Yuma East Wetlands

Quechan Arizona Water Protection Fund Revegetation Project

(Grant # 05-134WPF)

Final Report

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Quechan Indian Tribe

Prepared for:

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The Arizona Water Protection Fund Commission has funded this entire Project. The views and findings presented are the Grantee's and do not necessarily represent those of the Commission, the State, or the Arizona Department of Water Resources.

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Executive Summary

The riparian area in the Yuma East Wetlands and the Lower Colorado River have been referred to as "one of the most ecologically altered landscapes in the southwest" (Stevens, 2003) primarily due to the effects of dam impoundments on the river system. Historically, large stands of native cottonwood/willow gallery forests and mesquite bosques flourished along the river corridor. Under current conditions, non-native, invasive tamarisk and phragmites dominate the riparian areas and banks of the lower Colorado River. Monotypic stands of tamarisk have created a degraded habitat for birds and other wildlife, including many endangered and threatened species. In 2001, a comprehensive restoration plan was produced by Fred Phillips Consulting to restore the wetlands and riparian areas into valuable wildlife habitat. The Quechan Indian Tribal Arizona Water Protection Fund (QAWPF) riparian and wetland restoration project (Grant # 05-134WPF) has helped realize the vision outlined in this Plan.

The QAWPF 25 acre restoration site is located on the southern side of the Colorado River adjacent to and north of the South Channel Revegetation Site and east of the YEW Pilot Project within the Yuma East Wetlands Restoration Project on the Lower Colorado River. The site was cleared of non-native vegetation in December 2005. After the initial clearing, maintaining and clearing the re-growth of the non-native species continued until the planting of native species began in September 2006 and was completed in October 2006. The wetland habitat that primarily consists of California bulrush (*Schoenoplectus californicus*) and Olney threesquare (*Schoenoplectus americanus*) occupies 5.4 acres of the site, which primarily grew from the native seed bank present in the soil. The 12.5 acre native riparian habitat was re-vegetated with riparian tree and shrub species such as: Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), sandbar willow (*Salix exigua*), honey mesquite (*Prosopis glandulosa*), screwbean mesquite (*Prosopis pubescens*), four-wing saltbush (*Atriplex canescens*), Emory's baccharis (*Baccharis emoryi*), blue palo verde (*Cercidium microphyllum*). Also, native herbaceous species were seeded in the riparian and upland areas, including salt heliotrope (*Heliotropium curassavicum*), western sea purslane (*Sesuvium verrucosum*), alkali sacaton (*Sporobolus airoides*), inland saltgrass (*Distichlis spicata*), and evening primrose *(Oenothera deltoids)*. The upland areas comprised of 2.8 acres and were planted with ironwood (*Olneya tesota*) and wolfberry (*Lycium andersonnii*).

Overall, the 25-acre QAWPF project successfully transformed severely degraded habitat dominated by exotic saltcedar and desiccated wetlands into naturally functioning wetlands and productive riparian and upland habitat. Total growth showed a decline for the 2008 growing season when compared to 2007 primarily due to a large flood event in August 2008 (**Figures 1-1 and 1-2**). The flood waters spanned the low lying areas of the project site, causing salts to migrate to the surface, making the area inhospitable for many species. Despite the declined growth and condition of the riparian species, little mortality occurred with the

exception of Emory baccharis which had 100% mortality. By the end of the growing season all riparian species showed signs of recovery. The wetland experienced vigorous growth with dense thickets of native California bulrush, Olney threesquare, and alkali bulrush. The site has recovered the bird life that once utilized this site prior to wetland desiccation and non-native species invasion, including the Yuma clapper rail and least bitterns.

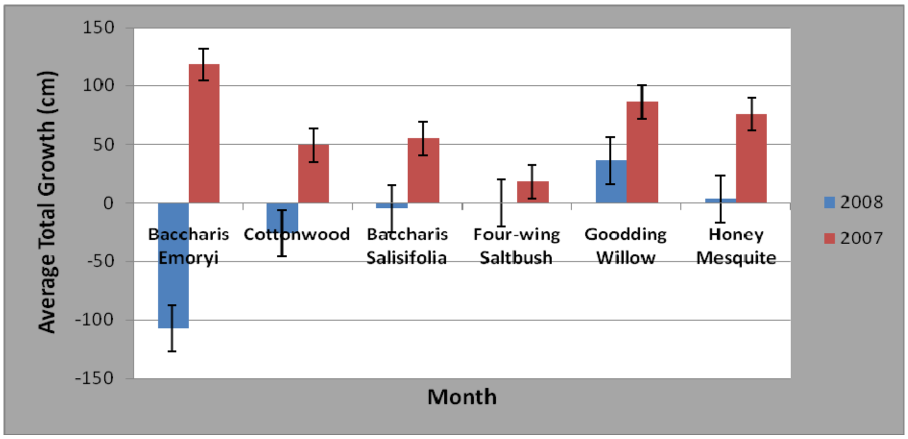

Figure 1-1. Average total growth (cm) of Emory baccharis, Fremont cottonwood, *Baccharis salisifolia*, four-wing saltbush, Goodding willow and honey mesquite from May to October, 2007 and 2008 growing seasons for the riparian revegetation 25 acre QAWPF site. Error bars signify standard error.

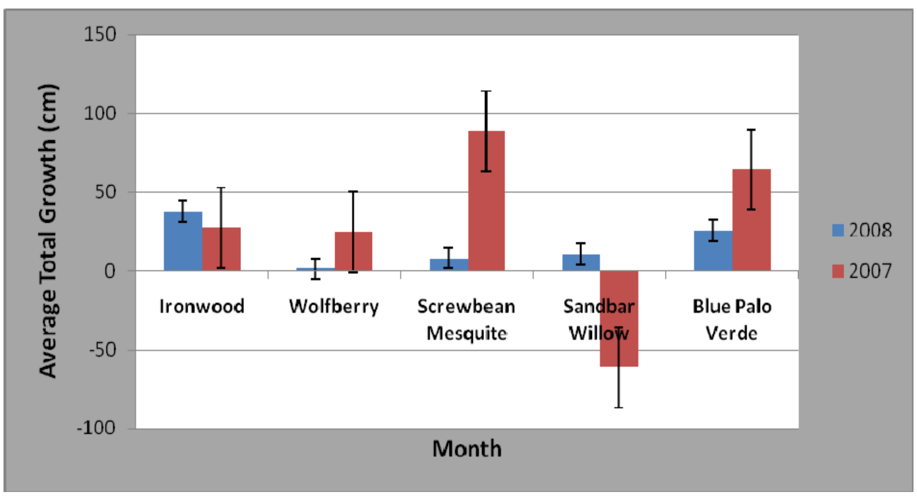

Figure 1-2. Average total growth (cm) for ironwood, wolfberry, screwbean mesquite, sandbar willow and blue palo verde from May to October, 2007 and 2008 growing seasons for the riparian revegetation 25 acre QAWPF site. Error bars signify standard error.

1.0 Introduction

The riparian areas surrounding the Yuma East Wetlands have been drastically altered by the historic damming and confinement of the river channel. These changes have decreased seasonal flooding and ended the natural process of salt removal from the soil, impairing the ability of native cottonwood trees, willow, and mesquite to thrive and regenerate. Non-native tamarisk, (*Tamarix ramosissima* and *Tamarix aphylla*), which is well adapted to high salinity levels and regenerates rapidly, has been able to out-compete native plants. Tamarisk and common reeds (*Phragmites* spp.) have invaded the lands of this highly vegetated river, altering the habitat of birds and other wildlife, including many endangered and threatened species.

The Yuma East Wetlands lie along the lower Colorado River, east of downtown Yuma. For years this land was used as an illegal dumping ground, as well as a make-shift home for transient people. However, the residents of Yuma recognized the value of the Colorado River and its wetland habitat. In 2001, a comprehensive restoration plan was produced by Fred Phillips Consulting to restore over 1,400-acres of the wetlands and riparian area into valuable wildlife habitat. Partnerships between the City of Yuma, The Quechan Tribe, the State of Arizona, The Yuma Crossing National Heritage Area as well as private land owners were formed. A great deal of planning, combined with generous grants have turned the former wasteland into a vibrant ecosystem to benefit wildlife and citizens alike.

The Quechan Indian Tribal 25 acre restoration site has been a fundamental component to help realize the Yuma East Wetlands Restoration Plan. The project area is located on the southern side of the Colorado River adjacent to and north of the South Channel Revegetation Site and east of the YEW Pilot Project within the Yuma East Wetlands Restoration Project on the Lower Colorado River.

The primary objective of this project was to restore 19.6-acres of native riparian habitat and 5.4-acres of historic river channel and wetlands along the 100-year floodplain of the Colorado River. In order to achieve this objective the goals of this project include: 1.) Completing a site analysis, including soil salinity and depth to water; 2.) Clearing invasive species from the site; 3.) Revegetating with native species; 4.) Monitoring the growth and condition of revegetated species; and 5.) Maintaining the irrigation and invasive species re-growth. This report summarizes the accomplishments achieved throughout the duration of the project from invasive species clearing to maintenance and monitoring. Also, this report will discuss the results of 2007-2008 plant monitoring and evaluate the success of the project.

2.0 Methods of Investigation

2.1 Task #2: Implementation of Site Analyses

Soil samples were collected at 3 randomly selected data points per acre, totaling about 80 samples. At each point, soil samples were collected at 2-foot and 5-foot depths. Since much of the site was low, many times the depth to water was found before reaching a five foot depth, resulting in fewer five foot depth samples. At each sampling point, the Trimble Geo XT survey unit identified the GPS location and elevation. The samples were sent to IAS laboratories in Phoenix for salinity analysis. The depth to water was also noted at more than the standard 10 sampling points. In much of the western part of the project site, the elevation was so low that it was possible to gather the depth to water at about 30 points.

The site and soil analysis results indicated that 19.6-acres of the site were suitable for mesquite, cottonwood and willow species, and 5.4-acres for historic river channel and wetlands. Depth to water (DWT) ranged from 0-13 feet across the entire site which will provide a suitable DWT for most riparian species. Depth to water and soil salinity graphs are located in Appendix A.

2.2 Task #4: Restoration of 30 Acres of Wetland/Aquatic Habitat

Adjacent to the QAWPF restoration project area, the U.S. Bureau of Reclamation funded the excavation of a 1.5-mile long backwater channel that followed the historic Gila River Channel, called the Phase I South Channel. Ibis Lake was the portion that is located adjacent to the QAWPF project area and the channel plus surrounding wetlands were created and revegetated as part of the QAWPF project. An amphibious excavator cleared invasive vegetation from this site prior to channel excavation. After the channel area was cleared and prior to channel excavation, follow up land surveys were preformed to assure that accurate quantities and channel alignment were specified in the construction document bid package. The Clearing Map for the South Channel is located in Appendix B.

Once all clearing of exotic/invasive vegetation, the final design and bidding was completed the channel excavation commenced. The historic channels were excavated using an amphibious excavator, a low-ground pressure bulldozer, tractors, and land-grading equipment. An 8-10-foot-deep channel was excavated until they attain an average width of 50 feet (3/1 slope) and an average depth of 9 feet at low river flow. This channel was created to reconnect river flow to the historic backwaters and wetlands. Excavation occurred in historic channels that contained fully aggraded deposits of fine sediments in remnant sloughs. Valuable native habitat (cattail/bulrush, cottonwood/willow/ mesquite) was avoided during excavation. Along with channel excavation and deepening, a shallower aquatic area, approximately 4 to 8 feet deep, with pockets of deeper water adjacent to the excavated main flow channel was created. A shallow shelf was created adjacent the restored channel on the edges of the restored area, in order to revegetate with cattail, bulrush and native sedges and rushes. The shoreline was revegetated with cottonwood/willow trees and other suitable native riparian plants. This topographic configuration diversified habitats for terrestrial and aquatic wildlife. A total of approximately 103,000 cubic yards of material (sand, silt, and silty clay) was removed from the historic channels and riverbank.

The South Channel was opened to the Colorado River flow through a series of 2 stoplog/flap-gate water-control structures. The irrigation design and stop-log structure construction drawings are located in Appendix B. These structures consisted of 72-inch culverts, and were constructed after the river-bottom elevation was excavated in various sections. Large riprap rock was installed in the areas around the structures to stabilize them from high-velocity river flows and flooding. Concrete anchors were placed on the exposed inflow and outflow sections of the culverts to prevent the effects of buoyancy. The culverts were constructed during the winter, when endangered species were not present and the Colorado River levels were low.

The South Channel was planted with the appropriate native vegetation for the habitat type and was set up as an experimental demonstration project that tested various methods of wetland and riparian revegetation. Planting included the following methods:

- 1000- 6-8 foot vertical bundles of sandbar willow planted along the 2.5 miles of new shoreline in the channel area.
- 2000- 4-6 inch plugs of giant bulrush planted along the toe of the 2.5 miles of shoreline in the channel area.
- 3400- 3 foot sandbar willow poles planted along the top of the slope of the 2.5 miles of channel area.
- 200- 6-12 foot cottonwood and Goodding willow posts planted 10-40’ from the top of the channel slope.
- 44 pounds of native seed planted in the wetland areas and top of channel slope along the 2.5 miles of channel.
- 665 one gallon cottonwood/willow/mesquite trees.
- 2708 2” plugs of various native wetland plants.

The 30 acre South Channel aquatic/wetland habitat restoration does not require supplemental irrigation. Through the use of the water control structures installed in the channel design the entire 30 acre area is flood irrigated by simply putting stoplogs in the water control structures to raise the water level in the 30 acre area. The Planting Map for the South Channel is located in Appendix B.

The 2008 Monitoring Report for the South Channel revegetation activities is located in Appendix C.

