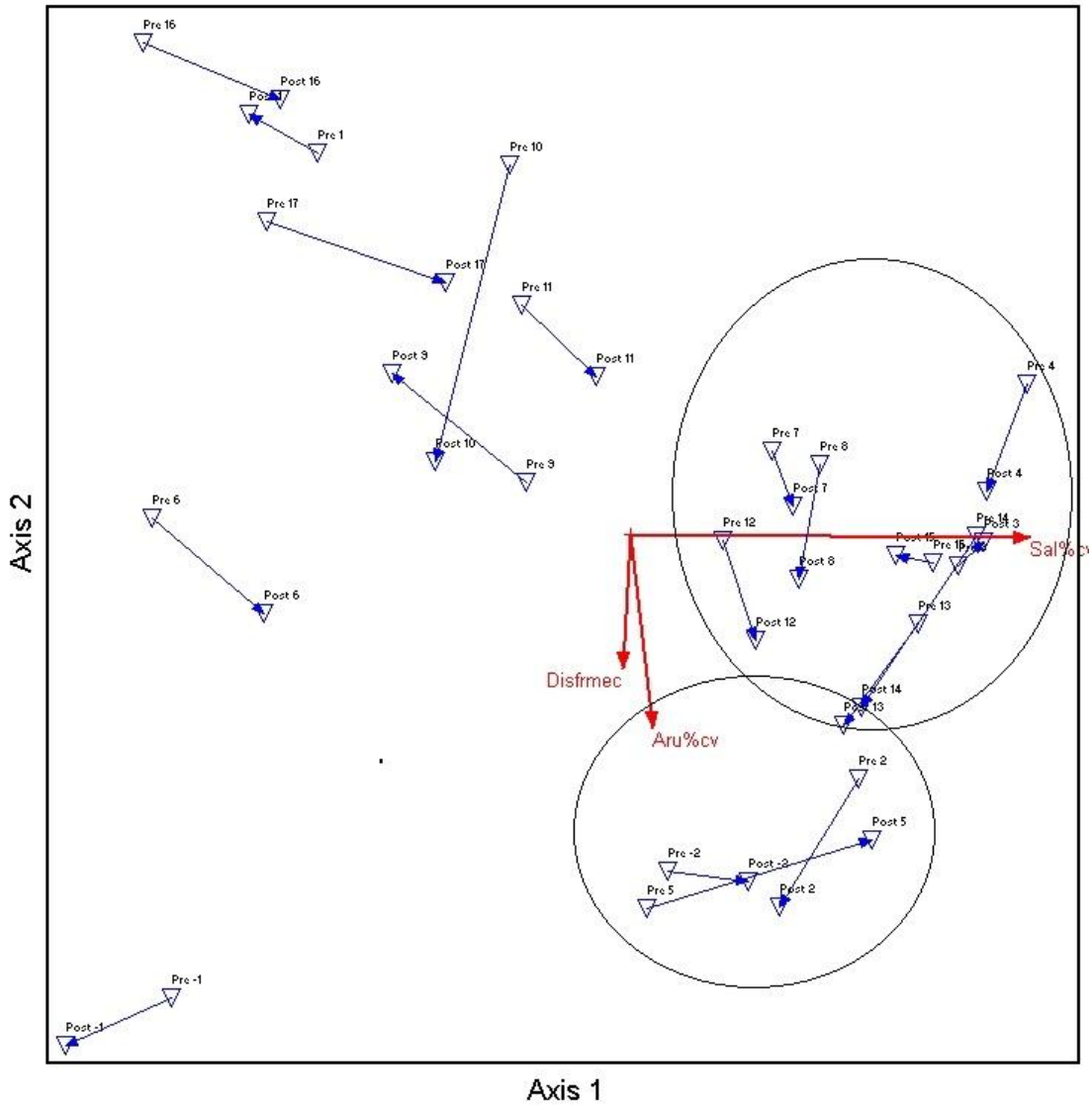
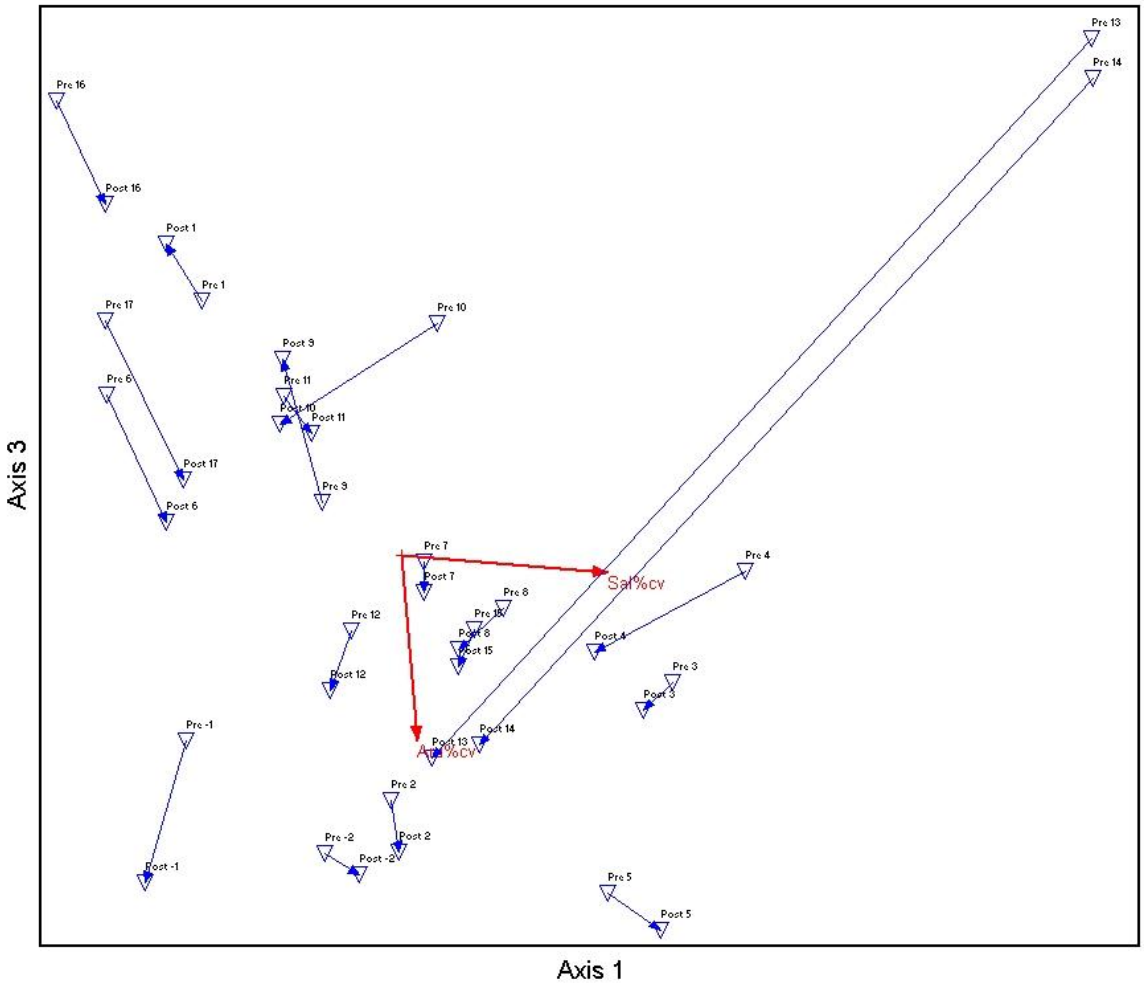
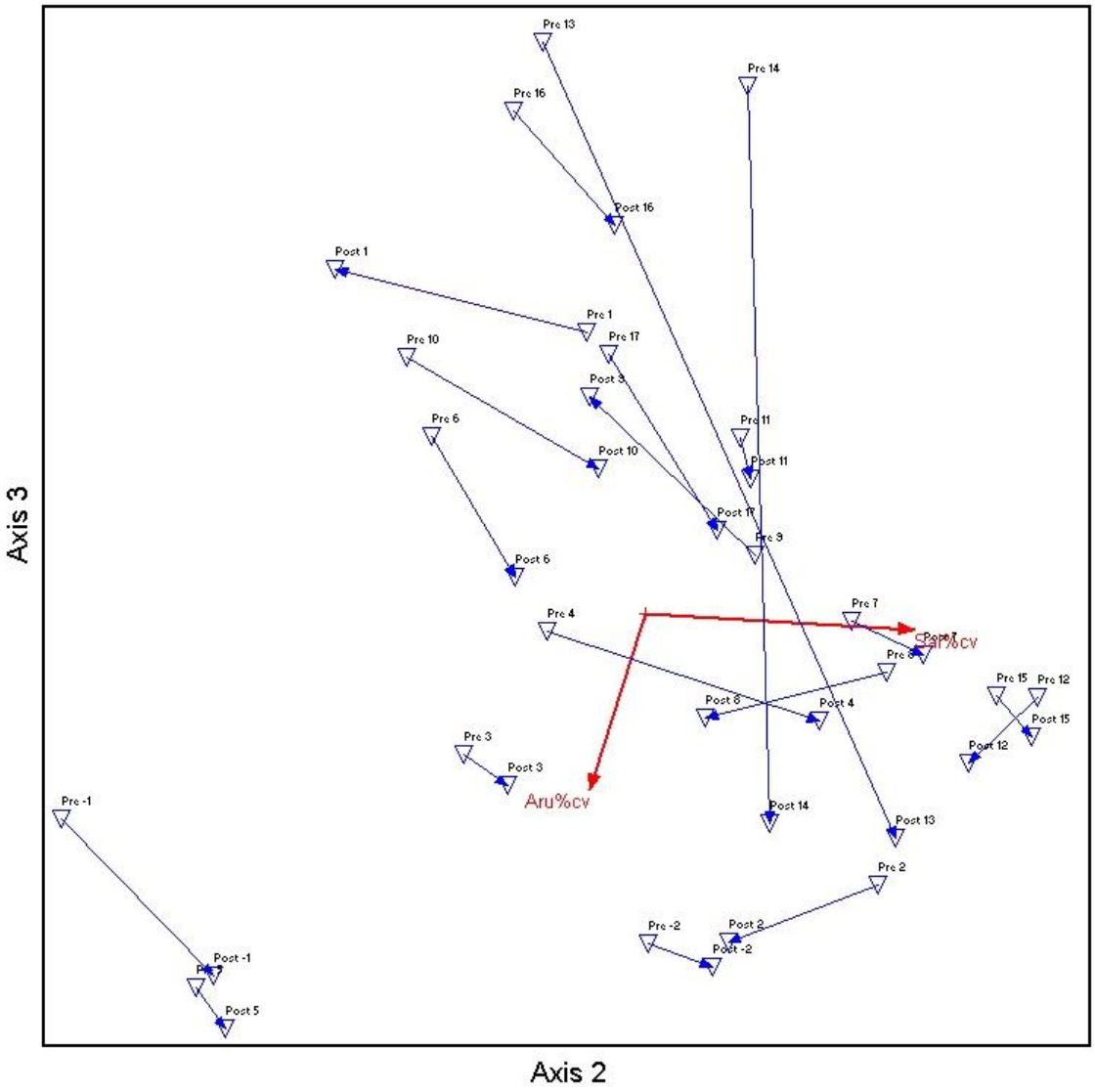


