Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Beal Riparian and Marsh Restoration 2006 Annual Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

August 2008

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Lower Colorado River
Multi-Species Conservation Program

Beal Riparian and Marsh Restoration
2006 Annual Report

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Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
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Acronyms and Abbreviations

AW	Arrowweed land cover type, as defined in the LCR MSCP HCP
AGFD	Arizona Game and Fish Department
ANOVA	Analysis Of Variance (statistical)
AOU	American Ornithological Union
BWRNWR	Bill Williams River National Wildlife Refuge
C°	Celsius
cm	Centimeter
CW	Cottonwood-Willow land cover type, as defined in the LCR MSCP HCP
DBH	Diameter at Breast Height
E	Evenness
EC	Electro-conductivity
F°	Fahrenheit
FT	Feet
Gm/m^3	Units of grams of water vapor per cubic meter of air
gpm	Gallons per minute
GPS	Global Positioning System
ha	Hectare
HCP	Habitat Conservation Plan
HM	Honey Mesquite land cover type, as defined in the LCR MSCP HCP
kg	Kilogram
kg/cm^2	Kilograms per square centimeter
in	Inches
lb	Pound
L	Liter
LCR	Lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	Meter
min	Minutes
mg/kg	Milligram per kilogram
mm	Millimeter

MNSW	MacNeill's Sootywing Skipper
mS/cm	Milli-Siemens per centimeter
n	Sample size
N_1	Ecological Species Diversity
NWR	National Wildlife Refuge
P	Probability (statistical)
pH	Concentration of hydrogen ions in a solution
Reclamation	Bureau of Reclamation
S	Species Richness
SE	Standard Error
SM	Saltcedar and screwbean mesquite land cover type, as defined in the LCR MSCP HCP
sp(p)	Species (plural)
SWFL	Southwestern Willow Flycatcher
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USDA	U.S. Department of Agriculture
UTM	Universal Transverse Mercator
WIFL	Willow Flycatcher
YBCU	Yellow-billed Cuckoo
%	Percent

Background

The Beal Riparian Restoration Project was initiated in 2001 by the Bureau of Reclamation's (Reclamation) Lower Colorado Regional Office in Boulder City, Nevada, in partnership with the land owner, the U.S. Fish and Wildlife Service (USFWS), Havasu National Wildlife Refuge (NWR). In 2001, Beal Lake was dredged to create refugia for native fish. The dredge material was distributed over adjacent areas to be planted at a later date with native riparian vegetation. Work on the riparian habitat area began in 2002. When implementation of the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) began in 2005, the project was utilized to test and demonstrate restoration and management techniques (Reclamation 2005).The site is being used to test various riparian restoration methods and techniques for site preparation, planting, irrigation, monitoring, managing, and maintenance (LCR MSCP 2005). The site was divided into individual fields that could be managed independently to test restoration and management techniques. In addition, this project will result in approximately 107 acres (43 ha) of cottonwood, willow, and mesquite landcover types, not including Phase 3, a 100-acre (81 ha) site that was cleared of existing vegetation and revegetated by scattering intact honey mesquite seed pods *(Prosopis glandulosa* var. *torreyana*).

The Beal Riparian Restoration site was planted using container plants grown in nurseries, cuttings, poles, and seeds. Phase 1 began in 2003 and was completed in 2005, resulting in 59.5 acres (24.1 ha) of Fremont cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii*), coyote willow (*Salix exigua*), screwbean mesquite (*Prosopis pubescens)*, and honey mesquite land cover types (Bureau of Reclamation 2005). Phase 2 was started in 2004 and completed in 2005, adding an additional 47.7 acres (19.4 ha) of cottonwood and willow land cover types. Areas with saline soils were planted with salt-tolerant shrubs (*Atriplex* spp., *Baccharis* spp.) and various groundcover plants. Planting details for each field can be found in the 2005 Annual Report (Bureau of Reclamation 2006).

1.0 General Site Information

1.1 Purpose

The project is being utilized to demonstrate native riparian plant restoration, habitat management, and monitoring techniques. Results will be monitored and documented annually to determine whether conditions are appropriate for LCR MSCP covered species, specifically the southwestern willow flycatcher (SWFL) and the yellow-billed cuckoo (YBCU).

1.2 Location/Description

The project is located in Reach 3, between Beal Lake and lower Topock Marsh, on Havasu NWR, near Needles, California. It is within the historic floodplain of the lower Colorado River (LCR), adjacent to River Mile 237 in Arizona (Figures 1.1 and 1.2).

1.3 Land Ownership

The project is located on Havasu NWR, which is owned and managed by the U.S. Fish and Wildlife Service.

1.4 Water

Colorado River water is diverted into Topock Marsh through two instrumented inlet canals. Irrigation water for the project is supplied from Topock Marsh. Water utilized to irrigate habitat restored during the project comes from Havasu NWR's combined second and third priority entitlements of 37,339 acre feet per year consumptive use and 41,839 acre feet diversionary right. Havasu NWR possesses a second/third priority water entitlement provided by Supreme Court Decree No. 7 to fulfill the purposes of the refuge (Executive Order No. 8647 and Public Land Order No. 559).

1.5 Agreements

Restoration efforts at Beal Lake represent an ongoing partnership between the Havasu NWR and Reclamation. If the decision is made to request habitat creation credit under the LCR MSCP for the project site, a Land Use Agreement (LUA) will be drafted to secure the land and water to maintain the riparian habitat for 50 years. The LUA will also outline the rights and responsibilities of each partner in the project's future development and maintenance.

During the interim period, Reclamation has entered into an Interagency Agreement with the USFWS to fund a position for an employee to manage the site through 2009. At that time, evaluation of the site will determine if acreage credit will be applied under the LCR MSCP.

2.0 2006 Habitat Development

2.1 Planting

Native riparian vegetation planting was completed in December 2005 (Reclamation 2006). Since then, only cover crops have been planted on some fields for weed control and to help condition the soils for future planting. In the fall of 2006, the centers of fields AA, CC, HH, and LL were seeded with wheat, while sections of fields FF, JJ, MM, II, DD, and BB were seeded with barley. Urea 46-0-0 was applied aerially to the seeded fields at a rate of 150 lbs per acre to add nutrients to the sandy soils.

2.2 Irrigation

The project is flood irrigated using one alfalfa valve per field (Reclamation 2006). A total of 1,635 acre feet of water were used to irrigate the entire site in 2006 (Table 2.1). Irrigation took place according to the schedule in Table 2.2.