2.3 Task #5: Site Preparation and Revegetation Activities for 25-Acres of Native Cottonwood/Willow Habitat

2.3.1 Invasive Species Clearing

Invasive species clearing was accomplished using low ground pressure bulldozers, land excavators and tractors. During the initial clearing, stands of native adult trees, such as mesquites and willows, were retained and not cleared. All exotic plant material was left on site, out of jurisdictional waters, in windrows (with the exception of the Ibis lake narrow channel). Locations for the excavated material piles were carefully chosen. Whenever possible, materials were placed on areas that contained no vegetation, areas that contained old spoil piles, and areas that had low value as wildlife habit. (Poor habitat includes low-stature, dense, decadent saltcedar; high-density giant cane; dead stands of trees; and/or arrowweed stands.) These cleared areas were surrounded by containment berms. Water flowing from these berms was directed onto the adjacent riparian habitat, where it increased soil moisture and promoted the natural regeneration of cottonwood and willow trees. This design largely eliminated turbid inflow from the bermed areas to the mainstream river. Initial clearing was completed in December 2005. The Clearing Map for the QAWPF Project is located in Appendix D.

2.3.2 Early Action Planting

Upon clearing the QAWPF site an early action planting area was identified in order to prevent aggressive re-colonization of invasive tamarisk and phragmites. By restoring water flow to the adjacent South Channel site, re-growth of native California bulrush that historically occupied the site increased, however re-growth of aggressive tamarisk and phragmites also increased. Phragmites is an aggressive colonizer of the lower Colorado River and has shown to dominate wetland and riparian areas. This species produces a root toxin that can exterminate any other vegetation species trying to colonize or thrive adjacent to or within a colony of this species (Rudrappa et al. 2007). The early action area was hand weeded prior to planting to remove recolonizing tamarisk and phragmites and planted with 1000-three cubic inch plugs spaced on 18” O.C. of the following wetland plants:

- Inland saltgrass *(Distichulus Spicata)*

- Alkali sacaton *(Sporobolus airoides)*
- Alkali bulrush *(Boboschoenus maritimus)*
- Hardstem bulrush *(Scirpus acutus*)
- Common spikerush (*Eleocharis palustris*)
- Olney threesquare *(Schoenoplectus americanus)*

Also, yerba mansa (*Anemopsis californica*), sandbar willow, cottonwood and screwbean mesquite were planted along the edge of the marsh. Sandbar willow poles were planted using a water auger and planted 2 foot deep on 5 foot centers directly into the water table. All poles were cut locally and soaked for a period of at least three days. Early Action planting was completed in March 2006. California bulrush and Mexican sprangletop (*Leptochloa uninervia*) naturally established in the marsh from the native seedbank and blown seed into the project area.

2.3.3 Native Vegetation Planting

Maintenance weeding continued at the site until native species planting commenced. The area was constructed with drip irrigation and upon completion of the Planting Plan (Task #3) native vegetation in the remaining 19.6 acre riparian and upland habitat commenced. The Irrigation Map for the QAWPF site is located in Appendix E. A total of 4,205 individual native riparian and upland species were planted. The plant species and number of individuals planted in this area included:

Species		Number Planted
Fremont cottonwood	(*Populus fremontii*)	325
Goodding willow	(*Salix gooddingii*)	135
Sandbar willow	(*Salix exigua*)	570
Honey mesquite	(*Prosopis glandulosa*)	805
Screwbean mesquite	(*Prosopis pubescens*)	560
Four-wing saltbush	(*Atriplex canescens*)	420
Emory baccharis	(*Baccharis emoryii*)	170
Blue Palo Verde	(*Cercidium floridum*)	170
Wolfberry	(*Lycium andersonnii*)	645
Ironwood	(*Olneya tesota*)	405

Native under-story plugs and seeds were planted throughout the riparian and upland areas to promote native under-story development. Inland saltgrass and alkali sacaton plugs were planted in the plant wells of the tree and shrub species planted and seeds were hand-broadcasted across the site. Following is a list of the plugs and seeds that were planted and the number of plugs or the amount of seed applied on-site.

Species		Number Planted
Inland saltgrass	*(Distichulus Spicata)*	100 plugs
Alkali sacaton	*(Sporobolus airoides)*	135 plugs
Evening primrose	*(Oenothera deltoids)*	11.75 lbs seed
Western sea purslane	*(Sesuvium verrucosum)*	2.6 lbs seed
Wild heliotrope	*(Heliotropium curassavicum)*	6.6 lbs seed

All native species planting at the QAWPF site was completed in October 2006. The Planting Design and Map is located in Appendix E. Site maintenance, including invasive species weeding and irrigation maintenance continued throughout the project time period, and will continue using alternative funding. Weeding during native phreatophyte establishment is important to limit the encroachment of saltcedar and giant cane, thereby enhancing the natural recruitment of native grasses and forbs.

2.4 Task #6: Monitoring Data Collection Methods

2.4.1 Photo Monitoring Analysis

Seven photo monitoring stations were established and panoramic pictures were taken three times during the growing season (May and November). The stations were located in elevated locations in order to obtain an overall perspective of the entire site. Monitoring photos, taken repeatedly over extended periods, provide a valuable scientific visual database. Photo monitoring results are shown in Section 6.0 (**Figures 6.0–6.7**)**.**

2.4.2 Plant Monitoring

After planting was completed, one baseline monitoring session was conducted in October 2006. Monthly monitoring continued during the 2007 growing seasons, and bi-monthly monitoring occurred during 2008 commencing each year in May. Data was collected for 125 individual trees (5 individuals for blue palo verde; 10 individuals for Emory baccharis, ironwood and wolfberry; and 15 individuals for four-wing saltbush, cottonwood, Goodding willow, sandbar willow, honey mesquite, and screwbean mesquite). The number of individuals monitored of each species depended on the total area planted of that species, where typically one transect was established per acre. There were a total of 25 transects with 5 individuals in each transect. Transect locations were randomly selected within the restoration area by a computer model. The Monitoring Design and Map is located in Appendix F. For each species, several parameters were recorded, including: height, growth rate, condition, and other influences on growth. Plant heights were measured to the tallest outstretched leaf and overall condition was estimated. Scores were assigned as follows:

- 0—dead plants
- 1—poor condition
- 2—fair condition
- 3—good condition
- 4—excellent condition

Evidence of browsing by insects or mammals was noted, along with other factors that could affect plant health, such as water stress, salt stress, competition from native and non-native volunteer colonization, and maintenance issues. Natural regeneration of both native and non-native plants was also noted.

2.4.3 Cover Estimates

Along with the aforementioned tree and shrub species planted at the site, various herbaceous species were planted by seed or plugs among alongside various tree species. These planting regimes varied and were not evenly dispersed within the tree species mentioned above. In order to measure the growth success for these herbaceous species, two randomly placed quadrats (1m x 1.5m) were located in each monitoring transect. Also, ten quadrats were located within the 5.4 acre wetland area. Monitoring in the marsh area began in July 2007, following the establishment of the quadrats and continued through the 2008 monitoring season. Marsh quadrats were established on the periphery of the marsh so as not to disturb dense habitat. For analyses, riparian and upland habitats were combined separately from the 10 wetland quadrats. Monitoring quadrat locations are located on the Monitoring Map in Appendix F.

In each quadrat, cover was measured separately for four strata classes, including tree tall canopy (>10 m), tree middle canopy (4- 10 m), shrub (0-4 m), and herbaceous and surface cover (<0.5 m). Ground cover, woody debris, and soil substrate was measured as a part of the herbaceous and surface cover. Cover for all species occurring in and hanging over the quadrat were estimated. If a species was unknown, the diagnostic parts were collected in order to identify. Small sprouts that did not have diagnostic characteristics remained unidentified and named “unknown herb”. The Daubenmire cover scale was used to estimate percent canopy cover of each individual species (Table 2-1). Total canopy, percent canopy cover, species composition and frequency was calculated for each individual species. Vegetation cover was measured on a monthly basis during the other vegetation monitoring sessions.

Cover Class	Range of Cover	Class Midpoints (%)	Class Name
1	0 -1%	0.5	Rare
2	1 -5%	2.5	Occasional
3	5 -25%	15	Uncommon
4	25 -50%	37.5	Somewhat common
5	50 -75%	62.5	Common
6	75- 95%	85	Abundant
7	95- 100%	97.5	Dominant

Table 2-1: The Daubenmire Cover Scale

2.4.4 Avifauna Monitoring

Three avifaunal monitoring points were established in the 25-acre Quechan Indian Tribe Revegetation Area to monitor endangered Yuma clapper rail and southwestern willow flycatcher. Two of the survey points were established in the mesquite bosque and one in wetland habitat. These points were additional to the already established avian monitoring points. Endangered bird surveys were conducted during the monitoring season for the two primary sensitive bird species, the Yuma clapper rail (15 March-15 May) and southwestern willow flycatcher (15 May- 17 July), using the methods recommended by the UFWS. Results from these surveys were included in the Yuma clapper rail and southwestern willow flycatcher annual reports and the annual AWPF monitoring reports.

In order to monitor for Yuma clapper rail, the standard USFWS YCRA playback tape protocol that had been in use since the 1970s was replaced in 2006 with a National Marsh Bird Monitoring Program protocol developed by USFWS (http://www.fws.gov/arizonaes/Documents/SpeciesDocs/YumaClapperRail/2006_YCR_surveyprotocol.pdf). Surveys will consist of visiting each site within 3 hr of sunrise. The protocol recording played at each site consisted of 5 minutes of silence followed by 30 seconds each of recordings of California Black Rail, Least Bittern, Virginia Rail, and Yuma Clapper Rail, each of which was followed by 30 seconds of silence. Responses were recorded on the marshbird data sheet, and other birds were documented on our data sheets. Special care was taken to avoid "double counts", and events or disturbances that may have affected the survey results were also recorded. Incidentally detected birds were recorded in field notes during other periods and at other sites. Weather data was recorded for each survey.

Southwestern willow flycatcher surveys were initiated within about 3 hr of sunrise. Surveys consisted of listening for 1-2 minutes, playing the SWFL tape for 0.25-0.5 minutes at approximately 80 decibels, and listening for responses for 1-2 minutes. Responses to the tape were recorded on the Service's revised 2004 data sheet and other avian species observed or heard were recorded (http://www.usgs.nau.edu/swwf/ wiflnew.html). Special care was taken to avoid “double counts”, and events or disturbances that may have affected the survey results were recorded. Incidentally detected birds were recorded in field notes during other periods and at other sites. Weather data and other birds detected were recorded for each survey point.

3.0 Results and Discussion

The results discussed in this section include the results from the plant monitoring conducted over the 2007 and 2008 growing seasons. The plant monitoring results reflect the success of all tasks completed, and therefore the results from other tasks will not be discussed. The first section of the monitoring results (3.1) reflects the growth, condition, and survivorship results of the riparian shrubs and trees planted in the 19.6 acre riparian/upland area. The second section (3.2) provides the results from the vegetation cover of the herbaceous species planted in the riparian/upland and wetland areas. The third section (3.3) discusses the results from the endangered species surveys conducted at the site.

3.1 Species-Specific Growth Rates and Conditions

The results presented below reflect the 2007 and 2008 growing seasons for species planted in the 19.6 acre riparian/upland area as part of the revegetation efforts for the 25 acre site. In this habitat, five individuals of blue palo verde; 10 individuals of Emory baccharis, ironwood and wolfberry; and 15 individuals of four-wing saltbush, Fremont cottonwood, Goodding willow, sandbar willow, honey mesquite, and screwbean mesquite were monitored.

3.1.1 Emory's Baccharis (*Baccharis emoryi*)

Emory baccharis height increased 1.6 times from May to October in 2007, the first growing season (**Figure 3-1**), for a total average growth of 118 cm (N=5, SE=52.93). Emory baccharis had a 100% survivorship for all individuals monitored during the 2007 growing season. From May to August 2008 Emory baccharis height increased an average of 64.8 cm (N=5, SE=22.1), and had a 100% survivorship for all individuals monitored during this period. In late August, there was a significant flood event, which redistributed the salt content in the soils across the Yuma East Wetlands. This flood event caused a high number of mortalities in many species, including 100% of the Emory baccharis.

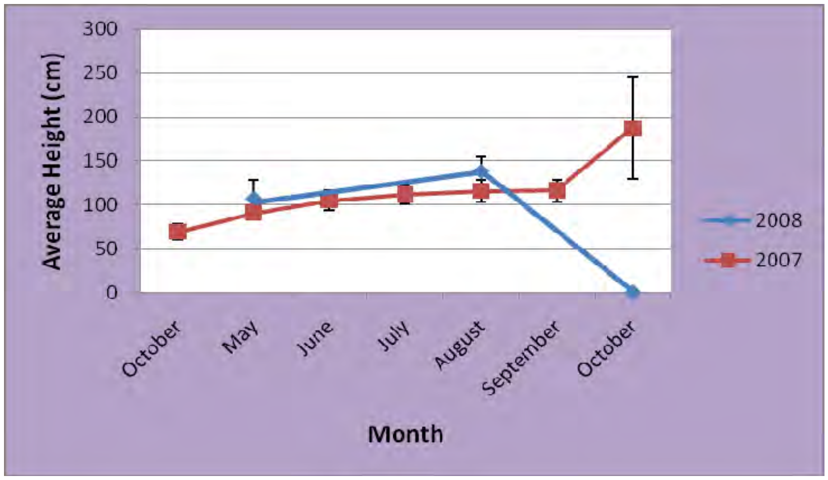

Figure 3-1. Average Emory baccharis height (cm) for October 2006, May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

Average Emory baccharis condition was good to excellent throughout the 2007 growing season, and continued to stay in excellent condition until the end of August 2008 (**Figure 3-2**). The main factors affecting 90% of the Emory baccharis's condition and growth throughout the 2007 growing season included water stress and insect browsing (**Figure 3-3**). The water stress during the beginning of the 2007 growing season was due to clogged emitters. During September and October 2007, individual condition was still affected by the early irrigation problems and the misplacement of the emitters. Since the drip irrigation infrastructure lies on top of the sediment, emitters are easily moved from the tree wells due to accidental causes. This water stress caused mortality in the main stem of 20% of the monitored plants. Insect browsing from aphids was a main factor affecting condition during May through July, however no mortality appeared to occur due to this factor.

