Cocopah Indian Tribe

Colorado River Restoration Project
Final Report

AWPF #08-156WPF
Task #8

Submitted to:
Arizona Water Protection Fund
3550 N Central Ave
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1 Introduction

The Cocopah Indian Tribe's (Cocopah) Colorado River Restoration Project was initiated in October 2008 with funding from the Arizona Water Protection Fund (AWPF) and matching money from the National Wildlife Federation (NWF). This final report is submitted to comply with AWPF guidelines under Task #8 of this project and includes a summary of all work completed on this project using AWPF or matching funds.

The AWPF grant received for this project allocated funding to eight distinct project tasks and required that all activities performed during the execution of the project be attributed to one of these tasks for the purposes of documentation and billing. This report includes reference to each of these tasks; however, the report is organized in chronological order rather than numerical order for improved comprehension.

2 Project Background

This project is a part of the Cocopah Indian Tribe's on-going efforts to restore riparian habitat along the Limitrophe of the Lower Colorado River. The riparian ecosystem along the Lower Colorado River has been greatly altered over the past century by water development projects, deforestation, agricultural development, and non-native species invasion. All of these activities have played a role in the shift from native stands of cottonwood, willow, mesquite, and other native species to dense stands of invasive species such as salt cedar (*Tamarix* spp.) and common reed (*Phragmites australis*).

In these altered environments it is often not enough to simply remove the invasive species. Desirable species must be planted in their stead to achieve successful restoration. Unfortunately, this altered environment often no longer supports the species which were growing there before the invasive species became established.

Historically, riparian areas along the Lower Colorado River benefited from seasonal flooding. These floods provided the required substrate for native species germination, flushed the soils of salts, cleaned out backwater wetlands, and recharged groundwater aquifers. Now, with so many upstream dams, this section of the Lower Colorado River very rarely receives overbank flows. Thus, the riparian zone on the West Reservation suffers from depressed water tables, minimal in-channel flows, and saline soils. In order to revegetate these areas, a combination of native species (some riparian and some upland) must be used to achieve the desired habitat and to deter renewed salt cedar invasion.

The best strategy for restoration at any given site will depend on the specific characteristics (both abiotic and biotic) of that site and the desired land use goals. The land use goals for this project area are to return it to a productive native habitat that is once again accessible and useful to Tribal members, the public, and local wildlife.

There were four steps required to complete this project:

1. Development of a revegetation plan based on current site, soil, and water table data.
2. Removal of remaining salt cedar
3. Revegetation of 40-acres of the Colorado River riparian zone with native habitat.
4. Monitoring of revegetation success for two years post-planting.

3 Contracting

The contract between the AWPF and the Cocopah (AWPF #08-156WPF) was executed October 24, 2008. The Cocopah then executed a contract with Habitat Management, Inc. (HMI) to provide project support, planning, design, and implementation services.

3.1 Amendments

The contract between the AWPF and the Cocopah was amended in March 2009. The Cocopah presented a modification to the existing Scope of Work at the March 10, 2009 meeting of the AWPF commission. The AWPF commission unanimously approved the modification at the March 10 meeting. The approved modification included:

- Removal of the endangered bird species monitoring from Task #7
- Reallocation of the funds towards an additional eight (8) acres of site clearing, revegetation, and vegetation monitoring.

The contract between the AWPF and the Cocopah was again amended in February 2010. Cocopah presented a modification to the existing Scope of Work at the February 8, 2010 meeting of the AWPF commission. The AWPF commission unanimously approved the modification at that meeting. The approved modifications included:

- Task #7 Scope of Work modification to include the installation and monitoring of rain gauges on the site
- Reallocation of $1,738.86 from Task #5 to Task #7 to cover the cost associated with the installation and monitoring of rain gauges on the site
- Task #5 Scope of Work modification to include an additional 15 acres of soil analyses immediately adjacent and to the south of the original 40-acre site.

Subsequent to each contract amendment, the Cocopah amended the subcontract with HMI to reflect the changes approved by AWPF.

3.2 Subcontracting

In addition to the Cocopah's subcontract with HMI, a subcontract was also executed with Riverside Environmental Services, Inc. (RESI) to complete the salt cedar clearing under Task #4 of the project. HMI also subcontracted with several other contractors to complete portions of the scope of work including NWF, RESI, and Yuma Desert Landscapes (YDL). NWF provided assistance with project coordination, deliverables, and management. RESI completed revegetation implementation and one round of weed maintenance under Task #6, and YDL also completed some weed maintenance under Task #6.

4 Overall Project Coordination (Task #3)

The majority of the project coordination activities completed for this project were conducted by HMI, with assistance from Cocopah managers and NWF. Project coordination activities included:

- Contracting, amendments, and AWPF presentations

- Coordination between Cocopah managers, HMI, NWF, US Border Patrol, and other parties
- Preparation and submittal of interim and annual reports
- Site visits, meetings, and communications to oversee project implementation

4.1 Deliverables

Deliverables submitted for Task #3 included:

- 2008 Annual Report — February 6, 2009
- 2009 Interim Progress Report - 1st Qtr — June 10, 2009
- 2009 Interim Progress Report - 2nd Qtr — August 17, 2009
- 2009 Interim Progress Report - 3rd Qtr — December 16, 2009
- 2009 Annual Report — April 16, 2010
- 2010 Interim Progress Report - 1st Qtr — May 11, 2010
- 2010 Interim Progress Report - 2nd Qtr — September 10, 2010
- 2010 Interim Progress Report - 3rd Qtr — November 1, 2010

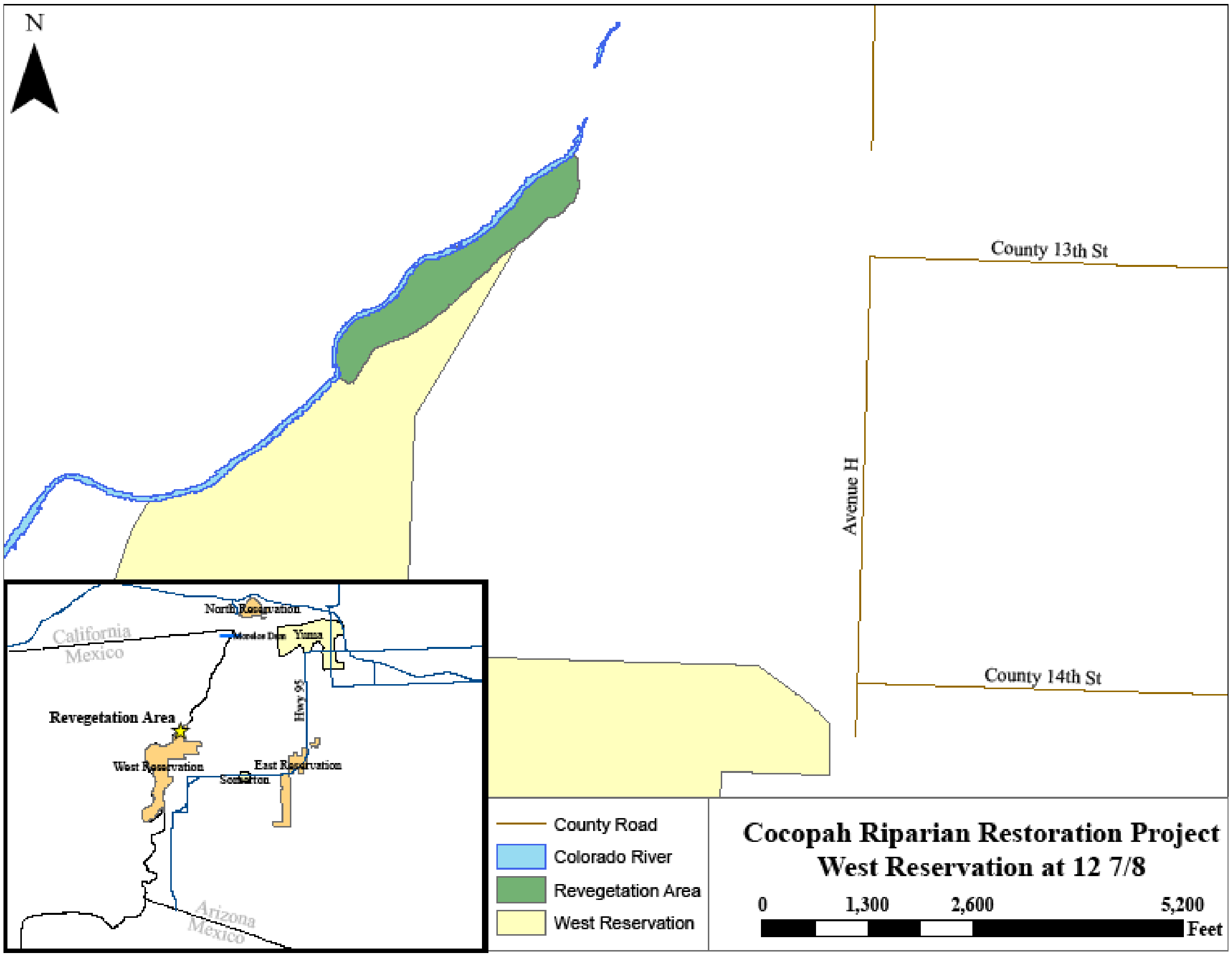
This report shall fulfill the requirement for the 2010 annual report outlined under Task #3 in the Scope of Work.

5 Site Description

5.1 Location

The revegetation area is located on the Cocopah West Reservation just west of Somerton, Arizona. It is comprised of approximately 40 acres along the Colorado River Limitrophe and is located approximately 5 miles downstream of the Morelos Dam on the United States side of the river. The revegetation area is between the BOR levee road and the river channel at what would be County Road 12 7/8 (Map 1).

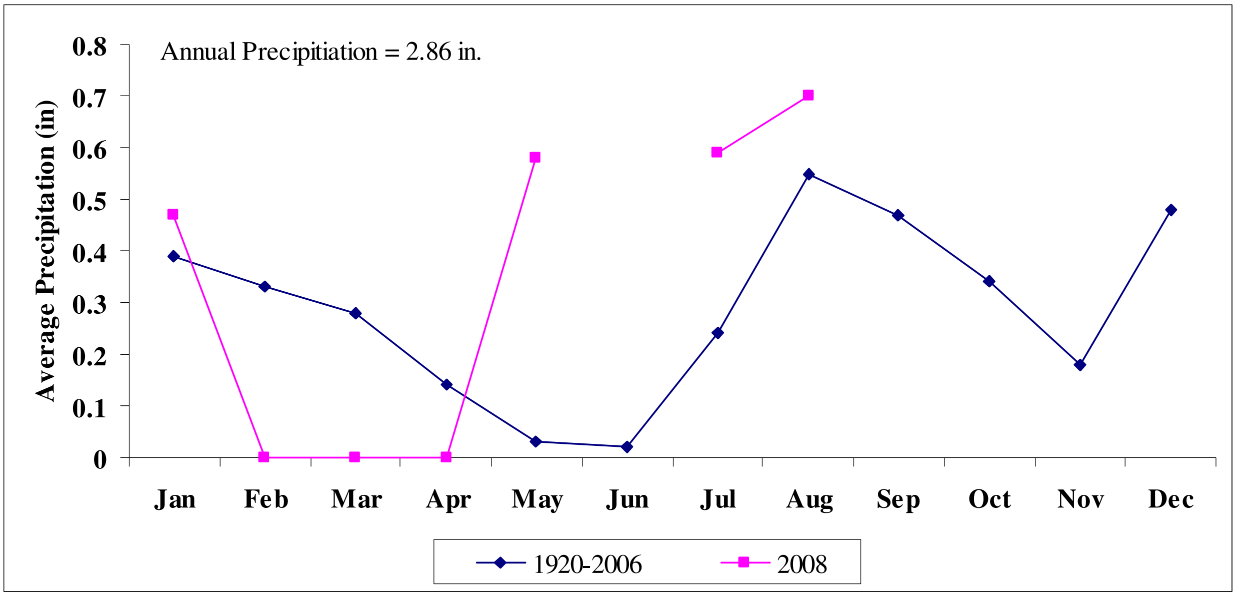
Map 1: Revegetation area location map



5.2 Climate

The Cocopah Reservation lies within the Sonoran Desert ecoregion characterized by low precipitation and high temperatures. Average annual precipitation at the closest monitoring station (5.5 miles northeast) in nearby Yuma (Yuma Valley Station, Western Regional Climate Center 2008) is only 2.86 inches with the majority falling in late summer and winter (Figure 1). Spring and early summer are generally dry with some months receiving almost no precipitation. The region also experiences very high evaporation rates between 6.5 and 9 feet per year (Cohen et al. 2001, Cohen and Henges-Jeck 2001, Tiegs and Pohl 2005). The Yuma Valley Climate Station only collected data through 2006; however, the Yuma Quartermaster Depot (6 miles to the east) has data through the present. These data show that the spring of 2008 was drier than usual, while the summer has been wetter than usual (Figure 1).

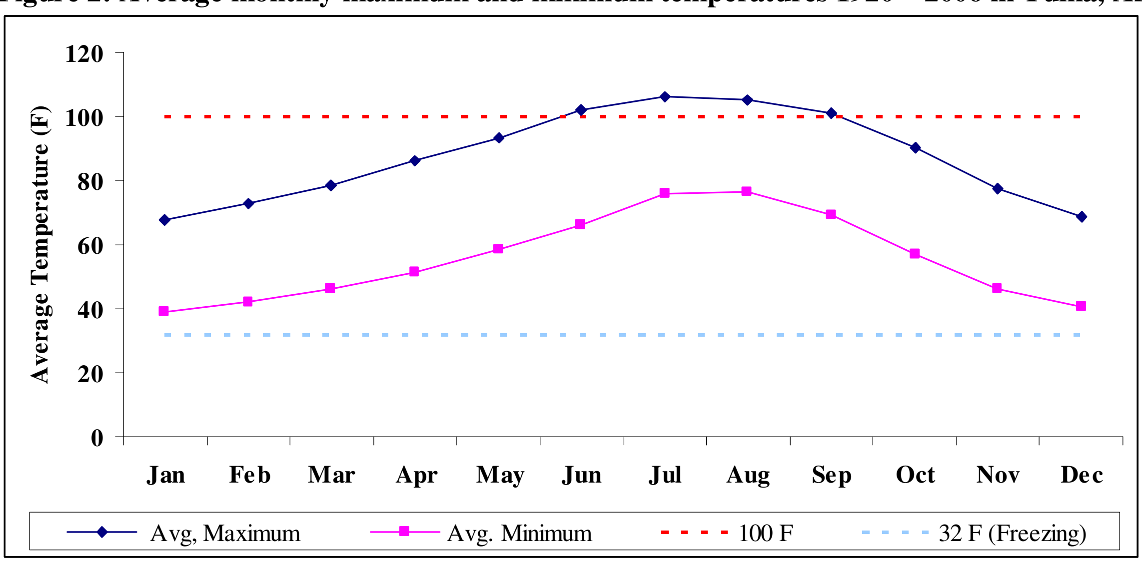
Figure 1: Monthly precipitation for 2008 and 1920–2006 average in Yuma, AZ*



* The historical data are from the Yuma Valley Climate Station which is nearest to the revegetation area (5.5 miles northeast). The 2008 data are from the Yuma Quartermaster Depot Climate Station approximately 6 miles to the east of the Yuma Valley Station and 10.5 miles from the revegetation area.

Average high temperatures range from 106° F in July to 68° F in December and January (Figure 2). Average low temperatures range from 39° F in December and January to 76° F in July and August (Figure 2). Average temperatures are above 100° F June through September and temperatures in Yuma are typically above 90° F an average of 195 days each year (www.weather.com). Average lows almost never reach freezing temperatures making the region ideal for year-round crop production.

Figure 2: Average monthly maximum and minimum temperatures 1920 – 2006 in Yuma, AZ

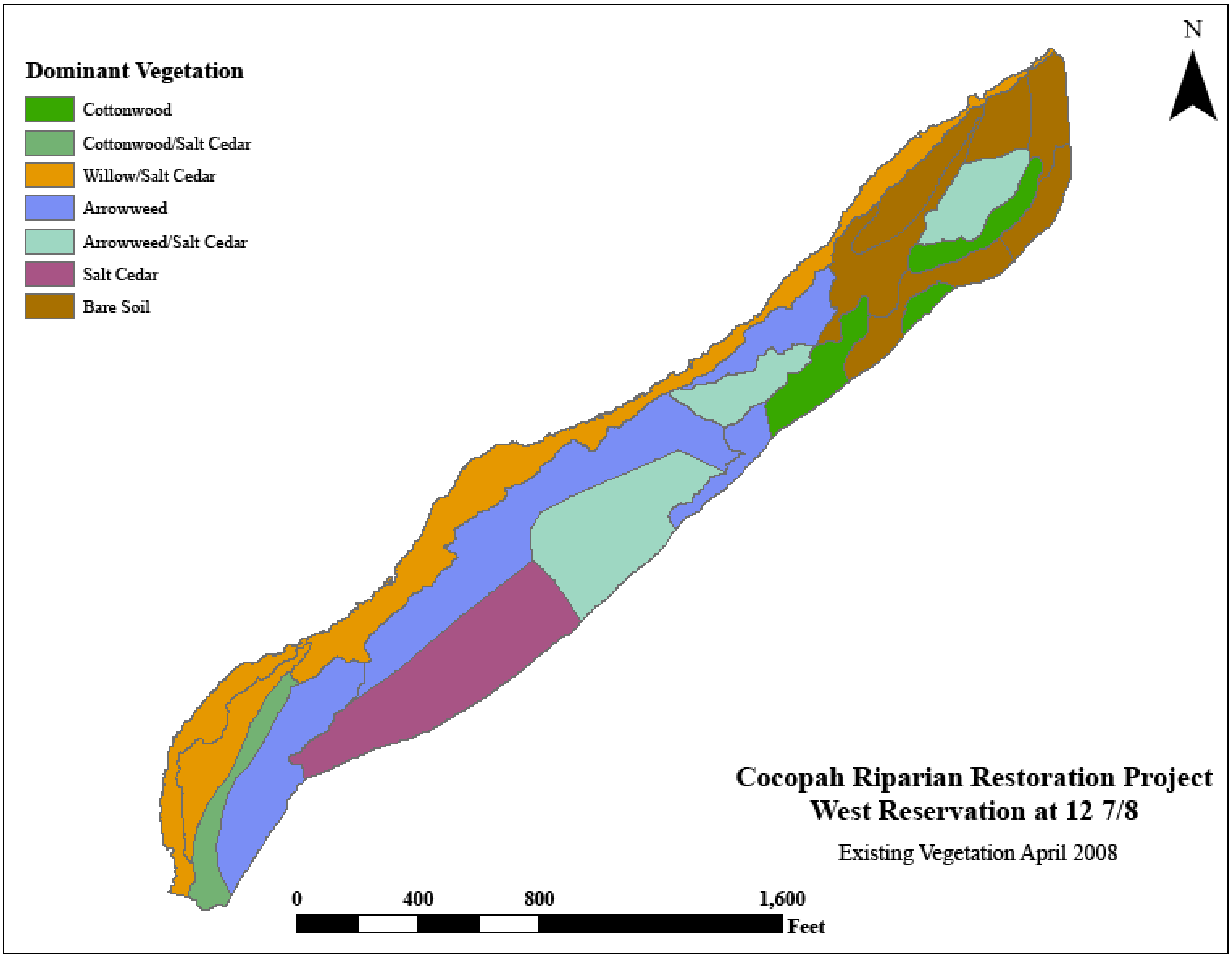


* Data from Western Regional Climate Center 2008 (www.wrcc.dri.edu).

5.3 Vegetation Communities

On April 13, 2008 the existing vegetation communities on the revegetation area were mapped. Since the site was cleared of salt cedar in 2006, a variety of plants have reestablished within the revegetation area (Map 2). The revegetation strategy needs to consider the various communities present and augment them in the planting plan.

Map 2: Dominant vegetation map for revegetation area



6 Groundwater Sampling (Task #5)

Soil and ground water sampling were critical to characterize the site before developing the revegetation plan. Due to the required timing of these activities and awarding of the AWPF grant, most of this work was funded with matching funds from the NWF. AWPF funds were used to produce and evaluate the final soil and ground water maps which are required AWPF deliverables under Task #5 of the grant.

6.1 Groundwater Sampling Methods

Knowing the average depth to ground water and seasonal fluctuations is critical to developing a native cottonwood and willow planting plan. Thus, ground water depths were monitored for seven months prior to revegetation plan development.

6.1.1 Well Installation

Ground water monitoring wells were installed in 15 locations throughout the revegetation area on April 8-10, 2008. A soil auger was used to drill a hole down to the water table. A perforated PVC pipe with a cap on the bottom end will be inserted into the hole until the end is at least 6-12" below the water table surface at the time of installation.

The 15 wells were spaced throughout the entire area using a grid. The grid was set up with 500 ft spacing perpendicular to the river channel and 50 ft spacing parallel to it. At least one well was installed at each 500 ft perpendicular interval and each 50 ft interval across the entire area to ensure that a variety of distances for the channel were observed. Each well was marked, capped, and its location recorded with a sub-meter accurate GPS unit in the field.

6.1.2 Well Monitoring

Each well was monitored at least once every two weeks from April 10 – October 17, 2008. A standard tape measure was dropped down into the pipe to determine the depth of the water below the top of the pipe. The height of the pipe above the ground surface was subtracted to determine the depth of the water below the ground surface. Each well was monitored for 7 months prior to revegetation activities and several times during and after revegetation.

6.1.3 Data Analysis

The data gathered from these wells was used to interpolate to the depth to water table between the wells. Kriging was used to create interpolated isomaps of groundwater in the area.

6.2 Groundwater Sampling Results

Groundwater is of critical importance to the survival of riparian species. Native cottonwood and willow transplants must be planted in the capillary fringe or in the water table itself (USDA, NRCS 2007). While these species can tolerate moderate seasonal drawdown of the water table, they cannot tolerate prolonged drought. Data collected in April through October includes the driest time of the year, but not necessarily the wettest. Monitoring in the dry season is crucial to ensure that plantings are not left dry through the summer when heat and evapotranspiration are greatest. The dry season data allowed for the design of a planting strategy that would have adequate water for driest scenario. Precipitation data from 2008 (Figure 1) suggested that it was a wetter than average summer which was also considered when creating the planting design.

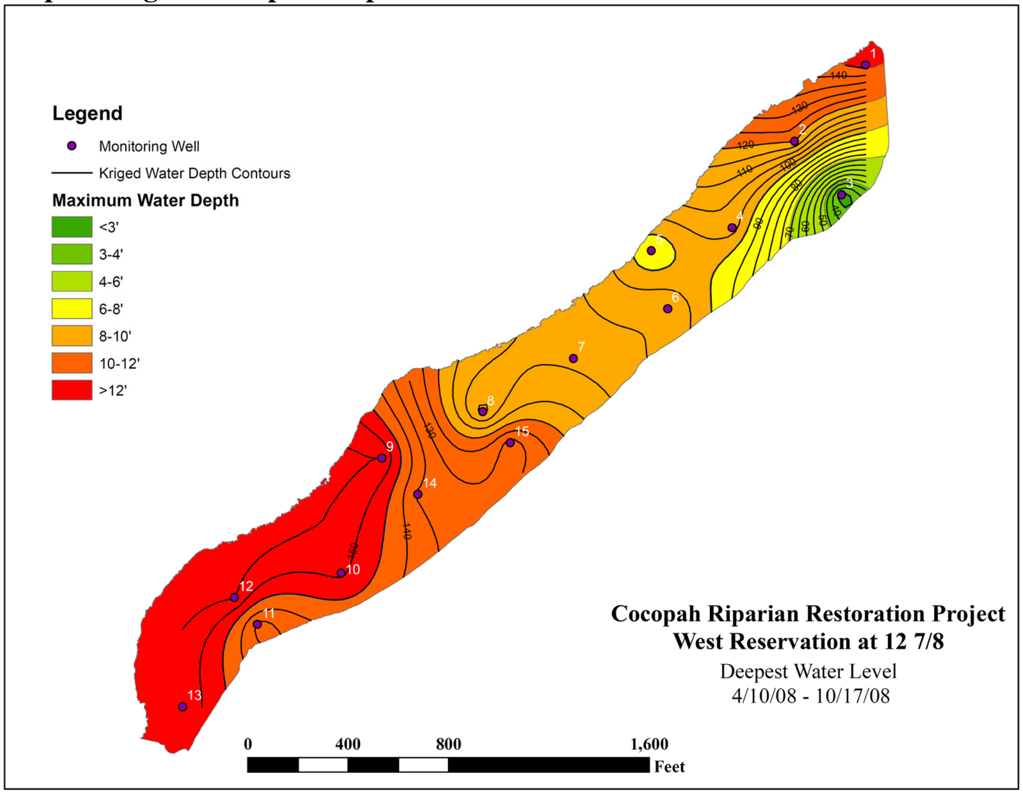
Using data from the 12 monitoring dates (Table 1), species selection and revegetation methods were selected by considering the deepest (Map 3) and shallowest (Map 4) water levels recorded during the monitoring time period. During this timeframe the water table varied substantially across the revegetation area (Table 1). Water levels in Well #3 stayed within 3 ft of the surface during this monitoring period, while Well #13 showed water levels over 10 ft deep during this time. Also, water levels in each well fluctuated over the season with only an 18 inch difference between the high and low levels in Well #1 and a 73 inch difference over time in Well #9.