Figure 1.1. Location of the Beal Lake Riparian Restoration Project

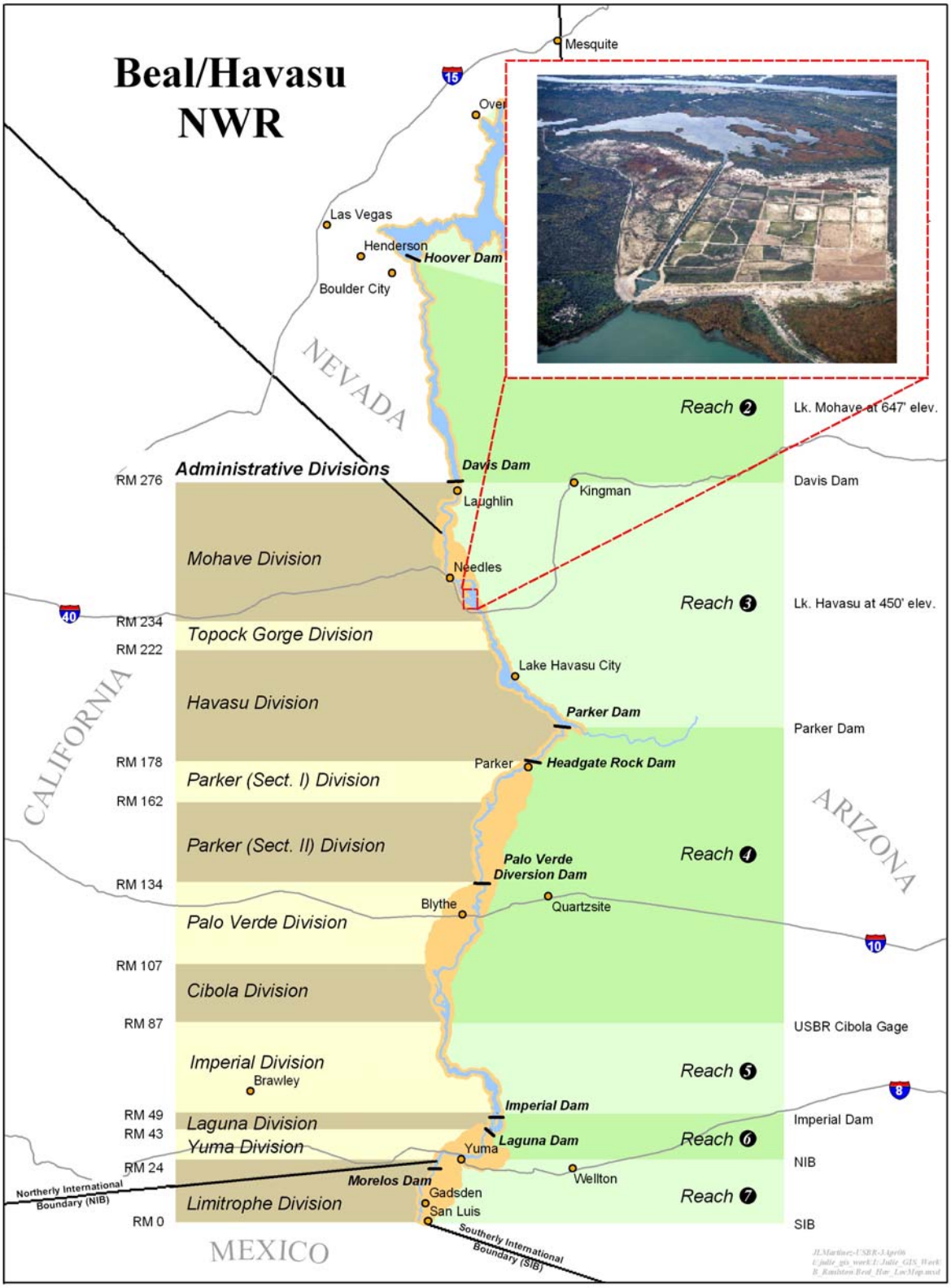


Figure 1.2. Aerial photo of the project taken in August 2006

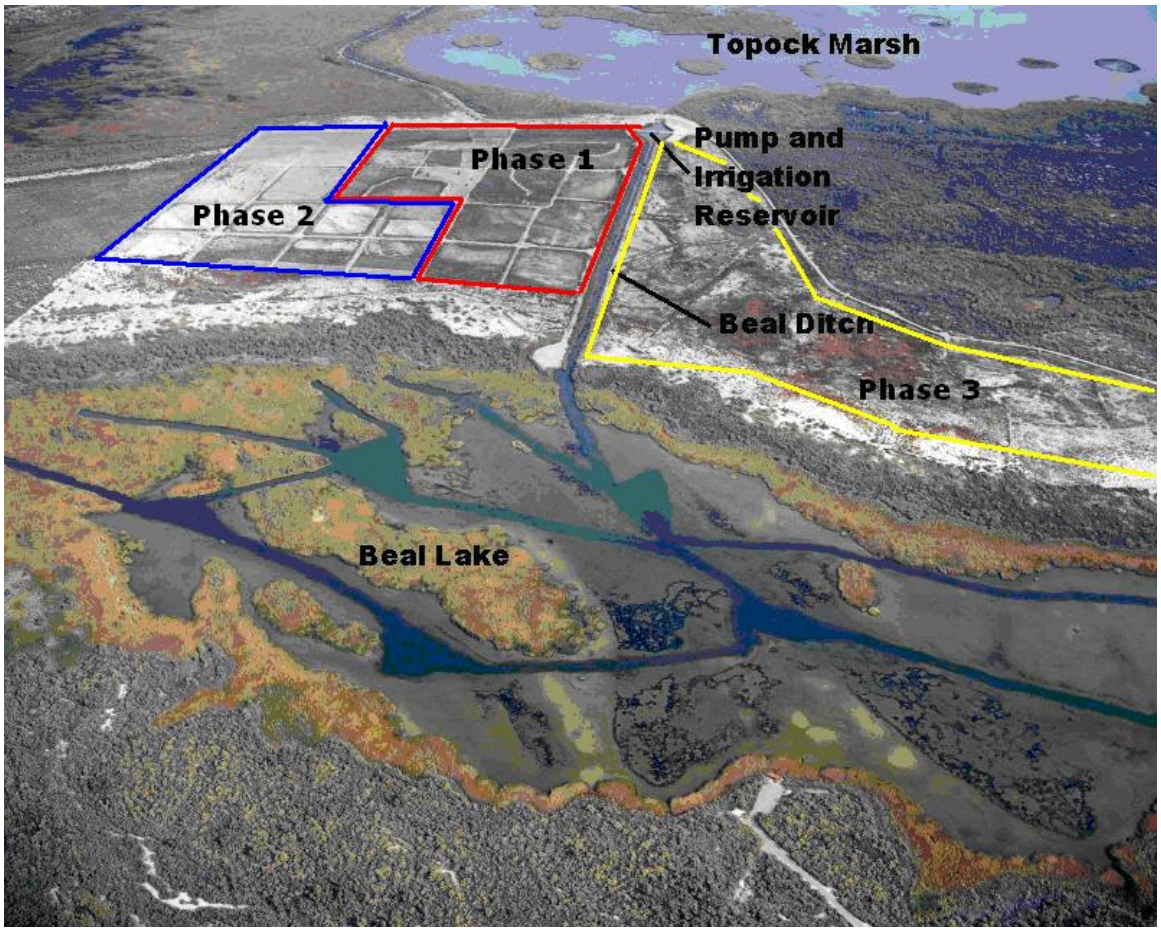


Table 2.1. Acre feet of water used per month at Beal Riparian Project in 2006

	2006												
Month	**Jan**	***Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Gallons x 10,000	33	2733	7989	5296	5901	5404	5259	8515	5934	4227	1994	2818	56103
Acre Feet (af)	0.0	84	245.0	162.0	181.0	166.0	161	261	182	130.0	61.0	86.0	1719.0
Acre Feet/Acre (af/ac)	0.0	0.8	2.3	1.5	1.7	1.5	1.5	2.4	1.6	1.2	0.6	0.8	15.9

Table 2.2. Irrigation frequencies by field

2006 Average Irrigation Frequency per Month by Field													
Field	**Acres**	**Vegetation Type**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
A,N	11.3	Salt-tolerant shrubs	0	0	1	0	0	0	0	1	0	1	0	0
B,C,D,E,F,G,I,J,M,O	48.3	CW (+2 yrs)	0	0	1	1	1	1	1	1	1	0	0	0
H, Q, K, L, P	14.9	CW (seed and container plants, 1 and 2 yrs	0	0	2	4	4	3	3	5	4	1	0	0
AA,CC,HH,LL	15.1	CW (1st & 2nd yr, container plants & poles)	1	1	1	2	2	1	2	2	2	1	0	0
BB,DD,II,MM	13.7	Mesquite (+2nd year/cover crop	1	1	1	1	0	0	0	1	0	0	0	0
FF, GG, JJ,KK	13.8	CW Container Plants/cover crop, 1st yr	1	1	1	2	2	2	2	2	2	1	0	0
EE	4.7	Not planted, saline												

Fields H, K, L, P, and Q were kept wetter than other fields in order to maintain conditions preferred by SWFL and other LCR MSCP covered avian species typically found in moist areas with dense vegetation. The fields planted in December 2005 (K, JJ, FF, KK, GG, LL) also received more water than the more established vegetation in the other fields. In February, 84 acre feet were used to flush the reservoir and test fish screening equipment (this water was not used to irrigate the fields).

2.3 Site Maintenance

The irrigation pump used approximately 5.1 gallons (19 L) of diesel fuel per hour of operation. Routine maintenance and refueling was performed on the pump throughout the year.

3.0 2006 Monitoring

3.1 Habitat Monitoring

3.1.1 Soils

Methods

Soil samples were collected at the project during April 2006. Two samples were collected per field in phases 1 and 2. Samples were taken from the same locations where previous samples had been collected in 2002 and 2004 (Franzen 1999). Samples were collected with soil augers measuring 4 in by 6 in (16 cm by 10 cm) at three depths per sample: surface, 1.0 ft (0.3 m), and 3.0 ft (0.9m). Samples were double-bagged with Ziploc bags and the following data were recorded for each sample: Universal Tranverse Mercator (UTM) location, time, sample number, collectors, temperature, and sample site description (Csuros 1994).

Analysis was performed at Reclamation's Lower Colorado Regional Laboratory in Boulder City, Nevada, according to the protocol established in the U.S. Department of Agriculture's (USDA) 1996 methods manual (USDA 1996). Samples were analyzed for percent saturation, soil salinity, texture, pH, nitrate, ortho-phosphate, and ammonia. The data for each parameter were graphed using histograms to check normality of data. The mean and 95% confidence interval for each parameter measured were calculated per phase. Soil data from 2006 were compared to soil data from previous years using unpaired t-tests assuming equal and unequal variances. Nutrient data from Phase 1 were compared using unpaired t-tests assuming equal and unequal variances. Data collected in 2006 from Phase 1 and 2 were compared using unpaired t-tests assuming equal and unequal variances.

Results

Soil data showed a normal distribution; thus, parametric statistical tests could be used. In 2006, soil salinity values at the project ranged from 0.4 to 82.9 mS/cm for all depths (Table 3-1). Soil salinity and nitrate levels in Phase 1 were less than soil salinity and nitrate levels in Phase 2 (P = 0.006, P = 0.00, respectively). The highest soil salinity values were detected in fields A, K, N, EE, and NN. The soil salinity values in these fields were also among the highest in 2002 and 2004. Soil salinity did not differ between years at the project (P = 1.97 Phase 1, P = 1.97 Phase 2). There were higher nitrate and ortho-phosphate levels in fields C, G, H, K, and O in Phase 1 in 2003 than in 2006 (P = 1.9 E-07, 1.33 E-09, respectively) (Table 3-4). There were higher

nitrate and ortho-phosphate levels in Phase 2 in 2004 than in 2006 (P = 2.33 E-06, P = 2.32 E-15, respectively).

Discussion

The salinity values in fields N, EE, and NN were fairly high (22.8mS/cm, 36.2 mS/cm, and 23.1 mS/cm, respectively), which may have driven up the mean soil salinity. When the project is irrigated, the salts tend to move into the fields that are located at the edge of the project. Salinity between years did not change much for either phase. Nitrate and ortho-phosphate levels decreased as the project matured. Possible reasons for this are nutrient uptake by the plants and the leaching of nutrients through irrigation. Soil sampling will continue in future years and will yield important information on fluctuations and trends of important parameters from year to year.

Table 3.1. Soil sampling results at the Beal Lake Riparian Project, 2002-2006 (mean with 95% confidence interval)

	2002 Phase 1 n = 53	2003 Phase 1** n = 29	2006 Phase 1 n = 101	2004 Phase 2 n = 83	2006 Phase 2 n = 89
Percent saturation (%)	32.3 (0.6)	31.3 (1.3)	31.9 (0.6)	31.9 (0.9)	32.6 (0.6)
Ece (mS/cm)	4.1 (1.3)	1.2 (0.3)	2.7 (1.1)	9.9 (4.1)	7.5 (3.2)
pH	--*	--*	8.1 (0.1)	--*	8.2 (0.1)
Percent sand (%)	93.0 (2.7)	92.1 (6.0)	91.5 (2.3)	83.9 (5.8)	90.6 (2.6)
Percent clay (%)	2.7 (0.4)	1.6 (0.8)	2.6 (0.4)	4.1 (0.7)	4.1 (0.5)
Percent silt (%)	4.1 (2.4)	6.3 (5.2)	5.9 (1.9)	12.0 (4.2)	5.4 (2.2)
Phosphate (mg/kg)	--*	0.1 (0.1)	0.003 (0.0008)	0.1 (0.02)	0.003 (0.001)
Ammonia (mg/kg)	--*	0.2 (0.02)	0.2 (0.04)	0.2 (0.1)	0.2 (0.03)
Nitrate (mg/kg)	--*	5.2 (1.3)	0.3 (0.01)	8.0 (2.3)	1.9 (0.6)

*Measurement not taken.
** In 2003, soil samples were only taken in select fields (C, G, H, K, and O) in Phase 1.

3.1.2 Microclimate and Soil Moisture

Methods

Temperature and relative humidity were measured with HOBO® H8 Pro data loggers made by Onset Computer Corporation in Pocasset, Massachusetts. The device combines an internal thermometer measuring temperature in degrees Celsius (ºC) and degrees Fahrenheit (ºF), a relative humidity sensor, and a data logger (also called a sensor array).

Four data loggers (B1, B2, B3, B4) were placed in cottonwood-willow (CW) land cover types being targeted for SWFL and other covered avian species (fields P, L, Q, H). These fields were irrigated weekly during the breeding season. One data logger was placed in each field. Four data loggers (A1, A2, A3, and A4) were placed in CW land cover types that were irrigated monthly during the breeding season. Microclimate parameters were compared between the two different watering regimes. Data logger locations were subjectively chosen without

preconceived bias to ensure that data loggers were placed in representative CW land cover types (Mueller-Dombois and Ellenberg 1974).

All eight data loggers were placed in an inverted small, plastic bowl, coated with spray adhesive and local vegetation. The opening at the bottom of the bowl was covered with shade cloth, allowing air to circulate around the sensor. Household adhesive and sealant was used to seal openings in the plastic bowl to create a waterproof container.

Data loggers were placed a random distance, ranging from 0.0 ft (0.0 m) to 9.8 ft (3.0 m), from the bole of a suitable cottonwood or willow tree. All data loggers were placed facing a random direction from the bole of the tree.

Six of the data loggers were placed at the site on 31 March 2006 and two data loggers were placed at the site on 11 May 2006. All data loggers remained at the location where they were placed until 21 September 2006. All data loggers were set to record data every 15 minutes. Data loggers were manually downloaded every 3 months. Parameters recorded included temperature (°F and °C), high-res temperature (°F and °C), absolute humidity (gm/M^3), and relative humidity (%).

The mean diurnal temperature (°F and °C), mean maximum diurnal temperature (°F and °C), and mean diurnal relative humidity (%) were calculated for each of the eight data loggers. A 95% confidence interval was calculated for each parameter. Diurnal period was calculated by using the actual daily sunrise and sunset times reported for the region by the National Weather Service. Data were graphed with histograms using Minitab to check for normality of data. The mean values of data loggers at each location were compared with reference values for the creation of SWFL habitat using a one-sample t-test (McLeod et al. 2005, McLeod et al. 2006) (Table 3-2). A one-way analysis of variance test (ANOVA) was conducted between HOBO data loggers at the eight locations for difference in mean values. A Tukey one-way multi comparison test was conducted to determine which mean values actually differed. The mean values of the two irrigation regimes were compared using a two-sample t-test assuming equal variances. Statistical tests were conducted using SYSTAT version 11 and MINITAB for Windows 95.

Volumetric soil moisture content was recorded with a Theta Probe ML2x soil moisture probe coupled to an HH2 Moisture Meter made by Dynamax Corporation in Houston, Texas. Volumetric soil moisture content is the ratio between the volume of water present and the total volume of the sample (Dynamax Inc. 1999).