In the 2008 growing season there were no factors affecting plant condition during the beginning of the growing season (Figure 3-3). The flood in late August 2008 caused a distribution of salts within the soil, especially in areas where salt content in the soil was low. This resulted in 100% mortality among the Emory baccharis.

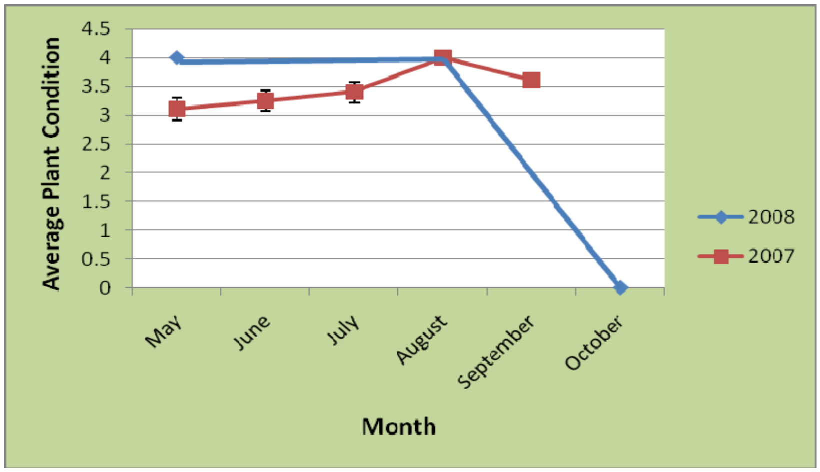

Figure 3-2 Average Emory baccharis condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

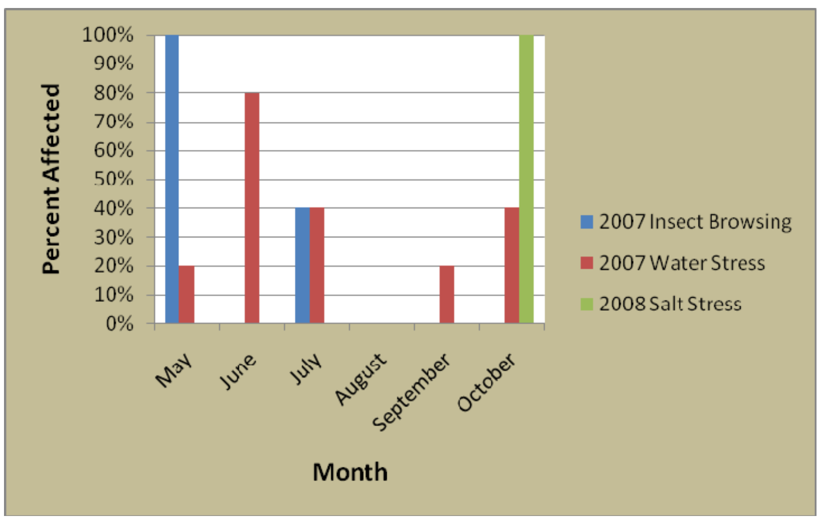

Figure 3-3 Factors influencing Emory baccharis conditions and growth for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands.

3.1.2 Fremont Cottonwood (*Populus fremontii*)

Overall, the planted cottonwood trees experienced positive growth during the first 2007 growing season, and from May to August of 2008 in the QAWPF revegetation site (**Figure 3-4**). The average cottonwood height was 1.2 times higher in October 2007 than when the trees were first monitored in May 2007 (**Figure 3-4**). Cottonwoods grew an average total of 49 cm during the first growing season (N=12, SE=7.22), and an average total of 23 cm from May to August in 2008. After August 2008, cottonwoods showed negative growth due to the high salt content caused by redistribution of salts in soil from the flood event discussed above.

Cottonwoods experienced 80% survivorship for the first growing season, with 13% of the trees dying between planting (October 2006) and the first monitoring session (May 2007). The highest growth of the surviving individuals was experienced between July and August 2007, with an average growth per day of 0.27 inches (N=12, SE= 0.06). Negative growth occurred from August to September 2007 due to probably herbicide over-spray likely from a crop dusting plane flying over-head (cotton was being harvested by a defoliating herbicide at fields adjacent to the YEW project). Many cottonwoods were completely defoliated and showed no growth during this time period. However, the October monitoring session revealed that most of the trees were recovering.

For the 2008 growing season, the highest growth of the surviving individuals was experienced between July and August, with an average growth per day of 0.36 cm (N=12, SE= 5.14). Total average growth by the end of the 2008 season was at -26.08 cm (N=11, SE=24.45) (**Figure 3-4**). After August, cottonwoods experienced negative growth due to the re-distribution of salts caused by the flood. Despite this decline in height and condition, the survival rate at the end of the season was 92%.

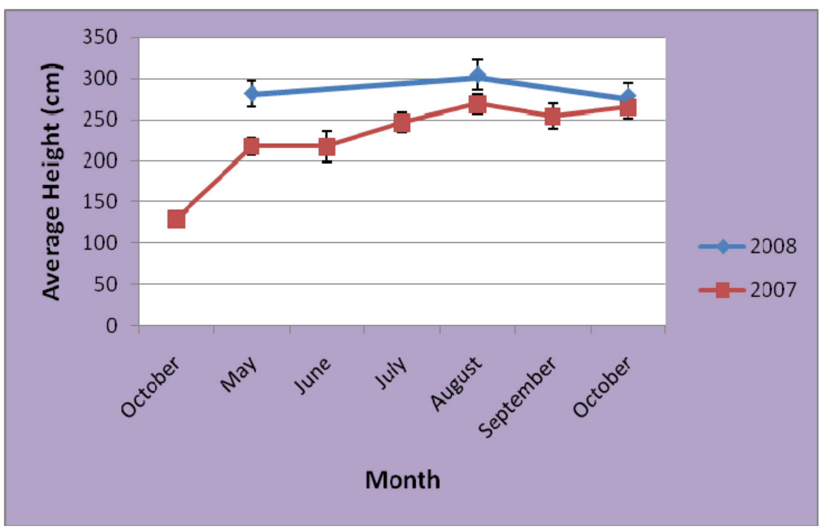

Figure 3-4. Average cottonwood height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

The overall condition of the cottonwoods for the 2007 and 2008 growing season was good (**Figure 3-5**). The primary factors affecting cottonwood condition and survival in the beginning of the 2007 growing season (May-July) was insect browsing and water stress (**Figure 3-6**). Throughout the 2007 growing season 77% of the cottonwoods experienced water stress and 77% of them experienced insect browsing. During this period, the irrigation pump was not functioning properly and lacked pressure to deliver water to the plants, and the emitters were clogged with sediment. Insect browsing probably had a minor effect on cottonwood growth, since this shows evidence of a natural ecosystem. Once the irrigation problems were resolved, the herbicide over-spray mentioned above was the primary factor effecting cottonwood growth in 2007 (**Figure 3-6**). Thirty-three percent of the individuals were affected by the herbicide over-spray, and one mortality occurred. In 2007, volunteer competition with arrowweed affected approximately 17% of the cottonwoods. This species is a weedy native that naturally colonizes restoration sites in the YEW. Maintenance has occurred to cut back the arrowweed to allow the cottonwoods to flourish.

In May 2008, cottonwoods were affected again by herbicide over-spray from a crop duster plane spraying defoliant over adjacent cotton fields. Cottonwoods were the main plant species affected by the spraying, declining slightly in growth and condition (**Figure 3-**6). Cottonwood growth and condition both decreased drastically after the flood in late August 2008. Salt stress affected 100% of the cottonwoods (**Figure 3-**6).

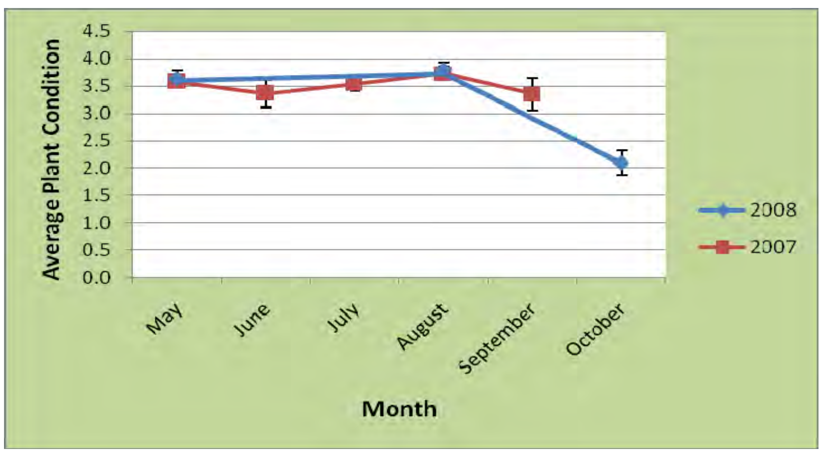

Figure 3-5 Average cottonwood condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

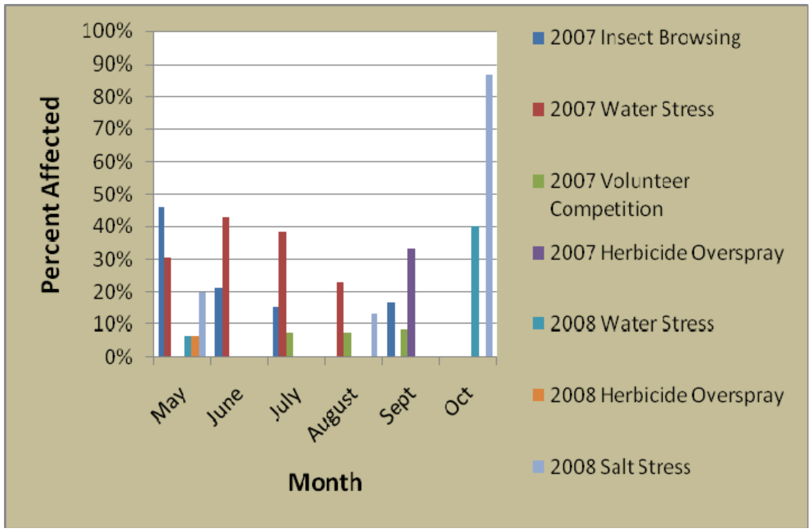

Figure 3-6 Factors influencing cottonwood conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

3.1.3 Seep Willow (*Baccharis salisifolia*)

Overall, seep willows had positive growth for the 2007growing season, as well as for the first four months of the 2008 growing season (**Figure 3-7**). In 2007, seep willows had an average total growth of 23cm (N=5, SE=23.76), and in 2008 the average total growth was 3cm (N=5, SE=19.57). Once again, the flood event in August 2008 caused a decline in growth as well as in condition for seep willows.

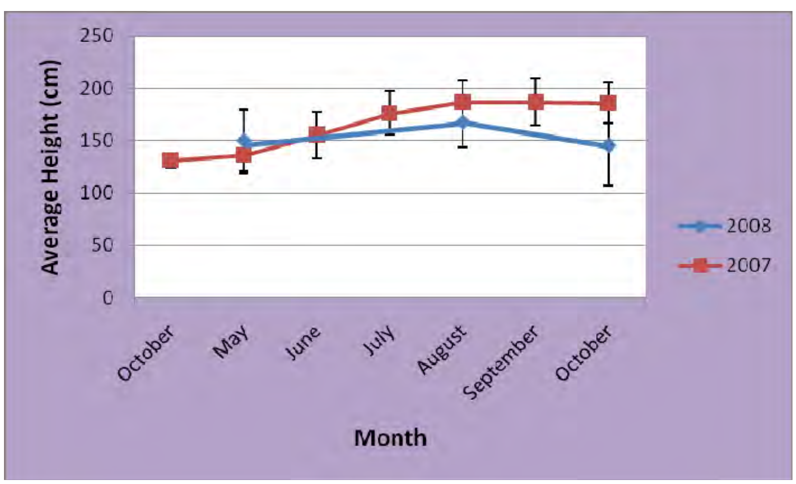

Figure 3-7. Average seep willow height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

Overall condition of seep willows increased from good to excellent, declining slightly in August due to extreme summer temperatures in 2007. In 2008, seep willow condition was excellent slightly dropping throughout the season, and finally dropping down good condition after the flood in late August (**Figure 3-8**).

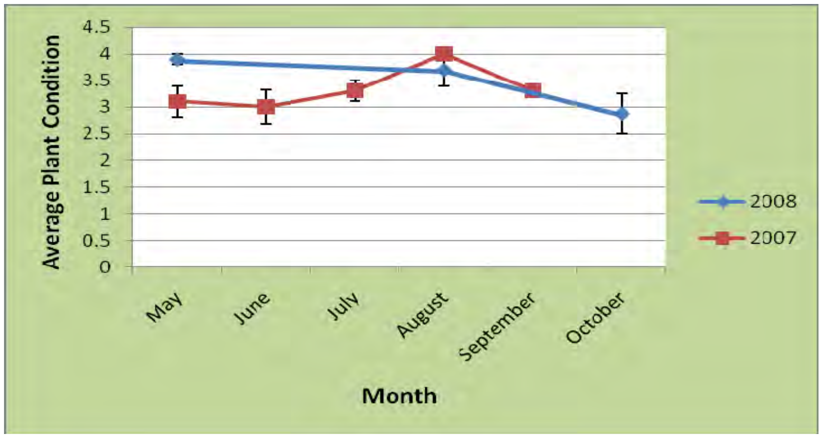

Figure 3-8 Average seep willow condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

In 2007, insect browsing and water stress were the two factors affecting seep willow condition, and in September water stress affected 100% of the individuals (**Figure 3-9**). Salt stress was the only factor affecting seep willow condition during the 2008 growing season (**Figure 3-9**). Although this factor was detected during the May and August 2008 monitoring sessions, it only affected 20% of the monitored individuals. By October, after the August flood event, 80% of the individuals were affected by salt stress. Despite the decline of growth and condition of seep willows, the 2008 survival rate was 80%.