Table 1: Depth to water table (in.) during monitoring period within the revegetation area

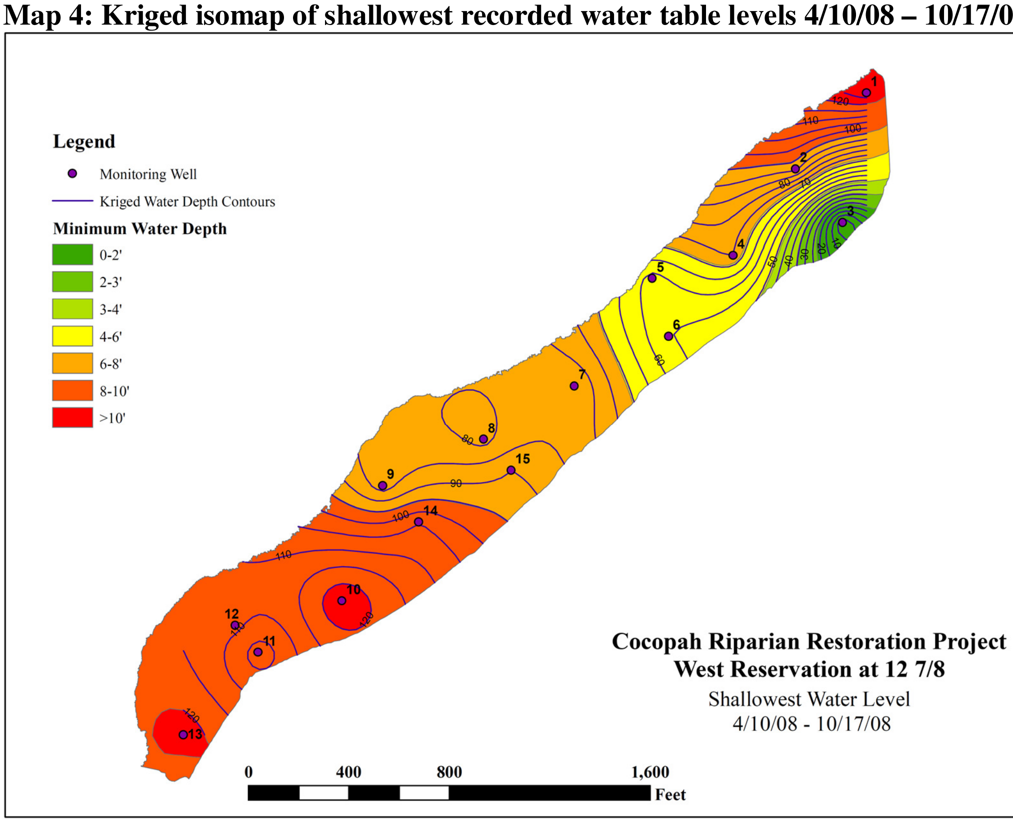
Date Monitored	Well Number														
	1*	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
4/10/2008	136	109.75	27	98	70.25	100	106	101.5	126.5	151	130.5	155.5	153.75	109	130
4/28/2008	146	120.75	31.25	102.5	75.75	105.25	109	101	151	147	132.5	154.5	151.25	134	128
5/6/2008	147	108.75	21.25	98.5	71.75	100.25	105	101	150	146	128.5	154.5	148.25	132	126
5/14/2008	136	106.75	21.25	98.5	71.75	104.25	106	99	155	146	128.5	149.5	148.25	133	126
5/22/2008	133	106.75	25.25	96.5	71.75	102.25	107	103	155	145	127.5	147.5	146.25	130	133
6/6/2008	133	104.75	16.25	97.5	68.75	100.25	103	96	154	143	129.5	147.5	146.25	134	125
7/18/08	130	104.75	18.25	93.5	65.75	102.25	103	96	154	146	124.5	147.5	146.25	134	125
8/8/08	129	96.75	0	79.5	57.75	89.25	90	78	135	125	109.5	124.5	123.25	108	102
8/22/08	141	96.75	6.25	87.5	65.75	89.25	94	88	146	133	117.5	135.5	131.25	114	113
9/5/08	136	95.75	0	75.5	61.75	94.25	85	80	146	132	101.5	117.5	123.25	105	90
9/19/08	n.d.	91.75	0	78.5	89.75	55.25	99	80	82	133	113.5	111.5	123.25	112	106
10/17/08	n.d.	100.75	13.25	80.5	72.75	89.25	91	94	145	133	115.5	134.5	135.25	118	113
High	147	120.75	31.25	102.5	89.75	105.25	109	103	155	151	132.5	155.5	153.75	134	133
Low	129	91.75	0	75.5	57.75	55.25	85	78	82	125	101.5	111.5	123.25	105	90

* Well number 1 was vandalized after the 9/05/08 and before the 9/19/08 monitoring events. N.d. = no data.

Map 3: Kriged isomap of deepest recorded water table levels 4/10/08 – 10/17/08



Map 4: Kriged isomap of shallowest recorded water table levels 4/10/08 – 10/17/08



7 Soil Sampling (Task #5)

7.1 Soil Sampling Methods

Determining the soil characteristics of the revegetation area is critical to planning a successful restoration project (Bay & Sher 2008). Soil chemistry and texture can affect revegetation success from germination and establishment through vegetation community development. Many native riparian species have a low tolerance for salinity and alkalinity. Additionally, some species are not adapted to fine textured soils. Therefore, it is important to characterize and understand site specific soil characteristics when developing a revegetation plan. Soil characteristics influenced selection of revegetation methods and plant species.

7.1.1 Soil Sampling

Soil sampling was conducted based on the different surface soil conditions or plant communities present at the site at the time of sampling. On April 8-11, 2008, the entire area was mapped with a GPS to separate areas with differing vegetation or observed soil differences. Each of these map units was then sampled separately to determine actual differences in soil chemistry or texture. A minimum of one composite sample for every 5 acres was collected. A total 3 to 6 samples, each 12" deep, was taken from each unit and mixed together for the composite. The locations of each sample were recorded on the GPS.

In addition to the composited surface soil samples, a single sample was collected every 10 acres in conjunction with well installation. For three of the wells, the soils removed during augering were salvaged for chemical and textural analysis. As the well was dug, the soils were separated into 1-ft increments all the way down to the water table.

7.1.2 Soil Analyses

All soil samples were sent to a soil laboratory for analysis. Analyses included:

- pH (saturated paste)
- Electroconductivity (EC, saturated paste)
- Sodium absorption ratio (SAR)
- Fertility/Nutrients (ppm)
- Organic matter (%)
- Metals (S, Fe, Al, Mn, Cu, Zn, B)
- Textural analysis (sand, silt, and clay)

7.1.3 Data Analysis

The lab analysis results were used to interpolate to the soil characteristics across the site. Kriging was used to create isomaps of pH, salinity (EC), and texture to determine appropriate revegetation species for any given area.

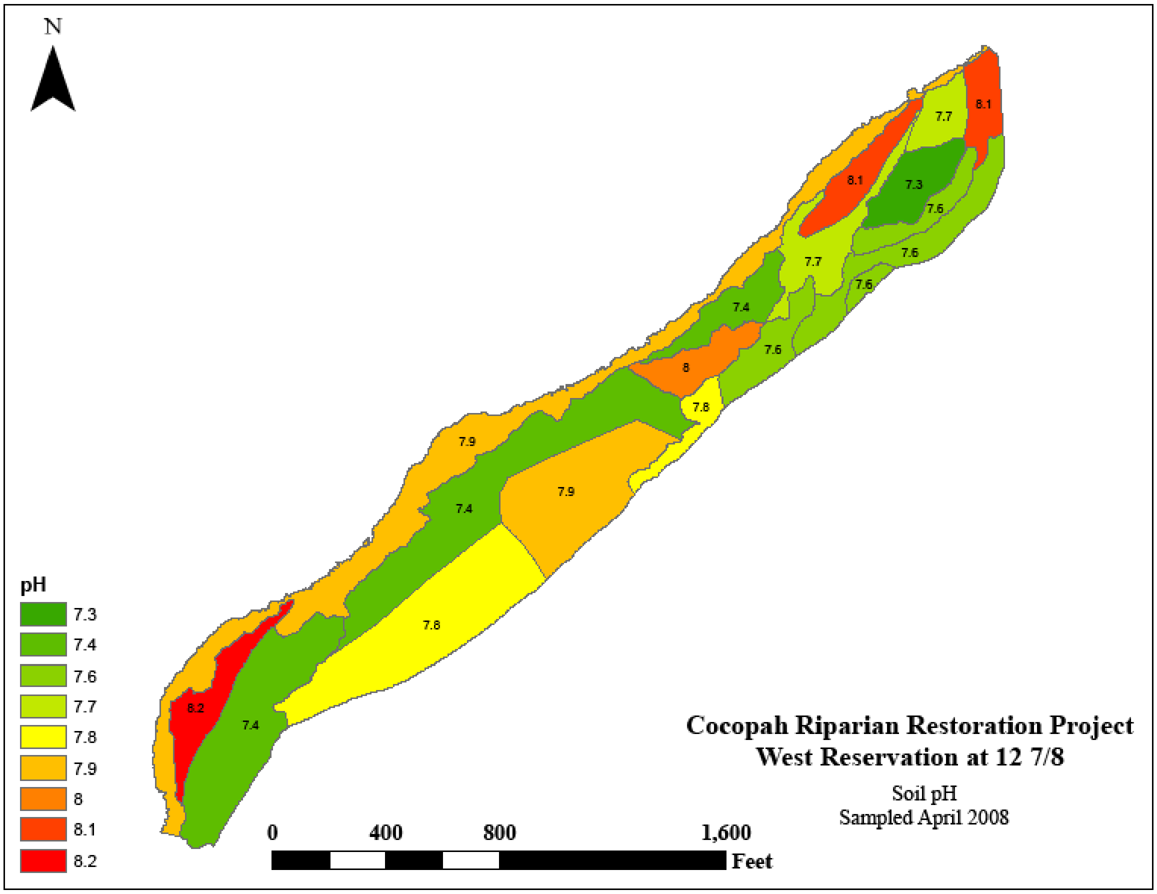
7.2 Soil Sampling Results

Soils that do not receive frequent flooding, especially those that have been growing salt cedar, may have chemistry that will no longer support some native species. Additionally, some plant species are not adapted to fine textured soils and should not be planted in areas where soils have such textures.

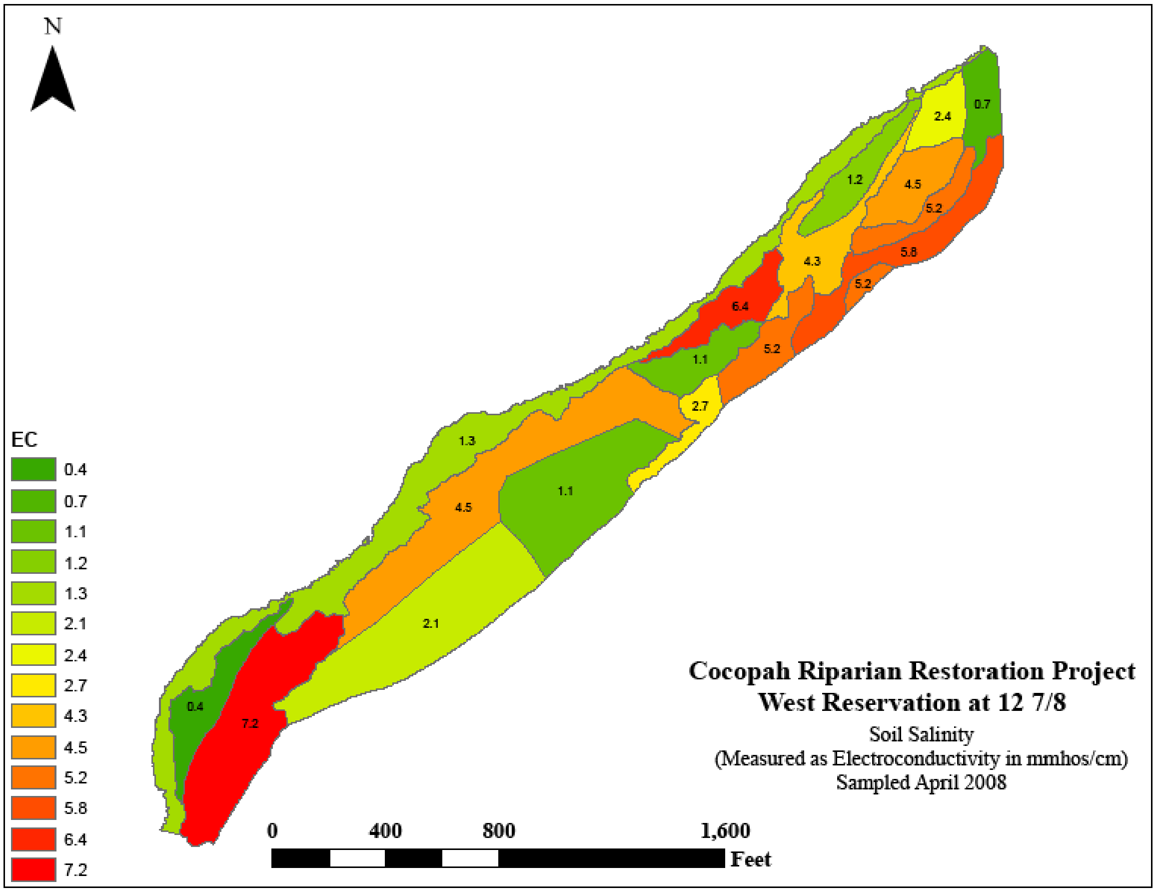
7.2.1 Chemistry

A full suite of soil chemistry characteristics were analyzed and are presented in Appendix A. The characteristics that are of the most importance to revegetation success are pH, salinity, and sodium absorption ratio (SAR). Most potential revegetation species will not tolerate a pH greater than 8.5 and most of the soil samples were below this threshold (Map 5). Soil salinity was measured as electroconductivity (mmhos/cm). Salinity ranged from 0.4 – 7.2 mmhos/cm in the revegetation area (Map 6). Some of these areas are too saline to support cottonwood and willow. However, none of the soils are too saline to support other more salinity tolerant species. SAR values in the reclamation should ideally be less than 10; all of the areas sampled met this condition.

Map 5: Soil pH map for revegetation area



Map 6: Soil salinity (EC, mmhos/cm) map for revegetation area



7.2.2 Texture

The soil texture can play an important role in species selection, use of revegetation techniques and potential for revegetation success. For instance, cottonwoods and willows are not adapted to soils with high clay or silt content. Additionally, dry sand can make pole planting difficult if the sand collapses into augered holes. Past studies of revegetation success suggest that a range of 40% – 70% sand is best for revegetation success (Bay and Sher 2008).

Soil texture across the revegetation area ranges from silt loam to sand and all areas have very minimal clay content (Table 2). Sand content ranged from 26% to 96% (Map 7) and silt content ranged from 2% to 68%.

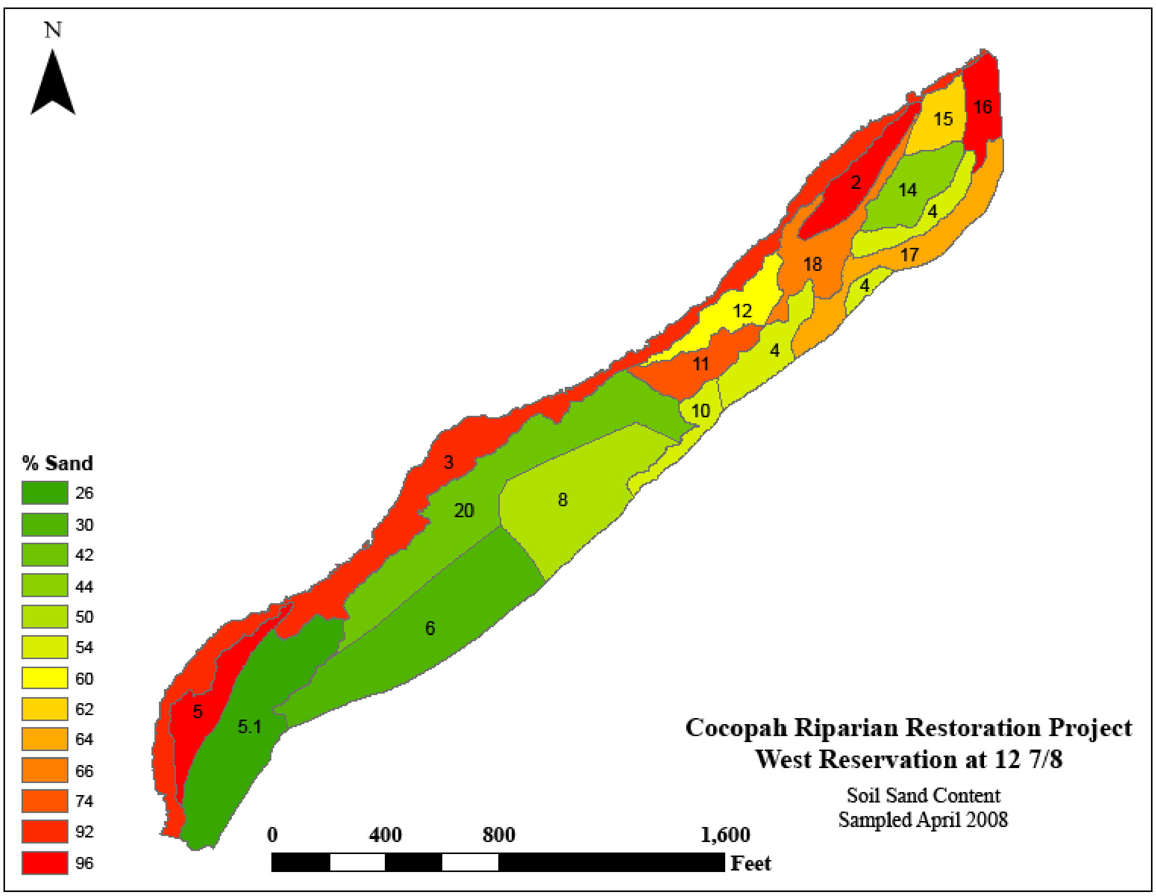
7.2.3 Fertility

Assessment of soil fertility was limited to the analysis of the macronutrients of nitrogen (N), phosphate (P), and potassium (K). Organic matter (OM) content of the soil was also analyzed because it plays a critical role in nutrient cycling. Soils deficient in macronutrients or organic content can be augmented with fertilizer and/or organic amendments to improve a soil's growing conditions. Ideally N would be at least 10 ppm, P would be at least 15 ppm, and K would be at least 140 ppm. Additionally, a minimum of 0.5% organic matter content in the soil is required to support revegetation efforts. Based on the April 2008 soil sampling data, many parts of the revegetation area do not meet these criteria (Table 3).

Table 2: Sampled soil texture in revegetation area

Sample ID	% Sand	% Silt	% Clay	Soil Texture
Area 2	96	2	2	Sand
Area 3	92	6	2	Sand
Area 4	54	42	4	Sand
Area 8	50	48	2	Sandy Loam
Area 10	54	44	2	Sand
Area 5	96	2	2	Sand
Area 5.1	26	68	6	Silt Loam
Area 6	30	68	2	Silt Loam
Area 11	74	24	2	Loamy Sand
Area 12	60	36	4	Sandy Loam
Area 14	44	52	4	Silt Loam
Area 15	62	36	2	Sandy Loam
Area 16	96	2	2	Sand
Area 17	64	32	4	Sandy Loam
Area 18	66	32	2	Sandy Loam
Area 20	42	54	4	Silt Loam

Map 7: Soil sand content map for revegetation area



To increase soil organic matter Biosol® organic fertilizer was added at a rate 500 lbs/acre to those areas with less than 0.5% OM (Table 3). This product has over 70% OM along with 6% N, 1% P, and 3% K. Even with this added N, P, and K, some additional fertilizer was required. It would not be cost-effective to spread fertilizer at a different rate in each sampling area, so a few generalized applications rates were used. After the Biosol application, two areas required 10 lbs/acre of N, all but two areas required an addition of 200 lbs/acre of P, and 3 areas required 25 lbs/acre of K (Table 3).

Table 3: Soil fertility status and amendment requirements

Sample ID	Current Soil Content				Prescribed Application Rate			
	N	P	K	OM	Biosol	N	P	K
	(ppm)			(%)	(lbs/acre)			
Area 2	4	2	66	0.2	500	0	200	25
Area 3	11	5	82	0.1	500	0	200	0
Area 4	6	5	213	0.5	0	0	200	0
Area 5	2	2	49	0.1	500	0	200	25
Area 5.1	83	13	339	0.8	0	0	0	0
Area 6	8	5	236	0.5	0	0	200	0
Area 8	2	4	207	0.3	500	0	200	0
Area 10	4	6	226	0.5	0	10	200	0
Area 11	8	4	145	0.3	500	0	200	0
Area 12	11	8	156	0.7	0	0	200	0
Area 14	15	11	229	0.5	0	0	0	0
Area 15	21	4	190	0.3	500	0	200	0
Area 16	4	2	79	0.1	500	0	200	25
Area 17	1	4	191	0.8	0	10	200	0
Area 18	8	4	162	0.5	0	0	200	0
Area 20	24	9	318	1.1	0	0	200	0

8 TWG Groundwater and Soil Sampling (Task #5)

In February 2010, the Scope of Work was modified to include an additional 15 acres of soil and ground water sampling immediately adjacent to the project area. As described above the majority of the AWPF project area soil and groundwater work was funded with matching money leaving this task complete, with very little expenditure of AWPF funds. In 2009, the Cocopah received a Tribal Wildlife Grant (TWG) from the U.S. Fish and Wildlife Service to complete similar revegetation activities on 7 acres immediately adjacent to the AWPF project area. Using the AWPF funds remaining in Task #5 to complete the same activities outlined in Task #5 on the adjacent area the Cocopah was able to use the TWG funds to revegetate 15 acres rather than the original 7 acres.

8.1 Sampling Methods and Results

Ground water wells were installed in the TWG project area on February 9 – 10, 2010. The methods used were the same as was outlined in Section 6.1.The original plan called for 5 additional wells. The first two wells had to be over 12 ft deep to reach saturated soils and the third well was over 13 ft deep. Given this depth and that groundwater appeared to get deeper to the south, the last two wells were not installed. Depths of this magnitude are too deep for pole planting, thus monitoring water in wells deeper than 12 ft was not likely to yield additional beneficial information. Because the first three wells were so deep they also took longer than anticipated to drill and install. These new wells along with the five southern-most wells from the original 40-acre site were monitored for seven months (Table 4).

Table 4: Depth to water table (ft.) for TWG Project

	Well Number				
Date Monitored	**11**	**12**	**13**	**16**	**17**
2/9/2010	9.8	11.5	11.2	12.8	11.7
4/19/2010	9.6	10.9	10.9	12.4	11.4
5/3/2010	10.3	11.4	11.5	12.4	11.4
5/17/2010	10.5	11.7	11.6	12.4	11.4
6/1/2010	10.3	11.7	11.5	12.4	11.5
6/14/2010	10.1	11.3	11.5	12.4	11.5
6/28/2010	10.0	11.3	11.4	12.5	11.5
7/12/2010	10.1	11.6	11.4	12.4	11.5
7/26/2010	9.9	11.3	11.2	12.4	11.5
8/9/2010	10.1	11.4	11.4	12.4	11.5
8/23/2010	10.0	11.3	11.2	11.5	11.5
9/7/2010	9.8	10.2	11.2	12.4	11.5
9/27/2010	10.0	11.3	11.2	12.4	11.5
10/4/2010	9.3	10.2	9.9	12.1	11.5
10/18/2010	9.9	11.1	11.1	12.4	11.5
High	10.5	11.7	11.6	12.8	11.7
Low	9.3	10.2	9.9	11.5	11.4

In addition to the groundwater wells, soil samples were collected from the TWG project area. A total of six composite samples each comprised of 4 to 6 subsamples were collected on February 9-10, 2010. These samples were collected and analyzed as outlined in Section 7.1. The data collection and analysis portion of this was funded by AWPF, while the revegetation planning will be funded by the TWG grant. Soil results are included in Table 5.

Table 5: Soil characteristics for TWG project

Sample ID	Soil Chemistry			Soil Texture				Fertility			
	pH	EC	SAR	Sand	Silt	Clay	Desc	N	P	K	OM
	paste	mmhos/cm	calculated	%				(ppm)			(%)
TWG 1	7.4	4.7	3.7	64	30	6	SL	14	11	107	0.5
TWG 2	7.4	3.92	2.6	70	20	10	SL	12	7	178	0.2
TWG 3	7.5	8.83	9.8	70	22	8	SL	17	9	99	0.2
TWG 4	7.7	8.16	9.5	70	4	26	SCL	14	10	126	0.1
TWG 5	7.7	1.88	4.1	48	42	10	L	10	9	148	0.3
TWG 6	7.6	4.08	6	70	22	8	SL	24	7	94	0.3

9 Permits, Authorizations, Clearances, and Agreements (Task #1)

All necessary permits, authorizations, clearances, and agreements as outlined in Task #1 of the AWPF grant were researched and obtained prior to the initiation of revegetation work. All restoration activities were performed in compliance with local, state, and U.S. environmental regulations. Clearances addressed included land owner clearances and agreements, water rights, the Endangered Species Act (ESA), National Environmental Policy Act (NEPA), Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), National Historic Preservation Act (NHPA), Clean Water Act (CWA), Water Quality Act (WQA), Rivers and Harbors Act (RHA), and Executive Orders 11988, 11990 and 13112. This deliverable was approved by AWPF on February 3, 2009.