Figure 5.9. CCA biplot of pre and post plots distributed along ordination axes 1 and 3.



Plots 13 and 14 are shifting significantly down axis 3 and across axis 1 in the same direction and both appear to be strongly correlated with willow and Arundo percent cover.

Figure 5.10. CCA biplot of pre and post plots distributed along ordination axes 2 and 3.



Plots 13 and 14 are shifting significantly down axis 3 and across axis 1 in the same general direction and both appear to be strongly correlated with willow and Arundo percent cover.

5.3.3 NMS (Spring Season)

The early spring season NMS main matrix included 38 pre and post averages (rows) and 51 species (columns). The Sorensen distance measure was used for all analyses with a random starting configuration of time of day. The number of runs with real data was 200. The total number of axes was 3 with a reduction in dimensionality at each cycle of one. The final stress for 3-dimentional solution was 6.91518 with 250 iterations.

5.3.4 CCA (Spring Season)

The spring season CCA run included the NMS matrix with the same second matrix as the overall analysis. With respect to Eigenvalues, 43% of the variation within the species data is represented by the 3 ordination axes generated from the CCA (Table 5.21).

Table 5.21. Axis Summary Statistics.
Number of canonical axes: 3
Total variance ("inertia") in the species data: 2.2670

	Axis 1	**Axis 2**	**Axis 3**
Eigenvalue	0.432	0.383	0.160
Variance in species data			
% of variance explained	19.1	16.9	7.0
Cumulative % explained	**19.1**	**35.9**	**43.0**
Pearson Correlation, Spp-Envt*	0.977	0.918	0.803
Kendall (Rank) Corr., Spp-Envt	0.826	0.624	0.565

In this CCA analysis, willow percent cover is strongly correlated with axis 1 and to a lesser degree, axis 2 while Arundo percent cover is strongly correlated with axis 2. Distance from effluent channel and water presence/absence are also correlated to axis 2 (Table 5.22).