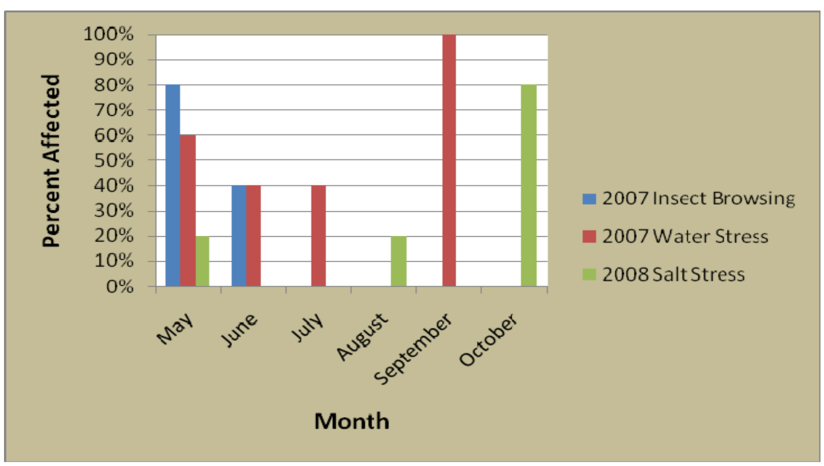

Figure 3-9 Factors influencing seep willow conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

3.1.4 Four-Wing Saltbush (*Atriplex canescens*)

Four-wing saltbush on average grew steadily through July and then leveled off through October, during the 2007 growing season (**Figure 3-10**). Average height during 2007 was 1.3 times greater in October than at the beginning of the growing season. Four-wing saltbush on average grew steadily through the winter and then increased their growth drastically in the period from May to August 2008 (**Figure 3-10**). During this period the survivorship was 100%. By the end of the 2008 monitoring season, survivorship for the monitored four-wing saltbush was 93%. The mortality that occurred during the August and October 2008 monitoring sessions appeared to be caused by water stress.

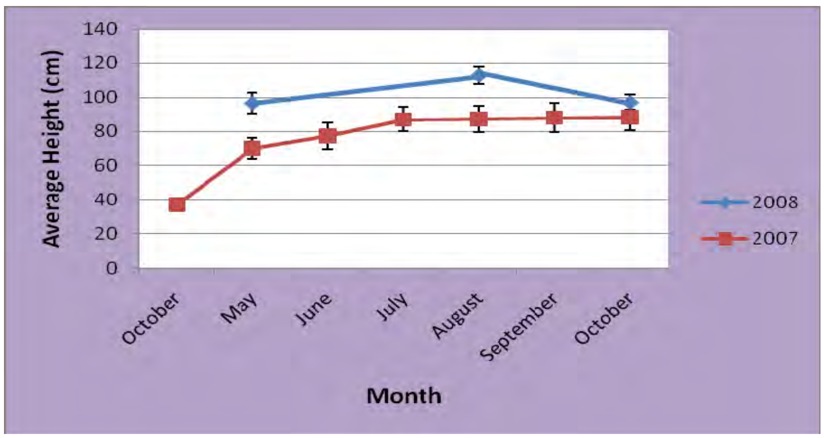

Figure 3-10. Average four-wing saltbush height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

The monitored surviving four-wing saltbush individuals were in good condition throughout the 2007 growing season with a slight decline in October **(Figure 3-11)**. Water stress appeared to be the main factor affecting plant condition throughout the 2007 growing season **(Figure 3-11)**. Thirty-six percent of the surviving individuals were affected by water stress throughout the season and the one mortality that occurred was probably due to water stress. Volunteer competition from quailbush was a minor factor in May and June, however in October affect 36% of the monitored individuals. Quailbush is a fast growing native species that voluntarily colonizes and is planted in restoration sites in the YEW. Another factor that affected 21% of the monitored individuals in September and October was damage caused by human disturbance (an off-road motorized vehicle). This may have been caused during routine maintenance activities. Finally, mammal browsing showed a minimal effect during the October monitoring session.

In 2008, the monitored individuals were in excellent condition throughout the season. The only factor affecting plant condition was water stress in May 2008. This species is draught tolerant with high salinity tolerance.

Therefore, it is typically planted in upland areas where the depth to water is deep. The August flood had no affect on this species probably due to its high placement on the site.

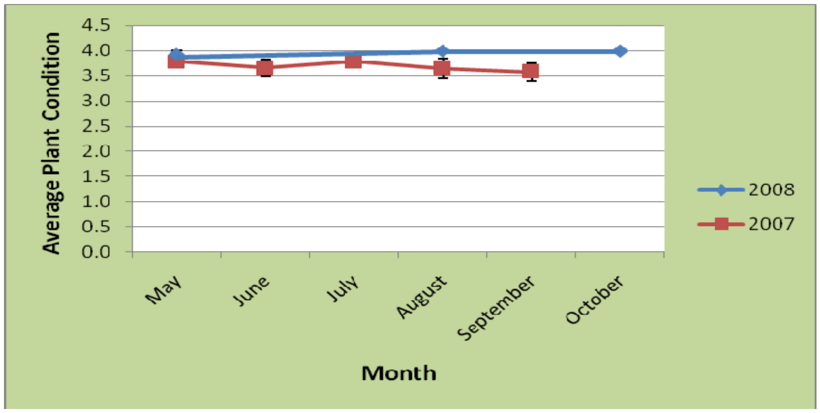

Figure 3-11 Average four-wing saltbush condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

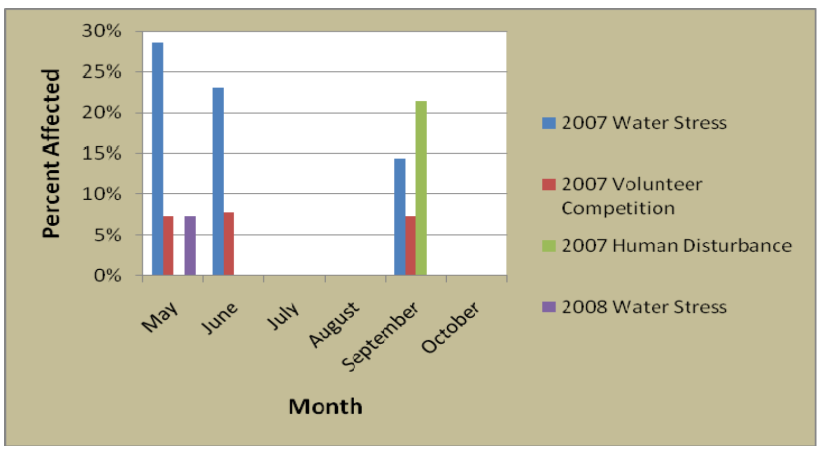

Figure 3-12 Factors influencing four-wing saltbush conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

3.1.5 Goodding Willow (*Salix gooddingii*)

Goodding willow showed a positive growth response during the 2007 and 2008 growing season in the 25 acre QAWPF site (**Figure 3-13**). The average Goodding willow height was 1.6 times higher in October than in May 2007. In 2008, average Goodding willow height was thirty percent higher in October than in May (**Figure 3-13**). Goodding willows grew an average of 86 cm (N=10, SE=17.62) for the 2007 growing season. The highest growth was from May to June. In 2008, the total average growth was 36 cm (N=10, SE=31.30). Goodding willow had a 66% survivorship rate for the 2007 growing season and an 88% survival rate in 2008. Sixty percent of the mortality occurred from planting completion in October

2006 to May 2007, the start of the 2007 growing season. This indicates that mortality occurred due to planting stress, however individuals were not being monitored over the winter 2007.

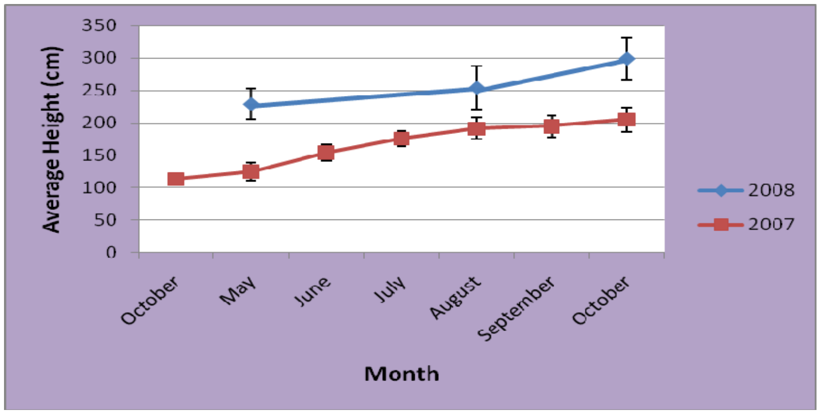

Figure 3-13. Average Goodding willow height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

The condition of the surviving Goodding willow plants was good to excellent throughout the 2007 growing season, and in 2008 the condition was excellent with a slight decline to a very good condition later in the growing season (**Figure 3-14**). Water and salt stress affected 58% of the Goodding willows throughout the 2007 growing season (**Figure 3-15**). In the 2008 growing season salt stress affected 55% of the Goodding willows in the month of August and affected 86% of the Goodding willows in the month of October. The Goodding willows were planted along the perimeter of the 5.4 acre wetland area. Soil salinity is high in this area which is evident due to the salt crust on the soil's surface. Also, when the water levels are increased in the South Channel by the placement of the stoplogs in the outlet, the wetland, including the willow planted area is inundated for long periods of time, which may adversely affect the trees. This is also the most likely cause for the mortality experienced during the 2007 growing season. Mammal and insect browsing affected 16% and 8% of the trees respectively during May 2007, however these effects were not observed later on in the growing season. Overall, Goodding willow showed to have great success throughout the two growing seasons, with condition and growth declining slightly, caused by the flood in late August.

Figure 3-14 Average Goodding willow condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

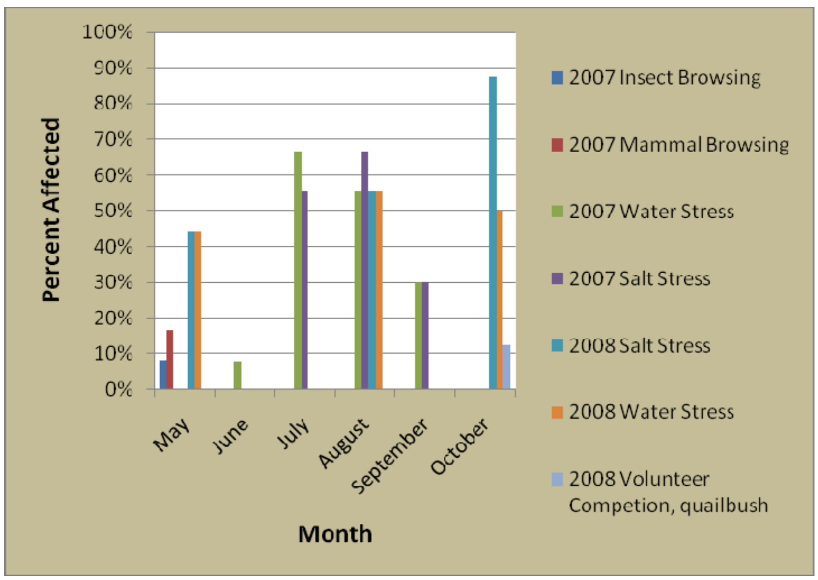

Figure 3-15 Factors influencing Goodding willow conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

3.1.6 Honey Mesquite (*Prosopis glandulosa*)

Honey mesquite height increased steadily from June to October of the first growing season (**Figure 3-16**). Average height was 1.7 times higher at the end of the growing season than in May, at the beginning of the season. Total average growth for honey mesquite for the 2007 growing season was 75cm (N=15, SE=11.41). For 2008, height increased from May to August, but declined from August to October. This decline resulted in a minimal average total growth of 3cm (N=12, SE=19.57) for the 2008 growing season (**Figure 3-16**). Honey mesquite showed 100% survivorship for all individuals monitored during the 2007 growing season and 88% for the 2008 growing season.

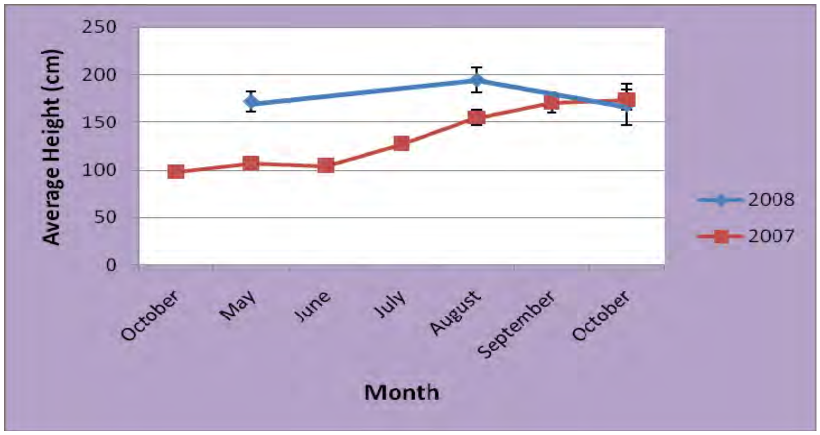

Figure 3-16. Average honey mesquite height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

Honey mesquite condition was good to excellent for surviving individuals throughout the 2007 season and stayed in excellent condition with a slight decline to very good status after the flood event in late August 2008 (**Figure 3-17**). The main factors affecting honey mesquite condition and growth during the beginning of the 2007 growing season included water stress and mammal browsing. Approximately 47% of the individuals were affected by the irrigation condition explained above in the cottonwood section. Although protective tree covers (tubex) were placed around all honey mesquite individuals, mammals were able to forage on the limbs growing out of the covers. Although 47% of the individuals were affected by mammal browsing, this factor did not have as significant effect to the condition of the trees as water stress. Insect browsing and volunteer competition from alkali sacaton had minimal effects on the monitored individuals, affecting 20% and 7% respectively for the growing season. (**Figure 3-18**). Both these factors, although may affect condition of honey mesquite, reflect a natural ecosystem. Since these effects did not cause mortality it shows that honey mesquite have adapted to natural conditions. The main factor affecting honey mesquite condition and growth during the beginning of the growing season was insect browsing.