9.1 Land Owner Clearance

No land owner clearances or agreements were required because all work was performed on Cocopah Indian Tribe lands. The U.S. Border Patrol was involved in project management discussions and activites were coordinated with their representatives continuously throughout the project to ensure adequate security measures were implemented.

9.2 Water rights

Water rights are very important on the Lower Colorado River where water resources are scarce. The Cocopah Tribe has annual rights to 9,700 acre-feet of water from the Colorado River. This project required minimal water use and all work activities were conducted to ensure allocated water rights were properly exercised and not adversely impacted.

9.3 The Endangered Species Act of 1973 (ESA)

The only species protected by the ESA of concern for this project are the Southwestern willow flycatcher and Yuma clapper rail. Consultations with the local Fish and Wildlife Service (FWS) office were carried out before and during the project to ensure no adverse impacts to these species.

9.4 The National Environmental Policy Act of 1969 (NEPA)

This project is on land owned and managed by the Cocopah Indian Tribe and thus does not fall under NEPA requirements. This project will result in very minimal ground disturbance and will effectively enhance the environmental conditions at the site. The U.S. Department of Homeland

Security, U.S. Customs and Border Protection, and U.S. Border Patrol developed an "Environmental Stewardship Plan" in compliance with NEPA for this same area in December 2008. The proposed activities conform to the objectives of this plan.

9.5 The Federal Insecticide, Fungicide, and Rodenticide Act of 1972 (FIFRA)

Some of the herbicides that were used on salt cedar control efforts as a part of this project are restricted use herbicides. These herbicides were applied by a certified herbicide applicator and all EPA regulations for application and storage were followed.

9.6 The National Historic Preservation Act of 1966 (NHPA)

The Cocopah Cultural Resources Manager works with State Historic Perservation officers to assess all management areas for potential cultural impacts before any ground disturbance is completed on Cocopah Lands. Both Cocopah cultural resources and the other state protected archaeological and historical resources are considered. A SHPO certification was obtained for this project and the terms and condition of the SHPO certification were satisfied during the performance of the work.

9.7 Clean Water Act of 1977 (CWA) & Water Quality Act of 1987 (WQA) & Rivers and Harbors Act of 1899 (RHA)

Although this project is along the Colorado River it did not require National Pollutant Discharge Elimination System (NPDES) or RHA permits. No discharges of any kind were made into the river. There were minimal ground disturbance near to the river and precautions were taken to ensure no sediment entered the river during this project.

9.8 Executive Orders

Several executive orders potentially apply to this project. Executive Order 11988 (Floodplain Management), Executive Order 11990 (Protection of Wetlands), and Executive Order 13112 (Invasive Species). One of the primary goals of this project was to restore and preserve the flood plain communities along this section of the Colorado River. This project effectively enhanced the floodplain communities addressed by Executive Orders 11988 and 11990 and therefore complies with their directives. This project also also included removal of invasive salt cedar and was designed to retard its growth and reinvasion of reclaimed lands. As a result, the project is also in alignment with Executive Order 13112.

10 Revegetation and Monitoring Plans (Task #2)

10.1 Revegetation Plan

Development of the revegetation plan as outlined in Task #2 of the AWPF grant began immediately after the execution of the contract in 2008. Using the soil, ground water, and vegetation data already collected in April 2008 (see Sections 6 and 7), a revegetation plan was developed for the entire site. This revegetation plan included site maps, climate information, soil characteristics (chemistry, texture, and fertility), ground water maps, current vegetation communities, salt cedar control requirements, and a planting design. The planting design included maps outlining which species were appropriate for transplanting and seeding in each section of the revegetation area and the fertility amendments needed for each section. Specific information on planting techniques and timing was also included in the planting design. This revegetation plan was approved by AWPF on January 26, 2009.

The majority of the information included in the revegetation plan is included in this report:

- Site maps, climate information, and current vegetation communities are all included in Section 5.
- Groundwater sampling methods and results are included in Section 6.
- Soil sampling methods and results are included in Section 7.
- Salt cedar control methods and results are included in Section 11.
- Planting design is included in Section 12.

10.2 Post-Revegetation Monitoring Plan

The Monitoring Plan was submitted separately from the Revegetation Plan after the approval of the first amendment to Task #7. Task #7 originally called for monitoring of vegetation and endangered bird species. The March 10th amendment to Task #7 removed the endangered bird species monitoring, but required monitoring of an additional 8 acres of revegetation. The monitoring plan called for monitoring vegetation cover and woody density along 20 transects. It also called for monitoring a randomly selected subset of the transplanted individuals for survival, growth, and vigor. The monitoring plan was approved by AWPF on March 27, 2009. The details of the monitoring methods are included along with the monitoring results in Section 13.

11 Site Clearing (Task #4)

The site clearing plan was included in the revegetation plan prepared under Task #2. Initial site clearing at this site was conducted in 2004-2005 using heavy equipment. However, salt cedar had resprouted and follow-up clearing was required. Salt cedar clearing on the initial 32 acres was completed by RESI on February 9 – 16, 2009. The additional 8 acres were cleared on March 11 – 13, 2009 after the approval of the amendment to the Scope of Work. The details of the site clearing efforts were described in the Site Clearing Report that was submitted to the AWPF on June 10, 2009.

11.1 Site Clearing Methods

Past studies have shown that salt cedar seedlings are not strong competitors (Sher et al. 2000, Sher et al. 2002, Sher and Marshall 2003). Therefore, aggressive revegetation efforts can potentially prevent the reestablishment of salt cedar in the near future. The revegetation efforts completed on this site were designed to accomplish this goal along with the follow-up salt cedar removal.

11.1.1 Small Re-sprout Control

The majority of the salt cedars re-sprouts on the 12 7/8 site were relatively small (< 3 ft tall). These individuals were controlled in one of two ways depending on their location. In open areas where few or no native species were present the salt cedar were mowed using a mowing attachment on a skid loader, and the cut stems were treated with Element 4 herbicide. Element 4 is a triclopyr herbicide approved for "control of woody plants in non-crop areas including non-irrigation ditch banks, forests and in the establishment and maintenance of wildlife openings".

In areas were the salt cedar were close to desirable native species, the re-sprouts were treated with a foliar application of Element 4 using a backpack sprayer. Special care was taken to ensure that no desirable adjacent vegetation was damaged during the herbicide application.

11.1.2 Large Tree Control

The large-scale removal in 2005 used heavy equipment to remove the majority of the salt cedar on the site; however, salt cedars that were growing among native trees and shrubs were left behind if their removal would have disturbed desirable species. These remaining larger salt cedar trees were removed by hand with a chainsaw and herbicide was applied to the stump immediately after cutting.

11.1.3 Maintenance

While the salt cedar control on this site has been successful, both short-term and long-term maintenance are generally required to ensure that salt cedar does not return to the site. It is often necessary to follow up initial salt cedar control with spot-treatments for up to 5 years. Funding was included in the AWPF grant for additional spot-treatments as necessary over the term of the grant in Task #6 (see Section 12).

11.2 Site Clearing Success

The salt cedar control on the site was generally very successful. Almost all salt cedar remaining or re-sprouted after the 2005 work were treated in 2009 and the area was open and clear for planting activities. Additionally, post-revegetation monitoring data suggest that the clearing was successful (see Section 13).

12 Native Revegetation (Task #6)

Revegetation activities on the 40-acre site followed the methods outlined in the Revegetation Plan. The majority of revegetation activities were completed between February and April 2009 by RESI. Revegetation activities included:

- Cottonwood and willow pole planting February 17 - 24, 2009
- Container transplants February 25 - 27, 2009
- Watering transplants February 17 - 25, 2009
- Watering transplants March 10 - 12, 2009
- Fertilizer Application April 21, 2009
- Seed Application April 23, 2009
- Harrowing April 27 - May 1, 2009
- Weed Maintenance February 11 - 24, 2010
- Weed Maintenance January 17 - 21, 2011

Details of the 2009 revegetation activities including schedules, methods, plant species, material sources, and equipment used were included in the Revegetation Report which was submitted on July 24, 2009.

12.1 Revegetation Methods

The Revegetation Plan considered climate, existing vegetation communities and densities, soil chemistry and texture, depth to water table, hydrologic conditions, budget constraints, and land use priorities in selecting a revegetation strategy for the project site (Table 6,Map 8). Using the groundwater data the area was split up into 3 zones:

1. Wetland seeding and transplanting,
2. Pole planting and understory seeding, and
3. Upland seeding.

The area was further divided by soil characteristics to determine what if any species of poles or transplants could be used. Wetland species were planted in areas where the water table was always within 4 feet of the surface and the surface is saturated for at least part of the season. Pole planting was done where water was always within 10 feet of the surface, water was within 6 feet for at least part of the year, and the electroconductivity (EC) and pH were appropriate for cottonwood and willow species.

All other areas that were not appropriate for pole planting or wetland planting were seeded with upland species. The existing vegetation at the site was used to guide which of the three seed mixes was used. Wetland areas were seeded with a wetland mix, areas with a substantial cover of native species were seeded with the understory mix, and all other areas were seeded with the general upland mix. Overall, the guidelines in the Revegetation Plan were followed with only minor exceptions. All revegetation work was completed by RESI with management and oversight from HMI.

Map 8: Map of final revegetation methods

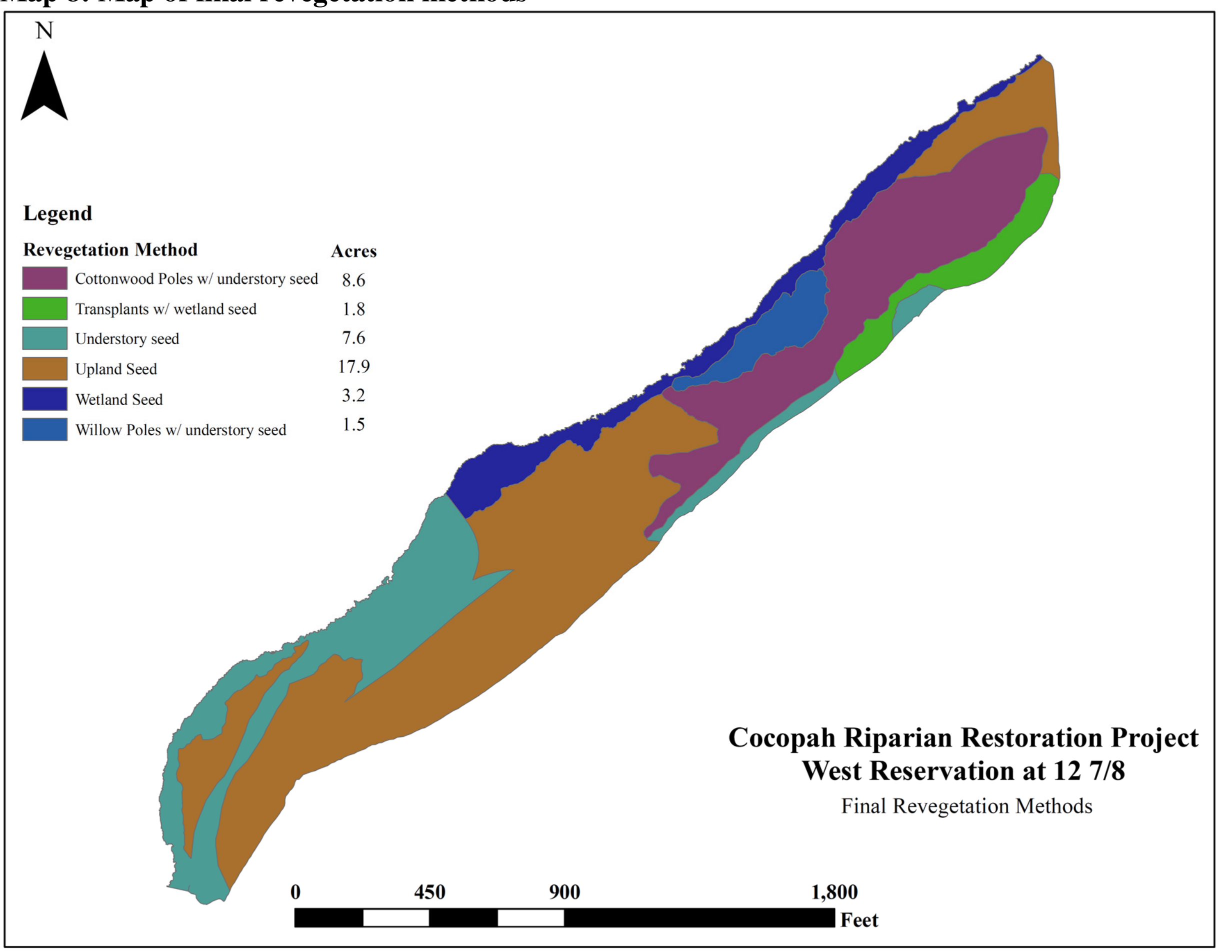


Table 6: Site characteristics summary table (Modified from the Revegetation Plan)

				Soil Characteristics				Fertility Requirements				Revegetation Method		Depth to Water Table	
ID	Dominant Species April 2008	Existing Density*	Acres	EC (dS/cm)	% Sand	pH	SAR	N	P	K	Biosol	Whole Plants	Seed	Min Range	Max Range
1	Cottonwood/Arrowweed	3	2.38	5.2	54	7.6	4.6	0	200	0	0	None	Understory	2-6'	3-10'
2	Arrowweed/Willow	4	3.43	1.3	92	7.9	3.3	0	200	0	500	None	Wetland	4-10'	6-12'
3	Salt Cedar	2	5.43	2.1	30	7.8	4.4	0	200	0	0	None	Upland	8-10'	10-12'
4	Arrowweed/Salt Cedar	3	3.56	1.1	50	7.9	3.6	0	200	0	500	Cottonwood	Understory	6-8'	8-12'
5	Arrowweed	4	0.77	2.7	54	7.8	4.5	10	200	0	0	Cottonwood	Understory	4-8'	8-10
6	Arrowweed/Salt Cedar	2	1.20	1.1	74	8.0	3.6	0	200	0	500	Cottonwood	Understory	4-8'	8-10
7	Arrowweed	2	1.26	6.4	60	7.4	5.4	0	200	0	0	Willow	Understory	4-6'	6-10'
8	Arrowweed/Salt Cedar	2	1.37	4.5	44	7.3	5.0	0	0	0	0	Cottonwood	Understory	3-7	4-10'
9	None	1	0.62	2.4	62	7.7	4.0	0	200	0	500	None	Upland	8-10'	10-12'
10	None	1	0.59	0.7	96	8.1	2.8	0	200	25	500	None	Upland	8-10'	10-12'
11	Arrowweed	3	3.43	4.5	42	7.4	5.3	0	200	0	0	None	Upland	6-8'	8-12'
12	Arrowweed/Baccharis	2	2.89	7.2	26	7.4	6.2	0	0	0	0	None	Upland	8-10'	10-12'
13	Salt Cedar/Willow	1	1.45	0.4	96	8.2	2.5	0	200	25	500	None	Upland	8-10'	>12'
14	Hydric forbs/Mesquite	1	1.76	5.8	64	7.6	8.6	10	200	0	0	Containers	Wetland	0-6'	3-8
15	Sparse forbs/grasses	1	1.68	4.3	66	7.7	5.3	0	200	0	0	Cottonwood	Understory	4-8'	6-10'
16	Cottonwood/Salt Cedar	2	0.79	1.2	96	8.1	3.1	0	200	25	500	Cottonwood	Understory	6-8'	8-10
17	Cottonwood/Salt Cedar	4	1.23	7.2	26	7.4	6.2	0	200	0	0	None	Understory	8-10'	>12'
18	Arrowweed/Willow	4	3.40	1.3	92	7.9	3.3	0	200	0	500	None	Understory	6-10'	>12'
19	Arrowweed	3	1.98	4.5	42	7.4	5.3	0	200	0	0	None	Understory	6-10'	10-12'
20	Sparse forbs/grasses	1	0.26	2.4	62	7.7	4.0	0	200	0	500	Cottonwood	Understory	6-8'	8-10
21	Cottonwood/Salt Cedar	2	0.49	1.2	96	8.1	3.1	0	200	25	500	None	Upland	8-10'	10-12'
22	Sparse forbs/grasses	1	0.23	5.8	64	7.6	8.6	10	200	0	0	None	Upland	4-6'	6-8'
23	Sparse forbs/grasses	1	0.35	0.7	96	8.1	2.8	0	200	25	500	Cottonwood	Understory	4-8'	6-10'

* 1=sparse, 2=somewhat sparse, 3=somewhat dense, 4=dense

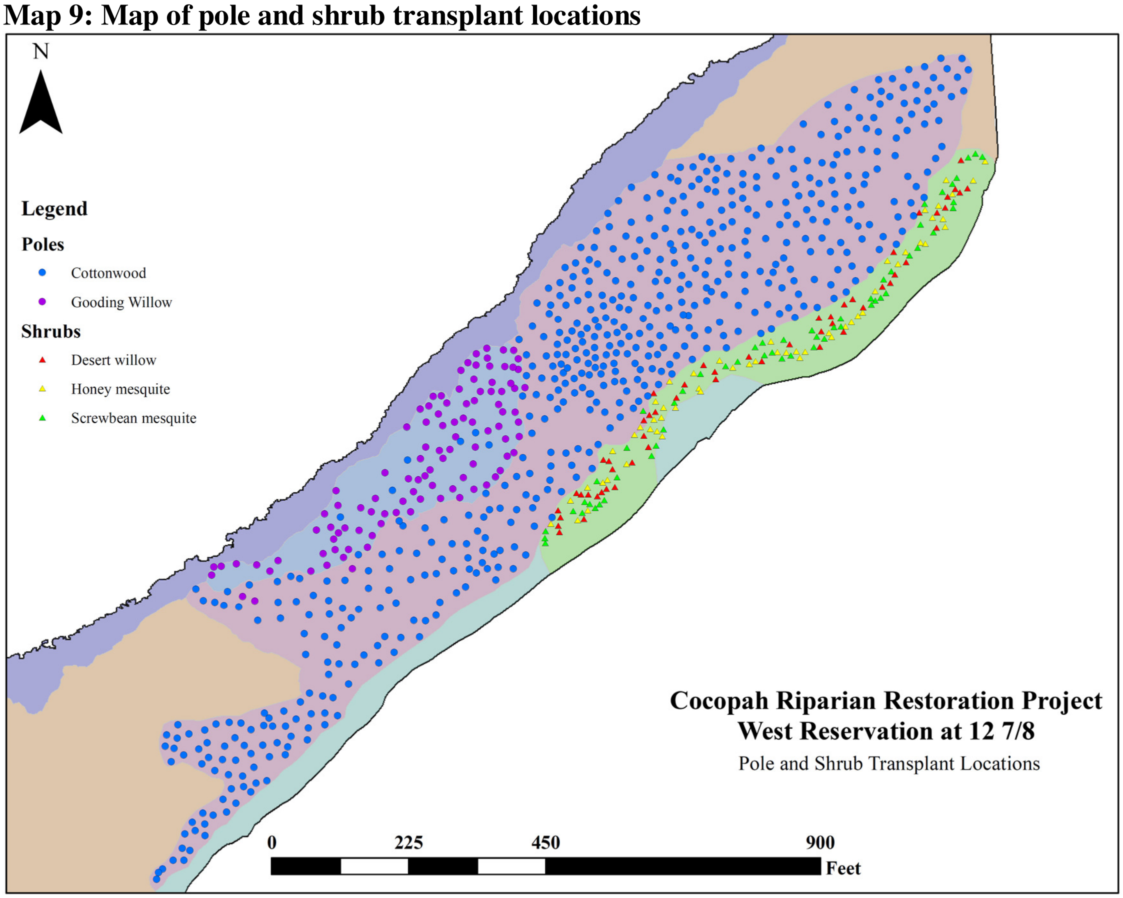
12.1.1 Pole Planting

Pole planting was completed between February 17 and 24, 2009. Fremont cottonwood (*Populus fremontii*) and Goodding willow (*Salix gooddingii*) poles were used for this project. Goodding willow has a lower pH tolerance than cottonwood and was thus only used in limited areas (Map 8). After the revegetation plan was written the groundwater levels were monitored several more times and some of the areas designated for pole planting were deemed to be potentially too dry. Additionally, the U.S. Border Patrol constructed a vehicle barrier between the road and the revegetation area that limited the type of equipment that could be used for transplanting. The maximum depth for planting with the available equipment was nine feet instead of 10 feet. One area that was too dry was not planted with poles as had been planned and a few other areas were planted at a lower density (Table 7). In total, 581 cottonwood and 126 willow poles were planted on a total of 10.1 acres (Table 7, Map 9).

Table 7: Number of poles and acres planted

Species		Acres	Poles/Acre	Poles
Fremont cottonwood	*Populus fremontii*	4.6	~100	309
Fremont cottonwood	*Populus fremontii*	4.0	~75	272
Cottonwood Total		*8.6*		*581*
Goodding willow	*Salix gooddingii*	1.5	~100	126
Total		**10.1**	**707**	**707**

Map 9: Map of pole and shrub transplant locations



The vehicle barrier precluded the use of equipment that was wider than the post spacing, so a tracked skid loader was deemed to be the most effective equipment for pole planting. A customized ramp was placed from the end of a truck over the vehicle barrier to gain access to the site (Figure 3). This allowed the equipment to be removed from the site each night to prevent vandalism and theft.

Figure 3: Custom ramp used to gain equipment access

The cottonwood and willow poles were purchased from the Ahakhav Tribal Preserve near Parker, AZ. They were delivered the day before planting and were kept moist until planting. All poles ranged in length from 12 feet to 16 feet and appeared to be dormant at the time of planting. The holes were drilled using a tracked skid loader with an auger attachment and a 9-foot long by 6-inch diameter bit (Figure 4). The holes were drilled to a depth where the soil came up wet to ensure that the poles were planted in the capillary fringe or the water table. The holes were backfilled by hand and watered immediately to ensure adequate soil/stem contact and minimize air pockets that could inhibit survival (Figure 5). All of the poles were watered a second time three weeks after planting on March 10 – 12, 2009.

Figure 4: Drilling holes for pole planting

Figure 5: Poles were (A) backfilled by hand and (B) watered immediately
(A) (B)

12.1.2 Container Transplants

The containerized transplants were planted between February 25 and 27, 2009 in the areas where the water table was characteristically closer to the ground surface. One gallon pots of honey mesquite (*Prosopis glandulosa*), screwbean mesquite (*P. pubescens*), and desert willow (*Chilopsis linearis*) were purchased from Arbortech Landscaping in Yuma, AZ. These shrubs were planted in a 1.8 acre area near the levy at the far edge of the site from the river (Map 8, Map 9). This area appeared to be a former meander or backwater where the groundwater was always within 4 feet of the surface and at several times in the last year there was surface water present. The existing vegetation at the site was characteristic of a backwater wetland.

Due to the wetter than average winter the existing vegetation was denser than expected in the backwater area and along the river bank. Thus, the transplants were planted at a lower density than originally planned. A total of 218 containers were planted in the backwater site (Table 8, Map 9). The tracked skid loader was used, but this time it was equipped with a 3-foot long by 12-inch diameter drill. The container plants were hand backfilled and watered immediately to ensure adequate soil/stem contact and to minimize the potential for air pockets that could inhibit survival. The transplanted shrubs were also watered a second time along with the poles between March 10–12, 2009.