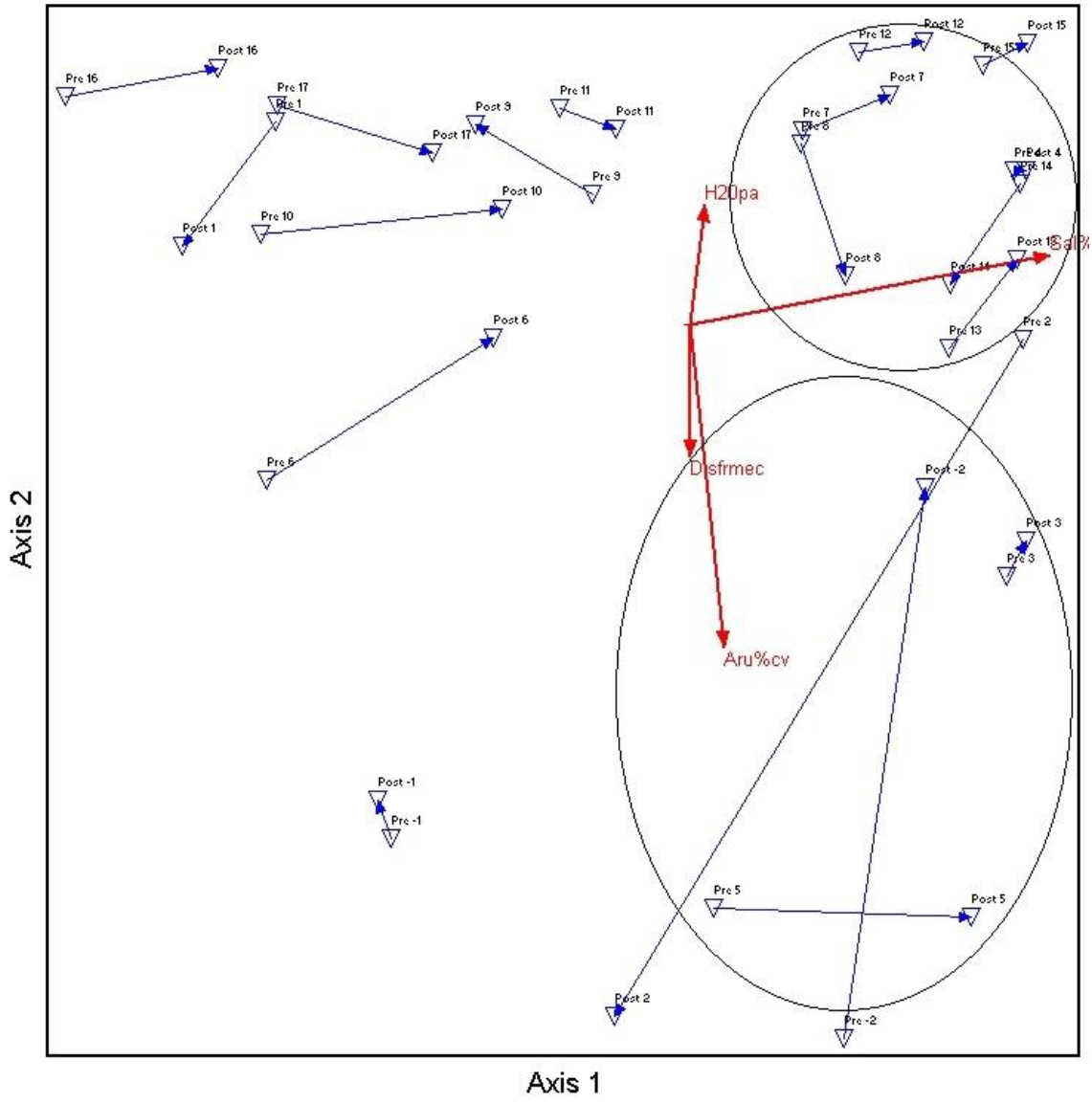
Table 5.22. CCA correlations and biplot scores for seven physical site variables in relation to change in species mean absolute percent cover at each plot. Only two axes were significant.

Variable*	Correlations Axis 1	Correlations Axis 2	Biplot Scores Axis 1	Biplot Scores Axis 2
1 Elev	0.086	-0.477	0.057	-0.295
2 **H20pa**	-0.287	**0.590**	-0.188	**0.365**
3 Aru%cv	-0.194	**-0.913**	-0.127	**-0.565**
4 **Sal%cv**	**-0.916**	0.370	**-0.602**	0.229
5 Disfrmec	0.053	**-0.588**	0.035	**-0.364**
6 Barbtlpa	-0.216	0.118	-0.142	0.073
7 Deadsal	-0.125	-0.351	-0.082	-0.217

*Bold indicates physical site variables most strongly correlated with axes 1, 2.

The 38 pre and post plots are broadly distributed along axes 1 and 2, based on the CCA scores derived for each plot (Fig. 5.10). Shifts in mean absolute percent cover for plant species at each plot appear to be random. Plots 4, 7, 12 and 13 are shifting in the same general direction (up axis 2 and to the right on axis 1) and are correlated to willow percent cover, and to a lesser degree, distance from effluent channel.

Figure 5.11. Spring Season Analysis. CCA biplot of pre and post plots distributed along ordination axes 1 and 2. Successional vectors indicate compositional shifts in mean absolute percent cover of 51 of the most frequently occurring species over two pre and post collection events representing the early spring season (Jan.-Feb.).



Plots in the upper left corner of the graph are shifting in different directions and compositional variation in plant percent cover appears to have low correlative values as compared with the environmental variables. Plots in the upper right corner of the graph are correlated to the presence or absence of water and willow percent cover. Changes occurring at plots -2, 2, 3 and 5 are correlated to change in Arundo percent cover.

5.3.5 NMS (Summer Season)

The early spring season NMS main matrix included 38 pre and post averages (rows) and 48 species (columns). The Sorensen distance measure was used for all analyses with a random starting configuration of time of day. The number of runs with real data was 200.

5.3.6 CCA (Summer Season)

The spring season CCA run included the NMS matrix with the same second matrix as the overall analysis. With respect to Eigenvalues, 36.3% of the variation within the species data is represented by the 3 ordination axes generated from the CCA (Table 5.23).

Table 5.23. Axis Summary Statistics.
Number of canonical axes: 3
Total variance ("inertia") in the species data: 2.1601

	Axis 1	**Axis 2**	**Axis 3**
Eigenvalue	0.386	0.277	0.120
Variance in species data			
% of variance explained	17.9	12.8	5.6
Cumulative % explained	**17.9**	**30.7**	**36.3**
Pearson Correlation, Spp-Envt*	0.983	0.887	0.687
Kendall (Rank) Corr., Spp-Envt	0.812	0.653	0.559

In this CCA analysis, willow percent cover is strongly correlated with axis 1 while Arundo percent cover is strongly correlated with axis 2. Distance from effluent channel, elevation and water presence/absence are also correlated to axis 2 (Table 5.22).

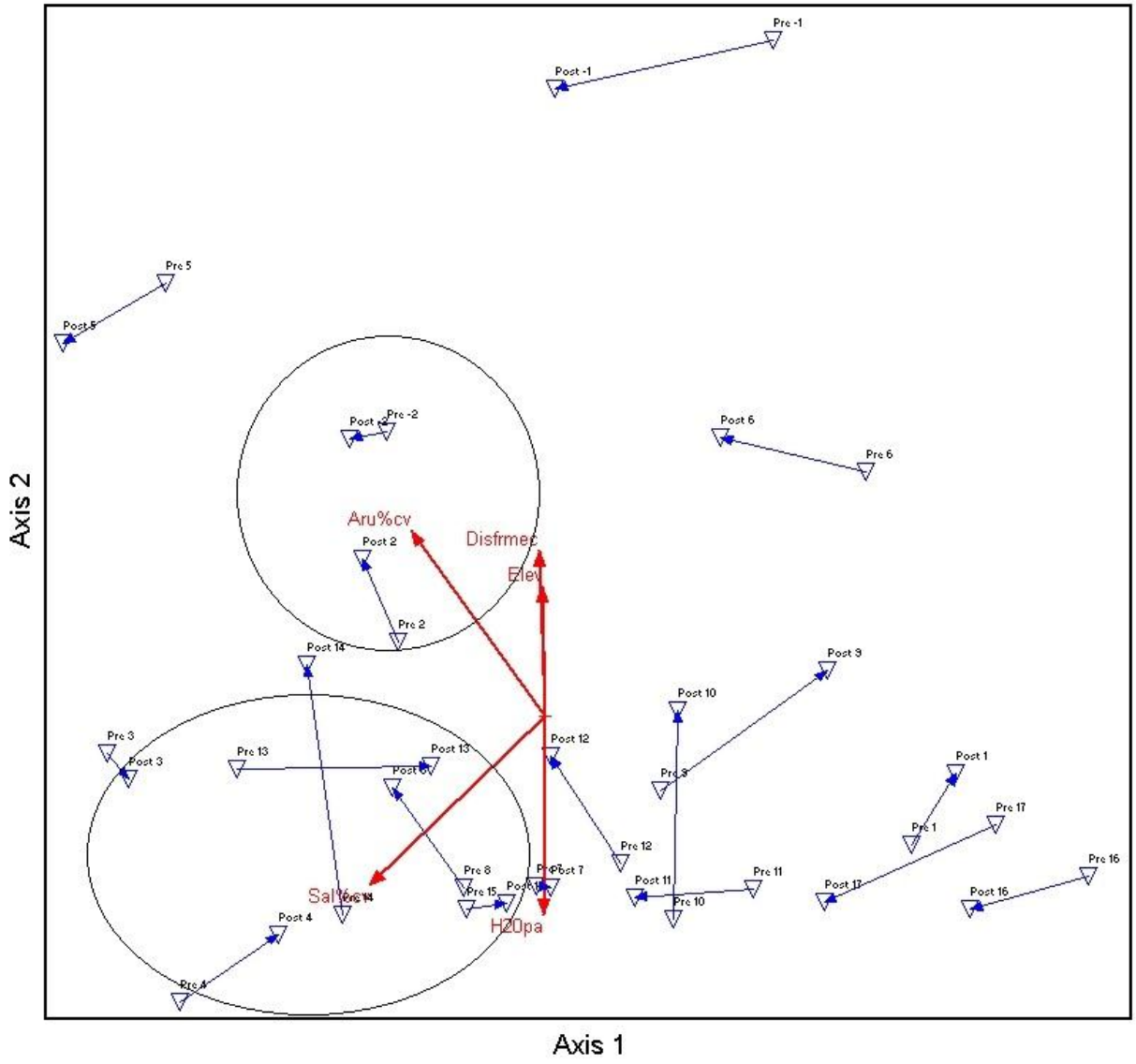
Table 5.24. CCA correlations and biplot scores for seven physical site variables in relation to change in species mean absolute percent cover at each plot.