After the October 2007 monitoring session an infestation of celids, small leafhopper-like insects, occurred, which denuded the foliage off of the honey mesquites. However, once the weather cooled the celids left the site allowing the plants a chance to recover. In 2008, the main factors affecting growth and condition of honey mesquite were water stress and salt stress. These factors affected nearly 20% of the mesquite trees (**Figure 3-18**).

Figure 3-17 Average honey mesquite condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

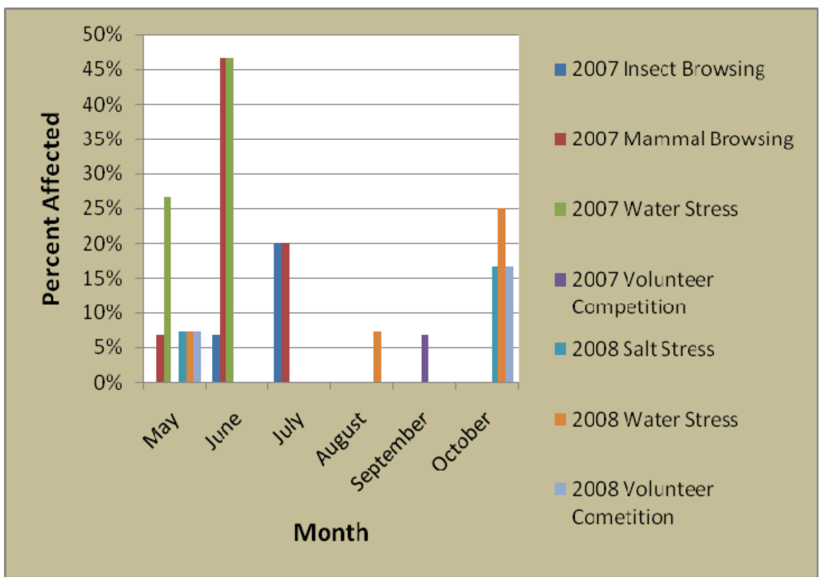

Figure 3-18 Factors influencing honey mesquite conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

3.1.7 Ironwood (*Olneya tesota*)

Average ironwood height increased steadily throughout the 2007 and 2008 growing seasons (**Figure 3-19**). Average tree height was 3.6 times greater in October than in May during the first growing season. Ironwood grew an average of 27 cm for the 2007 season (N=6, SE=16.83), and 38 cm (N=5, SE=12.15) for the 2008 growing season. Ironwoods experienced 60% survivorship, where 40% of the mortalities occurred from October 2006, when the trees were first planted, to May 2007, the beginning of the first monitoring season. Therefore, mortality may have occurred due to planting stress. All of the dead individuals were re-planted in July 2007, but are not represented in the data presented below. By the end of the 2008 growing season ironwood had 100% survivorship.

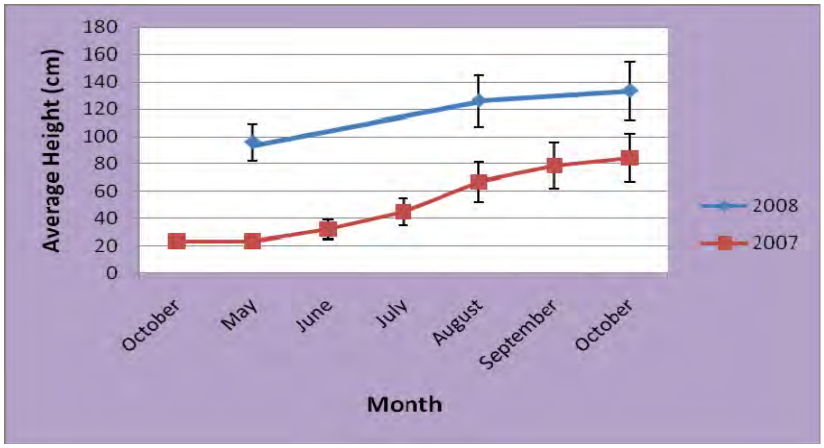

Figure 3-19. Average ironwood height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

The surviving ironwood individuals were in good to excellent condition throughout the 2007 growing season and stayed in excellent condition throughout the 2008 growing season (**Figure 3-20**). The primary factor affecting 83% of the ironwood condition and growth during May and June 2007 was water stress (**Figure 3-21**). Irrigation lines were cut too short to reach the individual plants. Also, since ironwood was planted on the created berms, the decreased pressure in the irrigation lines deriving from the pump was too minimal to supply water up-slope to the ironwood trees. Once these problems were fixed, ironwood condition increased. Insect browsing also played a role in the decreased condition of ironwood during the May 2007 monitoring session. Insect browsing affected 33% of the individuals, however it is unknown what species was responsible. Insect browsing had a minor role in the overall condition.

In 2008, water stress was the only factor that affected the condition in 20% of the monitored ironwood during August and October. The flood water that occurred during August and the resulting rise in soil salinity did not affect ironwoods due to their dry upland habitat.

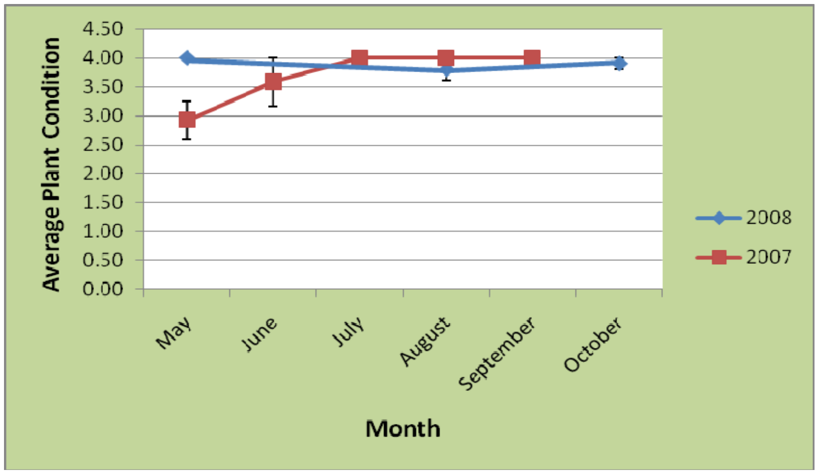

Figure 3-20 Average ironwood condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

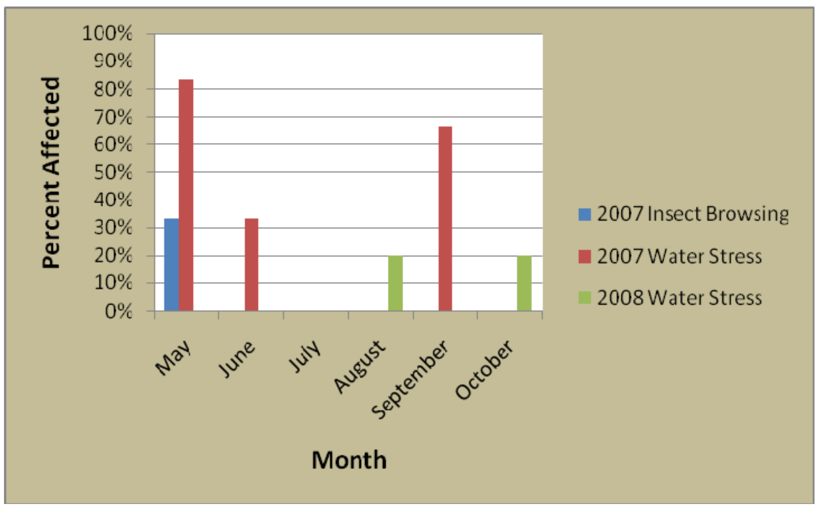

Figure 3-21 Factors influencing ironwood conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

4.1.8 Wolfberry (*Lycium andersonnii*)

The irrigation problems that occurred throughout the QAWPF site from May- July 2007 had the some detrimental effects to wolfberry growth and condition. Because of the negative growth that occurred from May to August of 2007, wolfberry growth through the season was minimal (**Figure 3-22)**. Wolfberry grew a total of 24 cm (N=10, SE=6.98) from May to October 2007. One hundred percent of the wolfberry monitored in the transects survived the 2007 growing season. In 2008, wolfberry average height steadily increased throughout the growing season. The average growth was 37cm (N=8, SE=12.15). The average height increased by 66% from October 2007 to August 2008, a total increase of 42.2 cm *(*N=10, SE=3.87).

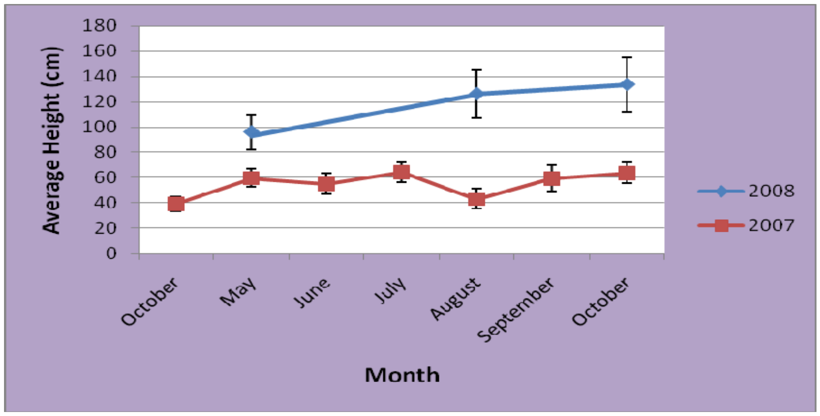

Figure 3-22. Average wolfberry height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

Wolfberry individuals were in poor to fair condition from May to September 2007, and recovered to good condition by October (**Figure 3-23**). The primary factor affecting 100% of the wolfberry condition and growth throughout the 2007 season was water stress (**Figure 3-24**). Wolfberry suffered from the same irrigation problems as ironwood in 2007 in that the emitters were clogged and the line pressure was too low to supply water up to the individuals planted on the berms. Unlike ironwood, wolfberry condition remained poor even after the irrigation problems were resolved. By October 2007, wolfberry showed an increase in condition. Volunteer competition from quailbush also was observed throughout the growing season, however did not seem to significantly affect plant condition (**Figure 3-24**). The natural cycle for wolfberry is to reach its peak, flower and fruit in winter then to decline in condition as the heat comes. The rebound to fair condition in August 2007 is a reflection of the cessation of some minor irrigation problems (**Figure 3-24**).

In 2008, the condition stayed at an excellent status throughout the growing season (**Figure 3-23**). Water stress was the only factor present at 20% of wolfberry in the month of August and October, but didn't affect growth or condition (**Figure 3-24**).

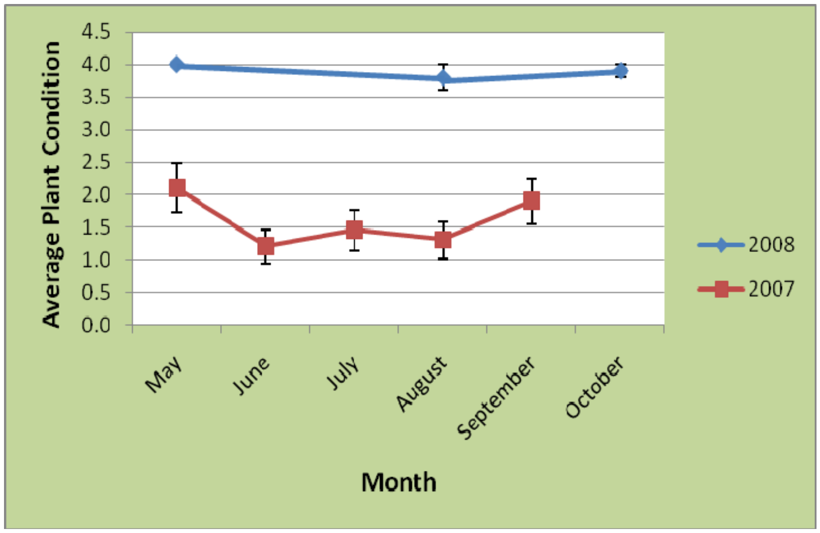

Figure 3-23 Average wolfberry condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

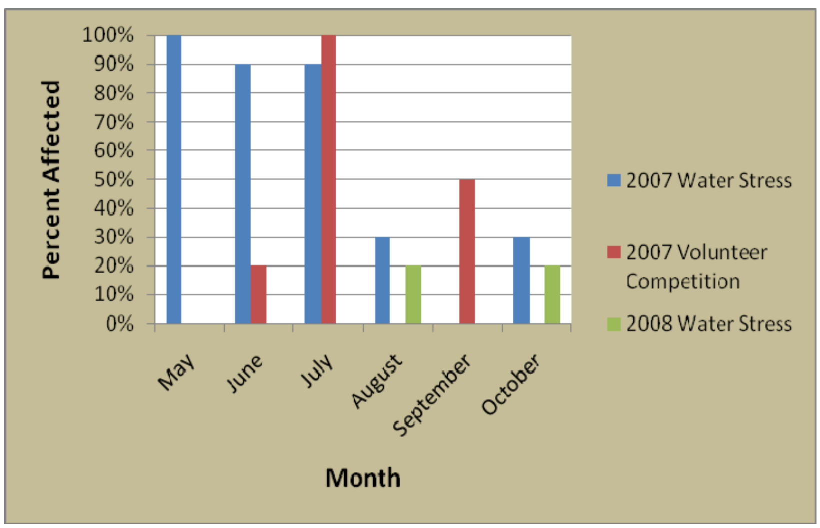

Figure 3-24 Factors influencing wolfberry conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

4.1.9 Screwbean Mesquite (*Prosopis pubescens*)

Screwbean mesquite showed a slight increase in average height over the 2007 growing season in the 25 acre QAWPF site (**Figure 3-25**). Average height at the end of the monitoring season was 1.6 times higher than in May, the beginning of the monitoring season (**Figure 3-25**). The average total growth of surviving screwbean mesquite was 88 cm (N=12; SE=20.30) for the 2007 growing season. Screwbean showed the greatest growth between May to June at 1 cm per day (N= 14; SE=5.08). Eighty percent of the individuals monitored survived the first growing season. It is suspected that water stress caused mortality in this species during 2007.