Table 8: Number of shrub transplants planted

Species		Containers
Screwbean mesquite	*Prosopis pubescens*	73
Honey mesquite	*Prosopis glandulosa*	73
Desert willow	*Chilopsis linearis*	72
Total		218

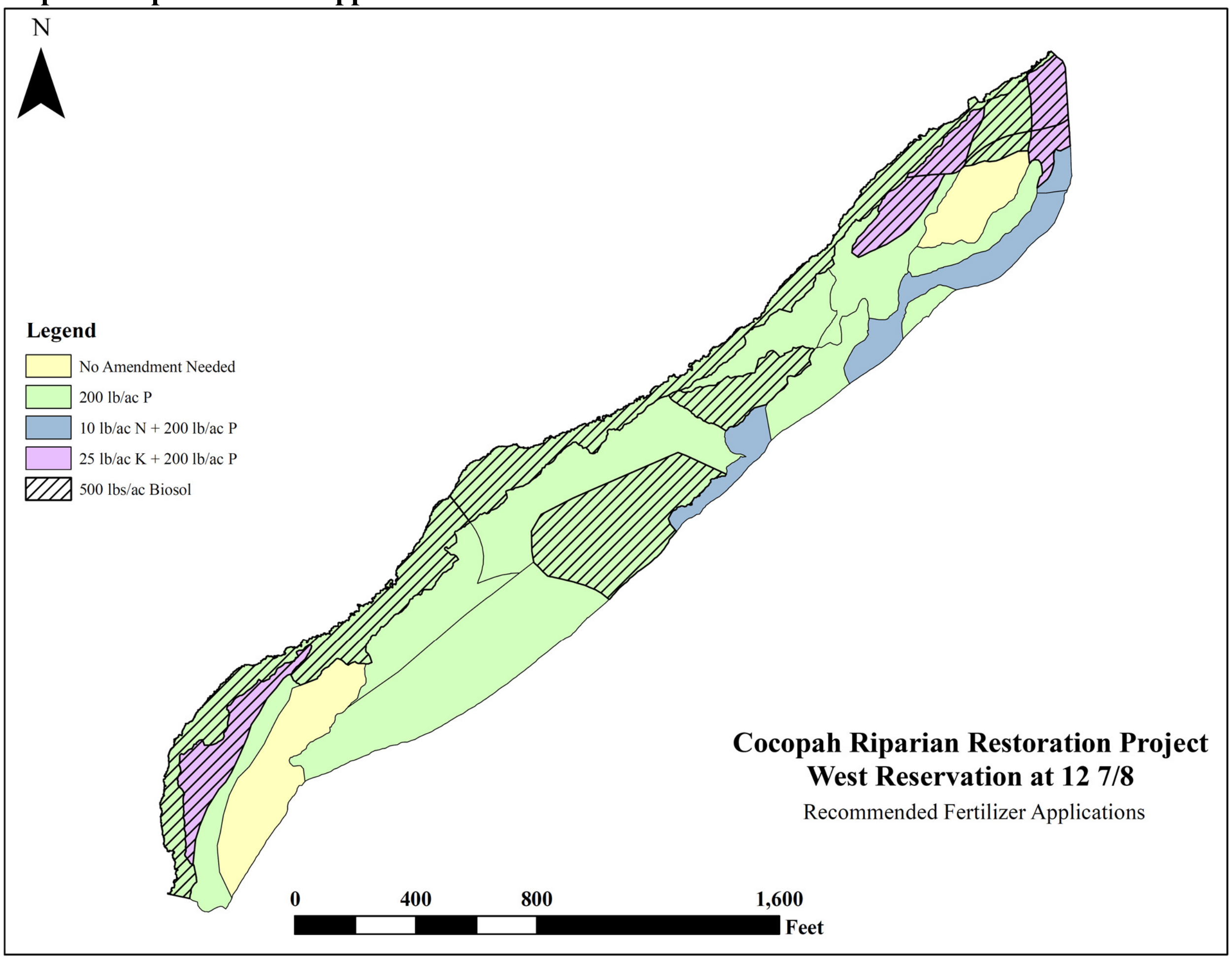
12.1.3 Fertilizer

Assessment of soil fertility for revegetation planning was limited to the analysis of the macronutrients of nitrogen (N), phosphate (P), and potassium (K). Organic matter (OM) content of the soil was also analyzed because it plays a critical role in nutrient cycling. Soils deficient in macronutrients or organic content can be augmented with fertilizer and/or organic amendments to improve a soil's growing conditions. Ideally N would be at least 10 ppm, P would be at least 15 ppm, and K would be at least 140 ppm. Additionally, a minimum of 0.5% organic matter content in the soil is required to support revegetation efforts. Applications of Biosol organic fertilizer along with chemical N, P, and K fertilizers were prescribed.

12.1.3.1 Quantities

Several types of fertilizer were applied as described in the Revegetation Plan (Map 10). Final application amounts and percentages were modified based on the availability and form or the nutrients used (Table 9). Phosphorous was applied as superphosphate (P_2O_5) in at 45% (0-45-0), potassium was applied as 50% potash (0-50-0), and nitrogen was applied as urea at 45% (45-0-0). The Biosol applied contained 7% N, 2% P, and 3% K (7-2-3).

Map 10: Map of fertilizer applications



12.1.3.2 Application

Fertilizer was applied using a fixed wing aircraft with GPS functionality (Figure 6). Tri-Rotor Ag Services of Yuma, AZ applied the fertilizer on April 21, 2009. The airplane's GPS was loaded with polygons for each application (Biosol, P, K, and N) and the pilot controlled the spread based on the GPS position on his screen. The Biosol was applied in 4 loads of approximately 2,100 lbs each, the P was applied in 7 loads of approximately 3,200 lbs each, and the N and K were each applied in one load.

Table 9: Final fertilizer application rates

Nutrient	Acres	Actual Lbs/Acre	Total Lbs
N	2.76	10 lbs/ac	28
P	31.55	200 lbs/ac	6,310
K	3.67	25 lbs/ac	92
Biosol	12.31	500 lbs/ac	6,155
Total	**50.29**		**12,585**

Figure 6: Fertilizer application with fixed wing airplane

12.1.3.3 Quality Control

To test the accuracy of fertilizer application, a 1-square yard tarp was placed in each of three locations across the site. After the Biosol was applied the material on the tarp was collected and weighed for comparison to the expected quantity (Table 10). The same process was repeated for the P. Because the P was larger, denser, round pellets they tended to bounce when they hit the tarp. Thus, the quantity of P on the tarp was lower than expected, but there was a greater density on the ground along the edges of the tarp (Figure 7A). Photographs taken of the ground after Biosol and P application show an even distribution of both products (Figure 7B) and suggest that the P was likely applied accurately even though the tarp tests were inconclusive. Because the quantities and areas of N and K application were so small, they were not evaluated using the tarp test.

Table 10: Fertilizer application quality control

Nutrient	Acres	Expected Lbs/Acre	Expected Oz/SqYd	Observed Oz/SqYd				Accuracy
				Tarp 1	Tarp 2	Tarp 3	Average	
Biosol	12.31	500 lbs/ac	1.65	1.7	1.7	1.9	1.77	107%
P	31.55	444 lbs/ac*	1.46	0.7	0.7	0.5	0.63	43%
Total	**50.29**							

* The actual P was applied at 200 lbs/acre, but the superphosphate used was only 45% P, so 44 lbs were applied.

Figure 7: Fertilizer (A) along the edge of the P2O5 tarp, and (B) on the ground near the tarp
(A) (B)

12.1.4 Seeding

The entire revegetation area was seeded with one of three seed mixes depending on the specific site conditions (Table 6, Map 8). Just as the final pole planting areas were modified before planting, the seeding areas were modified as well. Those areas that could not be pole planted because of the deep water table were seeded with the upland mix instead of the understory mix. Also, due to the better than expected growth of native species in some areas the understory mix was spread at a slightly lower rate. The final acreage of upland seeding was 18.6, the understory mix was seeded on 16.7 acres, and the wetland mix was used on 5.2 acres (Table 11).

Table 11: Acres seeded

Seed Mix	Acres	Lbs/Acre	Seeds/SqFt
Upland	18.6	7.76	50
Understory	16.7	2.31	30
Wetland	5.2	6.34	50
Total	**40.5**		

12.1.4.1 Seed Mixes

Three seed mixes[1] were designed for use in the 12 7/8 revegetation area. An upland mix of native drought tolerant and many salt tolerant plant species was used where water tables were deep and/or where the soil chemistry would not support transplants (Table 12). A mixture of upland and wet meadow species (wetland mix) was used in areas where surface soils were saturated at least part of the year (Table 13). A limited upland mix (understory mix) was interseeded into the understory of areas that already had mature, desirable vegetation established (Table 14).

Table 12: Upland seed mix

Species	**Common Name**	**Desired Species Comp. (%)**	**Average No. Seeds/ Pound**	**Pounds PLS/ Acre**	**Pound PLS/ Site**	**PLS/ Sq.Ft.**
Graminoids						
Aristida purpurea	purple threeawn	10.0%	250,000	0.87	16.29	5.00
Bouteloua curtipendula	sideoats grama	8.0%	159,200	1.09	20.47	4.00
Bouteloua gracilis	blue grama	8.0%	724,400	0.24	4.50	4.00
Distichlis spicata	inland saltgrass	12.0%	519,000	0.50	9.42	6.00
Panicum virgatum	switchgrass	10.0%	300,000	0.73	13.58	5.00
Sporobolus airoides	alkali sacaton	15.0%	1,750,000	0.19	3.49	7.50
Sporobolus cryptandrus	sand dropseed	10.0%	5,600,000	0.04	0.73	5.00
Graminoid Subtotal		*73.0%*		*3.66*	*68.47*	*36.50*
Forbs						
Sphaeralcea ambigua	desert globemallow	5.0%	500,000	0.22	4.07	2.50
Senna covesii	desert senna	5.0%	110,000	0.99	18.51	2.50
Oenothera speciosa	evening primrose	5.0%	2,500,000	0.04	0.81	2.50
Forb Subtotal		*15.0%*		*1.25*	*23.40*	*7.50*
Shrubs						
Atriplex canescens	saltbush	5.0%	52,000	2.09	39.16	2.50
Atriplex lentiformis	quailbush	5.0%	500,000	0.22	4.07	2.50
Larrea tridentata	creosote	2.0%	80,000	0.54	10.18	1.00
Shrub Subtotal		*12.0%*		*2.86*	*53.42*	*6.00*
Combined Totals		100.0%		7.77	145.29	50.00

[1] Scientific nomenclature follows USDA, NRCS 2008.

Table 13: Wetland seed mix

Species	Common Name	Desired Species Comp. (%)	Average No. Seeds/ Pound	Pounds PLS/ Acre	Pound PLS/ Site	PLS/ Sq.Ft.
Graminoids						
Distichlis spicata	inland saltgrass	20.0%	519,000	0.84	4.36	10.00
Panicum virgatum	Mexican panic grass	10.0%	389,000	0.56	2.91	5.00
Schizachyrium scoparium	little bluestem	15.0%	377,000	0.87	4.51	7.50
Schoenoplectus	American three	15.0%	180,000	1.82	9.44	7.50
Schoenoplectus maritimus	Cosmopolitan	15.0%	160,000	2.04	10.62	7.50
Sporobolus airoides	alkali sacaton	15.0%	1,750,000	0.19	0.97	7.50
Graminoid Subtotal		*90.0%*		*6.31*	*32.81*	*45.00*
Forbs						
Typha latifolia	broadleaf cattail	10.0%	10,000,000	0.02	0.11	5.00
Forb Subtotal		*10.0%*		*0.02*	*0.11*	*5.00*
Combined Totals		100.0%		6.33	32.92	50.00

Table 14: Understory seed mix

Species	Common Name	Desired Species Comp. (%)	Average No. Seeds/ Pound	Pounds PLS/ Acre	Pound PLS/ Site	PLS/ Sq.Ft.
Graminoids						
Sporobolus airoides	alkali sacaton	20.0%	1,750,000	0.15	2.49	6.00
Sporobolus cryptandrus	sand dropseed	20.0%	5,300,000	0.05	0.82	6.00
Aristida purpurea	purple threeawn	15.0%	250,000	0.78	13.09	4.50
Panicum virgatum	Mexican panicgrass	20.0%	389,000	0.67	11.22	6.00
Graminoid Subtotal		*75.0%*		*1.65*	*27.63*	*22.50*
Forbs						
Sphaeralcea ambigua	desert globemallow	15.0%	500,000	0.39	6.55	4.50
Atriplex lentiformis	quailbush	10.0%	500,000	0.26	4.36	3.00
Shrub Subtotal		*0.65*	*10.91*	*7.50*	*0.65*	*10.91*
Combined Totals		100.0%		2.31	38.54	30.00

These final seed mixes were slightly different from those in the Revegetation Plan due to regional market availability and price at the time of purchase. When possible an alternate, locally appropriate, native species within the same genus was substituted for the species requested. If this was not possible an alternate, locally appropriate, native species not within the same genus was substituted. In some cases species were removed and not replaced, but the other species quantities in the seed mix were increased to keep the seeding rate consistent. In one case the seed company accidentally replaced hardstem bulrush (*Schoenoplectus acutus*) with little bluestem (*Schizachyrium scoparium*). Little bluestem is native to northern Arizona and is not likely to germinate at the site; however, if it does it will not pose a problem within the habitat.

12.1.4.2 Application

Seed was also applied using a fixed wing aircraft with GPS functionality (Figure 8). Tri-Rotor Ag Services of Yuma, AZ applied the seed on April 23, 2009. The airplane's GPS was loaded with polygons for each application (upland, understory, and wetland) and the pilot controlled the spread based on the GPS position on his screen.

Figure 8: Seed application with fixed wing airplane

The seed was mixed with inert rice hulls at a ratio of 2:1 (rice hulls:seed) prior to spreading to increase the bulk and improve the spreading accuracy. Seed and rice hulls were mixed with a cement mixer in small batches and loaded into the hopper on the airplane (Figure 9).

Figure 9: Seed mixed with rice hull and loaded into airplane in batches.

The purple threeawn, which was substituted for the Arizona threeawn, has much longer awns (up to 4 inches) and could not be mixed with the other species. The awns tended to clump together making mixing and spreading evenly very difficult. This species was not included in the mix that was applied by Tri-rotor. Instead it was spread by hand by the RESI crew at the time of harrowing.

12.1.4.3 Quality Control

To test the accuracy of seed application, a 1-square yard sheet of adhesive contact paper was placed in the middle of each of the three seeding areas. After the seed was applied the contact paper was removed and the seeds adhered to the surface were counted. Due to small seed size, more rice hulls than seeds, and other debris on the contact paper is was difficult to get an accurate count. However, the estimated observed seed rate was 34.2 seeds/sqft in the areas seeded at 30 seeds/sqft and 64.4 seeds/sqft in the areas seeded at 50 seeds/sqft (Table 15). The correct amount of seed was spread over the total area and a visual observation of the site suggested that all areas did receive some seed. Likely the areas in the center where the tests were placed were seeded a little too heavily and the edges were seeded too lightly, but overall the seeding was considered successful, with the seed being adequately distributed across the site.

Table 15: Seed application quality control

Seed Rate	Expected Seeds/sqft	Observed Seeds/sqft	Accuracy
Understory	30	34.2	172%
Upland	50	42.7	114%
Wetland	50	86.1	128%

12.1.5 Harrowing

Harrowing was completed after fertilizer and seed application between April 27 and May 1, 2009 (Figure 10). Harrowing helps to incorporate the fertilizer in the soil and provide a thin soil cover for the seed to mitigate desiccation and predation. Because much of the site had existing, desirable, native vegetation that we wanted to protect, only the open areas were harrowed. In general, this meant that areas seeded with the upland mix were harrowed, but the areas seeded with the wetland or understory mixes were not.

12.2 Follow-up Salt Cedar Control

Two rounds of follow-up herbicide spraying were conducted on the 40-acre site in February 2010 and January 2011. On February 8 – 19, 2010, RESI's certified pesticide applicators conducted a targeted application of triclopyr 4EC mixed in basal oil using backpack sprayers.

In December 2010, YDL was contracted to complete an additional targeted herbicide application on the AWPF site while they were completing mechanical removal on the adjacent TWG area. YDL completed some initial salt cedar and phragmites control on the AWPF site before their contract was terminated for failure to follow Cocopah security procedures. HMI stepped in to complete the targeted herbicide application on January 17 – 21, 2011. HMI's certified pesticide applicators applied a mixture of Garlon 4 Ultra and methylated seed oil using backpack sprayers.

Figure 10: Harrowed open area

13 Post-Revegetation Monitoring (Task #7)

After revegetation activities were completed in the spring of 2009, HMI monitored the site on May 26 – 29, 2009 to establish a vegetation baseline. HMI again monitored the site to evaluate revegetation success on October 27 – 28, 2009, April 19 – 22, 2010, and October 25 – 28, 2010. Results of the 2009 monitoring events were included in the 2009 Monitoring Report submitted to AWPF on January 25, 2010. Results of the 2010 monitoring events were included in the 2010 Monitoring Report submitted to AWPF February 1, 2011. Raw data from the 2009 and 2010 monitoring events are included in Appendix B and Appendix C, respectively.

13.1 Vegetation Sampling Methods

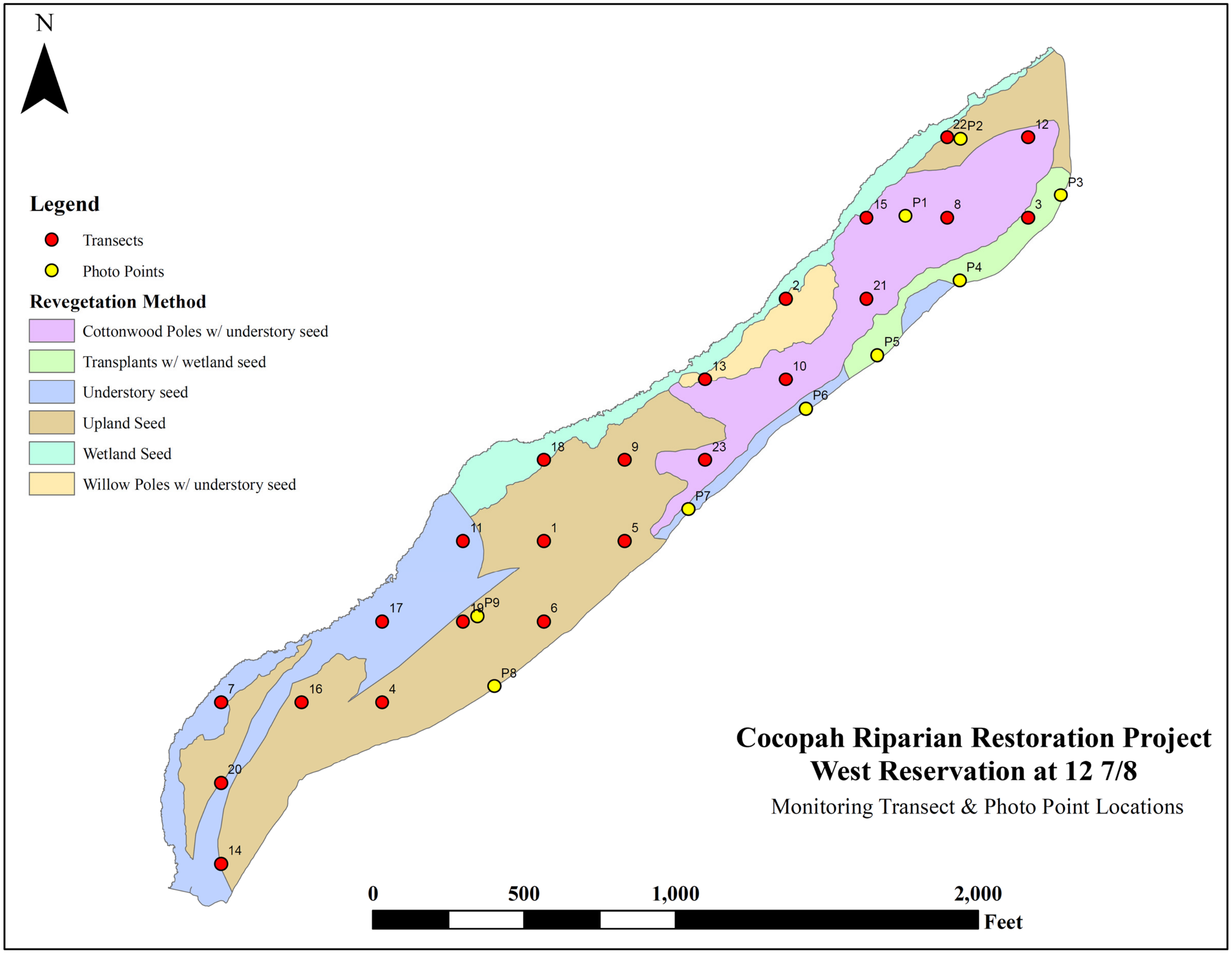
Vegetation monitoring methods followed those outlined in the approved Monitoring Plan developed under Task #2.

13.1.1 Monitoring Transects

A total of 20 monitoring transects were sampled in an effort to collect data that represent vegetation community variability (Map 11). The same transects were sampled in all four monitoring events to facilitate data comparison and enable trend analysis. The only exception was one transect which was changed from May to October 2009; however, the same transect used in October 2009 was used for both events in 2010.

Transect locations were selected using a grid spacing overlaid on a map of the project area. Transect locations were then transferred to a hand-held GPS unit for field location. At each sample point a randomly generated compass direction (azimuth) was used to orient the transect. The orientations used for the first monitoring in May 2009 were used again for all subsequent sampling events.

Map 11: Map of transect and photo point locations



13.1.2 Vegetation Cover

Point-intercept methods were used to collect most vegetation parameters, including vegetation cover, ground cover, and species frequency. Each 25-m transect represents a single sampling unit. A total of 50 point-intercepts were collected along each line-transect. Two point-intercept cover measurements were recorded at one-meter intervals along each line-transect, 0.5 meters to each side of the transect at a right angle. A laser bar was used to determine hits, with the beam being projected vertically to the ground surface. Each point-intercept was assigned an absolute cover value of 2%.

Cover measurements of "first-hit" point-intercepts (the first item that the laser beam intercepts) were recorded as either: live vegetation (by plant species), litter, rock, or bare ground. Litter includes all dead plant material. Total vegetative cover is reported in absolute percentages from the point-intercept data using all 50 ground cover observations for each sample point. Vegetation cover parameters evaluated included total vegetation cover, native vegetation cover, salt cedar cover, and seeded species cover.

All plant species observed along transects were recorded or collected for later identification. Other plant species present at the site, but not encountered along transects were also recorded for inclusion in a site-wide species list.

13.1.3 Woody Density

Woody species density was also recorded along each 25-meter transect. All individuals of woody species present within 1 meter on either side of the vegetation cover transect were counted and recorded by species.

13.1.4 Transplanting Success

Over 900 individuals of cottonwood poles, willow poles, and/or containerized native shrubs were planted on the site. To evaluate transplanting success a subset of the transplants was monitored (Table 16, Map 12). Following transplanting, each pole and container transplant was mapped with a sub-meter accuracy GPS unit in the field. For the spring 2009 monitoring, a subset of the transplants was randomly selected and monitored (Table 16). The sample set included some of each species transplanted. The same individual transplants were monitored during subsequent monitoring events.

Each selected transplant was evaluated for the following criteria:

- Height (base of trunk to tallest stretched leaf)
- Basal diameter (at ground level)
- Survival (alive vs. dead)
- Condition (include factors affecting the growth, e.g. browsing, insects, nutrient deficiencies, etc.)

Map 12: Map of monitored poles and transplants

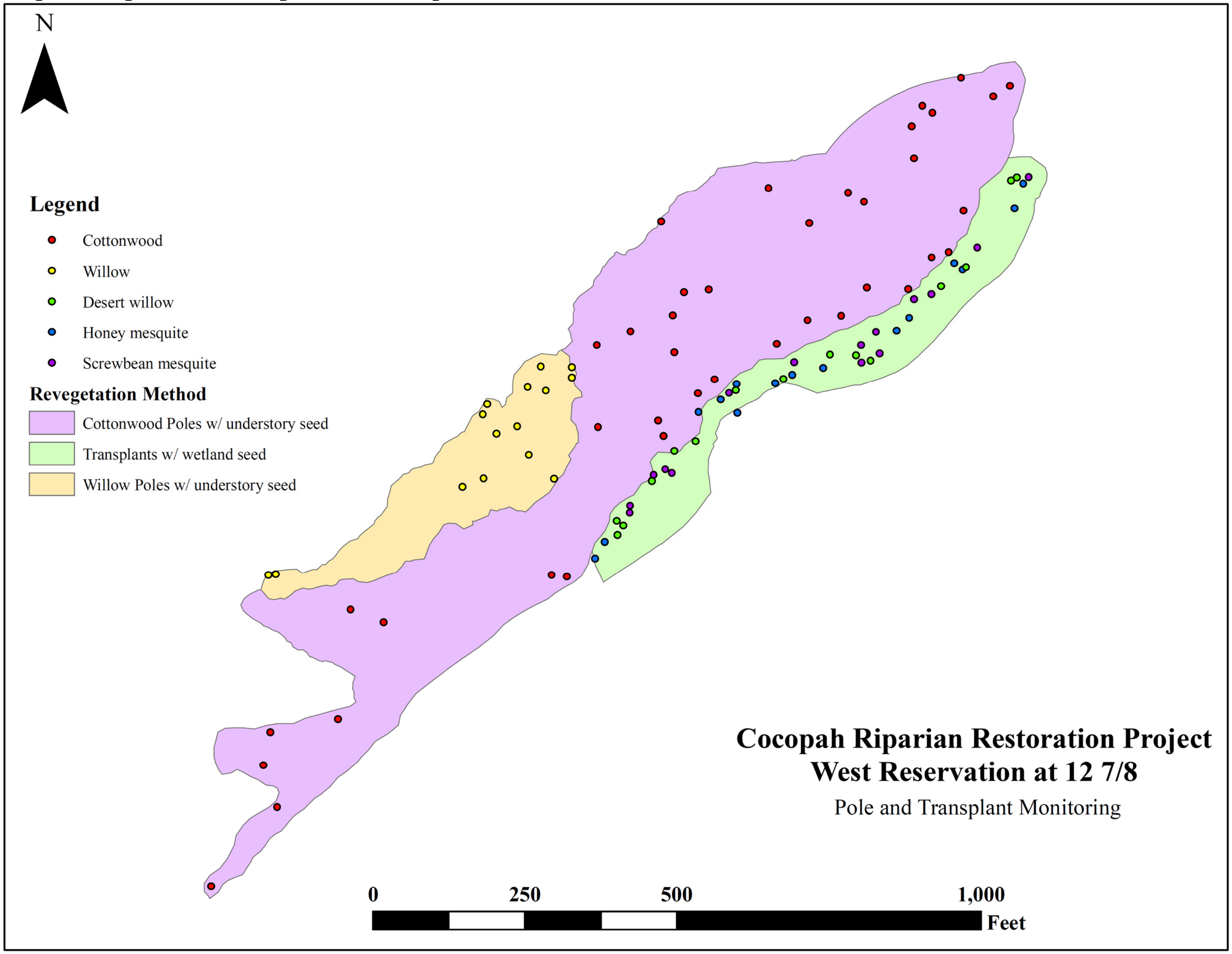


Table 16: Quantity of transplants monitored by species.