	Correlations			Biplot Scores		
Variable*	**Axis 1**	**Axis 2**	**Axis 3**	**Axis 1**	**Axis 2**	**Axis 3**
1 **Elev**	0.167	**-0.576**	-0.289	0.104	**-0.303**	-0.100
2 **H20pa**	-0.343	**0.621**	0.348	-0.213	**0.327**	0.121
3 **Aru%cv**	-0.150	**-0.946**	0.223	-0.093	**-0.498**	0.077
4 **Sal%cv**	**-0.932**	0.299	-0.100	**-0.579**	0.158	-0.035
5 **Disfrmec**	0.125	**-0.626**	-0.601	0.077	**-0.330**	-0.209
6 Barbtlpa	-0.149	0.096	-0.361	-0.093	0.051	-0.125
7 Deadsal	-0.173	-0.175	-0.445	-0.108	-0.092	-0.154

*Bold indicates physical site variables most strongly correlated with axes 1, 2.

The 38 pre and post plots are broadly distributed along axes 1 and 2, based on the CCA scores derived for each plot (Fig. 5.11). Successional vectors indicate shifts in mean absolute percent cover for plant species at each plot and generally these patterns appear to be random. Like the spring analysis, changes occurring at plots -2, 2, 5 are correlated to change in Arundo percent cover.

Figure 5.12. Summer Season Analysis. CCA biplot of pre and post plots distributed along ordination axes 1 and 2. Successional vectors indicate compositional shifts in mean absolute percent cover of 48 of the most frequently occurring species over two pre and post collection events representing the mid-summer season (Jun.-Jul).



Most of the variation happens along axis 1. Plots to the right are shifting in different directions and compositional variation in plant percent cover appears to have low correlative values as compared with the environmental variables. Plots 12 and 7 show correlation with the presence or absence of water. Much like the other analyses, changes at plots 3, 4, 8, 13, 14 and 15 are correlated with willow percent cover.

Figure 5.13. Summer Season Analysis. CCA biplot of pre and post plots distributed along ordination axes 1 and 3.

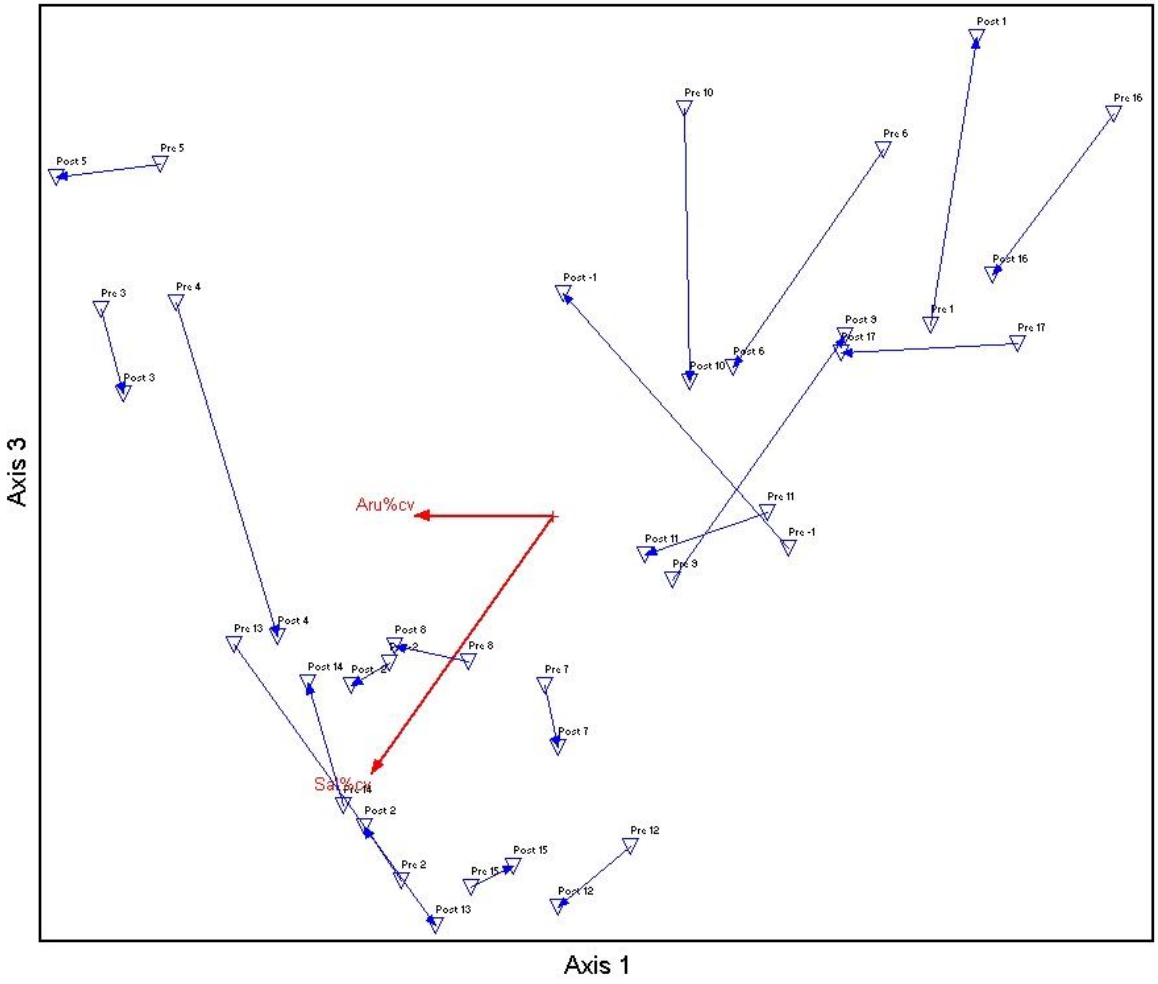
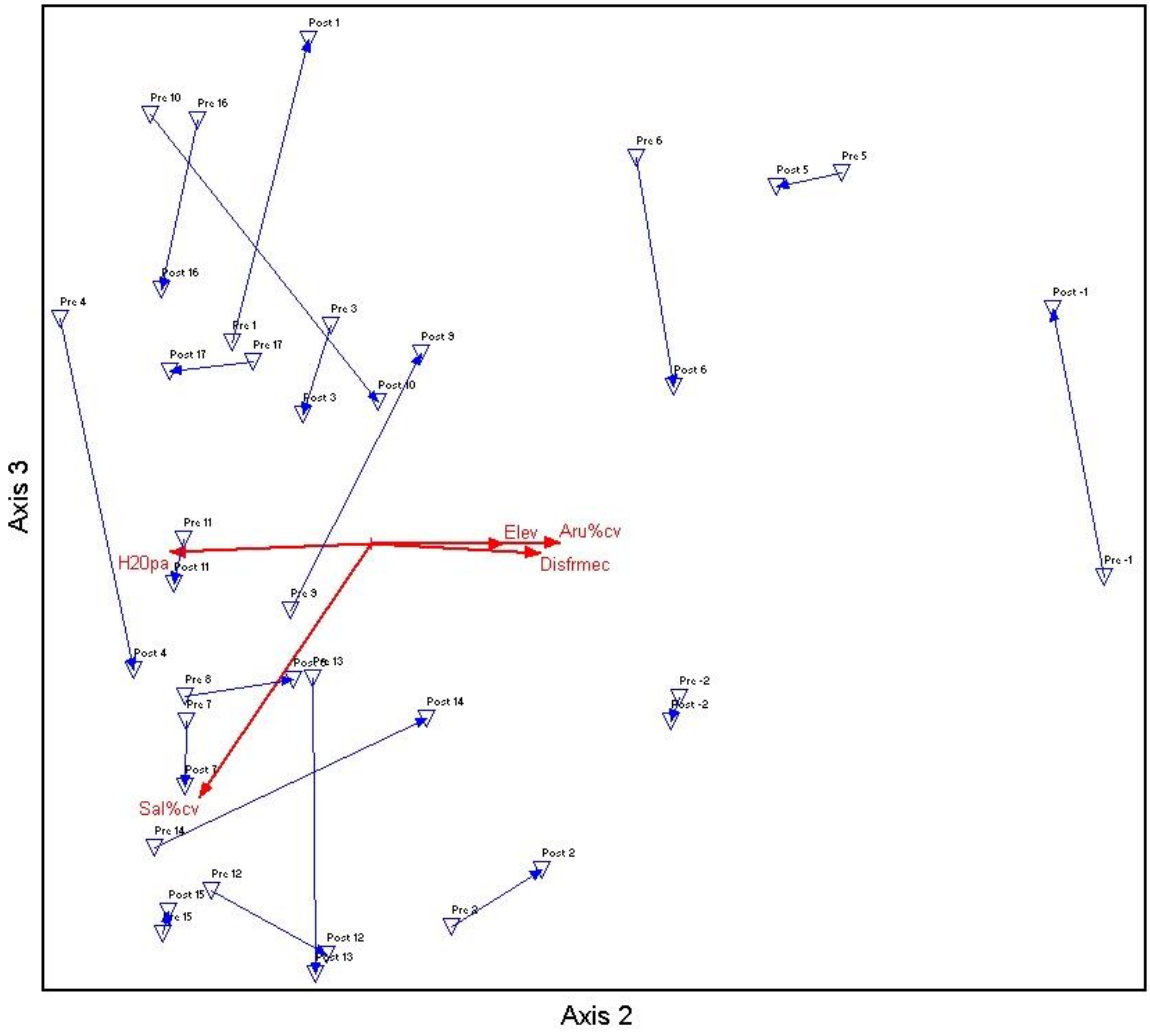