In 2008, screwbean mesquite showed a great increase in height from May to August, but after the flood event in late August, both growth and condition suffered. Average growth for screwbean mesquite was 8cm (N=9, SE=15.62) for the 2008 growing season. By the end of the 2008 growing season, screwbean mesquite survival rate was 75%. The mortality experienced was primarily caused by salt stress from the flood.

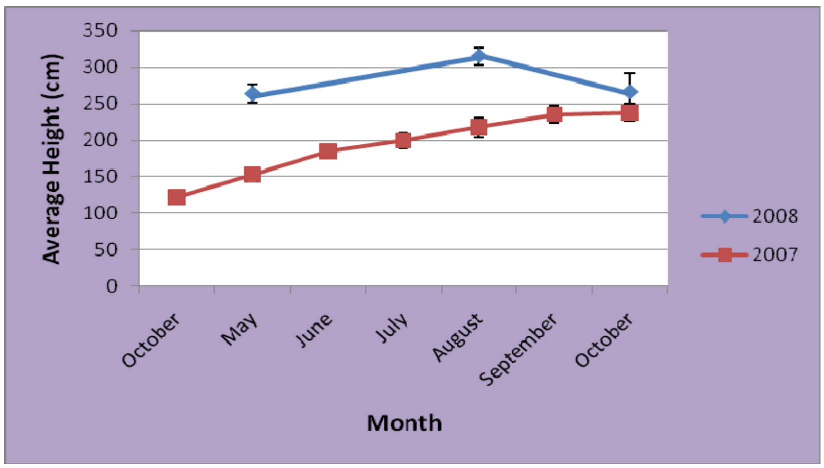

Figure 3-25. Average screwbean mesquite height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

The average condition of surviving screwbean mesquite was good to excellent throughout the first 2007 growing season (**Figure 3-26**). Water stress affected 33% of the monitored screwbean mesquite individuals throughout the growing season (**Figure 3-27**). Water stress occurred from the irrigation problems discussed above under the cottonwood section. Salt stress also appeared to be a factor effecting condition in 27% of the trees throughout the growing season (**Figure 3-27**). Since mesquites have a higher tolerance to lack of water and high soil salinities, it is not surprising that plant condition was minimally affected and mortality was low. Volunteer competition from Emory baccharis affected one individual during June and July 2007. However, this shows that the area is beginning to function like a natural ecosystem, since native plants are beginning to recruit.

Despite the high tolerance for lack of water and high salinity, screwbean mesquite had declines in growth and condition for the 2008 growing season (**Figures 3-26**). Salt stress was the major factor affecting screwbean mesquite growth and condition for the 2008 growing season

(**Figure 3-27**). In September, 60% of the screwbean mesquite individuals were affected by salt stress due to the flood that occurred in August.

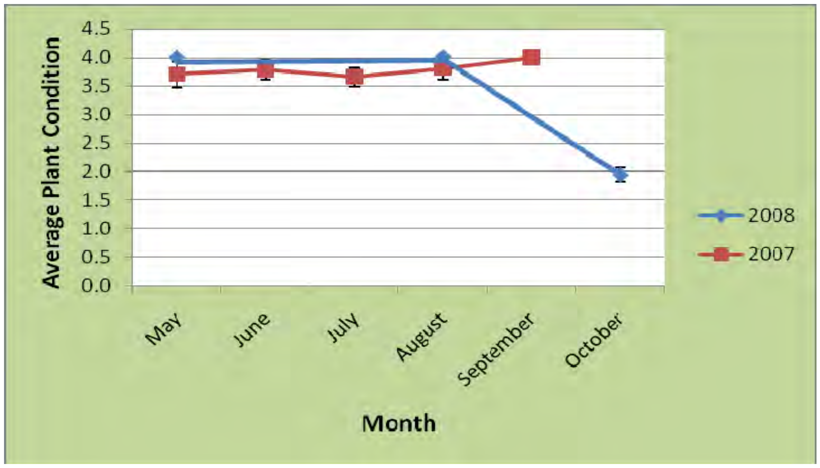

Figure 3-26 Average screwbean mesquite condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

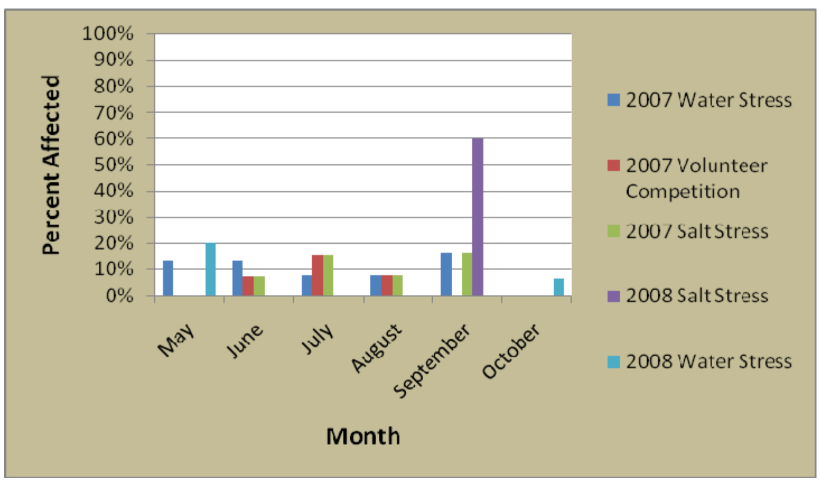

Figure 3-27 Factors influencing screwbean mesquite conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

3.1.10 Sandbar Willow (*Salix exigua*)

Sandbar willow showed slight positive growth for the first growing season in the 25 acre QAWPF site. By the end of the 2007 growing season, sandbar willow growth was 1.1 times higher than at the beginning of the growing season in May (**Figure 3-28)**. The total average growth for the 2007 season was 18cm (N=5, SE=1.5). Sandbar willow experienced high mortality, with only 43% survivorship rate. However, only one mortality occurred between October 2006 and May 2007. The primary factors contributing to this high mortality was water and salt stress, the same factors discussed above for Goodding willow.

In 2008, average growth for the surviving sandbar willows was 10cm (N=4, SE=6.39). The surviving sandbar willows had a survivorship of 80%.

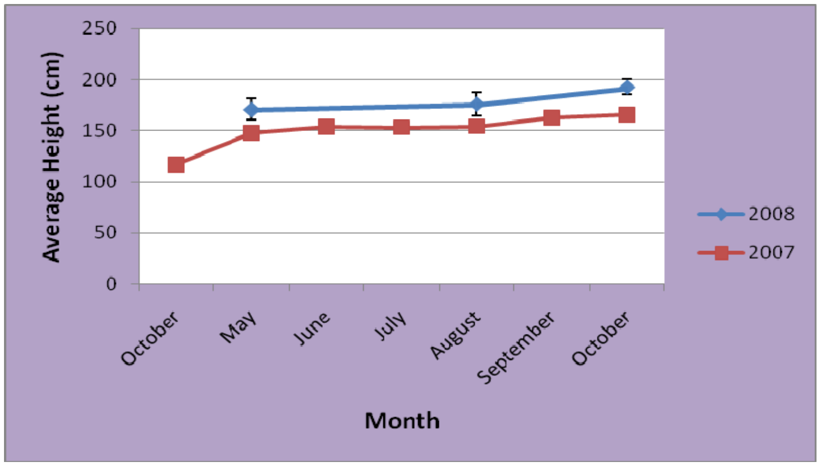

Figure 3-28. Average sandbar willow height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

The average condition of sandbar willow was fair to good overall for the surviving individuals during the 2007 growing season (**Figure 3-29**). Condition decreased from May to August and slightly increased from August to October (**Figure 3-29**). Water and salt stress were the primary factors for the decreased condition and high mortality observed at the site (**Figure 3-30**). Salt stress was observed in 73% of the individuals while 64% experienced water stress. These conditions are discussed above for Goodding willow. It is hard to determine between salt stress and water stress in a plant's physical attributes by observation. Plants experiencing either condition display yellowing leaves, defoliation, extremity mortality, and eventual plant mortality. Therefore, both factors are determined to affect the plants in the data presented for May- July, however it may be that one or the other factor is actually affecting plant condition. This can only be determined if inundation period and soil salinity levels are monitored.

For the 2008 growing season, condition actually increased from good to excellent despite the redistribution of salts in the soil due to the late August flood event (**Figure 3-30**). Some factors that showed to affect growth and condition included water stress and salt stress, which were most evident in August. Salt stress affected 65% and water stress 60% of the monitored individuals in August. Another factor that affected 7% of sandbar willows but was volunteer competition by quailbush (**Figure 3-30**). By the end of the 2008 growing season, sandbar willow survival rate was at 80%.

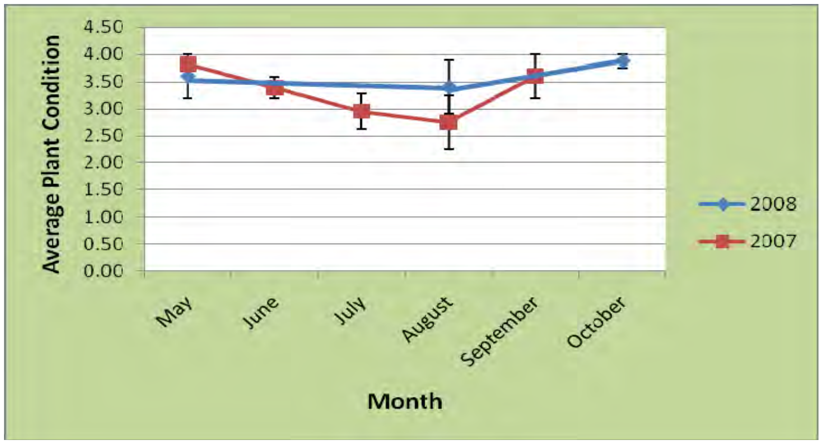

Figure 3-29 Average sandbar willow condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

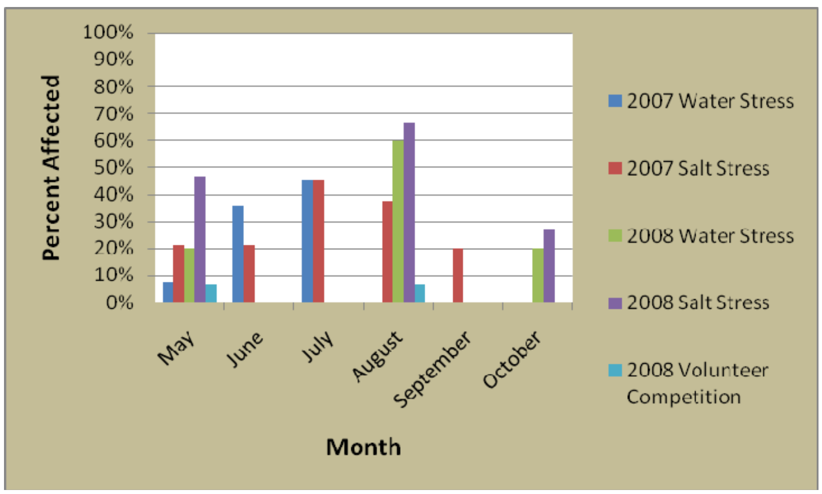

Figure 3-30 Factors influencing sandbar willow conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

3.1.11 Blue Palo Verde (*Cercidium microphyllum*)

Average blue palo verde height increased steadily throughout the growing season. Average tree height was 2.7 times greater in October than in May of the first growing season (**Figure 3-31**). Blue palo verde grew an average of 64cm for the 2007 season (N=5, SE=15.74). Blue palo verde experienced 100% survivorship during their first growing season. Only 5 individuals were monitored of this species, because of its minimal planting area. In 2008, the average total growth was 12cm (N=5, SE=4.46) and a 100% survivorship (**Figure 3-31**).

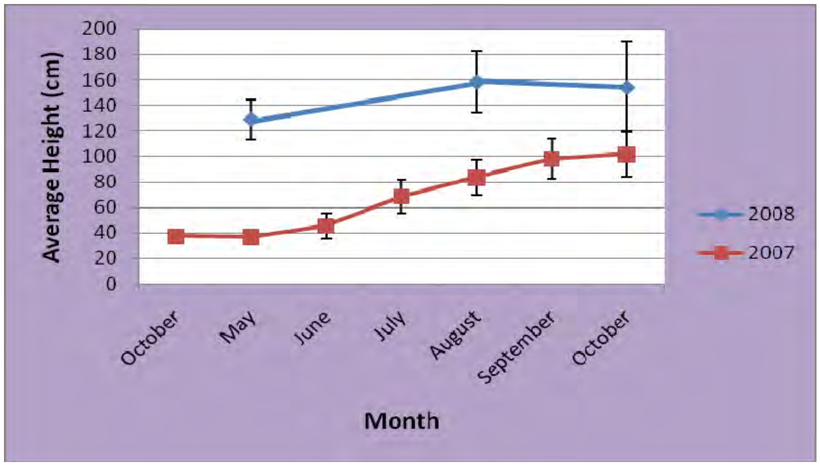

Figure 3-31. Average blue palo verde height (cm) for October 2006, and May to October, 2007 and 2008 at the QAWPF site, Yuma East Wetlands. Error bars signify standard error.