Species	# Planted	2009 # Monitored	2009 % of Total Planted	2010 # Monitored	2010 % of Total Planted
Poles					
Willow	126	15	12%	25	20%
Cottonwood	574	40	7%	50	9%
Total Poles	*700*	*55*	*8%*	*75*	*11%*
Transplants					
Desert willow	69	15	22%	16	23%
Honey mesquite	73	14	19%	17	23%
Screwbean mesquite	70	16	23%	16	23%
Total Transplants	*212*	*45*	*21%*	*49*	*23%*
Total	912	100	11%	124	14%

13.1.5 Photographs

Photographs were taken during each monitoring event at each of 9 established photo points throughout the project area. A photograph was also taken from the start point along each transect during each monitoring event. Each photograph was taken from an approximate height of 5 feet (ft). These photos are all included in the 2010 Vegetation Monitoring Report submitted to AWPF on February 1, 2011.

13.1.6 Data Analysis

Data collected during each session was compiled and compared to data from previous sessions to determine if there are changes in vegetative cover, woody density, and/or transplant growth and survival over time. Transplant survival data were also correlated with soil and ground water data as well as physical characteristics of the transplants (i.e. height and diameter) to determine trends in transplant survival.

13.2 Results

Trends in data from April to October and from 2009 to 2010 were assessed for absolute cover (total ground cover, total vegetation cover, native cover, salt cedar cover, and seeded species cover), relative cover (native species, salt cedar, and seeded species), diversity (species richness and native richness) (Table 17). Woody density (total, native, and salt cedar) and transplant survival were also assessed by life form and by species. All data were analyzed separately for spring and fall, and both values are presented for each variable. Additionally, a plant species list for the entire site was compiled including all species observed in the project area during spring and fall monitoring (Table 18).

Raw data collected in both spring and fall of 2009 and 2010 are presented in Appendix B and Appendix C, respectively.

13.2.1 Vegetation Cover

Total vegetation cover increased substantially from around 17% in 2009 to 28% in fall 2010 (Figure 11, Table 17). Total ground cover (vegetation and litter) also increased from an average around 50% in 2009 to over 70% by fall of 2010. Both total vegetation cover and total ground cover did not differ significantly between the spring and fall monitoring events in either year (Figure 11).

Vegetation cover at the site was dominated by shrubs in all 4 monitoring events (Figure 12). However, while shrub cover increased only slightly from 2009 to 2010, herbaceous cover increased substantially from less than 1% in fall 2009 to over 15% in spring 2010 (Table 17).In 2009 shrubs comprised 86% and 93% of relative cover in the spring and fall respectively and herbaceous cover comprised 7.9% and 2.9% (Figure 13, Table 17). In 2010, shrubs were still the dominant life form with 54.3% and 60.9% of relative cover in the spring and fall respectively, but herbaceous cover increased to 44.1% and 37.6%, respectively.

Figure 11: Total vegetation cover and total ground cover (mean ± 1SE)

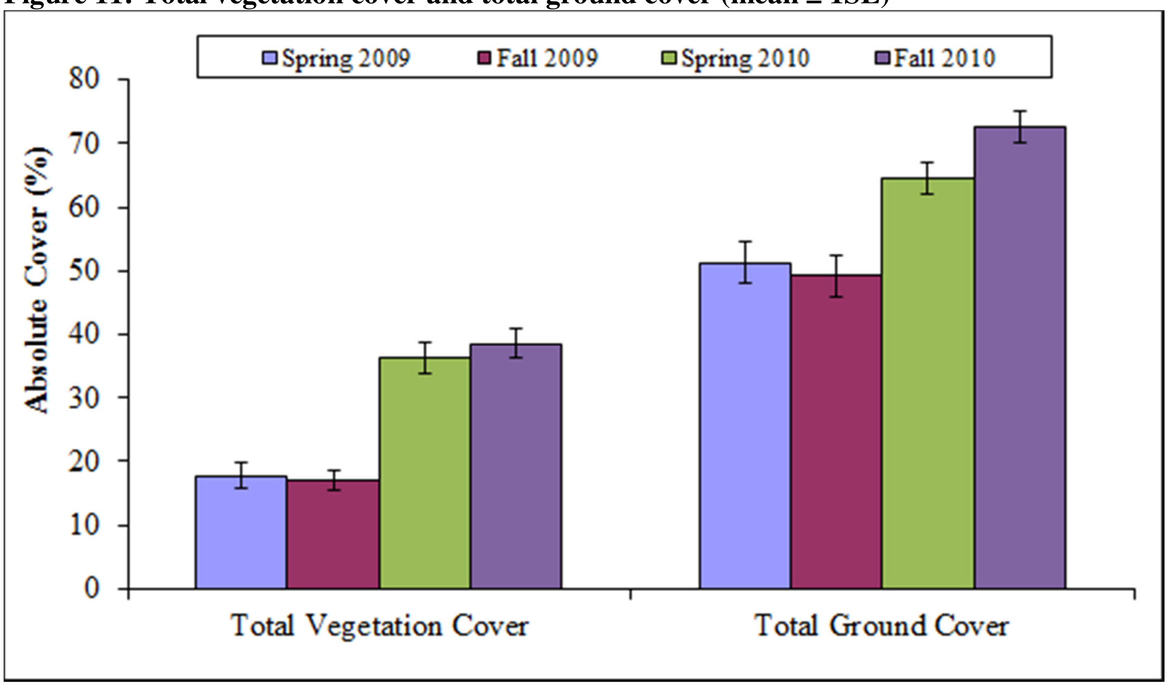


Table 17: Summary statistics (mean ± standard error) for 2009 and 2010 monitoring

	2009				2010			
	Spring		Fall		Spring		Fall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Absolute Cover Statistics (%)								
Total Vegetation Cover	17.7	2.0	17.1	1.7	36.3	2.5	38.6	2.4
Total Ground Cover	51.3	3.2	49.2	3.2	64.6	2.5	72.6	2.5
Forb Cover	1.4	0.4	0.5	0.2	15.3	2.1	12.7	2.2
Herbaceous Cover	1.4	0.4	0.5	0.2	16.0	2.3	14.5	2.2
Shrub Cover	15.3	1.9	15.9	1.7	19.7	2.0	23.5	2.1
Tree Cover	1.0	0.2	0.7	0.2	0.6	0.2	0.6	0.2
Native Cover	16.1	2.0	14.7	1.7	33.7	2.4	34.5	2.2
Introduced Cover	1.6	0.4	2.4	0.4	2.6	0.4	4.1	0.6
Salt Cedar Cover	0.9	0.1	2.4	0.4	0.9	0.3	1.0	0.2
Perennial Cover	16.8	2.1	16.8	1.7	21.4	2.0	24.6	2.1
Planted Species Cover	0.0	0.0	0.0	0.0	0.2	0.1	4.0	0.8
Relative Cover Statistics (%)								
Herbaceous Cover	7.9		2.9		44.1		37.6	
Shrub Cover	86.4		93.0		54.3		60.9	
Tree Cover	5.6		4.1		1.7		1.6	
Native Cover	91.0		86.0		92.8		89.4	
Introduced Cover	9.0		14.0		7.2		10.6	
Salt Cedar Cover	5.1		14.0		2.5		2.6	
Perennial Cover	94.9		98.2		59.0		63.7	
Planted Species Cover	0.0		0.0		0.6		10.4	
Diversity Statistics (count)								
Total Species Richness	32.0		28.0		59.0		43.0	
Native Richness	23.0		22.0		38.0		29.0	
Introduced Richness	9.0		6.0		21.0		14.0	
Herbaceous Richness	19.0		15.0		44.0		28.0	
Shrub Richness	9.0		9.0		11.0		11.0	
Tree Richness	4.0		4.0		4.0		4.0	
Planted Species Richness	0.0		0.0		3.0		3.0	
Woody Density (stems/acre)								
Shrub Density	3,136	727	2,663	650	18,818	10,571	3,383	610
Tree Density	69	27	16	11	12	7	20	13
Total Woody Density	3,205	737	2,679	654	18,830	10,574	3,403	613
Native Density	2,772	658	2,420	651	18,688	10,572	3,274	597
Salt Cedar Density	433	283	259	86	142	41	129	49

Figure 12: Absolute cover by life form

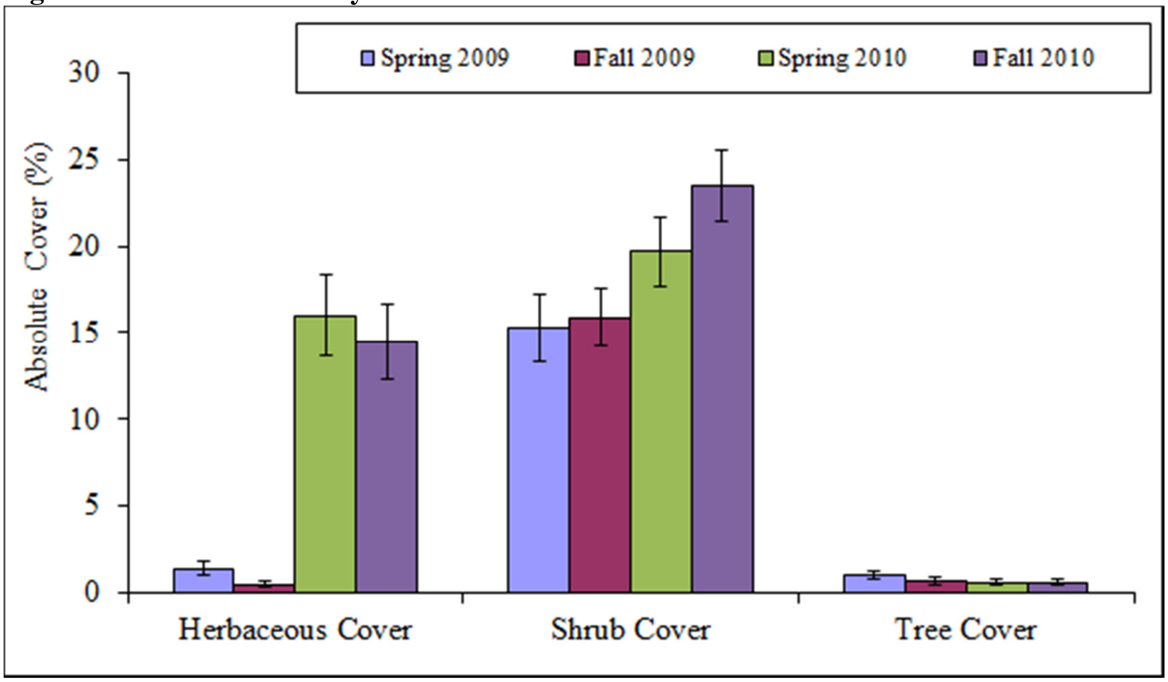
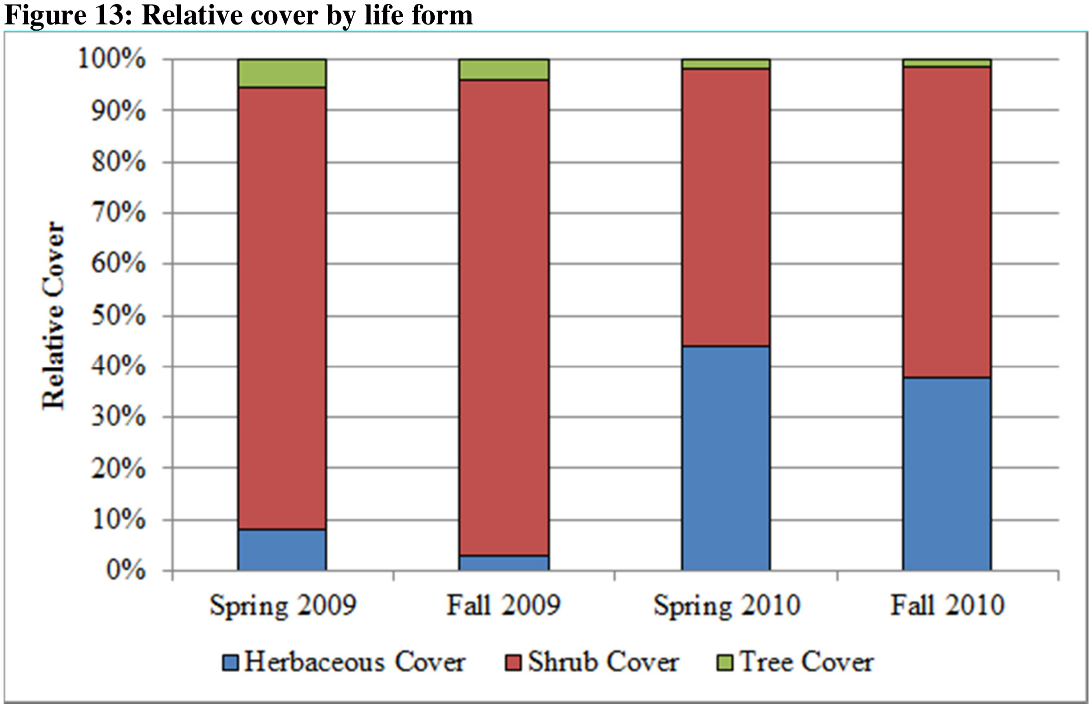


Figure 13: Relative cover by life form



The dominant shrub species on the site were arrowweed (*Pluchea sericea*), salt cedar (*Tamarix sp.*), and mulefat (*Baccharis salicifolia*) in 2009. In 2010, the seeded shrubs quailbush (*Atriplex lentiformis*) and fourwing saltbush (*A. canescens*) were also common with the cover of quailbush exceeding that of all other shrubs except arrowweed.

The increase observed in salt cedar cover from the spring (0.9%) to fall (2.4%) of 2009 resulted in the decision to do a targeted herbicide application on salt cedar resprouts. This seems to have been effective as salt cedar cover was back down to previous levels in both the spring (0.9%) and fall (1.0%) of 2010.

While no vegetation cover data were collected before revegetation began in early 2008, there is anecdotal evidence to suggest that salt cedar cover has decreased substantially during the project timeline. An example is illustrated in Figure 14. In April 2008, this area was dominated by salt cedar with some arrowweed. In October 2009, the same area exhibited almost no salt cedar and increased arrowed cover. Finally in October 2010, the area was densely vegetated with a combination of arrowweed and quailbush.

In addition to the arrowweed and quailbush two native annual species, redroot cryptantha (*Cryptantha micrantha*) and lineleaf whitepuff (*Oligomeris linifolia*), were prevalent in 2010. Redroot cryptantha was second only to arrowweed with 10.6% cover in spring 2010 and 8.9% cover in fall and lineleaf whitepuff was the fourth most common species with 2.6% and 2.4% in the spring and fall, respectively. These annual colonizer species were able to take advantage of available moisture and form a dense ground cover in many areas. These two species along with the arrowweed and quailbush comprised 83% of the relative cover on the site.

Figure 14: Transect 8 in (A) April 2008, (B) October 2009, and (C) October 2010

(A)

(B)

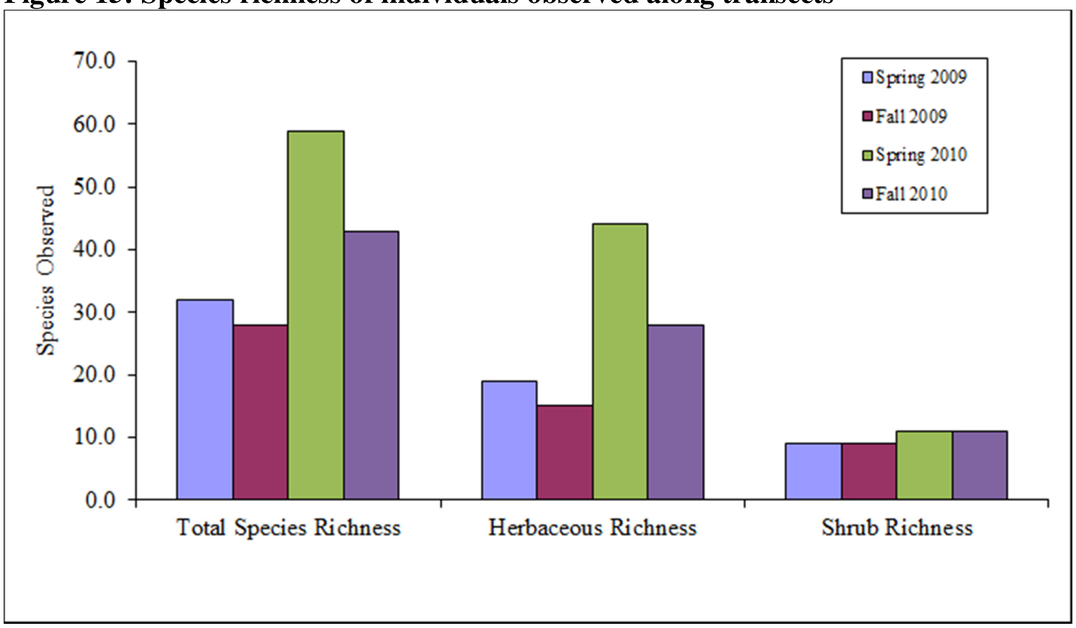
(C)

13.2.2 Species Diversity

The most common measure of diversity is species richness (the total number of species observed in a given area); however, the frequency of observations for any given species also helps to describe the diversity of the area. In both the spring and fall all species observed within the project area were recorded to estimate richness (Table 18). Additionally, all species observed within one meter on either side of each transect were recorded to measure frequency.

A total of 55 species were observed in the spring, 38 of which were native and 36 of which were observed along transects. In the fall 39 species (29 of them native) were observed, but only 21 were observed along transects. The difference between the spring and fall, especially along transects, is likely due to the substantial difference in herbaceous species observed (Table 17, Figure 15). This is primarily due to an increase in annual species observed in the spring. All species observed in the fall had also been present in the spring and of those species present in the spring and not fall, 18 of 23 were annuals. While many more species were observed in 2010 than 2009, the same trends in richness between growth forms and over time were observed in both years.

Figure 15: Species richness of individuals observed along transects



The frequency of each species observed helps to show which species were dominant and further evaluate the site diversity. A site with many species, but only one dominant species is considered much less diverse than a site with many species all contributing essentially equally.

In spring 2009, only five species were observed along more than 2 transects (Table 18). In 2010, 12 species were observed along more than 2 transects and all of the more common species from 2009 increased in frequency except cottonwoods. Of these 12 most common species, 4 were observed along more than 10 (50%) transects. Arrowweed was observed along 95% (19) of the transects, cryptantha was observed along 75% (15), salt cedar was observed along 65% (13), and sowthistle (*Sonchus asper*) was observed along 60% (12) of the transects in the spring (Table 18). Of these species only arrowweed was still present along more than 50% of transects in the fall and the sowthistle was not even present in the fall.

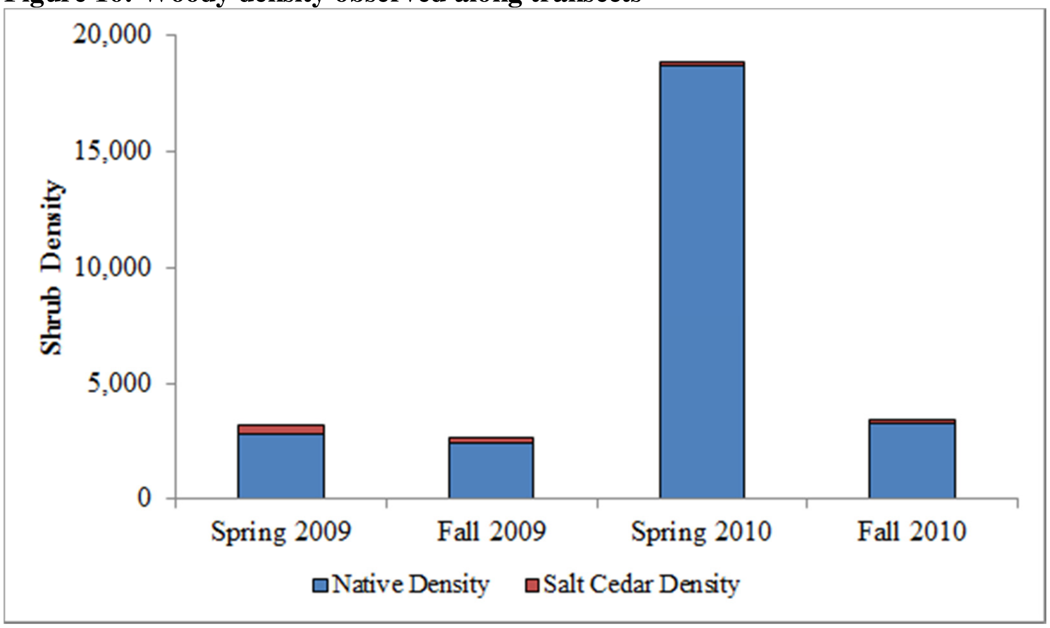
Table 18: Species observed in the project area and their frequency (%) along transects

			2009		2010	
Genus	**Species**	**Common Name**	**Spring**	**Fall**	**Spring**	**Fall**
Graminoids: Annual Introduced						
Polypogon	*monspeliensis*	annual rabbitsfoot grass			20	5
Schismus	*barbatus*	common Mediterranean grass			45	25
Graminoids: Perennial Introduced						
Phleum	*pratense*	common timothy			10	
Sorghum	*halepense*	johnsongrass			20	p
Graminoids: Perennial Native						
Phragmites	*australis*	common reed	5	p	5	5
Scirpus	*americanus*	chairmaker's bulrush	p	p	p	p
Unknown grass	*sp*	Unknown grass			5	
Forbs: Annual Introduced						
Amaranthus	*albus*	prostrate pigweed			p	
Chenopodium	*murale*	nettleleaf goosefoot			15	
Erodium	*cicutarium*	redstem stork's bill			p	
Lactuca	*serriola*	prickly lettuce	10		30	10
Medicago	*lupulina*	blackmedic			5	
Medicago	*sativa*	alfalfa			20	
Melilotus	*officianalis*	sweetclover	5			
Portulaca	*oleracea*	little hogweed			p	p
Salsola	*tragus*	Russian thistle	5		p	5
Sisymbrium	*irio*	London rocket	10	15	40	10
Sonchus	*asper*	spiny sowthistle			60	p
Sonchus	*oleraceus*	common sowthistle			20	10
Triticum	*sp*	wheat			p	
Forbs: Annual Native						
Abronia	*villosa*	desert sand verbena			p	
Achyronychia	*cooperi*	onyxflower			5	
Amaranthus	*palmeri*	carelessweed			5	
Calibrachoa	*parviflora*	seaside petunia			5	
Conyza	*canadensis*	Canadian horseweed			5	p
Cryptantha	*micrantha*	redroot cryptantha	25	35	75	40
Cryptantha	*sp*	cryptantha			10	p
Geraea	*canescens*	hairy desertsunflower			p	
Oligomeris	*linifolia*	lineleaf whitepuff	40	35	45	35
Dicoria	*canescens*	desert twinbugs				p
Xanthium	*strumarium*	rough cocklebur	5		p	
Forbs: Perennial Native						
Chloracantha	*spinosa*	spiny chloracantha	p	p	p	p
Eschscholzia	*californica*	California poppy			5	
Eustoma	*exaltatum*	catchfly prairie gentian	p	p	p	p
Glandularia	*gooddingii*	southwestern mock vervain			5	
Heliotropium	*curassavicum*	salt heliotrope	10	10	35	p
Pluchea	*odorata*	sweetscent	p	p	p	p
Porophyllum	*gracile*	slender poreleaf	p	10	30	15
Pseudognaphalium	*canescens*	Wright's cudweed	5	p	5	5
Rumex	*hymenosepalus*	canaigre dock			10	p
Sphaeralcea	*ambigua*	desert globemallow			10	10
Suaeda	*moquini*	Mohave seablite	p	p	p	p
Stephanomeria	*exigua*	small wirelettuce			p	
Tiquilia	*plicata*	fanleaf crinklemat	5	p	p	p
Typha	*domingensis*	southern cattail	5	p	p	p
Machaeranthera	*asteroides*	fall tansyaster	p	5	p	p
Shrubs: Perennial Introduced						
Tamarix	*sp.*	salt cedar	50	65	65	50
Shrubs: Perennial Native						
Atriplex	*canescens*	fourwing saltbush			20	40
Atriplex	*lentiformis*	quailbush			50	50
Baccharis	*sarathroides*	desertbroom	p	p	p	10
Baccharis	*salicifolia*	mulefat	20	10	50	50
Pluchea	*sericea*	arrowweed	70	85	95	85
Salix	*exigua*	coyote willow	5	p	p	p
Trees: Perennial Native						
Populus	*fremontii*	Fremont's cottonwood	30	10	20	20
Prosopis	*glandulosa*	honey mesquite	5	p	5	p
Prosopis	*pubescens*	screwbean mesquite	10	5	5	5
Salix	*gooddingii*	Goodding willow	10	5	15	5

13.2.3 Woody Density

Average woody density increased sevenfold from an average of 33 stems/transect (2,679 stems/acre) in fall 2009 to 233 stems/transect (18,830 stems/acre) in spring 2010 and then dropped back to only 42 stems/transect (3,403 stems/acre) in fall 2010 (Table 17, Figure 16). This substantial spring spike in woody density is likely due to the flush of new arrowweed, mulefat, and desert broom seedlings following the overbank flooding in March 2010. Additionally, while the density of shrubs and trees in fall 2010 was not substantially different from that observed in 2009, the relative density of salt cedar decreased from 14% in spring 2009, to 4% in fall 2010.

Figure 16: Woody density observed along transects



13.2.4 Transplant Survival

The pole transplants were monitored and analyzed separately from the native containerized transplants.