Soil moisture measurements were taken directly underneath each HOBO® H8 Pro data logger and at 1.6-ft (0.5-m) intervals from 1.6 ft (0.5 m) to 6.6 ft (2.0 m) in each cardinal direction for a total of 17 measurements per location. Measurements were taken 10 times during the breeding season (May-August) and one time in September. The date, time, observer, and volumetric soil moisture content were recorded for each measurement. If the soil was too dry to obtain a volumetric soil moisture reading, the logger read “under”. If the soil was inundated, a recording of “saturated” was given. Data analysis recordings of “saturated” were converted to a value of 50% and recordings of “under” were converted to a value of 0.0% (McLeod et al. 2005, McLeod et al. 2006). Data were graphed with histograms using Minitab to check for normality of data. The mean value of volumetric soil moisture content for each location was compared with the reference value for the creation of SWFL habitat with a one-sample t-test

(McLeod et al. 2005, McLeod et al. 2006) (Table 3-2). Volumetric soil moisture content between each of the eight locations where soil moisture was sampled was compared with a one-way ANOVA test. A Tukey one-way multi-comparison test was conducted to determine which mean values actually differed. The mean values of volumetric soil moisture content of the two irrigation regimes were compared using a two-sample t-test assuming equal variances. Statistical tests were conducted using SYSTAT version 11 and MINITAB for Windows 95.

Table 3.2. Reference variables for the creation of SWFL habitat

Canopy Height	Average greater than 13.1 ft (4.0 m)
Canopy Closure (% total)	Greater than 70%
Vertical Foliage Density	Density greatest between 3.3 ft (1.0 m) and 13.1 ft (4.0 m) above ground. This may change as additional analysis is completed.
Mean Soil Moisture (% volume)	Minimum of 17%, average of 23%
Mean Diurnal Temperature (degrees Celsius)	Between 79°F (26°C) and 91°F (33°C)
Mean Maximum Diurnal Temperature (degrees Celsius)	Maximum of 113°F (45°C) Average between 90°F (32°C) and 113°F (45°C)
Mean Diurnal Relative Humidity (%)	Greater than 33%

Results

Microclimate data followed a normal distribution; thus, parametric statistical tests could be used. Mean microclimate and soil moisture parameters were recorded at data logger locations from May to September 2006. Mean diurnal temperature ranged from 90.4°F (32.5°C) to 98.4°F (36.9°C). Mean maximum diurnal temperature ranged from 103.7°F (39.8°C) to 116.8°F (47.2°C). Mean diurnal relative humidity ranged from 26.7% to 38.1%. Mean volumetric soil moisture content ranged from 3.7% to 24.6% (Table 3-3). Volumetric soil moisture content varied greatly between sample dates as can be seen from the large confidence intervals. For all locations, mean diurnal temperature, mean maximum diurnal temperature, and mean diurnal relative humidity showed the same fluctuations through time (Figure 3-1, 3-2, 3-3).

Table 3.3. Microclimate and soil moisture data from HOBO® data loggers at the Beal Lake Riparian Project, 31 March 2006 to 8 August 2006 (Mean and 95%CI)

Hobo	Irrigation Schedule	Field	Mean Diurnal Temperature (C°)	Mean Maximum Diurnal Temperature (C°)	Mean Diurnal Relative Humidity (%)	Volumetric Soil Moisture Content (%)
A1	Monthly	C	33.1 (0.5)	47.1 (0.7)	36.6 (1.7)	7.2 (8.9)
A2	Monthly	D	33.5 (0.6)	39.8 (0.6)	29.3 (1.6)	16.0 (7.7)
A3	Monthly	B	35.8 (0.9)	45.2 (1.0)	26.6 (1.3)	3.7 (2.6)
A4	Monthly	I	35.5 (0.7)	46.4 (0.8)	31.3 (1.4)	10.8 (4.3)
B1	Weekly	Q	33.2 (0.6)	45.3 (0.9)	38.1 (2.3)	24.6 (9.7)
B2	Weekly	H	32.5 (0.7)	42.8 (1.0)	38.1 (1.7)	21.9 (10.6)
B3	Weekly	L	35.1 (0.8)	46.0 (1.1)	32.9 (2.0)	9.9 (8.7)
B4	Weekly	P	36.9 (0.6)	45.3 (0.7)	34.6 (2.0)	12.1 (8.5)

Figure 3.1. Mean maximum temperature over time, April-September 2006

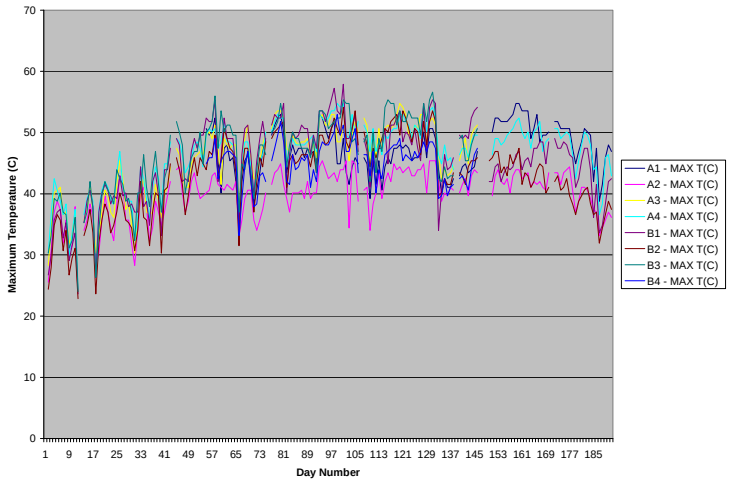


Figure 3.2. Mean diurnal temperature over time, April-September 2006

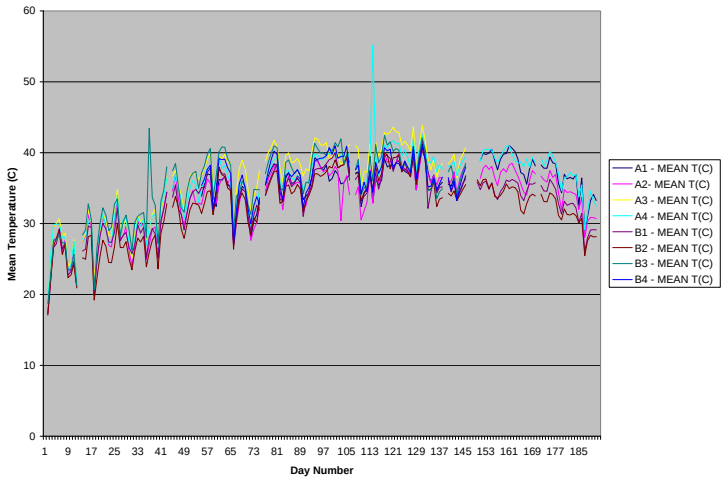
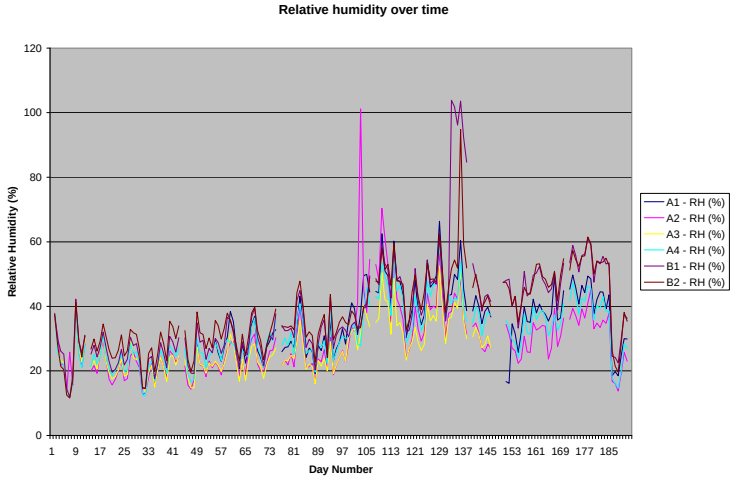


Figure 3.3. Mean diurnal relative humidity over time, April-September 2006



Data loggers at locations A2 and B2 recorded a lower mean maximum diurnal temperature than data loggers at the other locations (P = 0.00). The data logger at location A2 recorded a lower mean value than the data logger at location B2. There was no difference in mean diurnal temperature recorded between the different data logger locations (P= 0.29). There was a difference in mean diurnal relative humidity that was recorded between data loggers at the eight locations (P = 0.00). The mean recorded at locations B1 and B2 was higher than the mean recorded at locations A2, A3, A4, and B7. The mean recorded at location A1 was higher than the mean recorded at locations A2, A3, and A4. The mean recorded at location B4 was higher than the mean recorded at locations A2 and A3. The mean recorded at location B3 was higher than the mean recorded at location A3. There was no difference in relative humidity (P = 0.09), mean diurnal temperature (P = 0.48), and maximum diurnal temperature (P = 0.93) between areas with different watering regimes.

There was a difference in mean volumetric soil moisture content between data logger locations (P = 0.01). The volumetric soil content was higher at locations B1 and B2 than at the other six locations. The volumetric soil content was lower at location A3 than at the other seven locations. The volumetric soil content was higher at location A2 than at locations A1, A3, A4, B3, and B4. There was no difference in mean volumetric soil moisture content between areas with different watering regimes (P = 0.13)

Mean diurnal relative humidity of data loggers at locations A1 (P = 0.00), B1 (P = 0.00), and B2 (P = 0.00) were greater than 33%. Mean diurnal relative humidity of data loggers at locations A2 (P = 1.00), A3 (P = 1.00), A4 (P = 0.99), B3 (P = 0.56), and B4 (P = 0.14) were not greater than 33%. Mean diurnal temperature of data loggers at all locations were not less than 33°C (A1 P = 1.00, A2 = 0.945, A3 P = 1.00, A4 P = 1.00, B1 P = 0.78, B2 P = 0.06, B3 P = 1.00, and B4 P = 1.00). Mean maximum diurnal temperature of data loggers at locations A2 (P = 0.00) and B2 (P = 0.00) were less than 45°C. Mean maximum diurnal temperature of data loggers at locations A1 (P = 1.00), A3 (P = 0.68), A4 (P = 1.00), B1 (P = 0.73), B3 (P = 0.96), and B4 (P = 0.78) were not less than 45°C. Mean volumetric soil content at all locations was not greater than 17% (A1 P = 0.965, A2 P = 0.596, A3 P = 1.00, A4 P = 0.987, B1 P = 0.089, B2 P = 0.207, B3 P = 0.919, and B4 P = 0.845).

Discussion

During the 2006 field season, two of the plastic cases containing data loggers deteriorated within 3 months, which caused the data loggers to become disconnected from the tree and subsequently lost by May. New data loggers were placed in the same location on 11 May 2006. Also, some of the data loggers and cases were occasionally found on the ground while temperature and humidity data were being recorded. This could have affected the data and should be noted when examining the data. When a data logger was found on the ground, the casing was replaced, and it was placed in its original location. Two possible ways to correct this problem in future years are to use a more durable material such as Nalgene for the casings, and to use new casings every season.

Soil moisture measurements varied depending on sample location and period. Soil texture at the project consists primarily of sand, which does not hold moisture well. Fields are inundated when flood irrigation occurs for approximately 1 day, are moist shortly afterward, and are then dry until the next flood irrigation. Mean volumetric soil moisture content during the breeding

season varied depending on when the measurements were taken. This suggests a need for permanent soil moisture monitoring data loggers at the project.

Mean maximum diurnal temperature, mean volumetric soil moisture content and mean diurnal relative humidity differed between sampling locations. These differences may be due to differences in species composition, stand density, foliage height diversity, or water availability due to irrigation regime and soil texture. Biologists expected that temperature would be lower and soil moisture and relative humidity higher in areas that had to be irrigated weekly than areas irrigated monthly. However, these patterns did not occur. Additional data are needed to determine if this is an anomaly or a consistent pattern.

Microclimate monitoring was initiated at the project in 2006. Additional microclimate data will be collected in 2007, including in a field that contains soil amendments (Field K).

3.1.3 Groundwater Depth

Methods

One piezometer per field was installed in fields A, C, D, and E on 3 October 2005. The height of the well was calculated. The depth to ground water was measured using a Watermark oil/ waterface tape from a mark on the inside of the well casing. Measurements were conducted in the datum NAD 83. Groundwater depth was calculated by subtracting the height of the well from the depth to ground water measurement. Groundwater depth was recorded for each piezometer monthly from 12 October 2005 to 6 August 2006.