The palo verde individuals were in good to excellent condition throughout the 2007 growing season (**Figure 3-32**). The primary factor affecting 80% of the palo verde condition and growth throughout the season was water stress (**Figure 3-33**). Palo verde individuals suffered the same irrigation problems as ironwood where emitters were plugged. Volunteer competition with western sea purslane also affected 40% of the individuals. Volunteer competition may have affected the palo verde's condition during May- July when the individuals were small, however currently they have probably filled a different niche than purslane as their roots extend deeper in the soil and they have obtained greater heights.

In 2008, plant condition was very good from May to August, but then dropped to good status after August to October due to the flood in late August (**Figure 3-32**). Some irrigation problems occurred during the end of the 2008 growing season, in which the emitters were clogged or moved away from the tree wells. A combination of irrigation problems and soil salinity caused by the flood event, resulted in water stress affecting 80% of blue palo verde in October (**Figure 3-33**).

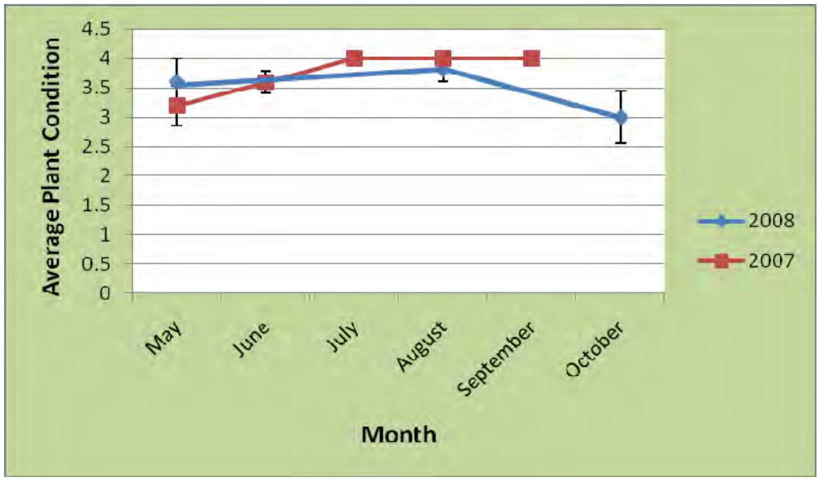

Figure 3-32. Average blue palo verde condition for May to October, 2007 and 2008 for the QAWPF site, Yuma East Wetlands. 0=dead, 1=poor, 2=fair, 3=good, and 4=excellent. Error bars signify standard error.

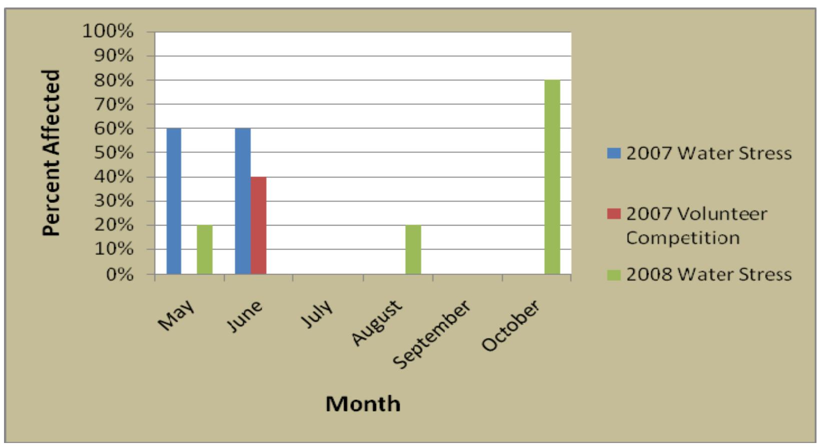

Figure 3-33. Factors influencing blue palo verde conditions and growth for May to October, 2007 and 2008 for the 25 acre QAWPF revegetation site, Yuma East Wetlands.

3.2 Plant Cover

Riparian and Upland Habitat

During the 2007 growing season, salt heliotrope (*Heliotropium curassavicum*), western sea purslane (*Sesuvium verrucosum*), Mexican sprangletop (*Leptochloa uninervia*) and an invasive phragmites (*Phragmites* sp.) had the greatest percent cover for the herbaceous ground cover (**Figures 3-34 to 3-36**). Salt heliotrope and western sea purslane showed the highest cover for the monitored quadrats and also showed the greatest frequency of occurrence in the quadrats 11- 28% for heliotrope and 14- 22% during the 2007 season and 24% for heliotrope and 18% for purslane in 2008. Heliotrope and purslane were seeded together in the 1.3 acre sandbar willow planting area and heliotrope seed was additionally planted in the 1.7 acre cottonwood planting area. These species have also been observed naturally re-colonizing riparian restoration areas. Sprangletop naturally recruited in the QAWPF restoration site. This species probably recruited to the site by wind-swept seeds from other project areas and/or from the native seed bank in the soil. Sprangletop thrives in moist areas and is a rapid colonizer of disturbed areas, and was concentrated around the moist areas near the wetland and within the riparian area. Sprangletop had a frequency of occurrence of 6- 14% during the 2007 growing season and 10% in 2008. Arrowweed, Goodding willow, sandbar willow, marsh fleabane, California bulrush, inland saltgrass and Olney threesquare were also observed in lower densities within the quadrats.

Western sea purslane steadily increased in cover throughout the 2007 growing season and leveled off at 4.5%. During the 2008 growing season, western sea purslane increased in cover from about 5% to 6.27% from May to August and declined under 2% cover in October (Figure 3-34). This observed decline in 2008 may have been due to the inundated conditions caused by the flood.

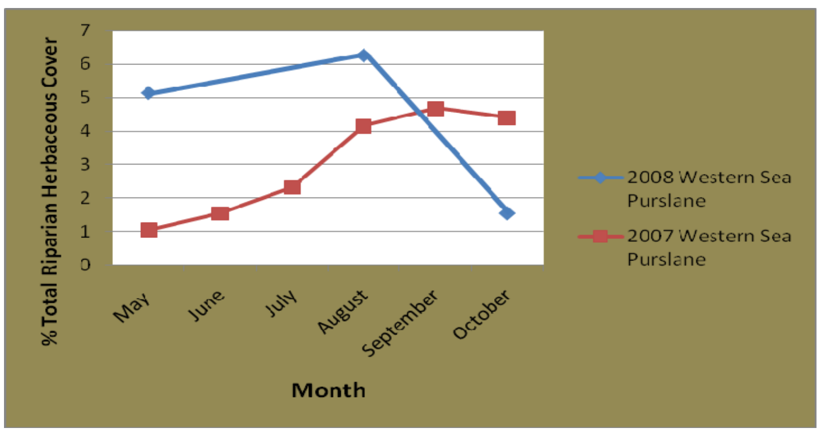

Figure 3-34. Total percent herbaceous cover for Western Sea Purslane from May to October, 2007 and 2008, for the 19.6 acre riparian and upland habitats in the QAWPF revegetation site, Yuma East Wetlands.

Salt heliotrope increased in cover throughout the 2007 growing season, with the highest cover observed in July at about 5% (**Figure 3-35**). Heliotrope cover decreased throughout the 2008 growing season from 3.14% in May to 1.54% in August. This species typically shows the highest cover during the cooler times of the year, and it is not surprising that cover decreased through the hottest time of the year.

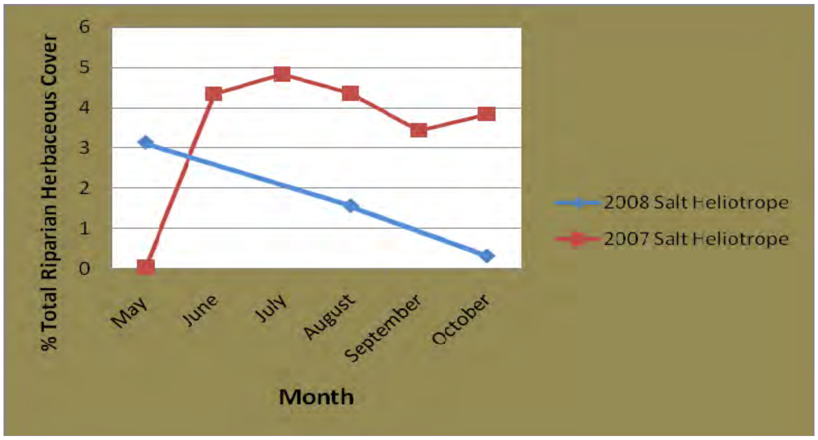

Figure 3-35: Total percent herbaceous cover for salt heliotrope from May to October, 2007 and 2008, for the 19.6 acre riparian and upland habitats in the QAWPF revegetation site, Yuma East Wetlands.

Mexican sprangletop steadily increased in percent cover throughout the 2007 growing season, with the highest cover in October at just over 2% (**Figure 3-36**). Cover increased in this species from May to August 2008, where it reached its zenith at about 5.5% (**Figure 3-36**). However, by October it declined to just under 2%, around the cover it had in October 2007. This may indicate the natural cycle of this species increasing in cover over the warm months and decreasing as temperatures cool.

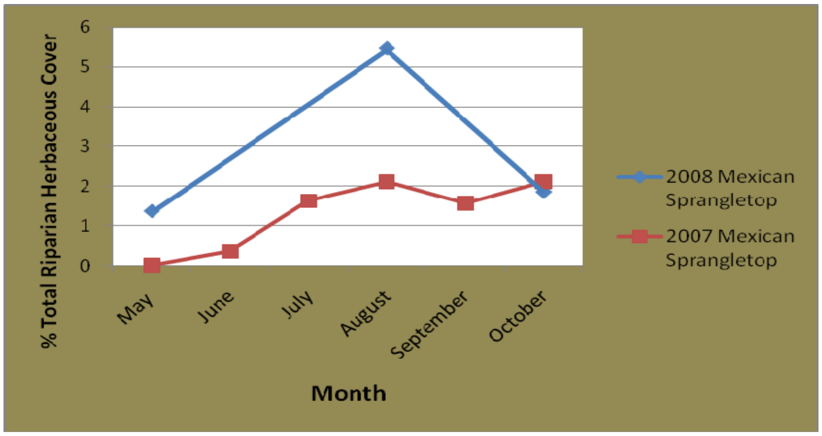

Figure 3-36. Total percent herbaceous cover for Mexican sprangletop from May to October, 2007 and 2008, for the 19.6 acre riparian and upland habitats in the QAWPF revegetation site, Yuma East Wetlands.

The invasive phragmites is an aggressive weed that has proved hard to control in the YEW. Its roots often reach deep into the ground and it colonizes areas rapidly allowing this species to dominate in areas where it has established. In the QAWPF restoration site phragmites has invaded the fringes of the wetland habitat into the riparian zone. Periodic weeding of this species has prevented it from dominating wetland and riparian areas, however it still has the third highest percent cover of all herbaceous species occurring at the site. Throughout the season, phragmites had a frequency of occurrence of 20- 25% in the quadrats during 2007 and 24% during 2008. Continual weeding will have to occur to prevent this species from dominating the site until the native ground cover matures and out-competes it.

The shrub cover within the monitoring quadrats in the riparian and upland areas of the QAWPF revegetation site was dominated by arrowweed (*Pluchea sericea*), screwbean mesquite, quailbush (*Atriplex lentiformis*) and four-wing saltbush throughout the 2007 growing season. Arrowweed, a weedy native species that often rapidly re-colonizes riparian restoration sites showed the greatest cover from May to August until it was manually removed in September 2007 to promote growth in some of the planted native species, particularly cottonwood. This species again increased in cover during the 2008, having the greatest cover at 4% in May and decreased in cover to 0% by October due to manual removal that took place in July. Screwbean mesquite was a planted native species at the site, and its percent cover was minimal in 2007 due to the irrigation problems discussed above. However, by 2008 screwbean mesquite cover increased from May at 2% to almost 3.5% in August. It is expected as trees and shrubs mature at the site, cover will continually increase. Honey mesquite was also detected with minimal cover in the shrub layer.

Wetland Habitat

Although the wetland habitat was planted with various native wetland species, the habitat primarily filled in with native species that established naturally through the seed bank present in the soil and/or from wind blown seed. Mexican sprangletop and California bulrush naturally established in the wetland and showed the highest cover in the quadrats in 2007 (**Figure 3-37**). However, by 2008 California bulrush colonized the area where Mexican sprangletop dominated in 2007, becoming the dominant species in the wetland habitat. Sprangletop decreased in cover from 42% in August 2007 to 22.3% in August 2008. California bulrush dominated this site prior to desiccation in 2001, therefore it is not surprising that after returning water to the site this species proliferated. By May 2008 the California bulrush cover increased from 17- 36%. However, by October the California bulrush cover decreased to 27%.

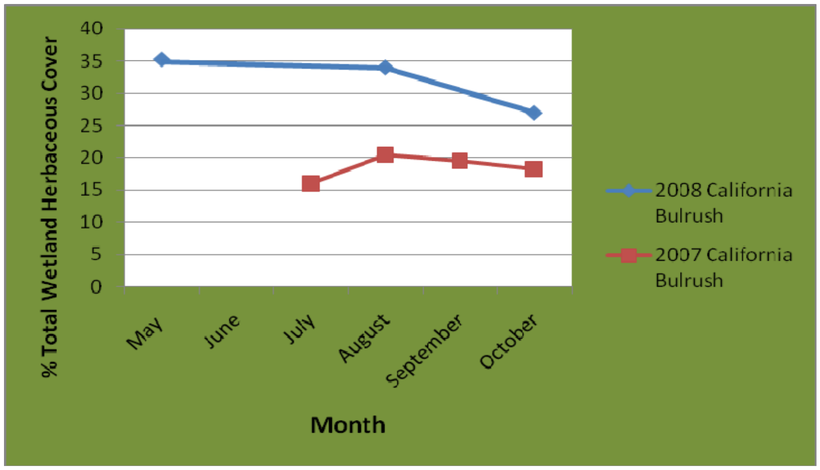

Figure 3-37. Total percent herbaceous cover for California bulrush from May to October, 2007 and 2008 for the 5.4 acre wetland habitat in the QAWPF revegetation site, Yuma East Wetlands.