13.2.4.1 Pole Transplants

In the spring, 17 of the 75 poles (cottonwood and willow) monitored (23%) were still alive, while in the fall only 9 (12%) were alive (Table 19). While in 2009 cottonwood survival was better than willow survival, in 2010 the two species were similar in survival rates.

Table 19: Pole transplant survival

	2009			2010		
	Poles	% Survival		Poles	% Survival	
Planted Species	Sampled	Spring	Fall	Sampled	Spring	Fall
Cottonwood	40	63%	28%	50	22%	12%
Willow	15	40%	33%	25	24%	12%
Total	55	56%	29%	75	23%	12%

13.2.4.2 Container Transplants

In the spring, the majority of transplanted native containerized shrubs were still alive. Of the 49 shrubs monitored 35 (71%) were alive (Table 20). All but one of the screwbean mesquites (94%) were alive, 75% of honey mesquites were alive, and 44% of desert willows were alive. In October, overall survival dropped to 67% with the loss of one honey mesquite and one desert willow.

Table 20: Containerized transplant survival

	2009			2010		
	#	% Survival			% Survival	
Planted Species	**Sampled**	**Spring**	**Fall**	**# Sampled**	**Spring**	**Fall**
Screwbean Mesquite	16	94%	94%	16	94%	94%
Honey Mesquite	14	93%	93%	17	75%	69%
Desert Willow	15	100%	60%	16	44%	38%
Total	45	96%	83%	49	71%	67%

13.3 Discussion

13.3.1 Vegetation Cover

The vegetative cover observed at the site in 2010 was more than double that observed in 2009. This is likely primarily due to the overbank flooding experienced in March 2010. A release of water from the Morelos Dam upstream of the project site on March 7, 2010 caused overbank flooding in the project area for the first time since 1993. The portions of the north end of the site were inundated for several days (Figure 17). The flood caused substantial erosion (Figure 18), but also provided the moisture for a huge flush of new germination (Figure 19).

Figure 17: Photo Point 5 in October 2009 and March 2010

Figure 18: Erosion caused by March 2010 overbank flooding

Figure 19: (A) Arrowweed seedlings in cracked soil and (B) Cryptantha cover in drier areas

The moisture provided for a huge spike in herbaceous species cover especially forb cover, which increased from 0.5% absolute cover in fall 2009 to 15.3% in spring 2010. The majority of this new forb cover was the native annual redroot cryptantha (Figure 19B). This species constituted only 0.3% absolute cover in 2009, but contributed 10.6% in spring 2010. Along with the cryptantha, one other annual native (lineleaf whitepuff or *Oligomeris linifolia*) and three perennial native forbs (salt heliotrope or *Heliotropium curassavicum*, Wright's cudweed or *Pseudognaphalium canescens*, and slender poreleaf or *Porophyllum gracile*) contributed 14.3% absolute cover. The last 1% of the forb cover was a combination of four annual introduced species. One annual introduced grass species (Mediterranean grass or *Schismus barbatus*) also contributed 0.7% absolute cover to the 16% overall herbaceous cover.

As would be expected, herbaceous cover decreased from the spring to the fall. However, this decrease was not as large as observed in 2009. In 2009, spring herbaceous cover averaged 1.4% and dropped to 0.4% in the fall, while in 2010 spring cover decreased only slightly from 16% in the spring to 14.5% in the fall. Many of the annual species observed in the spring usually die before the fall monitoring, but some were still alive in 2010 likely due to the longer than usual wet period in the spring.

The woody species on the site also benefited from the flooding, but not as drastically or as quickly as the herbaceous species. Shrub cover increased from 15.9% in fall 2009 to 19.7% in spring 2010 to 23.5% in fall 2010. Many new shrub seedlings were observed in spring 2010 especially arrowweed and desert broom (Figure 19A). However, because shrubs grow much more slowly than forbs (especially annual forbs) it takes longer for the increase in density to translate to an increase in cover. While the herbaceous cover peaked in the spring, the shrub cover continued to increase from spring to fall. Established shrubs also generally benefit from deep taproots making them relatively drought tolerant compared to herbaceous species and much less affected by fluctuations in climate.

The persistence and resprouting of the salt cedar is expected, but the results for this second growing season are very promising for the control of the salt cedar. Salt cedar is incredibly resilient and difficult to eradicate. It generally takes multiple control methods (e.g. mechanical and chemical) and repeated application of these methods to substantially decrease the population. This site has received an initial mechanical control with bull dozers followed 3 years later with mowing and herbicide application. Finally, an additional herbicide application was completed in February 2010. Given this history, it would be expected that the cover of salt cedar would decrease from fall 2009 (2.4%) to spring 2010 (0.9%). However, the spring 2010 flood would have been expected to result in an increase in salt cedar cover and density just as it did for the other shrub species. However, the salt cedar seed on the site also did not react to overbank flooding the same way as the native species. Because salt cedar is adapted to the same process of germinating after spring floods, the lack of germination and establishment is likely due to competition from the native species.

13.3.2 Species Diversity

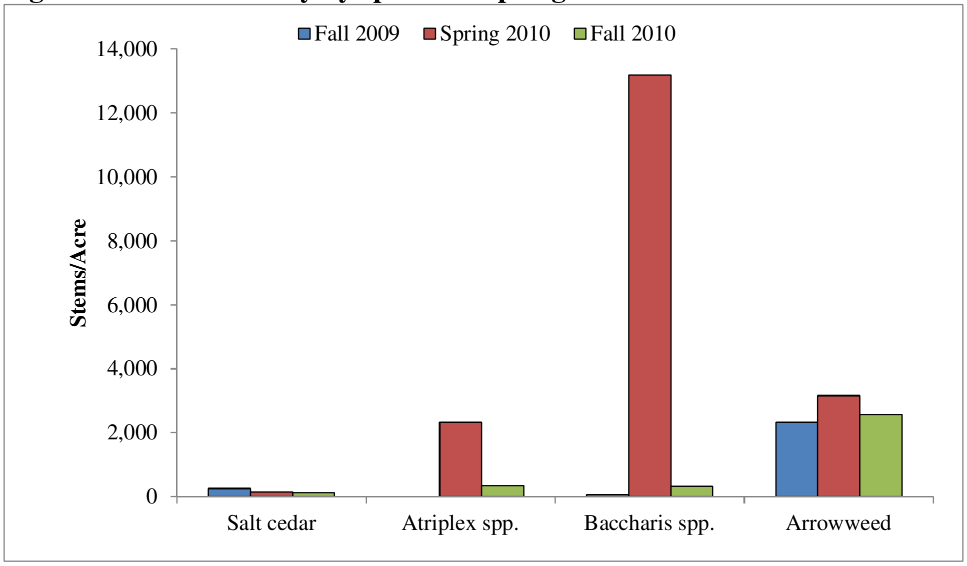
As was observed in 2009, diversity of woody species was constant throughout the year, while the herbaceous species richness decreased from 44 species in the spring to 28 in the fall. The decrease in diversity from spring to fall is likely due to the same climate characteristics as discussed above. Half of the herbaceous species observed in the spring were annuals. These species germinated in the early spring responding to the flooding and persisted through April. However, they did not persist through the hot, dry summer months.

The total number of species observed in 2010 (55) was almost double that observed in 2009 (28). This increase is again likely due to the moisture input from the spring overbank flooding as well as the germination of several of the seeded species.

13.3.3 Woody Density

The differences from spring to fall in woody density are due primarily to the March overbank flooding. After the floodwaters receded, a flush of new germination occurred throughout the site including thousands of *Baccharis* (mulefat and desert broom) and arrowweed seedlings (Figure 20). These seedlings were especially dense in the understory of established shrubs. However, during the hot, dry summer months the majority of these new seedlings desiccated and died. The few that were able to survive, however, did contribute to the increase in overall shrub density from that observed in 2009.

Figure 20: Shrub density by species in spring and fall



Additionally, a large number of the seeded *Atriplex* spp. (saltbush and quailbush) established in 2010. Again, these species were likely able to take advantage of the moisture caused by the overbank flooding as well as winter rains. However, as with the *Baccharis* and arrowweed, some of the spring seedlings did not survive the summer (Figure 20).

The density of salt cedar decreased by 50% during this same time period. Some of the salt cedar decline was due to an application of herbicide in February 2010. However, the salt cedar seed on the site also did not react to overbank flooding the same way as the native species. As was discussed for salt cedar cover above, the lack of germination and establishment could be due to competition from the native species.

13.3.4 Transplant Survival

13.3.4.1 Pole Transplants

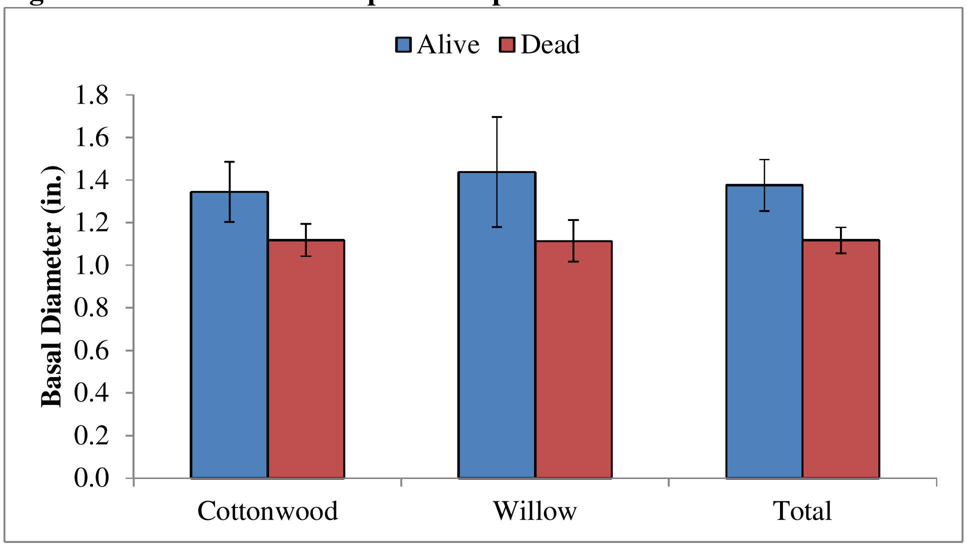
The pole survival was lower than expected for the project overall with only 12% of cottonwood and willow poles surviving. The survival of poles was very patchy with some areas having excellent survival and others almost none. This observation led to the hypothesis that location-specific soils or groundwater conditions could be affecting the tree survival.

Cottonwoods and willows are sensitive to high soil salinity and alkalinity and require almost continual access to ground water. These variables were used as a part of the criteria for selecting planting locations; however, some poles were planted in areas that were determined to be on the margin of ideal conditions. Also, soil and groundwater conditions are highly variable and it is possible that the pre-planting sampling was not at a scale fine enough to detect some differences in conditions.

In reviewing the available soil pH and salinity data for the site, no correlations between salinity or alkalinity and transplant success were found. Depth to water table (as measured in the wells) did not correlate either. The absence of correlations here could be a result of two possibilities. First, it could be that no correlation exists, or second, it is possible that the sample size is too small. Given the random sampling technique it is difficult to show statistically what was observed anecdotally.

Another variable that may have influenced pole survival was the poles themselves. The data do show a statistically significant difference between the basal diameters of living and dead poles. The basal diameters of living trees averaged 1.4 inches while dead trees averaged only 1.1 inches (Figure 21). Trees that were larger in diameter would have had more energy stores to develop new roots and withstand a longer period without water.

Figure 21: Basal diameter of pole transplants



The last variable potentially playing a role in pole survival is planting time. Ideal planting time in this region is winter (November – February). However, the poles were not planted until April. Therefore, the poles were planted after the winter rains and during the time when the weather had begun to heat up. The water table was lower than in winter and was dropping to its lowest seasonal level at the time of planting. The warm temperatures triggered the poles to begin leaf production along with (or instead of) root development. Leaf development likely used up much of the energy stored in the poles, but when the weather became too hot the leaves died without further support from an established root system. Leaf production also likely led to increased evapotranspiration, and therefore heat stress, during the hot summer months. Planting earlier in the year may have resulted in higher pole transplant success.

It may have also been beneficial to cut poles to prevent leaf development. This hypothesis was generated from the observation that poles cut down by beavers were able to resprout and survive (Figure 22). Some trees that had leafed out were also able to resprout from the base and survive. The removal of most of the above ground portion of the poles could have minimized the potential for bud and leaf development, and possibly reduced heat stress by minimizing the poles exposure to the elements. However, this would have also minimized the amount of stem that could store energy for root development.

Even with the low survival rates of poles we did end up with an average of 7 to 8 new trees per acre in the planting area. Even these few trees will help to improve the habitat in the area and compete with salt cedar to prevent reestablishment.

Figure 22: Resprouting pole (A) cut by beavers and (B) from the base of a dead stem
(A) (B)

13.3.4.2 Container Transplants

Containerized transplants had excellent survival rates with 2/3 of transplants surviving their first two growing seasons. The containerized transplants were only installed in areas with ground water within 4 feet of the surface at all times during the season. Thus, their survival was not as limited by water availability as the poles. Using containerized stock also ensured that the plants already had established root systems when they were planted.

Survival was especially good for the screwbean mesquites with almost all individuals (15 of 16 monitored) surviving. The survival rate of honey mesquite was slightly lower with 11 of 16 surviving, but 75% is still an excellent success rate. The desert willow individuals did not survive as well as would have been hoped, but 38% were still alive at the end of the second growing season.

The screwbean mesquites are very common at this site naturally, while the honey mesquites are less common, and the desert willows were absent. Likely the soil conditions naturally favored the screwbean mesquites leading to their greater overall survival. Also, the overbank flooding experienced in March 2010 likely affected the survival rates. Individuals that had clearly been inundated did not survive. None of these species tolerates prolonged inundation, but the mesquites likely tolerate it better than the desert willow. Also, while the desert willow is very drought tolerant it is not as tolerant of fine textured soils as the mesquites are. Some of the container planting areas had more clay in the soil, and desert willows planted in these areas did not fare as well.

13.3.5 Seed Mix Establishment

The upland seed mix used for most of the site included seven grasses, three forbs, and three shrubs. After two growing seasons only three of the seeded species were observed at the site (quailbush, fourwing saltbush, and desert globemallow) (Table 21). None of the grass species were observed on the site along with two of the forbs and one of the shrubs.

Table 21: Seeded species success

Species	Common Name	Seed Mix	Absolute Cover		Relative Cover		Frequency	
			Spring	Fall	Spring	Fall	Spring	Fall
Forbs								
Sphaeralcea ambigua	desert globemallow	5.0%					10.0%	10.0%
Shrubs								
Atriplex canescens	Saltbush	5.0%			0.4%	1.0%	20.0%	40.0%
Atriplex lentiformis	Quailbush	5.0%	0.2%	0.6%	3.6%	9.3%	50.0%	50.0%

The poor establishment of the seed mix is likely due to two factors. From the time of the seeding in April 2009 through December 2009, there was no appreciable precipitation at the site. During this time the seed on the surface may have been eaten by birds and insects in the area. The saltbush and quailbush have a salt coating that may have made them less palatable leaving more seed to germinate when water was available. Additionally, the overbank flooding in March 2010 which provided the much needed moisture may have washed the remaining seed away. The quailbush and salt bush having much larger seed than the grass and forb species may have been less likely to wash away.

13.4 Conclusions

After two growing seasons it is possible to draw some conclusions about revegetation success and project success. Overall, this project has been very successful in some respects and less successful in others. However, the results of this project and the lessons learned during implementation have been invaluable to the Cocopah Tribe for use on future restoration projects along the Colorado River.

This project spanned a very unusual period of time with regard to climate and moisture conditions. Precipitation in 2009 was below average in every month except February and total annual precipitation was less than 1 inch at the site. Conversely, in 2010, precipitation was at or above average in most months and the annual precipitation was over 5 inches. Additionally, overbank flooding occurred at this site for the first time since 1993. This extreme drought followed by flooding likely lead to unusual revegetation results. Evaluating the success of the site over a longer period of time (5 to 10 years) will result in a better understanding of the project success.

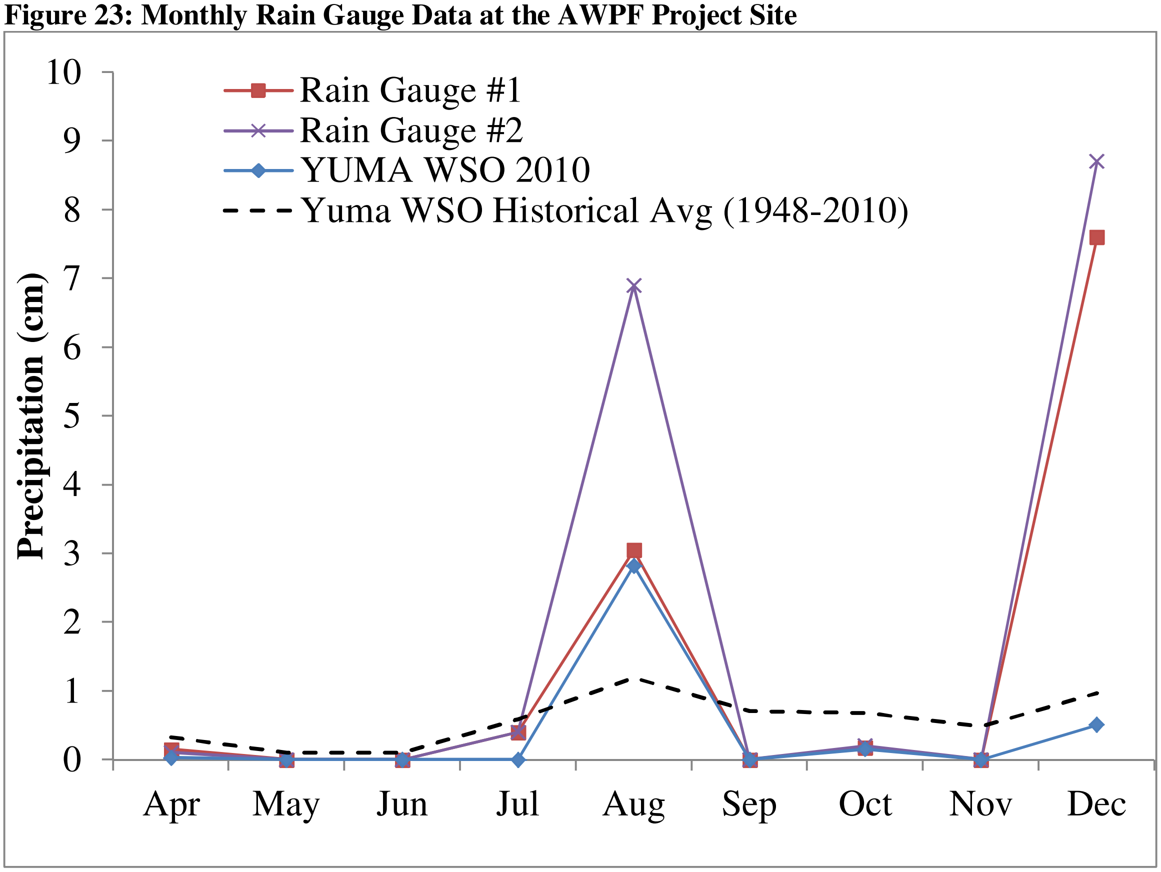
Vegetation cover after two growing seasons is excellent for an arid area with 38.6% cover in the fall of 2010. The vegetation cover also includes a large component of a few (3 of 13) of the seeded species suggesting that the seeding was successful to some extent. Salt cedar cover has also decreased over the project period suggesting that the project has been successful in controlling salt cedar and mitigating recolonization.

The containerized transplants have been incredibly successful, especially the mesquite species with 82% overall survival. Pole survival was not as good as expected though, with only 12% surviving after two growing seasons. Given the deep water table, the lack of precipitation, and the late planting, the poles did not have the best conditions to survive and 12% survival is not a complete loss. The additional seven or eight cottonwoods and willows established in the planting area will add to the habitat in the area and the lessons learned from the pole planting will hopefully lead to greater survival on future projects. Future success of planted species at the site will be dependent on rainfall and weather patterns, as well as ongoing management of invasive salt cedar.

14 Rain Gauge Monitoring (Task #7)

The contract amendment approved February 8, 2010 added rain gauge installation and monitoring to Task #7. The rain gauges were installed on April 1, 2010 after consultation with US Border Patrol and were monitored biweekly as well as any time a rain event occurred from April through December 2010. Collected rain gauge data are shown on Figure 1 along with monthly totals from the nearest western regional climate station (Yuma WSO AP, Western Regional Climate Center 2011). The on-site rain gauges allow for a more localized record of precipitation on the project area. Comparing the data collected in the rain gauges to that from the climate station shows major differences in monthly totals in August and December.

Figure 23: Monthly Rain Gauge Data at the AWPF Project Site



15 Summary

- Based on the results of the 2010 Vegetation Monitoring Report, the Cocopah Indian Tribe's AWPF-funded Colorado River Restoration Project has been relatively successful. After two years,
- the salt cedar cover on the site is down to less than 1%,
- a variety of native forb, shrub, and tree species have established and/or expanded their ranges,
- containerized tree transplants were very successful for establishing mesquite trees,
- pole planting was not as successful as was hoped, but not a complete loss,
- wildlife habitat in the project area has been greatly improved, and
- valuable lessons learned during implementation will benefit future restoration projects in the Limitrophe.

15.1 Task Completion

With the submission of this deliverable under Task #8 of the Cocopah's Colorado River Restoration Project AWPF Grant (#08-156WPF), this project is considered complete. All activities outlined in the contract and subsequent amendments have been completed:

- Task #1
  - All permits, authorizations, clearances, and agreements were obtained and approved by AWPF.
- Task #2
  - Revegetation and monitoring plans were completed and approved by AWPF.
- Task #3
  - Contracts were established and amended between the AWPF and the Cocopah and between the Cocopah and Habitat Management, Inc.
  - Interim Progress Reports and annual reports for 2008, 2009, and 2010 were submitted to AWPF for review and approval.
  - This report fulfills the deliverable requirement of the final report.
- Task #4
  - Site clearing was completed on the entire 40-acre amended area and the Site Clearing Report was submitted to AWPF for review and approval.
- Task #5
  - Soil analyses and groundwater monitoring were completed using AWPF and matching funds on the entire 40-acre amended area
  - AWPF funds were used to complete the soil analysis and groundwater monitoring on an adjacent 15-acre restoration area.
- Task #6
  - Revegetation was completed on the entire 40-acre amended area and the Revegetation Report was submitted to AWPF for review and approval.
  - Follow-up salt cedar control was completed on the entre 40-acre amendment area in 2010 and 2011.
  - This report fulfills the deliverable requirement of the final report.

- Task #7
  - Post-revegetation monitoring was completed on the entire 40-acre amended area in spring and fall of 2009 and 2010 and Vegetation Monitoring Reports for each year were submitted to AWPF for review and approval.
- Task #8
  - This report fulfills the deliverable requirement of the final report.