Results

The groundwater depth at the project ranged from 3.4 ft (1.1 m) to 6.7 ft (2.1 m) from October 2005 to August 2006 in fields A, C, D, and E (Table 3-7).

Table 3.4. Groundwater depth (in meters) for fields A, C, D, and E, and elevation of Topock Marsh and Beal Lake from October 2005 to August 2006

Date	Groundwater Depth (m)				Elevation (m)	
	Field A	Field C	Field D	Field E	Topock Marsh	Beal Lake
12 October 2005	1.3	2.0	1.6	1.5	No data	No data
18 November 2005	1.4	2.0	1.6	1.5	No data	No data
02 February 2006	1.6	2.0	1.8	1.7	No data	No data
03 March 2006	1.5	2.1	1.8	1.7	138.4	138.4
26 April 2006	1.2	2.1	1.7	1.7	138.9	138.3
24 May 2006	1.1	1.8	1.4	1.3	139.1	138.7
22 June 2006	1.1	1.8	1.5	1.4	138.7	138.8
13 July 2006	1.1	1.8	1.4	1.4	138.8	139.2
01 August 2006	1.1	1.6	1.2	1.2	138.7	138.9

Discussion

Piezometers were installed in fields A, C, D, and E to measure depth to groundwater on a cross section of the project. Groundwater did not vary much between fields or days. Field C had the highest groundwater depth and field A had the lowest groundwater depth throughout the monitoring period (October 2005-August 2006).

3.1.4 Vegetation

Vegetation was planted in phases 1 and 2 beginning in 2003. Phase 1 totaled 24 acres (59 ha), divided into 17 fields. Phase 2 totaled 19 acres (48 ha), divided into 13 fields. After vegetation became established, individual fields were classified into Ohmart and Anderson vegetation types as described below. Once classified, a stratified random sampling design was applied to collect vegetation data.

Methods

Survivorship of planted materials

Survivorship of planted seedlings, poles, and container plants was measured shortly after planting (year 0), after the 1st growing season (year 1), and after the 2nd growing season (year 2). Seedlings, container trees, and pole cuttings were tallied by species and recorded as live or dead. Additionally, the height and Diameter at Breast Height (DBH) of container trees and pole cuttings were measured after the first two growing seasons.

A complete count of all year 0 seedlings was conducted in April 2006. Fields K, FF, GG, JJ, KK, and LL, which were planted in December 2005, were monitored in 2006. Height, DBH, and vigor were measured for every one-hundredth tree after the first two growing seasons (December 2005 and November 2006).

Percent survivorship by species by field was calculated by dividing the number of current live trees by the number of trees initially planted.

Herbaceous data

A stratified random sampling design was employed to facilitate sampling of the herbaceous and sapling layers within each field. Universal Transverse Mercator (UTM) coordinates were generated within each vegetation type using ArcMap software. At each sampling location, a 3.3-ft (1.0-m) square quadrat frame was placed 3.3 ft (1.0 m) from the designated plot center in each of the cardinal directions (N, S, E, and W). Percent horizontal cover was measured and recorded by plant species or substrate (i.e., bare ground, leaf litter, woody debris) within the quadrat frame. The number of woody stems rooted within the quadrant less than 4.5 ft (1.4 m) tall were tallied by species.

The mean and standard error were calculated for the following parameters: 1) mean density per hectare of woody stems in the understory layer, 2) mean percentage of herbaceous canopy cover, and 3) mean percentage of horizontal cover for other substrates (bare soil, leaf litter, woody debris).

Stem Density and Tree/Shrub Measurements

A stratified random sampling design was employed to facilitate sampling of the tree and shrub components of each field. Variables were measured on nested circular plots. Plot centers were located within target vegetation types at randomly generated Universal Transverse Mercator (UTM) coordinate pairs. The UTM coordinates were generated within each vegetation type using ArcMap software. One one-tenth acre, fixed radius plot (37 ft (11.3 m)) was established for every acre (0.04 ha) in each vegetation classification type. When plot boundaries occurred outside the appropriate vegetation classification, or plot boundaries overlapped, the plot was rejected and a new set of UTM coordinates was generated (Elzinga et al. 2001).

A 16.4-ft (5.0-m) radius plot was established within the each one-tenth acre plot. Shrub/sapling variables were measured on the 16.4-ft (5.0-m) plot. Stems with a DBH less than 3.1 in (8.0 cm) were tallied by species and DBH class. For stems with a DBH of at least 3.1 in (8.0 cm), height, DBH, and species were recorded. Tree variables were measured on the 37-ft (11.3-m) plot. Trees with a DBH of 3.1-5.0 in (8.0-12.7 cm) were tallied by species. For trees with a DBH of at least 5.0 in (12.7 cm), total height, DBH, and species were recorded. Stems were only counted and measured if at least 50% of the basal area was rooted within the plot boundary.

The mean and standard error for the following parameters were calculated for fixed-radius plots: 1) mean density per 2.5 acre (1 ha) of overstory trees in the respective size classes, 2) mean density per 2.5 acre (1 ha) of shrub and sapling stems in the respective size classes, 3) mean DBH and height of overstory trees greater than 5.0 in (12.7 cm) in DBH, and 4) mean DBH and height of shrub and sapling stems greater than 3.1 in (8.0 cm) in DBH. Calculations were performed for each Anderson and Ohmart (1976, 1984) vegetation classification. Data were examined for normality. Histograms were also created. The Minitab program was used for data analysis and summarization.

Total Vertical Volume

Total vertical volume (TVV) represents a profile of vertical vegetation placement, as opposed to canopy cover measurements, which represent the placement of vegetation in a horizontal plane. The method we used to measure TVV is described by Mills et al. (1991), and is a variation of the vertical line intercept technique. It is an index of the volume of woody perennial plants in each meter layer above the ground. Vertical vegetation volume was measured at four points at each plot location, and results of these subplots were averaged by plot. A 24.6-ft (7.5-m) tall survey rod was placed 3.3 ft (1.0 m) from the plot center in each of the cardinal directions. The presence of live vegetation occurring within a 3.9-in (10.0-cm) radius of this rod was recorded by species in 0.3-ft (0.1-m) intervals (presence of vegetation within a 0.3-ft (0.1-m) interval equaled one “hit”). Hits were tallied for each 3.3-ft (1.0-m) interval. Dead vegetation was recorded in the same manner; however, dead vegetation was not identified to genus and species. At heights above 24.6 ft (7.5 m), occurrence of vegetation was estimated as either greater than or less than five hits per 3.3-ft (1.0-m) interval.

TVV was estimated by: TVV = h/10p; where h = the sum of the total number of hits over all meter layers at all sample points, and p = the total number of points sampled (Mills et al. 1991). The TVV unit of measure is cubic meter of vegetation per meter square of area (m^3/m^2). Mills et al. (1991) found TVV values ranged from 0.0 m^3/m^2 to 2.0 m^3/m^2 in desert shrub systems.

Results

Survivorship and growth of planted materials

In November 2006, first-year survivorship was measured for trees in 13 fields. Average survivorship per field was 67% for trees planted in December 2005 (Table 3.5). Fremont cottonwood and Goodding’s willow, planted in November 2004 around the perimeter of several fields as a windbreak to limit potential invasive species infestations, had survivorship rates measured at 60% after the second growing season, down from 74% in 2005. Fields BB, DD, II, and MM, planted with mesquite trees in November 2005, had survivorship rates calculated over 100% due to volunteer mesquites that came in between planted mesquites and in areas of the field where no mesquites were planted. Trees in 13 fields were measured for height and DBH

in 2006. Mean DBH ranged from 0.2 in (0.4 cm) to 0.8 in (2.1 cm) and mean height ranged from 3.7 ft (1.1 m) to 11.5 ft (3.5 m).

Herbaceous layer

The woody understory comprised arrowweed, dead vegetation, saltcedar, coyote willow, Goodding's willow, and Fremont cottonwood (Table 3.6). Arrowweed was the most abundant species in the woody understory, with a mean of 74,130 stems per acre (30,000 per ha).

Ground cover comprised mostly bare ground (56.9 %) and leaf litter (26.8%). The primary component of the non-woody herbaceous layer of the understory measured on these plots was Bermuda grass, with a mean canopy cover of 6.7 %. A trace amount (<1%) of native understory grasses (grama) were found, as were trace amounts of Russian thistle, salt heliotrope, inland saltgrass, and fanleaf crinklemat (Table 3.7).

Table 3.5. Survivorship rates after one year

Field	Species	Number planted 12/2005	Number alive 11/2006	% alive after 1 year
K	coyote willow	822	410	50%
	Goodding's willow	789	640	81%
	Fremont cottonwood	232	208	90%
FF	coyote willow	35	21	60%
	Goodding's willow	65	24	36%
	Fremont cottonwood	102	67	66%
GG	coyote willow	783	271	35%
	Goodding's willow	1370	852	62%
	Fremont cottonwood	1831	1522	83%
JJ	Goodding's willow	897	686	76%
	coyote willow	255	229	89%
	Fremont cottonwood	0	2	
KK	Fremont cottonwood	1402	1008	71%
	mesquite	0		
LL	Goodding's willow, coyote willow, and Fremont cottonwood combined	1464	1058	72%

Table 3.6. Woody understory stems (stems/ha) in 2006

Species	Mean number of stems (SE)
Fremont cottonwood	363 (255)
Goodding's willow	545 (309)
coyote willow	3636 (2786)
saltcedar	7090 (3990)
dead	14,909 (10506)
arrowweed	30,000 (7623)

Table 3.7. Mean percent ground cover in 2006

Species	Mean Percent (SE)
woody debris	0.06 (0.03)
inland saltgrass	0.1 (0.1)
fanleaf crinklemat	0.1 (0.1)
salt heliotrope	0.7 (0.3)
Russian thistle	0.9 (0.4)
grama species	1.0 (0.5)
Bermuda grass	6.7 (1.6)
leaf litter	26.8 (2.2)
bare ground	56.9 (2.5)

Stem Density and Tree/Shrub Measurements

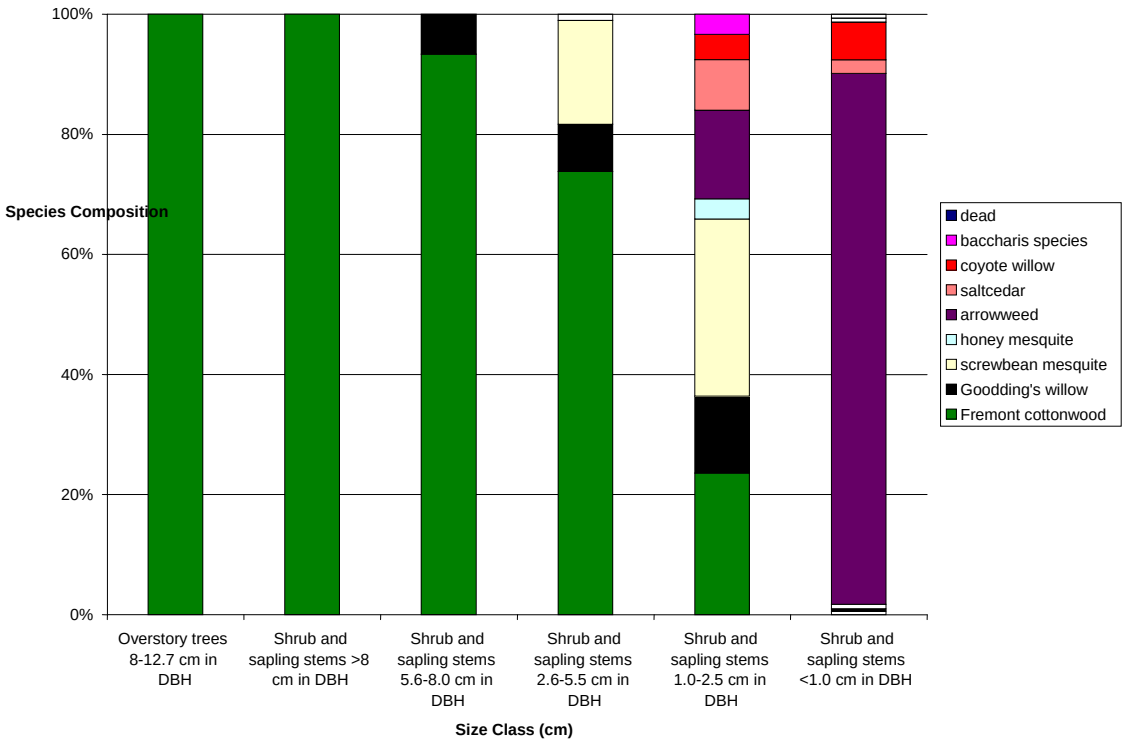
Trees and shrubs were measured in 16 fields in 2006. Fremont cottonwood was the only species recorded in the overstory on sample plots (Figure 3.4). Overstory tree densities averaged 22 cottonwoods per acre (9/ha). Fremont cottonwoods averaged 4.2 in (10.6 cm) DBH and 26.6 ft (8.1 m) tall (Table 3.8).