Figure 5.14. Summer Season Analysis. CCA biplot of pre and post plots distributed along ordination axes 2 and 3.



5.3.7 NMS (Fall Season)

The early spring season NMS main matrix included 38 pre and post averages (rows) and 42 species (columns). Note that the number of species occurring in at least three plots dropped from spring to fall as annual herbaceous plants generally die off in the summer and fall. The Sorensen distance measure was used for all analyses with a random starting configuration of time of day. The number of runs with real data was 200.

5.3.8 CCA (Fall Season)

The spring season CCA run included the NMS matrix with the same second matrix as the overall analysis. With respect to Eigenvalues, 39.1% of the variation within the species data is represented by the 3 ordination axes generated from the CCA (Table 5.25).

Table 5.25. Axis Summary Statistics.
Number of canonical axes: 3
Total variance ("inertia") in the species data: 2.1309

	Axis 1	**Axis 2**	**Axis 3**
Eigenvalue	0.416	0.278	0.141
Variance in species data			
% of variance explained	19.5	13.0	6.6
Cumulative % explained	**19.5**	**32.5**	**39.1**
Pearson Correlation, Spp-Envt*	0.983	0.892	0.697
Kendall (Rank) Corr., Spp-Envt	0.863	0.647	0.570

In this CCA analysis, willow percent cover is strongly correlated with axis 1 while Arundo percent cover is strongly correlated with axis 2. Water presence/absence is also correlated to axis 2 (Table 5.26).

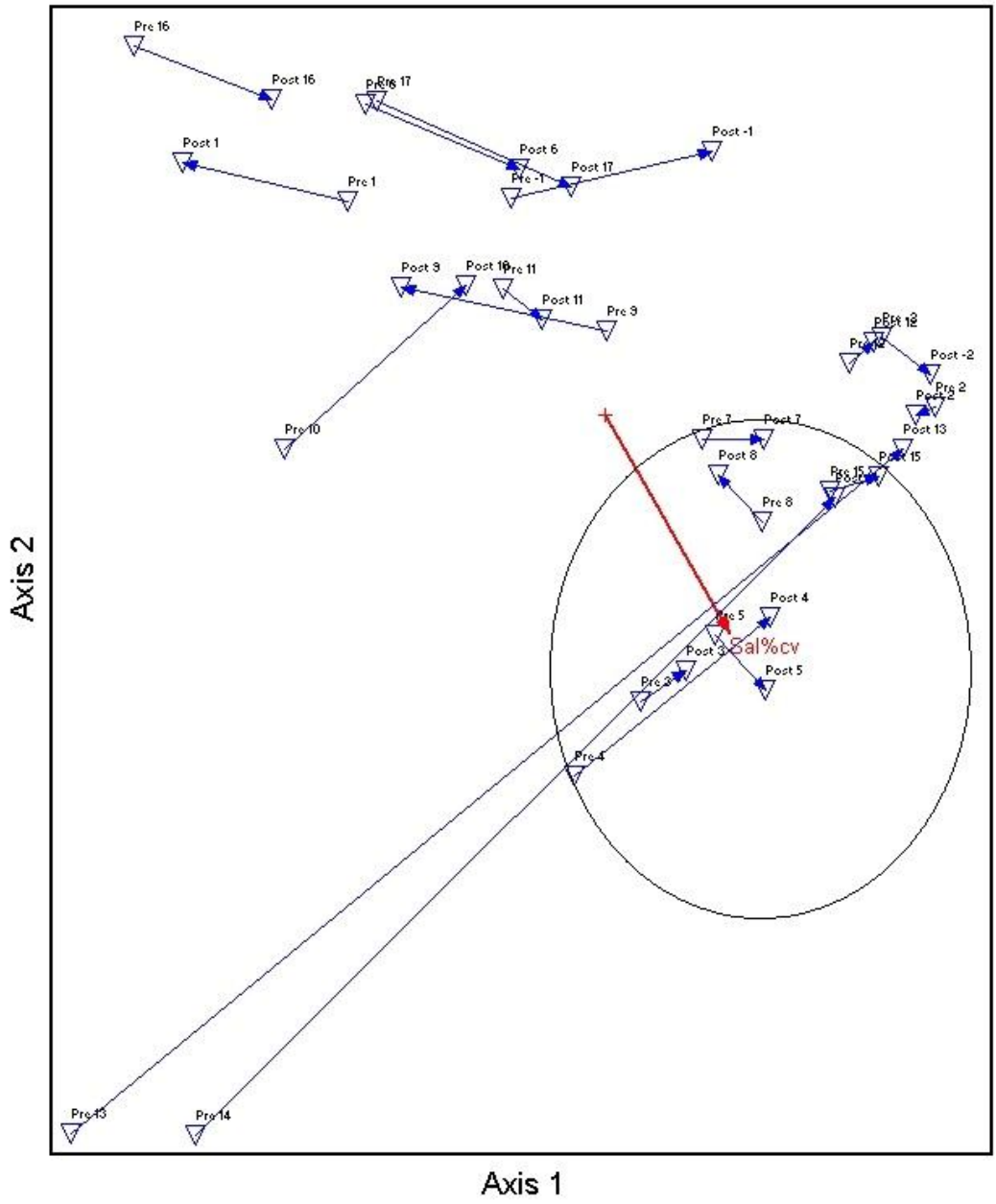
Table 5.26. CCA correlations and biplot scores for seven physical site variables in relation to change in species mean absolute percent cover.