16 References

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Appendix A: Raw Soil Data

April 2008

Table A1: Surface (0-6'') soil data (April 2008)

																		Texture				Metals													Sodium Absorption Ratio			
	OM	P_1	P_2	Bic-P	K	Mg	Ca	K	Mg	Ca	Surface Nitrate			Total Nitrate	CEC	pH	EC	Sand	Silt	Clay	Soil Type	N	S	P	K	Mg	Ca	Na	Fe	Al	Mn	Cu	Zn	B	Na	Mg	Ca	SAR
Sample ID	%	ppm						% Base Saturation			ppm	lbs/A	depth IN	lbs/A	meq/100	Sat. Paste		%				ppm													mg/L			Calculated
AREA 2	0.2	3	33	2	66	77	1177	2.5	9.6	87.9	4	14	0-12	14	6.7	8.1	1.2	96	2	2	SAND	**41**	**137**	**517**	**367**	**4955**	**22833**	**394**	**8387**	**3753**	**251**	**7**	**22**	**3**	**146**	**27**	**122**	**3.1**
AREA 3	0.1	2	37	5	82	121	1294	2.7	13.1	84.2	11	40	0-12	40	7.7	7.9	1.3	92	6	2	SAND	**75**	**194**	**658**	**912**	**6646**	**28404**	**431**	**10990**	**5234**	**361**	**10**	**31**	**3**	**148**	**31**	**105**	**3.3**
AREA 4	0.5	1	50	5	213	303	1728	4.7	21.6	73.7	6	22	0-12	22	11.7	7.6	5.2	54	42	4	SAND	**151**	**575**	**1217**	**2563**	**11960**	**41985**	**1162**	**20323**	**11062**	**494**	**30**	**57**	**2**	**570**	**237**	**762**	**4.6**
AREA 5	0.1	9	33	2	49	83	1077	2	11.2	86.8	2	7	0-12	7	6.2	8.2	0.4	96	2	2	SAND	**16**	**34**	**203**	**134**	**2451**	**10500**	**110**	**3981**	**1570**	**182**	**3**	**10**	**1**	**62**	**9**	**30**	**2.5**
AREA 5 1	0.8	2	67	13	339	502	2095	5.6	27	67.4	83	299	0-12	299	15.5	7.4	7.2	26	68	6	SILOAM	**341**	**506**	**672**	**2228**	**7775**	**24482**	**956**	**13411**	**8304**	**346**	**26**	**41**	**1**	**878**	**343**	**955**	**6.2**
AREA 6	0.5	1	59	5	236	295	1816	5	20.3	74.7	8	29	0-12	29	12.1	7.8	2.1	30	68	2	SILOAM	**163**	**172**	**652**	**1910**	**7533**	**23391**	**558**	**12732**	**7617**	**287**	**23**	**38**	**1**	**272**	**54**	**204**	**4.4**
AREA 8	0.3	2	55	4	207	291	1742	4.5	20.7	74.8	2	7	0-12	7	11.7	7.9	1.1	50	48	2	SALOAM	**63**	**193**	**1480**	**2513**	**12224**	**41345**	**770**	**21071**	**11005**	**419**	**31**	**59**	**2**	**149**	**25**	**89**	**3.6**
AREA 10	0.5	2	52	6	226	298	1849	4.7	20.2	75.1	4	14	0-12	14	12.3	7.8	2.7	54	44	2	SAND	**168**	**523**	**1245**	**2880**	**11966**	**42190**	**970**	**20548**	**11086**	**489**	**31**	**68**	**2**	**394**	**117**	**396**	**4.5**
AREA 11	0.3	1	41	4	145	224	1666	3.5	17.6	78.9	8	29	0-12	29	10.6	8	1.1	74	24	2	LOSAND	**99**	**153**	**523**	**845**	**4745**	**18162**	**280**	**8430**	**4218**	**234**	**10**	**23**	**1**	**144**	**24**	**84**	**3.6**
AREA 12	0.7	2	53	8	156	232	1670	3.7	18.1	78.2	11	40	0-12	40	10.7	7.4	6.4	60	36	4	SALOAM	**182**	**535**	**539**	**1096**	**5301**	**19606**	**557**	**8919**	**4571**	**238**	**12**	**27**	**1**	**741**	**272**	**979**	**5.4**
AREA 14	0.5	3	63	11	229	252	1640	5.4	19.3	75.3	15	54	0-12	54	10.9	7.3	4.5	44	52	4	SILOAM	**242**	**446**	**729**	**1731**	**6673**	**22925**	**673**	**11807**	**6585**	**295**	**18**	**34**	**1**	**535**	**165**	**583**	**5**
AREA 15	0.3	1	53	4	190	267	1743	4.3	19.5	76.2	21	76	0-12	76	11.4	7.7	2.4	62	36	2	SALOAM	**97**	**280**	**567**	**1369**	**5928**	**20211**	**717**	**10478**	**5929**	**242**	**15**	**29**	**1**	**289**	**72**	**278**	**4**
AREA 16	0.1	4	29	2	79	94	1214	2.9	11	86.1	4	14	0-12	14	7.1	8.1	0.7	96	2	2	SAND	**31**	**40**	**231**	**197**	**2623**	**12286**	**148**	**4142**	**1813**	**133**	**3**	**10**	**1**	**89**	**12**	**56**	**2.8**
AREA 17	0.8	2	31	4	191	295	1693	4.3	21.6	74.1	1	4	0-12	4	11.4	7.6	5.8	64	32	4	SALOAM	**275**	**680**	**527**	**1006**	**5265**	**19390**	**1008**	**8980**	**4503**	**218**	**12**	**26**	**1**	**842**	**187**	**405**	**8.6**
AREA 18	0.5	2	43	4	162	238	1727	3.8	18	78.2	8	29	0-12	29	11	7.7	4.3	66	32	2	SALOAM	**119**	**210**	**518**	**845**	**4787**	**17870**	**380**	**8386**	**4253**	**229**	**11**	**23**	**1**	**451**	**101**	**389**	**5.3**
AREA 20	1.1	2	61	9	318	415	2079	5.5	23.5	71	24	86	0-12	86	14.7	7.4	4.5	42	54	4	SILOAM	**306**	**455**	**681**	**1807**	**7069**	**24196**	**671**	**12232**	**6680**	**322**	**21**	**39**	**20**	**569**	**173**	**599**	**5.3**

Table A2: Deep (to groundwater) soil data (April 2008)

																			Texture				Metals													Sodium Absorption Ratio			
	Sample	OM	P_1	P_2	Bic-P	K	Mg	Ca	K	Mg	Ca	Surface Nitrate			Total Nitrate	CEC	pH	EC	Sand	Silt	Clay	Soil Type	N	S	P	K	Mg	Ca	Na	Fe	Al	Mn	Cu	Zn	B	Na	Mg	Ca	SAR
Well	Depth	%	ppm						% Base Saturation			ppm	lbs/A	depth IN	lbs/A	meq/100	Sat. Paste		%				ppm													mg/L			Calculated
WELL 15	0-12"	0.3	3	60	4	202	308	1875	4.1	20.5	75.4	2	7	0-12	7	12.5	8.3	1.1	66	32	2	SALOAM	58	216	1308	2513	10818	39720	840	20139	10452	419	30	57	3	174	19	71	4.7
	12-24"	0.3	5	55	2	179	300	1768	3.9	21.2	74.9	2	7	12-24	7	11.8	8.1	1.4	70	28	2	SALOAM	59	189	1290	1950	10418	38352	704	18858	9418	386	26	53	2	183	37	115	3.8
	24-36"	0.2	2	56	3	163	301	1761	3.6	21.4	75	2	7	24-36	7	11.7	8.2	1.3	62	36	2	SALOAM	29	188	1332	2232	11062	39753	757	19814	10397	398	27	56	2	164	37	115	3.4
	36-48"	0.3	3	53	4	190	313	1827	4	21.4	74.6	1	4	36-48	4	12.2	8.2	1.3	50	48	2	SALOAM	47	295	1351	2818	12608	43373	1088	22448	12409	465	34	65	2	229	27	90	5.4
	48-60"	0.5	3	41	3	165	309	1892	3.4	20.6	76	1	4	48-60	4	12.5	8	2.5	64	32	4	SALOAM	78	438	1013	1963	10243	41315	900	17726	9535	603	28	51	2	504	76	256	7.1
	60-72"	0.2	2	42	3	97	154	1510	2.7	14.1	83.2	1	4	60-72	4	9.1	8.4	0.9	84	14	2	LOSAND	16	127	537	456	5545	25907	424	9549	4574	390	11	26	2	158	12	46	5.3
	72-84"	0.5	3	31	1	67	109	1328	2.2	11.8	86	1	4	72-84	4	7.7	8.4	0.9	92	6	2	SAND	15	111	511	228	5334	26688	393	9123	4034	328	8	24	2	135	11	43	4.7
	84-96"	0.3	3	40	3	81	132	1347	2.6	13.8	83.6	2	7	84-96	7	8	8.1	1.2	88	10	2	SAND	30	131	501	479	5589	24687	455	9758	4583	316	10	26	2	176	22	76	4.6
	96-108"	0.5	5	39	2	88	156	1413	2.6	15.1	82.3	2	7	96-108	7	8.6	8.2	1.2	88	10	2	SAND	33	177	620	559	6176	28544	501	10578	5125	350	11	30	2	177	27	91	4.2
	108-120"	0.6	3	42	1	69	134	1295	2.3	14.3	83.4	1	4	108-120	4	7.8	8.2	1.6	92	6	2	SAND	24	195	494	474	5493	25328	473	9089	4300	277	9	25	2	228	36	127	4.6
	120-132"	0.2	2	32	2	55	101	1195	2	12	86	1	4	120-127	4	7	8.4	0.9	94	4	2	SAND	16	92	423	259	4322	20425	295	7423	3275	247	6	22	2	133	30	103	3
WELL 12	0-12"	1.1	4	78	16	457	580	2600	6.2	25.4	68.4	63	227	0-12	227	19	7.4	5.3	28	66	6	SILOAM	616	1292	1535	4879	16963	53457	1635	28511	17423	768	62	92	2	552	221	763	4.5
	12-24"	0.3	1	58	5	213	390	1937	4	24.1	71.9	20	72	12-24	72	13.5	7.9	3.2	32	64	4	SILOAM	170	594	1412	4029	15419	48253	1483	26595	16073	630	53	79	2	508	129	385	5.7
	24-36"	0.4	1	54	5	201	405	1914	3.8	25	71.2	21	76	24-36	76	13.5	7.7	2.8	34	62	4	SILOAM	180	503	1398	4177	15637	47898	1845	27529	16673	629	55	80	2	509	71	203	7.8
	36-48"	0.4	2	54	5	206	378	1863	4.1	24.2	71.7	10	36	36-48	36	13	7.8	2.5	38	58	4	SILOAM	115	411	1465	4101	15839	48884	1746	28136	17058	655	51	81	2	474	61	173	7.9
	48-60"	0.3	1	51	4	204	356	1834	4.1	23.4	72.5	7	25	48-60	25	12.7	7.8	2.5	30	64	6	SILOAM	91	390	1478	3967	15789	50007	1706	28131	17024	629	49	81	2	452	57	174	7.6
	60-72"	0.6	1	44	6	194	357	1880	3.9	23.1	73	9	32	60-72	32	12.9	7.7	3.3	44	52	4	SILOAM	95	395	1276	3072	13500	47751	1220	22889	13168	572	37	75	2	448	96	294	5.8
	72-84"	0.2	1	46	4	120	207	1574	3.1	17.4	79.5	10	36	72-84	36	9.9	8	1.7	84	14	2	LOSAND	55	241	576	1136	7177	28380	555	12145	6306	396	17	37	2	202	47	155	3.6
	84-96"	0.2	6	25	2	49	95	1199	1.8	11.5	86.7	2	7	84-96	7	6.9	8.3	0.6	96	2	2	SAND	13	63	277	2	3941	20937	201	5263	2198	293	4	15	5	79	14	45	2.6
	96-108"	0.2	4	33	2	53	97	1201	2	11.7	86.3	3	11	96-108	11	6.9	8.1	1	96	2	2	SAND	44	129	581	250	4118	21275	248	6994	2854	290	6	21	2	127	23	78	3.2
	108-120"	0.2	3	33	3	59	110	1244	2.1	12.6	85.3	3	11	108-120	11	7.3	8.3	1.7	94	4	2	SAND	63	172	433	112	4397	21373	398	6961	2852	277	6	21	3	279	30	110	6.1
	120-132"	0.2	3	36	2	72	115	1282	2.4	12.6	85	4	14	108-120	14	7.6	8	1.1	92	6	2	SAND	31	116	391	335	5098	22222	343	8125	3462	327	8	22	2	167	23	81	4.2
WELL 2	0-12"	0.3	1	45	4	126	194	1581	3.3	16.5	80.2	10	36	0-12	36	9.8	7.7	2.9	68	30	2	SALOAM	89	521	989	1744	9303	34395	744	16383	8723	452	22	46	2	323	105	456	3.5
	12-24"	0.5	4	55	4	146	244	1653	3.5	19	77.5	1	4	12-24	4	10.7	7.9	1.5	62	36	2	SALOAM	52	236	1198	2504	11230	37809	874	20172	11104	478	29	57	2	308	70	257	4.4
	24-36"	0.2	1	41	3	92	143	1439	2.7	13.9	83.4	1	4	24-36	4	8.6	8.1	1.1	82	16	2	LOSAND	29	87	655	823	6702	26732	414	10725	5289	327	13	30	2	198	22	81	5
	36-48"	0.2	3	32	3	53	84	1211	2	10.1	87.9	2	7	36-48	7	6.9	8.3	0.8	94	4	2	SAND	34	143	426	157	4960	22814	409	7351	3416	287	7	22	2	149	11	45	5.1
	48-60"	0.1	3	19	1	37	65	1075	1.6	9	89.4	1	4	48-60	4	6	8.5	0.3	96	2	2	SAND	16	52	380	2	3738	21520	179	5138	1866	241	3	14	3	69	3	14	4.4
	60-72"	0.1	3	17	2	35	75	1052	1.5	10.4	88.1	1	4	60-72	4	6	8.4	0.5	96	2	2	SAND	24	94	364	2	4306	22577	274	6237	2325	257	3	17	2	99	7	27	4.4
	72-84"	0.1	1	17	1	33	96	1085	1.3	12.7	86	1	4	72-84	4	6.3	8.5	0.8	96	2	2	SAND	25	41	150	85	2432	13410	240	3281	1443	186	2	10	1	150	8	22	6.9
	84-96"	0.1	3	18	2	36	81	1082	1.5	10.9	87.6	1	4	84-96	4	6.2	8.5	1	96	2	2	SAND	56	47	150	1	2105	12010	205	2956	1282	153	2	8	1	194	10	32	7.6
	96-108"	0.1	5	21	2	35	65	992	1.6	9.7	88.7	1	4	96-108	4	5.6	8.5	1.2	96	2	2	SAND	24	66	150	63	1881	10333	203	2802	1123	116	2	8	1	243	11	37	9

Appendix B: Post-Revegetation Monitoring Data 2009

Vegetation Cover Data May 2009
Vegetation Cover Data October 2009
Shrub Density Data May 2009
Shrub Density Data October 2009
Pole Survival Data May & October 2009
Shrub Survival Data May & October 2009

Table B1: Vegetation Cover Data May 2009

Genus	Species	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Hits	Average Absolute Cover (%)	Average Relative Cover (%)	Frequency (%)
Forbs: Annual Introduced																										
Lactuca	serriola	prickly lettuce																					0	0.00	0.00	0.00
Melilotus	officianalsi	sweetclover							6														6	0.60	3.39	5.00
Sisymbrium	irio	London rocket						1															1	0.10	0.56	5.00
Subtotal								1	6														7	0.70	3.95	10.00
Forbs: Annual Native																										
Cryptantha	sp.	cryptantha						1															1	0.10	0.56	5.00
Xanthium	strumarium	rough cocklebur							1														1	0.10	0.56	5.00
Subtotal								1	1														2	0.20	1.13	10.00
Forbs: Perennial Native																										
Porophyllum	gracile	slender poreleaf															1						1	0.10	0.56	5.00
Suaeda	moquini	Mohave seablite				1	1									2							4	0.40	2.26	15.00
Subtotal						1	1									2	1						5	0.50	2.82	20.00
Total Forb Cover			0	0	0	1	1	2	7	0	0	0	0	0	0	2	1	0	0	0	0	0	14	1.40	7.91	30.00
Shrubs: Perennial Introduced																										
Tamarix	sp.	salt cedar				2			1	1		1			2	1					1		9	0.90	5.08	35.00
Subtotal						2			1	1		1			2	1					1		9	0.90	5.08	35.00
Shrubs: Perennial Native																										
Baccharis	sarathroides	desertbroom							1			11						2					14	1.40	7.91	15.00
Pluchea	sericea	arrowweed		15	16		6				3	9	8	3	15	17		10	28				130	13.00	73.45	55.00
Salix	exigua	coyote willow																					0	0.00	0.00	0.00
Subtotal				15	16		6		1		3	20	8	3	15	17		12	28				144	14.40	81.36	60.00
Total Shrub Cover			0	15	16	2	6	0	2	1	3	21	8	3	17	18	0	12	28	0	1	0	153	15.30	86.44	75.00
Trees: Perennial Native																										
Populus	fremontii	Fremont's cottonwood		3					1			1			1								6	0.60	3.39	20.00
Prosopis	pubescens	screwbean mesquite																				1	1	0.10	0.56	5.00
Salix	gooddingii	Goodding willow										3											3	0.30	1.69	5.00
Subtotal				3					1			4			1							1	10	1.00	5.65	25.00
Total Tree Cover			0	3	0	0	0	0	1	0	0	4	0	0	1	0	0	0	0	0	0	1	10	1.00	5.65	25.00
Total Vegetation Cover			**0**	**18**	**16**	**3**	**7**	**2**	**10**	**1**	**3**	**25**	**8**	**3**	**18**	**20**	**1**	**12**	**28**	**0**	**1**	**1**	**177**	**17.70**	**100.00**	**90.00**
Total Ground Cover			**9**	**36**	**41**	**6**	**18**	**8**	**44**	**42**	**10**	**41**	**21**	**29**	**39**	**29**	**16**	**25**	**33**	**46**	**19**	**1**	**513**	**51.30**		**100.00**
Rock							1	3					1								3		8	0.80		20.00
Litter			9	18	25	3	10	3	34	41	7	16	12	26	21	9	15	13	5	46	15		328	32.80		95.00
Bare Ground			41	14	9	44	32	42	6	8	40	9	29	21	11	21	34	25	17	4	31	49	487	48.70		100.00
Total Hits			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	1000	100.00		100.00

Table B2: Vegetation Cover Data October 2009

Genus	Species	Common Name	1	2	3	4	5	6	21	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Hits	Average Absolute Cover (%)	Average Relative Cover (%)	Frequency (%)
Forbs: Annual Native																										
Cryptantha	sp.	cryptantha						3															3	0.30	1.75	5.00
Subtotal								3															3	0.30	1.75	5.00
Forbs: Perennial Native																										
Heliotropium	curassavicum	salt heliotrope							2														2	0.20	1.17	5.00
Subtotal									2														2	0.20	1.17	5.00
Total Forb Cover			0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.50	2.92	10.00
Shrubs: Perennial Introduced																										
Tamarix	sp.	salt cedar	2		2	6	2	1					1		1	2				5	2		24	2.40	14.04	50.00
Subtotal			2		2	6	2	1					1		1	2				5	2		24	2.40	14.04	50.00
Shrubs: Perennial Native																										
Baccharis	sarathroides	desertbroom										9						1					10	1.00	5.85	10.00
Pluchea	sericea	arrowweed		6	21		4		5	5	13	5	2	8	15	9			28		3	1	125	12.50	73.10	70.00
Subtotal				6	21		4		5	5	13	14	2	8	15	9		1	28		3	1	135	13.50	78.95	75.00
Total Shrub Cover			2	6	23	6	6	1	5	5	13	14	3	8	16	11	0	1	28	5	5	1	159	15.90	92.98	95.00
Trees: Perennial Native																										
Populus	fremontii	Fremont's cottonwood										1											1	0.10	0.58	5.00
Prosopis	pubescens	screwbean mesquite																				4	4	0.40	2.34	5.00
Salix	gooddingii	Goodding willow										2											2	0.20	1.17	5.00
Subtotal												3										4	7	0.70	4.09	10.00
Total Tree Cover			0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	4	7	0.70	4.09	10.00
Total Vegetation Cover			**2**	**6**	**23**	**6**	**6**	**4**	**7**	**5**	**13**	**17**	**3**	**8**	**16**	**11**	**0**	**1**	**28**	**5**	**5**	**5**	**171**	**17.10**	**100.00**	**95.00**
Total Ground Cover			**8**	**34**	**46**	**15**	**10**	**16**	**25**	**47**	**28**	**46**	**15**	**28**	**41**	**20**	**5**	**13**	**36**	**38**	**16**	**5**	**492**	**49.20**		**100.00**
Rock							1	5										1			1		8	0.80		20.00
Litter			6	28	23	9	3	7	18	42	15	29	12	20	25	9	5	11	8	33	10		313	31.30		95.00
Bare Ground			42	16	4	35	40	34	25	3	22	4	35	22	9	30	45	37	14	12	34	45	508	50.80		100.00
Total Hits			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	1000	100.00		100.00

Table B3: Shrub Density Data May 2009

Genus	Species	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Stems	Average Density (stems/50m2)	Average Density (stems/acre)
Shrubs: Perennial Introduced																									
Tamarix	sp.	salt cedar	5		2	9			71	1	1	3	1		3	1				6	4		107	5.35	433
Subtotal			5	0	2	9	0	0	71	1	1	3	1	0	3	1	0	0	0	6	4	0	107	5.35	433
Shrubs: Perennial Native																									
Baccharis	sarathroides	desertbroom							40			10						1					51	2.55	206
Pluchea	sericea	arrowweed	6	48	69		9			24	100	16	33	5	110	34		46	97			11	608	30.40	2,460
Salix	exigua	coyote willow							9														9	0.45	36
Subtotal			6	48	69	0	9	0	49	24	100	26	33	5	110	34	0	47	97	0	0	11	668	33.40	2,703
Trees: Perennial Native																									
Populus	fremontii	Fremont's cottonwood		1	1				3			1			1		2						9	0.45	36
Prosopis	glandulosa	honey mesquite			2																		2	0.10	8
Prosopis	pubescens	screwbean mesquite							1													1	2	0.10	8
Salix	gooddingii	Goodding willow			2							2											4	0.20	16
Subtotal			0	1	5	0	0	0	4	0	0	3	0	0	1	0	2	0	0	0	0	1	17	0.85	69
Total Density (Stems/50m2)			**11**	**49**	**76**	**9**	**9**	**0**	**124**	**25**	**101**	**32**	**34**	**5**	**114**	**35**	**2**	**47**	**97**	**6**	**4**	**12**	**792**	**39.60**	**3,205**
Total Density (Stems/acre)			**890**	**3,966**	**6,151**	**728**	**728**	**0**	**10,036**	**2,023**	**8,175**	**2,590**	**2,752**	**405**	**9,227**	**2,833**	**162**	**3,804**	**7,851**	**486**	**324**	**971**	**64,102**	**3,205**	

Table B4: Shrub Density Data October 2009

Genus	Species	Common Name	1	2	3	4	5	6	21	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Stems	Average Density (stems/50m2)	Average Density (stems/acre)
Shrubs: Perennial Introduced																									
Tamarix	sp.	salt cedar	8		4	11	3	1		1		2	1	2	9	1				18	3		64	3	259
Subtotal			8	0	4	11	3	1	0	1	0	2	1	2	9	1	0	0	0	18	3	0	64	3	259
Shrubs: Perennial Native																									
Baccharis	sarathroides	desertbroom										16						1					17	1	69
Pluchea	sericea	arrowweed	5	45	101		7		28	30	78	23	21	12	123	26		4	62	3	3	6	577	29	2,335
Salix	exigua	coyote willow																					0	0	0
Subtotal			5	45	101	0	7	0	28	30	78	39	21	12	123	26	0	5	62	3	3	6	594	30	2,404
Trees: Perennial Native																									
Populus	fremontii	Fremont's cottonwood			2																		2	0	8
Prosopis	glandulosa	honey mesquite																					0	0	0
Prosopis	pubescens	screwbean mesquite																					0	0	0
Salix	gooddingii	Goodding willow										2											2	0	8
Subtotal			0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	4	0	16
Total Density (Stems/50m2)			**13**	**45**	**107**	**11**	**10**	**1**	**28**	**31**	**78**	**43**	**22**	**14**	**132**	**27**	**0**	**5**	**62**	**21**	**6**	**6**	**662**	**33**	**2,679**
Total Density (Stems/acre)			**1,052**	**3,642**	**8,660**	**890**	**809**	**81**	**2,266**	**2,509**	**6,313**	**3,480**	**1,781**	**1,133**	**10,684**	**2,185**	**0**	**405**	**5,018**	**1,700**	**486**	**486**	**53,580**	**2,679**	

Table B5: Pole Survival Data May & October 2009

			Survival		Height		Diameter
SPECIES	**NUMBER**	**COMMENT**	**May 09**	**Oct 09**	**May 09**	**Oct 09**	**Oct 09**
Cottonwood	1		Dead	Dead	105		1.50
Cottonwood	2	Resprout 10/09	Alive	Alive	120		2.00
Cottonwood	3		Alive	Dead	86		0.75
Cottonwood	4	ants	Alive	Dead	48	9.5	1.75
Cottonwood	5	top dead	Alive	Alive	104	47.0	1.50
Cottonwood	6	ants	Dead	Dead	60		0.50
Cottonwood	7	ants	Alive	Alive	50		0.75
Cottonwood	8		Dead	Dead	112		1.00
Cottonwood	9		Alive	Dead	68		0.75
Cottonwood	10		Dead	Dead	99		1.25
Cottonwood	11		Dead	Dead	59		1.50
Cottonwood	12	Bark damage	Alive	Alive	130		1.25
Cottonwood	13		Dead	Dead	86		1.00
Cottonwood	14	bug holes	Dead	Dead	108		1.00
Cottonwood	15		Dead	Dead	78		1.50
Cottonwood	16	bark striped by animals	Alive	Dead	82		1.00
Cottonwood	17		Dead	Dead	95		1.13
Cottonwood	18		Dead	Dead	103		1.50
Cottonwood	19		Dead	Dead	86		0.50
Cottonwood	20		Alive	Dead	84		0.88
Cottonwood	21		Alive	Alive	75		1.25
Cottonwood	22		Dead	Dead	60		0.75
Cottonwood	23	GONE!	Alive	Dead	86	1.0	0.00
Cottonwood	24		Alive	Dead	79		1.50
Cottonwood	25		Alive	Dead	82	54.0	1.25
Cottonwood	26	top broken	Alive	Dead	88		1.50
Cottonwood	27	Beavered	Alive	Alive	28	44.0	1.00
Cottonwood	28		Alive	Alive	64		1.25
Cottonwood	29	Broken	Alive	Dead	53	29.0	1.50
Cottonwood	30	Resprout 10/09	Alive	Alive	87	37.0	1.25
Cottonwood	31		Dead	Dead	73		0.75
Cottonwood	32	top dead	Alive	Dead	95		1.00
Cottonwood	33	top dead	Alive	Alive	92		1.50
Cottonwood	34		Dead	Dead	49		0.25
Cottonwood	35	top dead	Alive	Dead	104		1.50
Cottonwood	36		Dead	Dead	93		1.50
Cottonwood	37	top dead	Alive	Dead	105		1.50
Cottonwood	38	top dead	Alive	Dead	96		1.50
Cottonwood	39	Resprout 10/09	Alive	Alive	53	21.0	1.00
Cottonwood	40	top dead	Alive	Alive	87		1.75
Willow	1		Alive	Dead	92		1.00
Willow	2		Dead	Dead	82		0.75
Willow	3		Dead	Not sure?	120		1.25
Willow	4		Dead	Dead	112		1.50
Willow	5		Dead	Dead	102		1.25
Willow	6		Alive	Alive	89		1.00
Willow	7	No soil-Outside	Alive	Dead	130		1.75
Willow	8		Dead	Dead	53		1.00
Willow	9		Dead	Dead	70		1.00
Willow	10		Alive	Alive	85		1.00
Willow	11		Dead	Dead	150		1.50
Willow	12		Dead	Dead	78		1.00
Willow	13	top dead	Alive	Alive	100		1.50
Willow	14		Dead	Dead	73		0.50
Willow	15	top dead	Alive	Alive	150		2.00