The highest density of stems per acre was found in the smallest DBH size class [<0.4 inches (<1.0 cm)]. Arrowweed was the most abundant species in this size class in all vegetation types. Plots sampled in screwbean mesquite structural type IV had the most arrowweed stems at 126,070 stems/acre (51,020 stems/ha). Plots measured in cottonwood willow structural type IV had the fewest number of arrowweed stems at 54,201 stems/acre (21,935 stems/ha). Screwbean mesquite was the most abundant species in the 0.4-0.9 inch (1.0-2.5 cm) DBH size class [140/acre (350/ha)].

Table 3.8. Height and DBH of stems >3.1 inches (8.0 cm) DBH in each Anderson and Ohmart (1976, 1984) structural type class in 2006

Anderson and Ohmart structural type class	Species	DBH (cm)	Height (m)
Cottonwood-willow III*	Fremont cottonwood	9.0	7.7
Cottonwood-willow IV*	Fremont cottonwood	12.2	8.5
Mean (SE) size of cottonwood across vegetation types		10.6 (1.6)	8.1 (0.4)

Figure 3.4. Percent species composition by DBH size classes in 2006



Total Vertical Volume (TVV)

Most foliage measured on TVV sample points occurred within the first 2 meters of the ground surface in all vegetation types (Table 3.9). Only CW IV had foliage tall enough to be measured in the 16.4-19.7 ft (5.0-6.0 meter) layer, and this was just a trace amount (<1%).

Arrowweed comprised the greatest volume of measured vegetation in the first meter layer [0.0-3.3 ft (0.0-1.0 m)] in all community types. The greatest volume of measured vegetation in the second meter layer [3.3-6.6 ft (1.0-2.0 m)] of SM IV, CW III, and AW was also arrowweed (Figure 3.5).

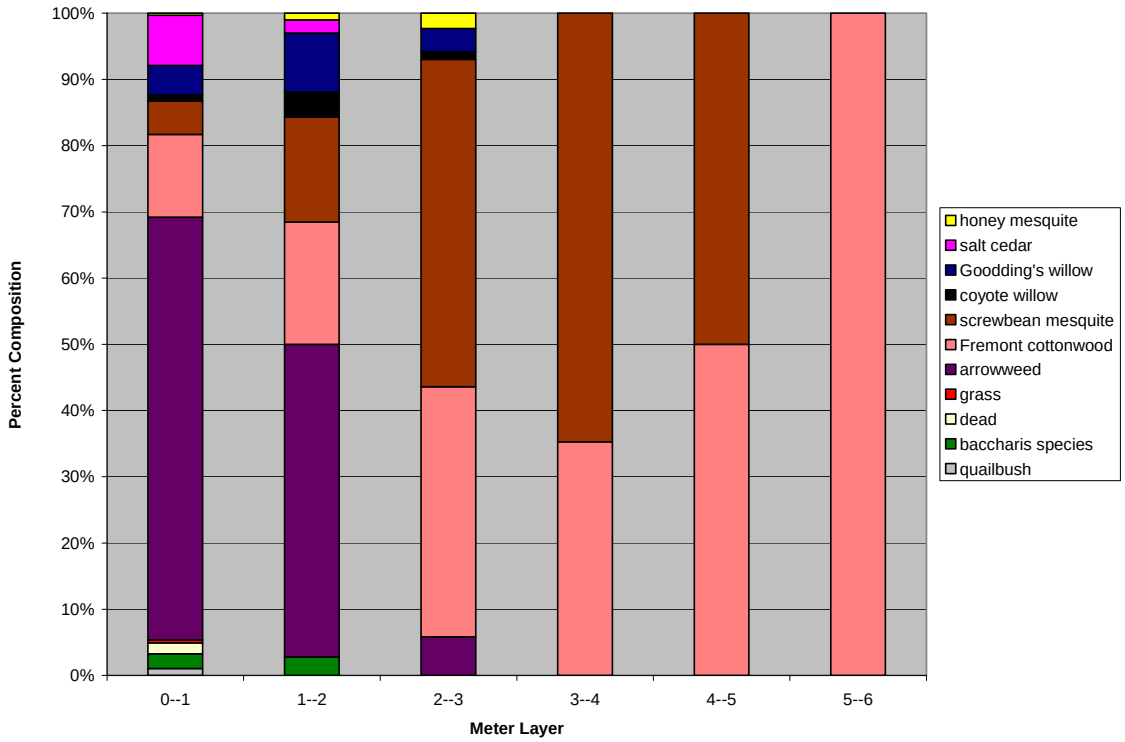
The largest volume of foliage measured in the second through fifth meter [3.3-16.4 ft (1.0-5.0 m)] layers of SM III was screwbean mesquite. This was also the case for the third through fifth meter layers [6.6-16.4 ft (2.0-5.0 m)] of SM IV and CW III (Figure 3-5).

The largest volume of vegetation in the third through sixth meter layers [6.6-19.7 ft (2.0-6.0 m)] in CW IV and the third through fifth meter layers [6.6-16.4 ft (2.0-5.0 m)] in CW V was Fremont cottonwood (Figure 3.5).

Table 3.9. Mean total vertical volume (TVV) per meter layer by vegetation classification (Anderson and Ohmart 1976, 1984) for 2006 (TVV = m^3/m^2)

	Structural Community Type Class					
Meter Layer	**SM III**	**SM IV**	**CW III**	**CW IV**	**CW V**	**AW**
0-1	5.7 (1.2)	3.6 (0.4)	2.4 (0.5)	2.3 (0.4)	5.4 (0.7)	3.2 (1.1)
1-2	3.6 (1.0)	3.2 (0.6)	2.3 (0.7)	1.9 (0.4)	3.1 (1.1)	1.0 (0.4)
2-3	1.3 (1.0)	0.9 (0.4)	1.1 (0.5)	0.8 (0.3)	0.7 (0.5)	0
3-4	0.8 (0.8)	0.3 (0.2)	0.7 (0.6)	0.3 (0.2)	0.5 (0.3)	0
4-5	0.1 (0.1)	0.05 (0.05)	0.3 (0.2)	0.1 (0.1)	0.1 (0.1)	0
5-6	0	0	0	0.04 (0.03)	0	0

Figure 3.5. Species composition of total vertical volume, per meter layer, 2006



Discussion

Survivorship

Survivorship counts were completed in 13 fields that were planted with container stock or pole cuttings. No counts were completed on fields that were hydro-seeded. This makes comparisons between these planting methods and development of success rates for these fields difficult using survivorship data gathered under current methods.

With the exception of field JJ, where 89% of plants survived after the first year, coyote willow had the poorest survival rate of the three planted riparian species in all measured locations.

Survival rates for coyote willow ranged from 35% in GG to 50% in K and 60% in field FF (Table 3.5). Recruitment of this species seems limited to small patches adjacent to irrigation valves, where soil becomes wet sooner and remains wet longer than soil in much of the rest of these fields. No recruitment occurred on planted rows measured for survivorship. The soils at Beal Lake are extremely coarse and sandy. Maintaining a sufficiently moist soil surface and rooting zone to promote vegetative reproduction and/or seed germination of coyote willow in this substrate is difficult, and may be a limiting factor for persistence of planted individuals as well as recruitment of new individuals.

Of the three planted riparian species, Fremont cottonwood exhibited the highest survivorship rates after the first year in all measured locations. Survival rates varied from a low of 71% in field KK to a high of 90% in field K.

Field FF had the poorest overall survival rates, with a low of 36% for Goodding's willow and a high of 66% for Fremont cottonwood. It is not immediately clear what the difference in growing conditions in this field may be compared to conditions in other measured fields.

Understory/Mid-story/Herbaceous layer

Arrowweed and coyote willow are the main components of the understory/mid-story at this site. In areas where the cottonwood and willow seedings failed and/or container plants died, arrowweed successfully established into contiguous dense monocultures. However, arrowweed does not appear to be negatively impacting the planted cottonwood, willow, or mesquite trees at this time. In fields E and J, arrowweed became established and replaced planted coyote willows that died.

An herbaceous layer is lacking over much of the area. In many fields, bare soil or leaf litter comprised a large amount of horizontal cover at the soil surface. For instance, most of the ground under the established cottonwood stands in fields B, C, and D is bare soil. In general, a striking lack of herbaceous diversity is apparent in the understory of most stands. Bermuda grass provides the most extensive herbaceous cover, and is probably more extensive than the 6.7% measured in plots. A large amount of Bermuda grass is found in fields A, F, G, M, and N. Where it occurs, Bermuda grass forms a dense, contiguous mat and may help to keep other undesirable species from becoming established. A small amount (<1%) of native bunch grass (grama) cover occurs in the same fields as listed for Bermuda grass.

Stem density, tree and shrub data

The only undesirable species found on measured plots was saltcedar. Approximately 12% of total stems found in the understory were saltcedar and these were less than 1.0 in (<2.6 cm) DBH. At this time, saltcedar does not appear to be developing into an important component of the larger stem size classes.

Arrowweed was the most numerous woody plant counted in plots for every structural community type. Arrowweed has become an important component of all communities at the site, although it was not planted, but rather became established on its own.

TVV

The greatest measured volume of foliage occurred in the first meter layer of SM III (5.7 m^3/m^2) and CW V (5.4 m^3/m^2). The second meter layer of these two types also had a significant volume of foliage (3.1 and 3.6 m^3/m^2).

These stands are still relatively young and it is not surprising to find most of the foliage volume in the lowest meter layers. As these stands mature, more foliage volume should be distributed in upper meter layers away from the ground, especially in the taller more mature cottonwood willow community types.

3.2 Avian Monitoring

3.2.1 Point Counts

Methods

Reclamation utilized point count protocol established by the Great Basin Bird Observatory (2003). Surveys were conducted on 24 May, 22 June, and 20 July 2006. Points were chosen using a systematic random study design. Fourteen points were set up throughout the project using an 820-ft (250-m) grid pattern. The points were located using a handheld Garmin GPSMAP 76 S, GPS unit, and marked with flagging.

From each point, surveyors identified all birds either heard or seen. All data were recorded on standardized data forms. Observations from greater than 328 ft (100 m) were recorded as such. Points were surveyed for 10 min and detections were recorded in three categories: 1) 0-3 min, 2) 4-5 min, and 3) 5-10 min. For each observation, the surveyor recorded any behaviors and movements observed. The first survey point started at sunrise and additional points were surveyed until 9:00 AM. Time, wind speed, cloud coverage, and temperature were recorded. All surveyors were experienced and trained in identifying birds of the desert Southwest.

Data Analysis

Data from birds observed beyond 328 ft (100 m) and recorded as flyovers were omitted from analysis. For each point, the relative abundance of individuals per period per species was calculated. Mean relative abundance was graphed with histograms using the program Minitab to check for normality of data. For each point, species richness, diversity, and evenness were calculated. A species diversity index value includes the number of species present as well as the abundance of each species. Evenness is a measurement of species similarity; it is the equitability with which individuals are distributed among the different species.