Variable*	Correlations Axis 1	Axis 2	Axis 3	Biplot Scores Axis 1	Axis 2	Axis 3
1 Elev	0.024	-0.571	-0.369	0.016	-0.301	-0.138
2 **H20pa**	-0.227	**0.651**	0.298	-0.147	**0.343**	0.112
3 **Aru%cv**	-0.324	**-0.901**	0.277	-0.209	**-0.474**	0.104
4 **Sal%cv**	**-0.873**	0.440	-0.197	**-0.563**	0.232	-0.074
5 Disfrmec	0.089	-0.677	-0.583	0.058	-0.357	-0.219
6 Barbtlpa	-0.147	0.094	-0.315	-0.095	0.050	-0.118
7 Deadsal	-0.166	-0.198	-0.320	-0.107	-0.104	-0.120

*Bold indicates physical site variables most strongly correlated with axes 1, 2.

The 38 pre and post plots are broadly distributed along axes 1 and 2, based on the CCA scores derived for each plot (Fig. 5.14). Successional vectors indicate shifts in mean absolute percent cover for plant species at each plot and generally these patterns appear to be random. Plots in the upper left corner of the graph are shifting in different directions and compositional variation in plant percent cover appears to have low correlative values as compared with willow percent cover. As with the other analyses, changes at plots 3, 4, 8, 13, 14 and 15 are correlated with willow percent cover.

Figure 5.15. Fall Season Analysis. CCA biplot of pre and post plots distributed along ordination axes 1 and 2. Successional vectors indicate compositional shifts in mean absolute percent cover of 38 of the most frequently occurring species over two pre and post collection events representing the fall season (Sept.-Nov.).



The largest variation occurs similarly with plots 13 and 14 across axis 1, indicating a strong correlation to willow percent cover. This is consistent with seasonal trends when willow cover generally declines due to drought stress in summer and fall months. Plot-by-

plot trends confirm that these plots saw a sharp decline in willow cover during the summer and fall months.

Figure 5.16. Fall Season Analysis. CCA biplot of pre and post plots distributed along ordination axes 1 and 3.

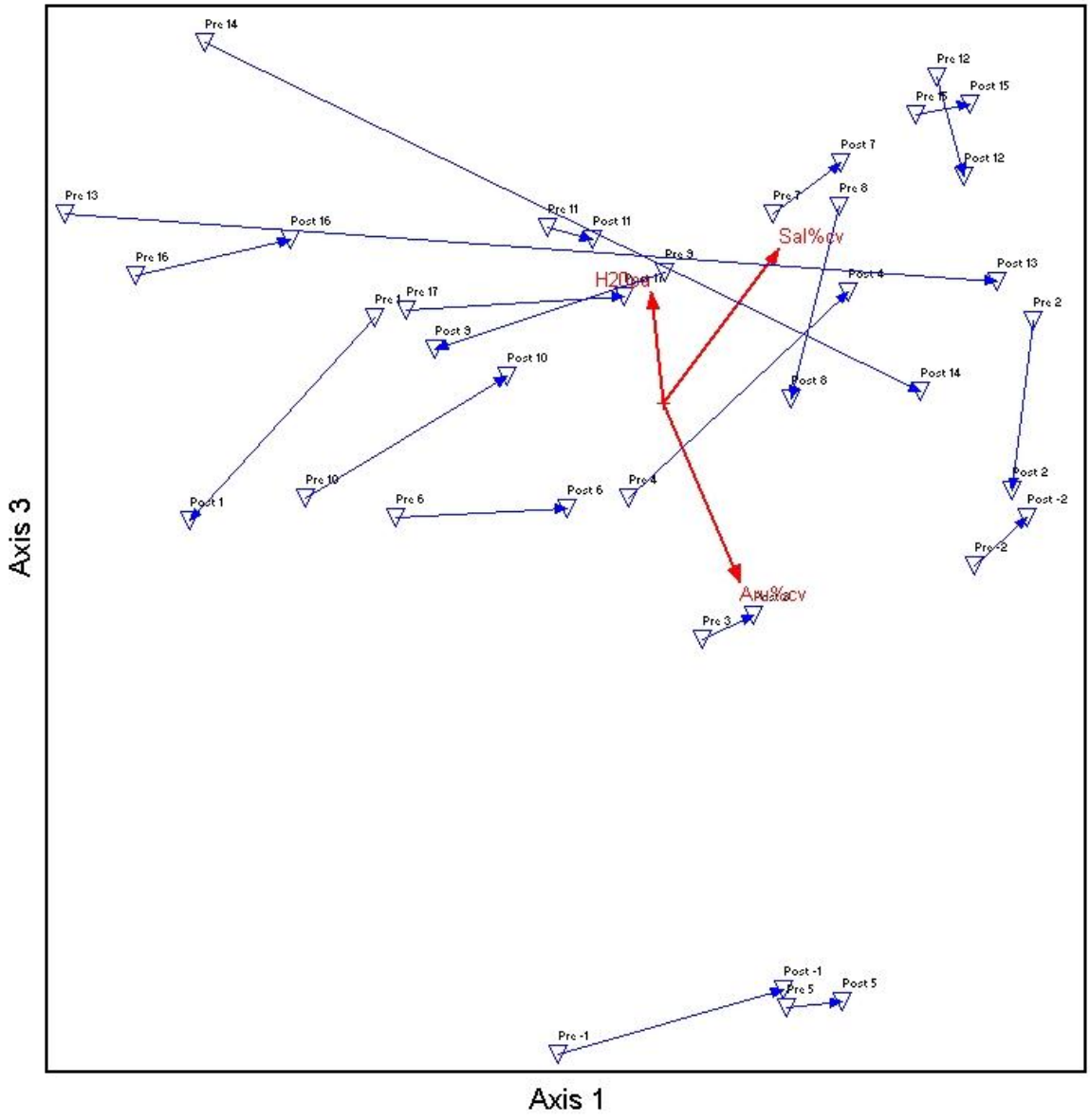
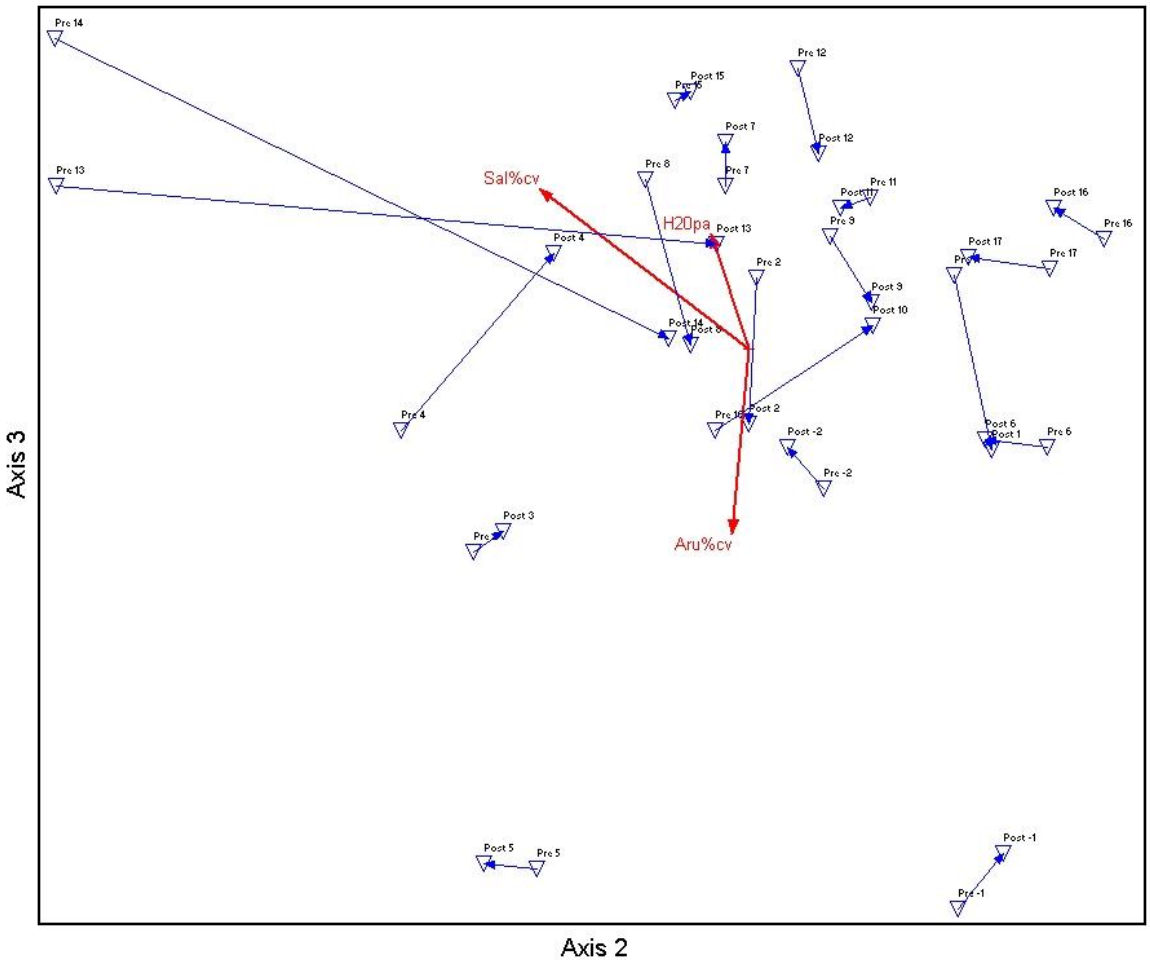