Table B7: Shrub Survival Data May & October 2009

			Survival		Height		Diameter
SPECIES	**NUMBER**	**COMMENT**	**May 09**	**Oct 09**	**May 09**	**Oct 09**	**Oct 09**
Desert willow	1		Alive	Dead	46	61.0	0.25
Desert willow	4		Alive	Alive	59	78.0	1.00
Desert willow	11	laying down	Alive	Alive	66	66.0	0.50
Desert willow	12		Alive	Dead	64	61.0	0.50
Desert willow	15		Alive	Alive	61	61.0	0.50
Desert willow	20		Alive	Alive	46	46.0	0.50
Desert willow	29		Alive	Alive	67	74.0	0.88
Desert willow	33		Alive	Dead	62	60.0	0.50
Desert willow	34		Alive	Alive	51	34.0	0.50
Desert willow	46	based chewed on	Alive	Alive	52	60.0	0.50
Desert willow	48	resprout from base 0.25 diam	Alive	Alive	65	10.0	0.50
Desert willow	54	flowers	Alive	Dead	59	57.0	0.50
Desert willow	58	good	Alive	Dead	54	52.0	0.50
Desert willow	61		Alive	Dead	58	49.0	0.75
Desert willow	69		Alive	Alive	50	50.5	0.38
Honey mesquite	70	dead branches floppped over	Alive	Alive	83	91.0	1.13
Honey mesquite	74	soil void @ base	Dead	Alive	63	81.0	0.75
Honey mesquite	78	2 stems	Alive	Alive	65	72.0	1.38
Honey mesquite	86	great	Alive	Alive	61	63.0	1.25
Honey mesquite	89	flowers	Alive	Alive	52	62.0	0.88
Honey mesquite	91	yellowing leaves	Alive	Alive	57	64.0	0.75
Honey mesquite	94	good	Alive	Alive	68	45.5	0.63
Honey mesquite	101	tpp dead	Alive	Alive	58	83.0	0.75
Honey mesquite	102		Alive	Dead	65	53.0	0.75
Honey mesquite	115		Alive	Alive	49	75.0	0.75
Honey mesquite	120		Alive	Alive	73	100.0	1.50
Honey mesquite	131		Alive	Alive	67	71.0	0.75
Honey mesquite	136	great	Alive	Alive	62	73.0	0.50
Honey mesquite	137	great	Alive	Alive	59	56.0	1.00
Honey mesquite	96	Added in October to replace mis-labelled sample		Alive		68.0	1.00
Screwbean mesquite	112	Relabelled in Oct, labeled Honey in May	Alive	Alive	75	53.0	0.50
Screwbean mesquite	141		Alive	Alive	66	73.0	1.25
Screwbean mesquite	144		Alive	Alive	84	86.0	1.00
Screwbean mesquite	155		Alive	Alive	62	71.0	0.88
Screwbean mesquite	157	resprout from base	Dead	Alive	63	26.0	0.38
Screwbean mesquite	164		Alive	Alive	62	83.0	0.50
Screwbean mesquite	168	lower branches dead, somewhat stressed	Alive	Alive	76	76.0	0.38
Screwbean mesquite	171	flopped over	Alive	Alive	65	68.0	0.50
Screwbean mesquite	172	laying down	Alive	Alive	65	83.0	0.75
Screwbean mesquite	178		Alive	Dead	76	67.0	0.50
Screwbean mesquite	179	2stems	Alive	Alive	64	77.0	0.50
Screwbean mesquite	190		Alive	Alive	75	52.0	1.00
Screwbean mesquite	201		Alive	Alive	62	58.0	0.38
Screwbean mesquite	202		Alive	Alive	84	86.0	0.63
Screwbean mesquite	203		Alive	Alive	60	58.0	0.50
Screwbean mesquite	211		Alive	Alive	70	67.0	0.50

Appendix C: Post-Revegetation Monitoring Data 2010

Vegetation Cover Data April 2010
Vegetation Cover Data October 2010
Shrub Density Data April 2010
Shrub Density Data October 2010
Cottonwood Pole Survival Data April & October 2010
Willow Pole Survival Data April & October 2010
Shrub Survival Data April & October 2010

Table C1:Vegetation Cover Data April 2010

Genus	Species	Common Name	1	2	3	4	5	6	21	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Hits	Average Absolute Cover (%)	Average Relative Cover (%)	Frequency (%)
Grass & Grass-Like: Annual Introduced																										
Schismus	*barbatus*	common Mediterranean grass	1					6															7	0.70	1.93	10.00
Subtotal			1					6															7	0.70	1.93	10.00
Total Graminoid Cover			1	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.70	1.93	10.00
Forbs: Annual Introduced																										
Chenopodium	*murale*	nettleleaf goosefoot								2													2	0.20	0.55	5.00
Sisymbrium	*irio*	London rocket					1	1		1								1					4	0.40	1.10	20.00
Sonchus	*asper*	spiny sowthistle															2						2	0.20	0.55	5.00
Sonchus	*oleraceus*	common sowthistle	1								1												2	0.20	0.55	10.00
Subtotal			1				1	1		3	1						2	1					10	1.00	2.75	35.00
Forbs: Annual Native																										
Cryptantha	*micrantha*	redroot cryptantha	4			19	15	29		1			15						6		17		106	10.60	29.20	40.00
Oligomeris	*linifolia*	lineleaf whitepuff	2			7	4						3			4		5			1		26	2.60	7.16	35.00
Subtotal			6			26	19	29		1			18			4		5	6		18		132	13.20	36.36	50.00
Forbs: Perennial Native																										
Heliotropium	curassavicum	salt heliotrope							4		2		2										8	0.80	2.20	15.00
Porophyllum	gracile	slender poreleaf															1						1	0.10	0.28	5.00
Pseudognaphalium	canescens	Wright's cudweed									2												2	0.20	0.55	5.00
Subtotal									4		4		2				1						11	1.10	3.03	20.00
Total Forb Cover			7	0	0	26	20	30	4	4	5	0	20	0	0	4	3	6	6	0	18	0	153	15.30	42.15	65.00
Shrubs: Perennial Introduced																										
Tamarix	sp.	salt cedar				4		1								2				1	1		9	0.90	2.48	25.00
Subtotal						4		1								2				1	1		9	0.90	2.48	25.00
Shrubs: Perennial Native																										
Atriplex	lentiformis	quailbush	1															1					2	0.20	0.55	10.00
Baccharis	salicifolia	mulefat		1		1						14						1		1			18	1.80	4.96	25.00
Pluchea	sericea	arrowweed	3	11	14		1		9	15	13	7	10	8	21	12		1	36		7		168	16.80	46.28	75.00
Subtotal			4	12	14	1	1		9	15	13	21	10	8	21	12		3	36	1	7		188	18.80	51.79	85.00
Total Shrub Cover			4	12	14	5	1	1	9	15	13	21	10	8	21	14	0	3	36	2	8	0	197	19.70	54.27	90.00
Trees: Perennial Native																										
Populus	fremontii	Fremont's cottonwood										2										1	3	0.30	0.83	10.00
Salix	gooddingii	Goodding's willow															3						3	0.30	0.83	5.00
Subtotal												2					3					1	6	0.60	1.65	15.00
Total Tree Cover			0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	1	6	0.60	1.65	15.00
Total Vegetation Cover			**12**	**12**	**14**	**31**	**21**	**37**	**13**	**19**	**18**	**23**	**30**	**8**	**21**	**18**	**6**	**9**	**42**	**2**	**26**	**1**	**363**	**36.30**	**100.00**	**100.00**
Total Ground Cover			**21**	**31**	**44**	**35**	**24**	**39**	**17**	**46**	**28**	**43**	**39**	**29**	**48**	**23**	**22**	**27**	**47**	**38**	**37**	**8**	**646**	**64.60**		**100.00**
Rock																		1					1	0.10		5.00
Litter			9	19	30	4	3	2	4	27	10	20	9	21	27	5	16	17	5	36	11	7	282	28.20		100.00
Bare Ground			29	19	6	15	26	11	33	4	22	7	11	21	2	27	28	23	3	12	13	42	354	35.40		100.00
Total Hits			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	1000	100.00		100.00

Table C2: Vegetation Cover Data October 2010

Genus	Species	Common Name	1	2	3	4	5	6	21	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Hits	Average Absolute Cover (%)	Average Relative Cover (%)	Frequency (%)
Grass & Grass-Like: Annual Introduced																										
Polypogon	*monspelensis*	annual rabbitsfoot grass									3												3	0.30	0.78	5.00
Schismus	*barbatus*	common Mediterranean grass	2				4	6												1	1		14	1.40	3.63	25.00
Subtotal			2				4	6			3									1	1		17	1.70	4.40	30.00
Grass & Grass-Like: Perennial Native																										
Phragmites	australis	common reed												1									1	0.10	0.26	5.00
Subtotal														1									1	0.10	0.26	5.00
Total Graminoid Cover			2	0	0	0	4	6	0	0	3	0	0	1	0	0	0	0	0	1	1	0	18	1.80	4.66	35.00
Forbs: Annual Introduced																										
Lactuca	serriola	prickly lettuce				1		1															2	0.20	0.52	10.00
Sisymbrium	irio	London rocket					1	4		2													7	0.70	1.81	15.00
Sonchus	oleraceus	common sowthistle									1												1	0.10	0.26	5.00
Subtotal						1	1	5		2	1												10	1.00	2.59	25.00
Forbs: Annual Native																										
Cryptantha	micrantha	redroot cryptantha	14			20	10	24					11			1			2		7		89	8.90	23.06	40.00
Oligomeris	linifolia	lineleaf whitepuff	2			8	3	1					6			1		3					24	2.40	6.22	35.00
Subtotal			16			28	13	25					17			2		3	2		7		113	11.30	29.27	45.00
Forbs: Perennial Introduced																										
Porophyllum	gracile	slender poreleaf															3						3	0.30	0.78	5.00
Pseudognaphalium	canescens	Wright's cudweed									1												1	0.10	0.26	5.00
Subtotal											1						3						4	0.40	1.04	10.00
Total Forb Cover			16	0	0	29	14	30	0	2	2	0	17	0	0	2	3	3	2	0	7	0	127	12.70	32.90	60.00
Shrubs: Perennial Introduced																										
Tamarix	sp.	salt cedar				2						3			2	2				1			10	1.00	2.59	25.00
Subtotal						2						3			2	2				1			10	1.00	2.59	25.00
Shrubs: Perennial Native																										
Baccharis	salicifolia	mulefat				1						9	3										13	1.30	3.37	15.00
Baccharis	*sarothroides*	desertbroom										1											1	0.10	0.26	5.00
Atriplex	canescens	fourwing saltbush		1			1			1											1		4	0.40	1.04	20.00
Atriplex	lentiformis	quailbush		1		6	3			13			2					4			7		36	3.60	9.33	35.00
Pluchea	sericea	arrowweed	4	11	14		3		15	13	11	8	2	12	16	12		11	37	1		1	171	17.10	44.30	80.00
Subtotal			4	13	14	7	7		15	27	11	18	7	12	16	12		15	37	1	8	1	225	22.50	58.29	90.00
Total Shrub Cover			4	13	14	9	7	0	15	27	11	21	7	12	18	14	0	15	37	2	8	1	235	23.50	60.88	90.00
Trees: Perennial Native																										
Populus	fremontii	Fremont's cottonwood		1	1							1											3	0.30	0.78	15.00
Prosopis	pubescens	screwbean mesquite																				1	1	0.10	0.26	5.00
Salix	gooddingii	Goodding willow			2																		2	0.20	0.52	5.00
Subtotal				1	3							1										1	6	0.60	1.55	20.00
Total Tree Cover			0	1	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	6	0.60	1.55	20.00
Total Vegetation Cover			**22**	**14**	**17**	**38**	**25**	**36**	**15**	**29**	**16**	**22**	**24**	**13**	**18**	**16**	**3**	**18**	**39**	**3**	**16**	**2**	**386**	**38.60**	**100.00**	**100.00**
Total Ground Cover			**34**	**43**	**50**	**45**	**38**	**41**	**29**	**50**	**37**	**42**	**38**	**34**	**46**	**32**	**11**	**31**	**47**	**40**	**32**	**6**	**726**	**72.60**		**100.00**
Rock					27																1		28	2.80		10.00
Litter			12	29	6	7	13	5	14	21	21	20	14	21	28	16	8	13	8	37	15	4	312	31.20		100.00
Bare Ground			16	7		5	12	9	21		13	8	12	16	4	18	39	19	3	10	18	44	274	27.40		90.00
Total Hits			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	1000	100.00		100.00

Table C3: Shrub Density Data April 2010

Genus	Species	Common Name	1	2	3	4	5	6	21	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Stems	Average Density (stems/50m2)	Average Density (stems/acre)
Shrubs: Perennial Introduced																									
Tamarix	sp.	salt cedar	5		4	8		1			1	2		1		1		3		3	5	1	35	1.8	142
Subtotal			5	0	4	8	0	1	0	0	1	2	0	1	0	1	0	3	0	3	5	1	35	1.8	142
Shrubs: Perennial Native																									
Atriplex	canescens	fourwing saltbush					2								523			1					526	26.3	2,129
Atriplex	lentiformis	quailbush	1			10	4	1		17			2		2			14					51	2.6	206
Baccharis	salicifolia	mulefat	24	22		331					168	2600	22					84	6			1	3258	162.9	13,185
Pluchea	sericea	arrowweed	41	53	126	1	11	3	80	34	92	23	29	9	119	19		26	93	1	10	10	780	39.0	3,157
Subtotal			66	75	126	342	17	4	80	51	260	2623	53	9	644	19	0	125	99	1	10	11	4615	230.8	18,676
Trees: Perennial Native																									
Populus	fremontii	Fremont's cottonwood			1				1			1											3	0.2	12
Subtotal			0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0.2	12
Total Density (Stems/50m2)			**71**	**75**	**131**	**350**	**17**	**5**	**81**	**51**	**261**	**2626**	**53**	**10**	**644**	**20**	**0**	**128**	**99**	**4**	**15**	**12**	**4653**	**232.7**	**18,830**
Total Density (Stems/acre)			**5,747**	**6,070**	**10,603**	**28,328**	**1,376**	**405**	**6,556**	**4,128**	**21,125**	**212,541**	**4,290**	**809**	**52,124**	**1,619**	**0**	**10,360**	**8,013**	**324**	**1,214**	**971**	**376,601**	**18,830**	

Table C4: Shrub Density Data October 2010

Genus	Species	Common Name	1	2	3	4	5	6	21	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Stems	Average Density (stems/50m2)	Average Density (stems/acre)
Shrubs: Perennial Introduced																									
Tamarix	sp.	salt cedar			3	4		1				11	1		5			1		3	3		32	1.6	129
Subtotal			0	0	3	4	0	1	0	0	0	11	1	0	5	0	0	1	0	3	3	0	32	1.6	129
Shrubs: Perennial Native																									
Baccharis	salicifolia	mulefat	9	1		30	1			2	1	4	10					21			1		80	4.0	324
Baccharis	*sarothroides*	desertbroom										1											1	0.1	4
Atriplex	canescens	fourwing saltbush	2	1		3	3			2			2			1		1			3		18	0.9	73
Atriplex	lentiformis	quailbush	2	1		17	6			21			2					11			8		68	3.4	275
Pluchea	sericea	arrowweed	26	57	68		12		47	33	102	53	29	17	111	26		37		3	4	12	637	31.9	2,578
Subtotal			39	60	68	50	22	0	47	58	103	58	43	17	111	27	0	70	0	3	16	12	804	40.2	3,254
Trees: Perennial Native																									
Populus	fremontii	Fremont's cottonwood			3				1			1											5	0.3	20
Subtotal			0	0	3	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	5	0.3	20
Total Density (Stems/50m2)			**39**	**60**	**74**	**54**	**22**	**1**	**48**	**58**	**103**	**70**	**44**	**17**	**116**	**27**	**0**	**71**	**0**	**6**	**19**	**12**	**841**	**42.1**	**3,403**
Total Density (Stems/acre)			**3,157**	**4,856**	**5,989**	**4,371**	**1,781**	**81**	**3,885**	**4,694**	**8,337**	**5,666**	**3,561**	**1,376**	**9,389**	**2,185**	**0**	**5,747**	**0**	**486**	**1,538**	**971**	**68,068**	**3,403**	

Table C5: Cottonwood Pole Survival Data April & October 2010

			Survival		Height		Diameter	
SPECIES	**NUMBER**	**COMMENT**	**Apr 10**	**Oct 10**	**Apr 10**	**Oct 10**	**Apr 10**	**Oct 10**
Cottonwood	1		Dead	Dead	0.00	0.00		
Cottonwood	2		Alive	Alive	4.20	4.20	0.5	2.0
Cottonwood	3		Dead	Dead	0.00	0.00		
Cottonwood	4	beaver	Dead	Dead	0.00	0.00		
Cottonwood	5		Alive	Alive	4.06	3.83		1.5
Cottonwood	6		Dead	Dead	0.00	0.00		
Cottonwood	7		Alive	dead	0.67	0.67		
Cottonwood	8		Dead	Dead	0.00	0.00		
Cottonwood	9		Dead	Dead	0.00	0.00		
Cottonwood	10		Dead	Dead	0.00	0.00		
Cottonwood	11		Dead	Dead	0.00	0.00		
Cottonwood	12	Resprout	Alive	Alive	23.00	5.50	0.1	0.5
Cottonwood	13		Dead	Dead	0.00	0.00		
Cottonwood	14		Dead	Dead	0.00	0.00		
Cottonwood	15		Dead	Dead	0.00	0.00		
Cottonwood	16		Dead	Dead	0.00	0.00		
Cottonwood	17		Dead	Dead	0.00	0.00		
Cottonwood	18		Dead	Dead	0.00	0.00		
Cottonwood	19		Dead	Dead	0.00	0.00		
Cottonwood	20		Dead	Dead	0.00	0.00		
Cottonwood	21		Alive	Alive	7.50	9.08		2.5
Cottonwood	22		Dead	Dead	0.00	0.00		
Cottonwood	23	missing	Dead	Dead	0.00	0.00		
Cottonwood	24		Dead	Dead	0.00	0.00		
Cottonwood	25		Dead	Dead	0.00	0.00		
Cottonwood	26		Dead	Dead	0.00	0.00		
Cottonwood	27	beaver but alive	Alive	dead	3.75	3.75	0.4	
Cottonwood	28		Dead	Dead	0.00	0.00		
Cottonwood	29	Broken	Dead	Dead	0.00	0.00		
Cottonwood	30		Alive	Dead	3.50	0.00		
Cottonwood	31		Dead	Dead	0.00	0.00		
Cottonwood	32	beaver	Dead	Dead	0.00	0.00		
Cottonwood	33		Dead	Dead	0.00	0.00		
Cottonwood	34		Dead	Dead	0.00	0.00		
Cottonwood	35		Dead	Dead	0.00	0.00		
Cottonwood	36		Dead	Dead	0.00	0.00		
Cottonwood	37		Dead	Dead	0.00	0.00		
Cottonwood	38		Dead	Dead	0.00	0.00		
Cottonwood	39		Dead	Dead	0.00	0.00		
Cottonwood	40	bafk peeled	Alive	dead	4.00	4.00		
Cottonwood	41	gone	Dead	Dead	0.00	0.00		
Cottonwood	42		Dead	Dead	0.00	0.00		
Cottonwood	43	Bark damage	Dead	Dead	0.00	0.00		
Cottonwood	44	resprout beaver stressed	Alive	Alive	3.50	4.33	0.4	0.8
Cottonwood	45	beaver but alive	Alive	Alive	4.50	9.17		2.5
Cottonwood	46		Dead	Dead	0.00	0.00		
Cottonwood	47		Dead	Dead	0.00	0.00		
Cottonwood	48		Dead	Dead	0.00	0.00		
Cottonwood	49		Dead	Dead	0.00	0.00		
Cottonwood	50		Alive	Dead	10.30	0.00		

Table C6: Willow Pole Survival Data April & October 2010

			Survival		Height		Diameter	
SPECIES	**NUMBER**	**COMMENT**	**Apr 10**	**Oct 10**	**Apr 10**	**Oct 10**	**Apr 10**	**Oct 10**
Willow	1		Dead	Dead	0.00	0.00		
Willow	2		Dead	Dead	0.00	0.00		
Willow	3	Outside	Dead	Dead	0.00	0.00		
Willow	4		Dead	Dead	0.00	0.00		
Willow	5		Dead	Dead	0.00	0.00		
Willow	6		Alive	Alive	6.00	6.25		1.5
Willow	7	No soil-Outside	Alive	Alive	7.80	8.00		2.0
Willow	8		Dead	Dead	0.00	0.00		
Willow	9		Dead	Dead	0.00	0.00		
Willow	10		Alive	Dead	8.50	0.00		
Willow	11		Dead	Dead	0.00	0.00		
Willow	12	Outside	Dead	Dead	0.00	0.00		
Willow	13	Outside	Dead	Dead	0.00	0.00		
Willow	14	Outside	Dead	Dead	0.00	0.00		
Willow	15		Alive	Dead	7.50	0.00		
Willow	16		Dead	Dead	0.00	0.00		
Willow	17		Dead	Dead	0.00	0.00		
Willow	18	Outside-Beaver	Dead	Dead	0.00	0.00		
Willow	19	gone	Dead	Dead	0.00	0.00		
Willow	20	Outside	Alive	Dead	7.67	0.00		
Willow	21		Alive	Alive	6.00	5.38		1.8
Willow	22		Dead	Dead	0.00	0.00		
Willow	23		Dead	Dead	0.00	0.00		
Willow	24		Dead	Dead	0.00	0.00		
Willow	25		Dead	Dead	0.00	0.00		

Table C7: Shrub Survival Data April & October 2010

			Survival		Height		
Species	NUMBER	Comment	Apr 10	Oct 10	Apr 10	Oct 10	Growth
Chilopsis	1	innundated	Dead	Dead	0.00	0.00	
Chilopsis	4		Dead	Dead	0.00	0.00	
Chilopsis	11		Alive	Alive	3.75	4.00	0.25
Chilopsis	12		Dead	Dead	0.00	0.00	
Chilopsis	15		Dead	Dead	0.00	0.00	
Chilopsis	20		Alive	Alive	3.67	3.25	-0.42
Chilopsis	29		Alive	Alive	6.50	5.42	-1.08
Chilopsis	33		Dead	Dead	0.00	0.00	
Chilopsis	34		Alive	Alive	2.30	3.00	0.70
Chilopsis	46	resprout	Alive	Alive	0.75	1.17	0.42
Chilopsis	48		Alive	Alive	5.25	5.25	0.00
Chilopsis	54		Dead	Dead	0.00	0.00	
Chilopsis	58		Dead	Dead	0.00	0.00	
Chilopsis	59		Dead	Dead	0.00	0.00	
Chilopsis	61		Dead	Dead	0.00	0.00	
Chilopsis	69		Alive	dead	3.00	3.00	
PRGL	70	innundated	Dead	Dead	0.00	0.00	
PRGL	74		Alive	Alive	7.10	9.25	2.15
PRGL	78		Alive	Alive	6.25	6.33	0.08
PRGL	86	alive but v sad few leaves	Alive	dead	9.50	9.50	
PRGL	89	alive but sad	Alive	Alive	6.00	6.00	0.00
PRGL	91		Alive	Alive	6.20	8.50	2.30
PRGL	94		Alive	Alive	5.00	5.00	0.00
PRGL	96		Alive	Alive	6.50	8.33	1.83
PRGL	101		Alive	Alive	4.30	5.08	0.78
PRGL	102		Dead	Dead	0.00	0.00	
PRGL	112		Alive	Alive	5.80	6.50	0.70
PRGL	115		Dead	Dead	0.00	0.00	
PRGL	120		Dead	Dead	0.00	0.00	
PRGL	131		Alive	Alive	6.20	6.25	0.05
PRGL	136		Alive	Alive	6.50	8.08	1.58
PRGL	137		Alive	Alive	4.75	4.75	0.00
PRPU	141	innundated-sad	Alive	Alive	6.25	3.67	-2.58
PRPU	144	overgrown w/ phau inunda	Alive	Alive	7.75	6.75	-1.00
PRPU	150		Alive	Alive	6.00	9.50	3.50
PRPU	155		Alive	Alive	6.50	10.67	4.17
PRPU	157	missing	Dead	Dead	0.00	0.00	
PRPU	164		Alive	Alive	5.75	10.50	4.75
PRPU	168		Alive	Alive	6.25	6.50	0.25
PRPU	171		Alive	Alive	5.25	8.50	3.25
PRPU	172		Alive	Alive	7.50	13.17	5.67
PRPU	178		Alive	Alive	5.00	5.50	0.50
PRPU	179		Alive	Alive	5.80	7.75	1.95
PRPU	190		Alive	Alive	4.75	7.75	3.00
PRPU	194		Alive	Alive	7.00	12.50	5.50
PRPU	201	mostly dead	Alive	Alive	5.00	3.67	-1.33
PRPU	202		Alive	Alive	7.25	6.25	-1.00
PRPU	203		Alive	Alive	5.25	5.50	0.25
PRPU	211		Alive	Alive	5.75	7.83	2.08