Species diversity and evenness were determined using a natural logarithm version (Nur et al. 1999) of Shannon's Index (Krebs 1989). The equation using natural logarithms is:

$$H' = \sum_{i=1}^{i=S} (p_i)(\mathrm{In}\,p),\ i = 1, 2, \ldots S \qquad N_1 = e^{H'},$$

where S = number of species in the sample, and p_i is the proportion of all individuals belonging to the *i*th species. H' = diversity in terms of bits and N_1 = diversity in terms of species. The transformation of H´ is given by $e^{H'}$ that is labeled as N_1 (MacArthur 1965). The original Shannon's Index is calculated in a logarithm base 2 (Nur et al. 1999). H' is expressed in terms of bits, which is the logarithmic unit of data storage capacity. The equation above is calculated using natural logarithms (Nur et al. 1999). N_1 is expressed in terms of species; for example, if there are five species present, an N_1 value of 4.2 yields the same diversity value as 4.2 species

of equal abundance (Nur et al. 1999). The minimum value for species richness is 1.0; there is no maximum value. The maximum value for species diversity is dependent on the species richness value. The maximum diversity values were calculated for each field (Nur et al. 1999).

Species distribution is maximally even when $S = N_1$. Evenness expressed as $H'/H_{max} = H'/In$. S is a measurement of how similar the abundance of different species are to each other. Evenness is equal to 1.0 when there are similar proportions of all species, and approaches zero as proportions of species become more dissimilar.

The data for mean relative abundance of all species, mean species diversity, mean species evenness, and mean species richness per point were graphed with histograms using the program Minitab to check for normality of data. Data was log transformed so data would follow a normal distribution. A one-way analysis of variance test was used to determine differences between parameters between years. A Tukey one-way multi-comparison test was conducted to determine years in which the mean differed.

Community similarity between years was measured with the Renkonen index (Percentage Similarity index) (Magurran 1988, Krebs 1989, Nur et al. 1999):

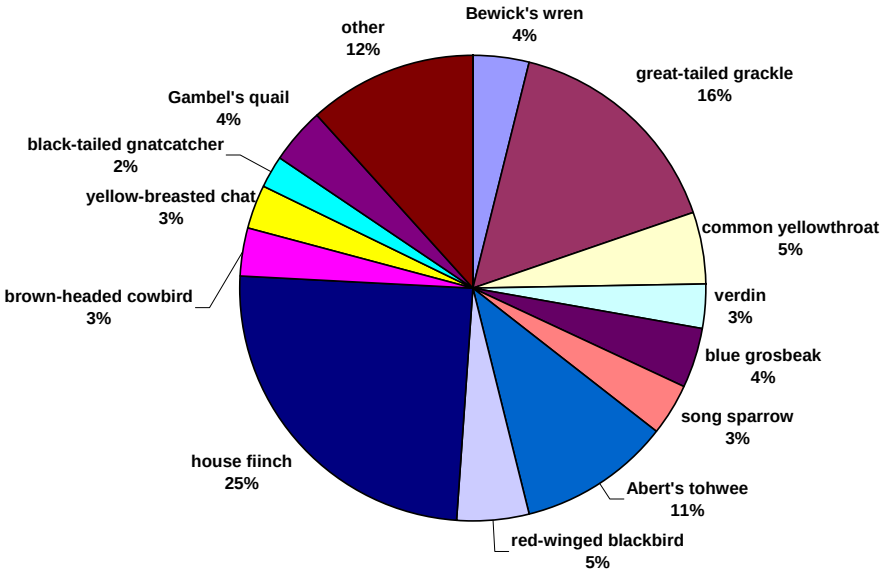
$$P=\sum \text{minimum}\ (P^A_i, P^B_i),$$

where $P^A i$ is the percentage of species *i* in sample A, p^B_i is the percentage of species *i* in sample B, and S is the number of species found in either sample (Nur et al. 1999). With no overlap between years the index would equal zero; with complete similarity between years the Renkonen index equals 100% (Nur et al. 1999).

Results

A mean of 11.18 (2.47 SE) individual birds per point per period, comprising 31 species, were detected at the project during the 2006 breeding season (Figure 3.6, Table 3.10). The three most abundant species were the house finch, great-tailed grackle, and Abert's towhee (Figure 3.6, Figure 3.7). Data for mean relative abundance of birds per species was not normally distributed; therefore, for these parameters, standard error and not confidence intervals were calculated. A species richness of 31 species, an ecological species diversity of 14.44, and an evenness of 0.78 on a scale of 0.0 to 1.0 were detected at the project during the 2006 avian point counts. A mean ecological species diversity of 31 would mean an equal number of individuals per species, as the value decreases as the number of individuals per species becomes increasingly unequal. The logs of the mean relative abundance of all species per point ($P = 0.008$), and the logs of the mean species diversity per point ($P = 0.009$) were higher in 2006 than in 2004 (Table 3.11). When comparing the data between years, log values were used to transform the data into a normal distribution so parametric statistical tests could be used. The Renkonen index for community similarity between 2005 and 2006 was 73% and between 2004, 2005, and 2006 was 48%. Refer to Table A.4 for a list of common names, scientific names, and American Ornithological Union (AOU) codes of species observed at the project.

Figure 3.6. Relative abundance of avian species during the 2006 breeding season



*Other category includes all species with less than 2% relative abundance: western wood pewee, ash-throated flycatcher, mourning dove, crissal thrasher, least bittern, yellow-headed blackbird, white-winged dove, ladder-backed woodpecker, killdeer, loggerhead shrike, yellow warbler, western kingbird, Bullock's oriole, clapper rail, Lucy's warbler, northern rough-winged swallow, and cliff swallow.

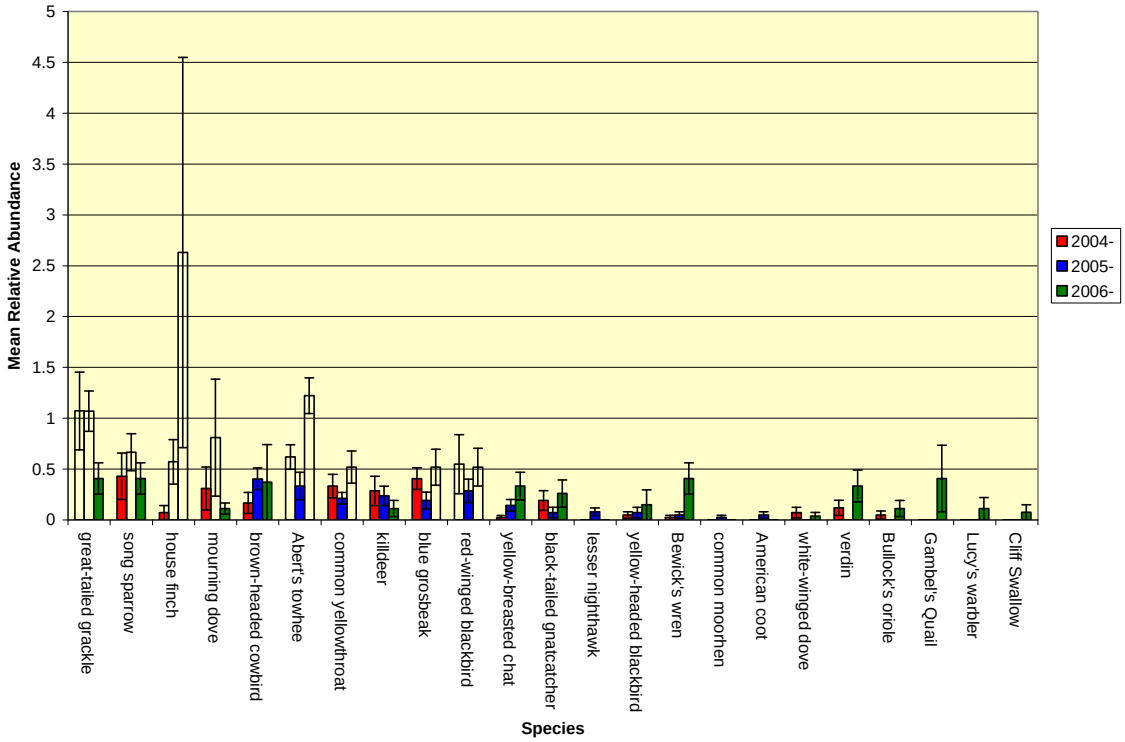
Table 3.10. Mean number of individuals, species richness, ecological species diversity, and evenness for avian point count stations during the 2006 breeding season

Point Count Station	Mean number of individuals	Species Richness (S)	Ecological Species Diversity (N_1)	Evenness (E)
1	9.33	12	9.72	0.92
2	11.00	12	9.79	0.92
3	14.33	13	7.18	0.77
4	28.67	13	4.43	0.58
5	7.67	10	7.98	0.90
6	7.00	12	10.16	0.93
9	3.67	7	6.34	0.95
10	6.33	7	4.88	0.81
11	9.67	8	6.06	0.87
Phase 1	38.00	26	17.67	0.88
Phase 2	59.00	22	9.54	0.73
Mean value per point	10.85 (2.44 SE)	10.44 (0.83 SE)	7.39 (0.72 SE)	0.85 (0.04 SE)
Entire Site all periods	96.33	31	14.44	0.78
Entire Site Period 1	84.00	12	6.23	0.74
Entire Site Period 2	130.00	21	8.33	0.70
Entire Site Period 3	82.00	18	12.55	0.88

Table 3.11. Mean number of individuals, species richness, ecological species diversity, and evenness for avian point counts, breeding seasons 2004-2006

Year	2004	2005	2006
Mean relative abundance per point	4.83 (0.83 SE)	6.19 (0.69 SE)	10.85 (2.44 SE)
Mean relative abundance entire site	67.67	87.16	96.33
Species richness (S) per point	5.57 (0.78 SE)	7.42 (0.47 SE)	10.44 (0.83 SE)
Species richness (S) entire site	20.00	24.00	31.00
Species diversity (N_1) per point	4.68 (0.63 SE)	5.83 (0.34 SE)	7.39 (0.72 SE)
Species diversity (N_1) entire site	12.18	13.43	14.44
Species evenness (E) per point	0.86 (0.04 SE)	0.88 (0.01 SE)	0.85 (0.04 SE)
Species evenness (E) entire site	0.82	0.82	0.78

Figure 3.7. Species with a mean relative abundance of >/= 0.1 per period, per point, 2004-2006. Error bars are standard errors



3.2.2 Presence/absence surveys for the yellow-billed cuckoo (*Coccyzus americanus occidentalis*).

Methods/Results

Yellow-billed cuckoo surveys were not conducted during the 2006 breeding season because requisite habitat requirements were not present.

3.2.3 Presence/absence surveys for the southwestern willow flycatcher (*Empidonax traillii extimus*).

Methods

To elicit responses from southwestern willow flycatchers (SWFL), conspecific vocalizations were broadcasted. Surveys were performed according to established protocols (Sogge et al. 1997, Branden and McKernan 1998). Surveyors used a portable "LifeSong Bird Call Recorder" by Summit Doppler, similar to an MP3 player with an external speaker as part of the device. Biologists performed 10 surveys during the breeding season (May-August) at least 5 days apart. Surveys began one-half hour before sunrise and ended by 0900 hours. Biologists broadcasted SWFL song (*fitz-bew*) and call (*breets*) for 40 seconds, listened 2 minutes for a response, then moved 98 ft (30 m) to broadcast the vocalizations again. If a SWFL was observed and did not respond to the initial song and call, other territorial calls (*breets, creets, wee-oos, whitts*) were played. Surveyors recorded all willow flycatchers (WIFL) observed visually and audibly, including behavioral activities and location. If territories were established or pairs observed, nest searches were conducted. Biologists utilized standard detection forms to record observations. The presence of cowbirds, water, and moist soils were noted during all surveys as they may affect the presence of SWFL (McKernan 1997, McKernan and Braden 1998, 1999, 2001a, 2001b, 2002, USFWS 2002, Koronkiewicz et al. 2004, McLeod et al. 2005). All survey forms and data were given to Arizona Game and Fish Department (AGFD).