Figure 5.17. Fall Season Analysis. CCA biplot of pre and post plots distributed along ordination axes 2 and 3.



6.0 CONCLUSIONS

6.1 General Discussion

Study trends and statistics show that willow percent cover declined throughout the study site during the post cessation collection events. Some plots saw sharp declines, while others increased slightly in willow coverage. Variation in species composition occurred seasonally, as expected. Decline in species richness occurred at some plots, however, it was not significant overall. No special-status plant species were observed during the study.

Arundo percent cover increased at several plots, although SEM with overall averages suggests statistically insignificant trends. Arundo abundance increased throughout the study site. Plots where water was not present, or where the plot occurred adjacent to, or upslope from the effluent channel, generally saw dominant percent coverage of giant reed or mulefat and willows co-dominant or not present at all. The plots with these conditions were -2, -1, 1, 5, 6 and 16. In terms of overall frequency, giant reed now occurs in some capacity in 14 of the 19 plots.

All the plots except plot -2, 5 and 6 were influenced by winter storms with scouring, sediment deposits and in some cases downed trees which are typical dynamics of the lower Santa Clara River. The plots that were not influenced by storms had no surface water present in the plot or were not adjacent to, or were upslope from the effluent channel.

6.2 Statistical Results Discussion

From these test results, we can conclude that there is a significant relationship between riparian species composition and the physical variables measured. The variables that are most highly correlated to change in mean absolute percent cover in plant species include:

- Percent willow cover
- Percent Arundo cover
- Distance from effluent outfall
- Presence/absence of surface water

CCA analysis revealed that axis 1 is strongly correlated with willow percent cover while axis 2 is strongly correlated with Arundo percent cover. These gradients were closely related to the first two canonical axes and accounted for approximately 30% of the species-environment relationship in the study plots. The results suggest that variation in species composition is related to percent cover change in willow and Arundo. As willows are an important indicator species for this ecosystem, we would expect that large compositional changes will have impacts on other plant species. As Arundo is an invasive plant that quickly outcompetes other plant species, we can infer that changes in its percent cover will also have impacts to the ecosystem.

Other environmental variables that were correlated to species data included distance of the study site to the center of effluent channel and the presence or absence of surface water. When this study was first designed, the site's hydrological regime was not well understood. It was assumed that the effluent channel's flows happened solely, or mostly because of the treatment plant. During the post cessation study, we discovered that

several wells on the adjacent farms discharge significant groundwater flows to the surface at several locations adjacent to the study site throughout the year (Appendix A).

6.3 Implications for Conservation and Restoration

Pressures on riparian habitats will not diminish in the future. Multiple and conflicting demands for clean domestic, industrial and agricultural water supplies, hydropower generation, and effluent dilution and transport all compete for the water needed to sustain riparian ecosystems. Those that are interested in assuring that their successors will enjoy and benefit from these habitats must learn about the physical and biological processes that shape them, for it is through informed, cogent arguments based on such facts [that we can begin to outline, and act upon, conservation and restoration goals] (Faber and Holland 1996).

Understanding relationships between environmental variables and vegetation dynamics along the Santa Clara River is helpful for the applying these findings and methods to future management and conservation of southern California riparian ecosystems. The findings of this study can help inform restoration strategy in several ways. For example, understanding the most important environmental parameters that effect changes in species composition can help determine optimal restoration site conditions for dominant plant species of that ecosystem. This information can also be used to discern which riparian plant communities are most vulnerable to impacts from invasive species such as giant reed. Finally, the methods of this study can also be applied to other similar projects where anticipated changes to environmental variables might impact the overall health of dominant plant species and their distribution within an ecosystem.