Alkali bulrush was the most well adapted species planted in the marsh area's saline soils, and therefore was able to thrive. Alkali bulrush cover in 2008 remained similar to that detected in 2007, until it sharply declined in October 2008 (**Figure 3-38**). This may have been caused by the inundated conditions at the wetland. This species prefers areas with shallow to no standing water present. This area may have been inundated with deep water during the August 2008 flood, causing this species to decline. However, this species had a cover of 10.5% and frequency of 40% during 2008.

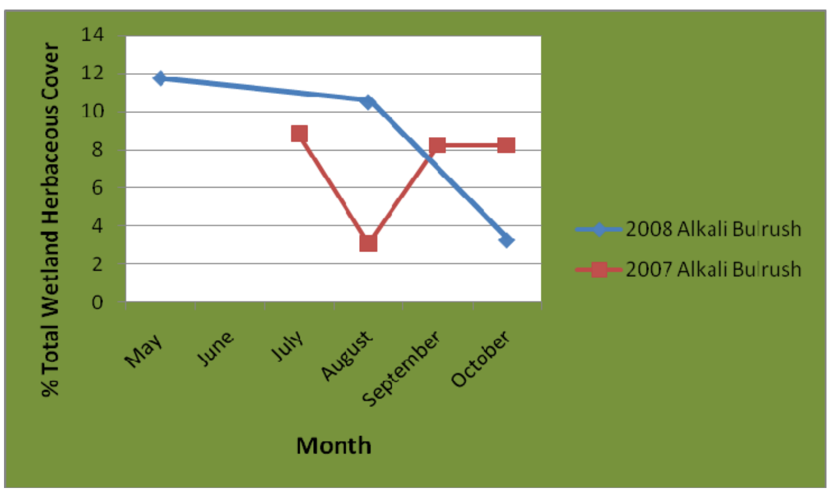

Figure 3-38. Total percent herbaceous cover for alkali bulrush from May to October, 2007 and 2008 for the 5.4 acre wetland habitat in the QAWPF revegetation site, Yuma East Wetlands.

Western sea purslane had similar total percent cover in 2008 as it did during 2007, however the frequency of occurrence decreased from 90% of the quadrats in 2007 to 30% in 2008 (**Figure 3-39**). Other species that were observed in the quadrats with less cover include marsh fleabane, inland saltgrass, threesquare bulrush, and phragmites. Invasive plants, such as phragmites, did not have high cover due to routine weed maintenance.

Figure 3-39. Total percent herbaceous cover for western sea purslane from May to October, 2007 and 2008 for the 5.4 acre wetland habitat in the QAWPF revegetation site, Yuma East Wetlands.

3.3 Endangered Species Surveys

Marsh bird surveys were completed for the 2008 monitoring season on May 28. These surveys included monitoring for the endangered Yuma clapper rail. Two survey points were established in the QAWPF Restoration Project area. No Yuma clapper rails were detected in the QAWPF project site, and no clapper rails were detected in the entire Yuma East Wetlands project area during the 2008 monitoring season. A Yuma clapper rail was detected in 2007 during the last monitoring session in May. However, no other individuals were detected, therefore indicating that no breeding occurred. The QAWPF marsh has grown into a mature marsh dominated by California bulrush. The individual detected during May 2007 remained at the site until winter 2008, however left the site upon initiation of the breeding season. Clapper rails have high site fidelity, and the individual may have returned to the breeding site it utilized in years past. Other shore and marsh birds were detected using the site during the survey period, including: black-necked stilts, western and least sandpipers, great and snowy egrets, cinnamon teals, mallards, killdeer, common moorhens, and killdeer.

Southwestern willow flycatcher (SWFL) endangered species surveys within the QAWPF project area and the entire Yuma East Wetlands were completed July 9. One SWFL survey point was established at the site. No willow flycatchers were detected during the 2008 survey period. Although the QAWPF project site was in excellent condition during 2008 monitoring season, the vegetation is still immature and is not quite suitable for willow flycatcher. Overall, willow flycatcher numbers increased over the past two years within the entire Yuma East Wetlands Project Area. As vegetation matures it is expected that willow flycatcher will continue to increase use in the restored habitat.

4.0 Conclusions and Recommendations

4.1 Project Conclusions

The Yuma East Wetlands QAWPF Project has successfully transformed the severely degraded stand of salt cedar (tamarisk) and dying wetlands starved of freshwater flow to a thriving wetland and riparian habitat supporting native wetland and riparian vegetation with a renewed freshwater input to sustain the wetlands. The initial growing season concluded with the overall health of the site in good to excellent condition. The native wetland species thrived in the moist areas of the site whereas some of the riparian species experienced decreased condition due to water and salt stress during the 2007 and 2008 growing seasons. Survivorship rates for most species were 80% and over, with the exception of sandbar willow, Goodding willow and ironwood, for the first two growing seasons until the August 2008 flood occurred. Despite the extreme environmental conditions that occurred during 2007 and 2008, the site has recovered the bird life that once utilized this site prior to wetland desiccation and non-native species invasion, including the endangered Yuma clapper rail. Also, the surviving native tree and shrub individuals showed increased growth and recruitment.

During the 2007 growing season, water stress was the primary culprit for the decreased condition in many species observed at the site. Early in the growing season the irrigation pump filters were not functioning and allowed sediment to enter the irrigation lines. The sediment in the lines clogged the emitters and prevented water from reaching the individual trees. Also, because the pump was not functioning properly there was not sufficient pressure in the lines to carry water up to the species planted on the berms, including ironwood, wolfberry and palo verde. These problems occurred for 2 months during which time the plants either did not receive water or were being watered by hand. Once the problem had been resolved, plant condition and growth improved.

Salt stress and water stress from inundated conditions were the primary reason for the mortality and decreased condition in the sandbar and Goodding willows. These species were planted along the fringe of the wetland and often were inundated from the increased water levels in the wetland area from the South Channel. The sandbar willow and Goodding willow poles were submerged through the soil into the water table. The soil salinity probably increased by the rising and ebbing of water in the groundwater from the channel flooding, which would deposit salts when the water receded. Also, prior to planting the surface to water depth was measured at 2 feet, indicated that soil saturation occurred even when the channel was not raised. Therefore, these trees probably experienced frequent and long duration inundation, which they are not adapted to withstand. Despite the poor condition of the sandbar and Goodding willows, the herbaceous cover, including western sea purslane, salt heliotrope, alkali bulrush and California bulrush flourished in this area.

The August 2008 flood inundated large areas of the QAWPF project site, causing salts to migrate to the soil surface and creating an inhospitable environment for many riparian and wetland species. In 2007, sandbar and Goodding willow were affected by inundation and salt migration due to the regular inundation of the wetland and South Channel. However, the flood distributed water to areas that did not inundate on a regular basis, which had a more widespread detrimental effect. The flood had the greatest effect on Emory baccharis, which had a 100% mortality rate. The condition of all riparian species declined after the flood waters receded due to the high salinity, however very little mortality occurred. Many of these species showed sign of recovery in October. Many of the upland plants were not affected by the flood, including four-wing saltbush, ironwood and wolfberry all species that had high survival rates.

The native groundcover throughout the site flourished and provided good cover, which has provided habitat for a variety of invertebrate species and has limited the re-colonization of non-native vegetation. Purslane and heliotrope were the two planted species that showed the greatest cover in the monitoring quadrats, however inland saltgrass was also detected with lower coverage. Alkali sacaton and inland saltgrass plugs were planted in the tree well of the revegetated species in order to receive water from drip irrigation. These two species were flourishing in the tree wells, however were not detected in the quadrats because they were located adjacent to the tree well. Also, herbaceous recruiters from the planted native trees, including Goodding and sandbar willow were also detected in the quadrats. This indicates natural ecosystem function. Maintenance and weeding will have to continue to limit the growth of invasive phragmites. This species is very aggressive and can grow in extreme environmental conditions such as high salinities. Recent evidence suggests that phragmites exudes a root toxin that is able to kill neighboring vegetation so that it can dominate large areas.

Project maintenance at this site will continue in the future, including irrigation line maintenance, non-native species removal, and re-planting of native species if necessary. Maintenance weeding has been really successful in controlling non-native species re-colonization. With these regular maintenance activities this site will approach self-sustaining wetland and riparian habitat, which will provide an excellent food source and habitat for birds and other wildlife.

4.2 Recommendations for Future Projects

Some of the environmental factors that occurred during the duration of this project, particularly the 2008 flood, could not be prevented nor prepared for in future projects. In an area that has limited availability of fresh water, one would have thought that a flood event would have improved conditions. However, due to the high soil salinities in the area, the flood waters acted to move those salts to the surface created an inhospitable environment for many species. The QAWPF site was initially challenged by high soil salinities, which can be observed in the 2007 data. Despite these environmental challenges, the majority of the planted native species at the QAWPF site are thriving. This indicates the hearty nature of these species and their adaptability to extreme conditions and catastrophic events. Future projects should continue to utilize these native species for revegetation.

With a limited water supply available for restoration, drip irrigation is often the most water saving and cost effective method for irrigation. However, drip irrigation needs to be constantly maintained as experienced during the 2007 growing season. Emitters get plugged, irrigation lines break and are easily displaced, and pumps need to be maintained, which all occurred at the QAWPF site. When possible, flood irrigation may have less maintenance required and have greater distribution of water to promote a healthy over- and under-story growth. By increasing the amount of water on a project site for longer duration, in order to leach the salts out of the soil, may increase plant growth rate and condition and provide a better habitat for wildlife.

Continual weeding of invasive phragmites will need to continue on the QAWPF site as well as any new project site. This species has a deep root system, which is near impossible to completely eliminate from a site. Therefore, it will need continual maintenance until the native under-story develops enough to out-compete this species.

5.0 References

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6.0 Photo Monitoring Results

6.1 QAWPF 25-Acre Revegetation Project 2007 Photo Monitoring Point #1

6.2 QAWPF 25-Acre Revegetation Project 2007 Photo Monitoring Point #2

6.3 QAWPF 25-Acre Revegetation Project 2007 Photo Monitoring Point #3

6.4 QAWPF 25-Acre Revegetation Project 2007 Photo Monitoring Point #4

6.5 QAWPF 25-Acre Revegetation Project 2007 Photo Monitoring Point #5

6.6 QAWPF 25-Acre Revegetation Project 2007 Photo Monitoring Point #6

6.7 QAWPF 25-Acre Revegetation Project 2008 Photo Monitoring Point #1

6.8 QAWPF 25-Acre Revegetation Project 2008 Photo Monitoring Point #2

6.9 QAWPF 25-Acre Revegetation Project 2008 Photo Monitoring Point #3

6.10 QAWPF 25-Acre Revegetation Project 2008 Photo Monitoring Point #4

6.11 QAWPF 25-Acre Revegetation Project 2008 Photo Monitoring Point #5

6.12 QAWPF 25-Acre Revegetation Project 2008 Photo Monitoring Point #6

7.0 Appendices

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 1. May 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 1. July 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 1. October 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 2. May 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 2. July 2007.

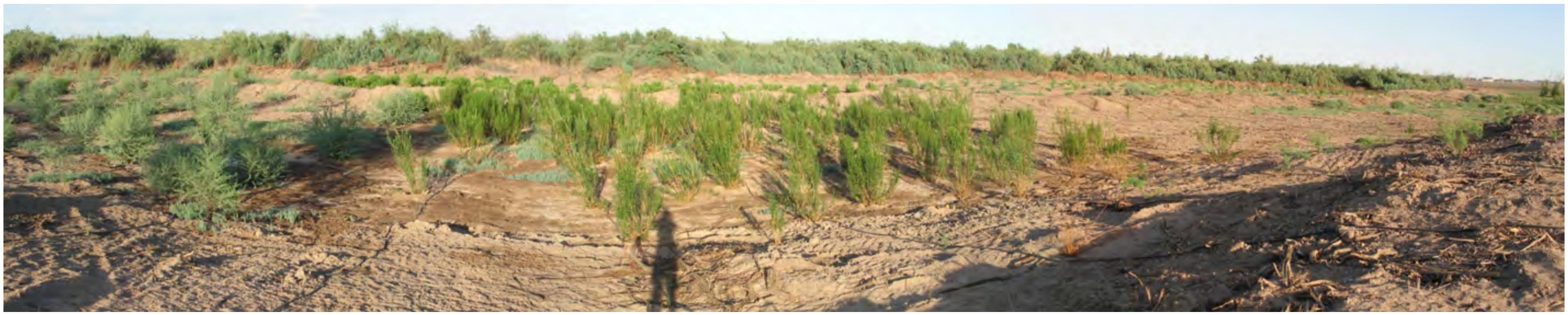
Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 2. October 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 3. May 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 3. July 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 3. October 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 4. May 2007.



Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 4. July 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 4. October 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 5 180 degrees off. May 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 5. July 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 5. October 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 6 . May 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 6. October 2007.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 1. May 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 1. August 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 1. September 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 2. May 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 2. August 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 2. September 2008.


Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 3. May 2008.


Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 3. August 2008.


Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 3. September 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 4. May 2008.

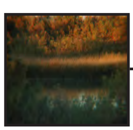
Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 4. August 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location #4. September 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 5. May 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 5. August 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 5. September 2008.



Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 6. May 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 6. August 2008.

Quechan Arizona Water Protection Fund (QAWPF) Photomonitoring Location # 6. September 2008.