Results

One WIFL was detected prior to 15 June 2006. Subsequent surveys did not detect the individual again; therefore, it was recorded as a migrant WIFL. Subspecies of willow flycatchers cannot be determined from visual detection. The SWFL is the only subspecies that breeds along the LCR. A willow flycatcher that is detected multiple times in the third survey period (22 June to 27 July) is considered to be a breeding individual. Whether the individual was banded or unbanded could not be determined (McLeod 2006).

Discussion

The only LCR MSCP covered avian species detected at the project was the yellow warbler, which comprised 1% of the avian population. Seven species listed in the LCR MSCP as sensitive, non-covered riparian species were present, including Abert's towhee, ash-throated flycatcher, blue grosbeak, Bullock's oriole, common yellowthroat, Lucy's warbler, and yellow-breasted chat, which together comprised 25% of the avian population. The Abert's towhee and Lucy's warbler are listed as species of concern in the Partners in Flight North American Landbird Conservation (Rich et al. 2004).

Species diversity and average number of birds per point were significantly higher in 2006 than in 2004. Possible reasons for this increase in bird use are habitat growth, establishment of additional habitat, and more frequent irrigation during the breeding season.

The project provided habitat to many riparian obligate species. House finches and great-tailed grackles, which are habitat generalists, were present in large flocks in areas where little vegetation was established or vegetation was in an early growth stage. Areas where older, taller vegetation was established provided habitat primarily to riparian obligate species and a few habitat generalists.

Species composition, abundance, diversity, and richness have changed gradually since 2004 as habitat matures over time. Whether the project will attract larger populations of LCR MSCP covered species in the future is unknown. Continued monitoring may provide information necessary to the implementation of future habitat creation projects. Avian species are good indicators of ecosystem health due to their sensitivity to environmental change regarding a variety of physical and biological factors (Elliot et al. 2004).

3.3 Small Mammal Surveys

Methods

Small mammal presence/absence surveys were conducted during the spring (7-10 March) and fall (13-17 November) of 2006. Three-hundred trap nights were conducted in undeveloped habitat at the northeastern edge of the project. Six hundred trap nights were conducted as post-development monitoring in the remainder of the project in the spring. Three-hundred and fifteen trap nights were conducted as post-development monitoring at the project in the fall.

Methodology for surveys was based on Wilson et al. (1996). Small and medium Sherman traps were placed every 33 ft (10 m) in parallel, linear transects of approximately 492 ft (150 m) in length throughout the project. Transects were located 50 ft (15 m) apart. Each transect was assigned a letter and each trap in the transect was assigned a number. Traps were placed at dusk and checked the following morning at dawn. Traps were baited with a mixture of peanut butter, oats, and vanilla.

The general location of the area sampled, UTM location of the starting point of each transect, numbers of traps in each transect, and wind speed, cloud cover, and temperature at the time the traps were checked were recorded on a standardized data sheet. Animals captured were placed in plastic Ziploc bags and identified to species using a key to local small mammal species and the Kays and Wilson field guide (2002). Scientific and common names were recorded along with corresponding trap locations. Animals were measured for body length and measured for any other morphological characteristics needed for identification of animals to species. The type of cover where traps were located was recorded.

Total capture percentage and capture percentage per species were calculated. Capture percentage was calculated by dividing the number of animals captured by number of traps set and multiplying this value by 100. The cumulative number of species captured was graphed against the cumulative number of traps to determine if trapping effort was sufficient.

Species diversity and evenness of small mammal species was determined using a natural logarithm version (Nur et al. 1999) of Shannon's Index (Krebs 1989):

$$H' = \sum_{i=1} (p_i)(\mathrm{In}\,p),\ i = 1, 2, \ldots S \qquad N_1 = e^{H'},$$

where S = number of species in the sample and p_i is the proportion of all individuals belonging to the *i*th species. H' = diversity in terms of bits and N_1 = diversity in terms of species. The transformation of H´ is given by $e^{H'}$, which is labeled as N_1 (MacArthur 1965). The original Shannon's Index is calculated in a logarithm base 2 (Nur et al. 1999). H' is expressed in terms of bits, which is the logarithmic unit of data storage capacity. The equation above is calculated using natural logarithms (Nur et al. 1999). N_1 is expressed in terms of species; for example, if

there are five species present, an N_1 value of 4.2 yields the same diversity value as 4.2 species of equal abundance (Nur et al. 1999). The minimum value for species richness is 1.0; there is no maximum value. The maximum value for species diversity is dependent on the species richness value. The maximum diversity values were calculated for each field.

Species distribution is maximally even when $S = N_1$. Evenness expressed as $H'/H_{max} = H'/\ln S$ is a measurement of how similar the abundance of different species are to each other. Evenness is equal to 1.0 when there are similar proportions of all species, and approaches zero as proportions of species become more dissimilar.

Results

Seven individuals, comprising three species, were captured in the undeveloped portion at the project in the spring of 2006, with a capture percentage of 2.3% (Table 3.12). Thirty-two individuals, comprising four species, were captured in the developed area at the project in the spring of 2006, with a total capture percentage of 1.3% (Table 3.13). Fifteen individuals, comprising five species, were captured in the developed area at the project in the spring of 2006, with a total capture percentage of 4.8% (Table 3.13). Captured animals were detected in the following habitat types: 1) bare ground, 2) arrowweed, 3) arrowweed-mesquite, and 4) cottonwood-willow (Table 3.14). After 1,415 trap nights, the number of species did not keep increasing as the number of traps increased; therefore, trapping was determined to be sufficient.

Total species richness of small mammals at the project site was five species. Ecological species diversity was equal to 4.2 species of equal abundance on a scale of 0 to 5. A value of 5 would mean an equal number of individuals per species; as the value decreases, the number of individuals per species becomes increasingly unequal. Evenness was 0.89 in species similarity on a scale of 0 to 1.

Table 3.12. Small mammal species captured in the undeveloped area at the Beal Lake Riparian Project, 2006

Species	Scientific Name	Number of Individuals	Number of Traps	Capture percentage
deer mouse	*Peromyscus maniculatus*	1	100	1.0%
desert pocket mouse	*Chaetodipus penicillatus*	2	100	2.0%
Merriam's kangaroo rat	*Dipodomys merriami*	4	100	4.0%

Table 3.13. Small mammal species captured during post-development monitoring (developed area) at the Beal Lake Riparian Project, 2006

Species (common name)	Species (scientific name)	Season	Number of Individuals	Number of Traps	Capture percentage
deer mouse	*Peromyscus maniculatus*	Spring	8	600	1.3 %
deer mouse	*Peromyscus maniculatus*	Fall	4	315	1.3 %
desert pocket mouse	*Chaetodipus penicillatus*	Spring	8	600	1.3 %
desert pocket mouse	*Chaetodipus penicillatus*	Fall	7	315	2.2 %
Merriam's kangaroo rat	*Dipodomys merriami*	Spring	10	600	1.7 %
Merriam's kangaroo rat	*Dipodomys merriami*	Fall	1	315	0.3 %
cactus mouse	*Peromyscus eremicus*	Spring	6	600	1.0 %
cactus mouse	*Peromyscus eremicus*	Fall	2	315	0.6 %
cotton rat	*Sigmodon* spp.	Fall	1	315	0.3%

Table 3.14. Number of individuals per species, per habitat type detected during small mammal surveys, Beal Lake Riparian Project, 2006

Species (common name)	Species (scientific name)	bare ground	arrowweed	arrowweed-mesquite	cottonwood-willow
deer mouse	*Peromyscus maniculatus*	1	10	0	3
desert pocket mouse	*Chaetodipus penicillatus*	2	7	4	4
Merriam's kangaroo rat	*Dipodomys merriami*	4	1	2	7
cactus mouse	*Peromyscus eremicus*	0	2	3	3
cotton rat	*Sigmodon* spp.	0	1	0	0

Discussion

There was one cotton rat detected at the project in 2006. There are two species of cotton rats that occur along the LCR: the Yuma hispid cotton rat (*Sigmodon hispidus eremicus*) and the Colorado River cotton rat (*Sigmodon arizonae plenus*). These two species cannot be distinguished from each other using external features; chromosomal data must be used to identify the cotton rats along the LCR to species. Reclamation biologists expect that it was the

Colorado River cotton rat that was detected because the project site is north of the expected range of the Yuma hispid cotton rat. Genetic analysis was not conducted during the surveys in 2006. The desert pocket mouse (*Chaetodipus penicillatus*), which was detected at the project, is not expected to be the subspecies (*Chaetodipus penicillatus sobrinus*) that is listed as an evaluation species in the LCR MSCP. The *sobrinus* subspecies does not seem to occur south of Hoover Dam; however, a study to delineate the range of *C. p. sobrinus* is ongoing (Ha 1946, Hoffmeister 1986, LCR MSCP 2006b, Micone 2002, Zane Marshal pers. comm.).

Small mammal monitoring at the project began in 2006. Future monitoring will be conducted to detect trends in small mammal populations and determine species composition, diversity, and richness changes as the site matures. If more cotton rats are detected in future presence/absence surveys, then density arrays might be conducted to determine the size of the population present at the project.

3.4 Bat Surveys

Methods

Acoustic surveys were conducted at the project in November 2006 for two sample nights (dusk to dawn). Seven Anabat bat detectors coupled to Zero Crossing Analysis Interface Modules (ZCAIM) were placed at the site. The detectors were placed on the ground in a suitable opening and angled at 45°. All units were placed in waterproof containers and camouflaged. Data were recorded directly on compact flash cards built into the ZCAIM. Call analysis was conducted by comparing minimum frequency, duration, and shape of each call sequence (bat pass) with reference calls from libraries of positively identified bats from throughout the western United States, following the method outlined in Thomas et al. (1987). A bat pass is defined as a call sequence of duration greater than 0.5 ms and consisting of more than two individual calls (Thomas 1998, O'Farell and Gannon 1999).

Results

Data for bat monitoring will be included in the 2007 annual report.

4.0 Established Land Cover and Habitat Credit

Methods

In 2006, land cover type was classified using aerial photographs and field examinations. A walk-through examination of each field was conducted where Anderson and Ohmart vegetation classification types were applied by using the dichotomous key provided in *Method's of Quantifying Vegetation Communities to Prepare Type Maps* (Anderson and Ohmart 1984), along with the tables and figures provided in Younker and Andersen (1986).

Results

Eighty acres (32.4 ha) were classified in November 2006 (Table 4.1). Fifty acres (20.5 ha) were identified as cottonwood-willow structural types, 24 acres (9.7 ha) as screwbean mesquite structural types, and 5 acres (2.0 ha) were identified as an arrowweed community type. As these stands mature, their structural types will likely change; these stands will need to be reclassified as that occurs. Currently, the structural types identified are III, IV, and V. These could be considered early to mid-seral structural categories.

Table 4-1. Acreage of Anderson and Ohmart (1976, 1984) vegetation structural type classes at Beal Lake, 2006

Structural Type Class	Symbol	Acres
Cottonwood-willow III	CW III	8.0 acres (3.2 ha)
Cottonwood-willow IV	CW IV	22.0 acres (8.9 ha)
Cottonwood-willow V	CW V	20.8 acres (8.4 ha)
Screwbean mesquite III	SM III	6.0 acres (2.4 ha)
Screwbean mesquite IV	SM IV	15.0 acres (6.1 ha)
Screwbean mesquite V	SM V	3.0 acres (1.2 ha)
Arrowweed	AW	5.0 acres (2.0 ha)
Total		79.8 acres (32.2 ha)

Discussion

In 2006, the total acreage of vegetation communities developed at Beal Lake was similar to the proposed vegetation communities. A difference occurred between the planned vegetation and current existing vegetation in fields E and J, where arrowweed dominates an area that was proposed for cottonwood-willow habitat development. A possible reason for this difference was high mortality rate of the planted coyote willows, possibly due to higher salinity and/or low moisture retention of the soils in these fields (Table 3.1).