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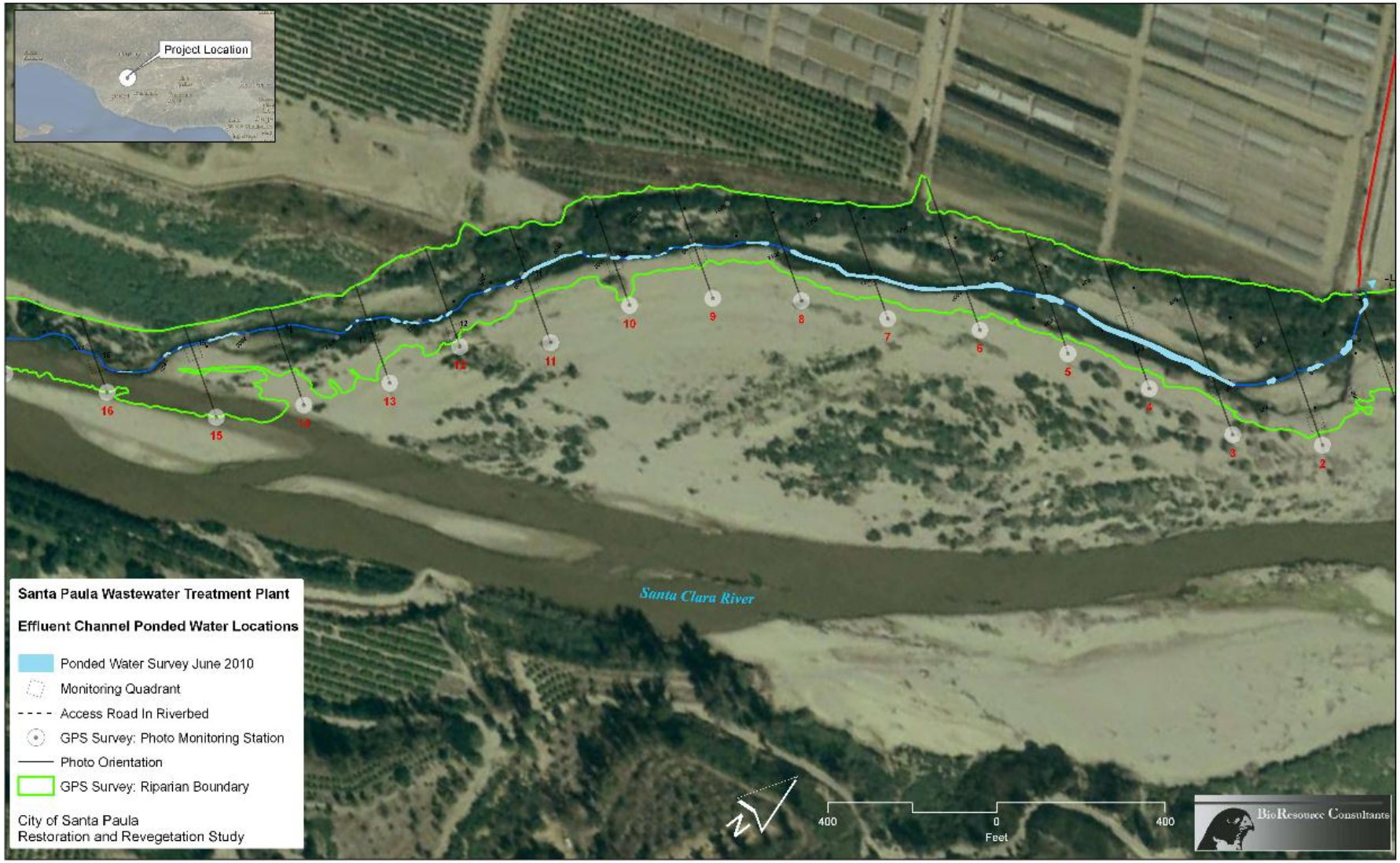
APPENDIX A

Tables, Figures, Observational Data

Overall Data Summary by Plot for Pre and Post Cessation Sample Results
Note: These are mean percentage summaries of all 16 data collection events

Parameter		***Plot***																			
		-2	**-1**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**Mean**
Mean Species Richness	Pre	10	20	8	14	6	18	7	16	16	23	26	19	22	19	16	17	12	6	17	15
	Post	9	17	12	15	4	15	6	10	12	16	21	18	19	20	9	17	8	5	12	13
Total Species detected (9/7 events)	Pre	15	26	10	21	12	26	11	25	27	37	44	31	37	32	23	24	20	8	23	24
	Post	11	23	17	30	5	22	9	16	20	25	33	30	27	30	13	24	14	5	23	20
Nativity																					
% Mean Native Species	Pre	61	34	56	41	67	48	39	38	46	32	34	48	53	61	61	64	59	69	47	50
	Post	75	32	33	28	71	46	39	59	53	46	31	40	49	44	73	66	57	76	57	51
% Mean Non-native Species	Pre	45	57	96	73	84	95	30	60	96	94	82	92	96	96	88	97	99	99	79	82
	Post	27	23	61	67	63	29	45	61	41	38	53	71	60	51	49	29	41	24	36	46
Cover																					
Total Mean Absolute Cover	Pre	93	73	94	111	98	86	91	95	95	97	117	100	112	100	99	96	111	113	105	99
	Post	92	109	82	63	138	98	74	111	97	124	132	94	120	90	79	92	102	126	87	101
Native Mean % Absolute Cover	Pre	50	55	93	67	82	91	29	60	97	92	83	90	95	94	82	95	99	98	80	81
	Post	53	24	77	44	85	97	33	72	98	84	78	78	94	89	87	72	99	100	91	77
Non-native Mean % Absolute Cover	Pre	50	45	6	32	18	8	71	40	3	7	17	10	4	5	15	5	1	2	20	19
	Post	25	47	75	15	56	15	2	67	28	2	16	22	22	6	11	17	1	0.4	8	23
Important Species																					
Willow Mean % Absolute Cover	Pre	41	3	21	64	72	54	28	9	76	77	50	38	52	76	62	83	93	4	20	49
	Post	44	5	6	29	97	90	25	25	81	87	44	36	70	67	60	55	97	22	37	51
Dead Willow Mean % Abs. Cover	Pre	0	25	2	0	0	0	0	0	0.4	1	0	1	0	.03	3	0	0.3	0	0	2
	Post	0	34	2	0	0	0	0	0	0	2	0	1	0	.03	3	2	0.3	0	0	2
Mulefat Mean % Absolute Cover	Pre	6	8	59	0.2	0	0.8	0.6	40	20	13	31	48	41	1	0	0	4	78	56	21
	Post	1	9	56	0	0	1	0	0	13	14	58	32	41	5	0	0	3	86	41	19
Giant Reed Mean % Absolute Cover	Pre	44	14	2	24	17	0	42	9	0	0	0.1	0.3	0.1	0	11	0.4	0	0	2	9
	Post	39	26	7	26	20	0	45	13	0	15	0	2	1	3	10	13	0	0	5	12

Study area showing mapped ponded water (light blue lines) observed during the post cessation study in June 2010. Several agricultural wells adjacent to the study area dischage groundwater on a regular basis throughout the year.



Obersverations of environmental factors during the post cessation collection events by event and plot.

Plot #	Post Cessation Collection Event						
	1	2	3	4	5	6	7
-1	DW	DW	DW	DW	DW	DW	DW majority of willow
-2						DW	DW
1	1 Willow died	DW	DW	DW	DW WPS	FS DW	DW
2	DS	DS	DW	All SALA dead or dying	All DW	FS All DW	All DW
3	SW	SW	SW	ASW,	SW	DW	SW
4	SW	SW	SW	SW	SW	FS DW	DW
5		DS	DS	DS	DS	DS	DW
6				FS		ADW DW	DW
7	SW	SW	SW	SW	SW	SW 1 willow dead	SW DW
8	DW SW	DW SW	SW	SW	ADW	DW WPS	DW WPS
9		ADW					ASW
10	DW SW	DS	DS	DS	DS	DS FS	DS
11					DS 1 willow dead	DW	ASW DW
12	DW SW	DW	WPS	WPS DS	WPS DS	WPS DS	DS WPS
13	WPS	DW	DW	DW DS	AWPS DW	WPS DW	WPS DW
14	DW 1 fallen tree	DW DS FS	DW	DW	DW WPS	DW WPS	DW WPS
15						WPS	WPS
16	SW						
17	SW						

DW – Dead Willow
DS – Drought stress/willow stress
WPS – Wood pecker holes resulting in beetle stress
FS – Evidence of flooding and scouring from recent storm event no surface water
ADW – Adjacent dead willow not in plot
SW – Surface water
ASW – Adjacent surface water
SALA- Salix lasiolepis
All DW – All willow trees dead