This project is a riparian habitat demonstration project designed to evaluate different riparian habitat creation techniques, watering regimes, and stand management. A portion of the project was designed to provide habitat for the SWFL. Specific habitat characteristics listed in Table 3-2 were found important for breeding SWFL. Reference variables for mean relative humidity were achieved at three of the eight data logger locations, two of which were in the portion of the site that is being managed for SWFL. Reference variables for mean maximum temperature were achieved at two of the eight data logger locations, one of which was in the portion of the site being targeted as SWFL habitat. Reference variables were at the very edge of the target range at locations where they were achieved. Temperature was at the high end of the range and relative humidity was at the low end of the range (Mcleod et al. 2005, 2006). The habitat met vertical foliage density structural requirements. One migratory WIFL was detected before 15 June utilizing the habitat.

5.0 Adaptive Management

5.1 Operation and Maintenance

Two main roads through the site will be maintained to allow access to the interior portion of the restored areas in Phases 1 and 2. These gravel roads are located along the same corridors as the main irrigation lines. Berms that were previously used as roads, but are not graveled, will be left undisturbed to gradually fill in with volunteer vegetation. There are no roads in Phase 3.

5.2 Soil Management

A 15-acre (6.1 ha) portion of the site is being managed to provide habitat requirements for SWFL. Frequent irrigation is intended to keep moist soil and vegetation dense. Soils at the project are composed mainly of sand, making it difficult to retain moisture. Over time, organic debris may build up in the soils and the tree canopy may increase, providing shade. Both of these factors may increase the retention of soil moisture and create the appropriate microclimate preferred by the SWFL. Coyote willow planted around the irrigation valve in the center of the SWFL habitat in 2003 has already spread to form a dense patch of CW III and CW IV, with leakage from the valves providing ephemeral moist conditions. To enhance this area, 30 plastic pools, 60 inches and 30 inches in diameter, were installed in Field K in the spring of 2003 (Figure 5.1, 5.2). These pools will prevent the rapid draining of water that occurs due to the sandy texture of the soils.

Figure 5.1. Plastic pool filled with water

Figure 5.2. Plastic pool filled with wet sand

5.3 Water Management

Irrigation of the site has several purposes: to maintain healthy and vigorous vegetation, to maintain the proper microhabitat conditions for SWFL and other species (McKernan and Braden 2002, USFWS 2002, Koronkiewicz et al. 2006), and to occasionally flush salts from the root zones of the plants. During the breeding season, portions of the site are kept moist by frequent irrigation to maintain conditions preferred by SWFL. Locations where plastic pools are installed will be irrigated weekly. The remainder of the site will be irrigated to control salt buildup and to maintain the health of the trees (approximately once per month).

Data from system-wide SWFL surveys along the LCR show that the following habitat characteristics are needed for suitable breeding habitat: 1) mean soil moisture greater than 17%, 2) mean diurnal temperature between 26°C and 33°C, 3) mean maximum diurnal temperature between 32°C and 45°C, and 4) mean diurnal relative humidity between 33% and 63% (LCR MSCP 2006a, Mcleod et al. 2005, Mcleod et al. 2006). Microclimate data from 2006 suggest these microclimate conditions are not being met. An increase in irrigation amounts and frequency in 2007 will be attempted to provide these habitat parameters. Management recommendations will be made for the 2008 breeding season, if microclimate conditions are not being met during the 2007 breeding season. Microclimate requirements for all other LCR MSCP species have not been quantified; therefore, microclimate (moist soil areas) is only being managed for the SWFL.

5.4 Vegetation Management

During the 2005-2006 growing season, the site was irrigated frequently to create dense habitat and retain moisture in soils. No management was implemented to alter the structural classification of the habitat.

5.5 Wildfire Management

The Havasu National Wildlife Refuge is under management by the U.S. Fish and Wildlife Service. The USFWS and other agencies on the LCR are responsible for wildfire control and will coordinate with Reclamation if a fire occurs that threatens the project.

5.6 Public Use

The project is on a portion of the refuge that is closed to the public.

5.7 Law Enforcement

The USFWS, Havasu National Wildlife Refuge is responsible for law enforcement at the project.

5.8 Future Habitat Development

Phases 1 and 2 are largely completed and will undergo periodic management, including re-planting, pruning for structural management, and seeding. The fields planted with a perimeter of trees around them will be seeded using natural seedfall techniques and flood irrigation. Other areas that are not of the targeted vegetation type (arrowweed, saltcedar) may be replanted with native vegetation. In 2009, the USFWS and Reclamation will determine whether the Beal Riparian Restoration Project will be managed, modified, or expanded to provide habitat for LCR MSCP covered species. At that time, a Land Use Agreement will be signed to define agency responsibilities for managing and maintaining the site.

5.9 Monitoring Modifications

Modifications will be made to microclimate protocol in 2007. An adequate sample size of HOBO data loggers to make microclimate inferences for the whole project, including portions managed as SWFL and YBCU habitat, will be determined. Modifications will be made to soil moisture monitoring protocol in 2007. Permanent data loggers will be installed and manual soil moisture measurements will be taken on the last day of each irrigation cycle.

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Appendix A

Table A.1: Mean stem density per hectare by DBH size class and species for each Anderson and Ohmart (1976, 1984) structural vegetation type.

Vegetation Type	Species	<1.0cm (<0.4”)	1.0-2.5cm (0.4-1”)	2.6-5.5cm (1-2”)	5.6-7.9 cm (2-3”)	8-12.7 cm (3-5”)	>12.7 cm (5”)
Screwbean mesquite III n = 6 plots	screwbean mesquite	212 (85)	846 (279)	190 (91)			
	honey mesquite	0	126 (86)	42(42)			
	arrowweed	46,961(8,248)	168 (144)	0			
	saltcedar	719 (572)	141 (100)	0			
	Baccharis species	1756(732)	253 (182)	0			
	Dead	338(338)	0	0			
	Mean total stems	*8331 (7730)*	*307 (136)*	*116 (74)*		*0*	*0*
Screwbean mesquite IV n = 10 plot	screwbean mesquite	469 (246)	457 (176)	38 (27)			
	Goodding’s willow	1625 (163)	152 (125)	12 (12)	13 (13)		
	arrowweed	51,020(7192)	711 (344)	0			
	saltcedar	1580 (453)	139 (118)	0			
	Baccharis species	292 (227)	50 (50)	0			
	honey mesquite	25(25)	126 (85)	0			
	Fremont cottonwood	25(25)	0	0			
	Mean total stems	*7862 (7197)*	*272 (104)*	*25(13)*	*13*	*0*	*0*
Cottonwood-willow III n = 8 plots	screwbean mesquite	698 (322)	666 (242)	158 (62)			
	Fremont cottonwood	396 (344)	603 (253)	841 (347)	79 (53)	9(9)	
	arrowweed	45,729(11,723)	31 (31)	0			
	saltcedar	3015 (1798)	349 (331)	0			
	Goodding’s willow	1137 (488)	79 (63)	0			
	Mean total stems	*10,195 (8895)*	*345 (130)*	*500 (341)*	*79*	*9*	*0*
Cottonwood-willow IV n = 17 plots	screwbean mesquite	134 (54)	149 (46)	74 (32)			
	Fremont cottonwood	470 (192)	530 (204)	560 (225)	67 (37)		
	Goodding’s willow	111 (68)	209 (146)	104 (57)			
	arrowweed	21,935(7575)	29 (29)	0			
	dead	665 (664)	0	0			
	saltcedar	90 (82)	0	0			
	coyote willow	7140 (4427)	0	0			
	honey mesquite	7 (7)	0	0			
	Mean total stems	*3819 (2726)*	*229 (107)*	*246 (157)*	*67*	*0*	*0*
Arrowweed n = 5 plots	screwbean mesquite	101 (101)					
	arrowweed	34,462 (5676)					
	Goodding’s willow	50 (50)					
	coyote willow	1193 (727)					
	Mean total stems	*10,711 (6820)*					

Table A.2. Mean height and Diameter at Breast Height (DBH) of trees after first and second growing season, Beal Lake Riparian Project

Species	Growing Year	DBH (cm)	Height (m)
		Mean (SE)	Mean (SE)
screwbean mesquite	after second year	2.1 (0.2)	3.5 (0.1)
coyote willow	after second year	0.4*	1.1 (0.1)
Goodding's willow	after first year	0.7 (0.2)	1.6 (0.2)
Goodding's willow	after second year	0.8 (0.5)	1.4 (0.3)
Fremont cottonwood	after first year	0.7 (0.2)	1.8 (0.1)
Fremont cottonwood	after second year	1.4 (0.3)	2.4 (0.2)

*No standard error was calculated because only one tree was tall enough to measure DBH

Table A.3. Plant species detected at the Beal Lake Riparian Habitat Creation Project, 2006

Common Name	Scientific Name
Fremont cottonwood	*Populus fremontii*
Goodding's willow	*Salix gooddingii*
coyote willow	*Salix exigua*
screwbean mesquite	*Prosopis pubescens*
honey mesquite	*Prosopis glandulosa*
baccharis species	*Baccharis* spp.
saltcedar	*Tamarisk* spp.
Russian thistle	*Salsola kali*
fanleaf crinklemat	*Tiquila plicata*
arrowweed	*Tessaria sericea*
salt heliotrope	*Heliotropium curassavicum*
inland saltgrass	*Distichlis spicata*
Bermuda grass	*Cynodon dactylon*
grama species	*Bouteloua* spp.

Table A.4. Avian species detected at the Beal Lake Riparian Project

Code	Common Name	Scientific Name
GAQU	Gambel's quail	*Callipepla gambelii*
PBGR	pied-billed grebe	*Podilymbus podiceps*
LEBI	least bittern	*Ixobrychus exilis*
CLRA	Yuma clapper rail	*Rallus longirostris yumanensis*
VIRA	Virginia rail	*Rallus limicola*
SORA	sora	*Porzana ocifero*
COMO	common moorhen	*Gallinula chloropus*
AMCO	American coot	*Fulica americana*
KILL	killdeer	*Charadrius vociferous*
WWDO	white-winged dove	*Zenaida asiatica*
MODO	mourning dove	*Zeniada macroura*
YBCU	yellow-billed cuckoo	*Coccyzus americanus occidentalis*
LBBO	ladder-backed woodpecker	*Picoides scalaris*
WWPE	western wood peewee	*Contopus sordidulus*
SWFL	southwestern willow flycatcher	*Empidonax trailii extimus*
ATFL	ash-throated flycatcher	*Myiarchus cinerascens*
WEKI	western kingbird	*Tyrannus verticalis*
LOSH	loggerhead shrike	*Lanius ludovicianus*
NRWS	northern rough-winged swallow	*Stelgidopteryx serripennis*
CLSW	cliff swallow	*Petrochelidon pyrrhonota*
VERD	verdin	*Auriparus flaviceps*
BEWR	Bewick's wren	*Thryomanes bewickii*
MAWR	marsh wren	*Cistothorus palustris*
BTGN	black-tailed gnatcatcher	*Polioptila melanura*
CRTH	crissal thrasher	*Toxostoma crissale*
LUWA	Lucy's warbler	*Vermivora luciae*
YWAR	yellow warbler	*Dendroica petechia*
COYE	common yellowthroat	*Geothlypis trichas*
YBCH	yellow-breasted chat	*Icteria virens*
ABTO	Abert's towhee	*Pipilo aberti*
SOSP	song sparrow	*Melospiza melodia*
BLGR	blue grosbeak	*Passerina caerulea*
RWBL	red-winged blackbird	*Agelaius phoeniceus*
WEME	western meadowlark	*Sturnella neglecta*
YHBL	yellow-headed blackbird	*Xanthocephalus xanthocephalus*
GTGR	great-tailed grackle	*Quiscalus mexicanus*

Code	Common Name	Scientific Name
BHCO	brown-headed cowbird	*Molothrus ater*
BUOR	Bullock's oriole	*Icterus bullockii*
HOFI	house finch	*Carpodacus mexicanus*