Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Cibola NWR Unit 1 Conservation Area
2008 Annual Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

April 2010

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U.S. Fish and Wildlife Service
National Park Service
Bureau of Land Management
Bureau of Indian Affairs
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Lower Colorado River Multi-Species Conservation Program

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Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
http://www.lcrmscp.gov

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Background

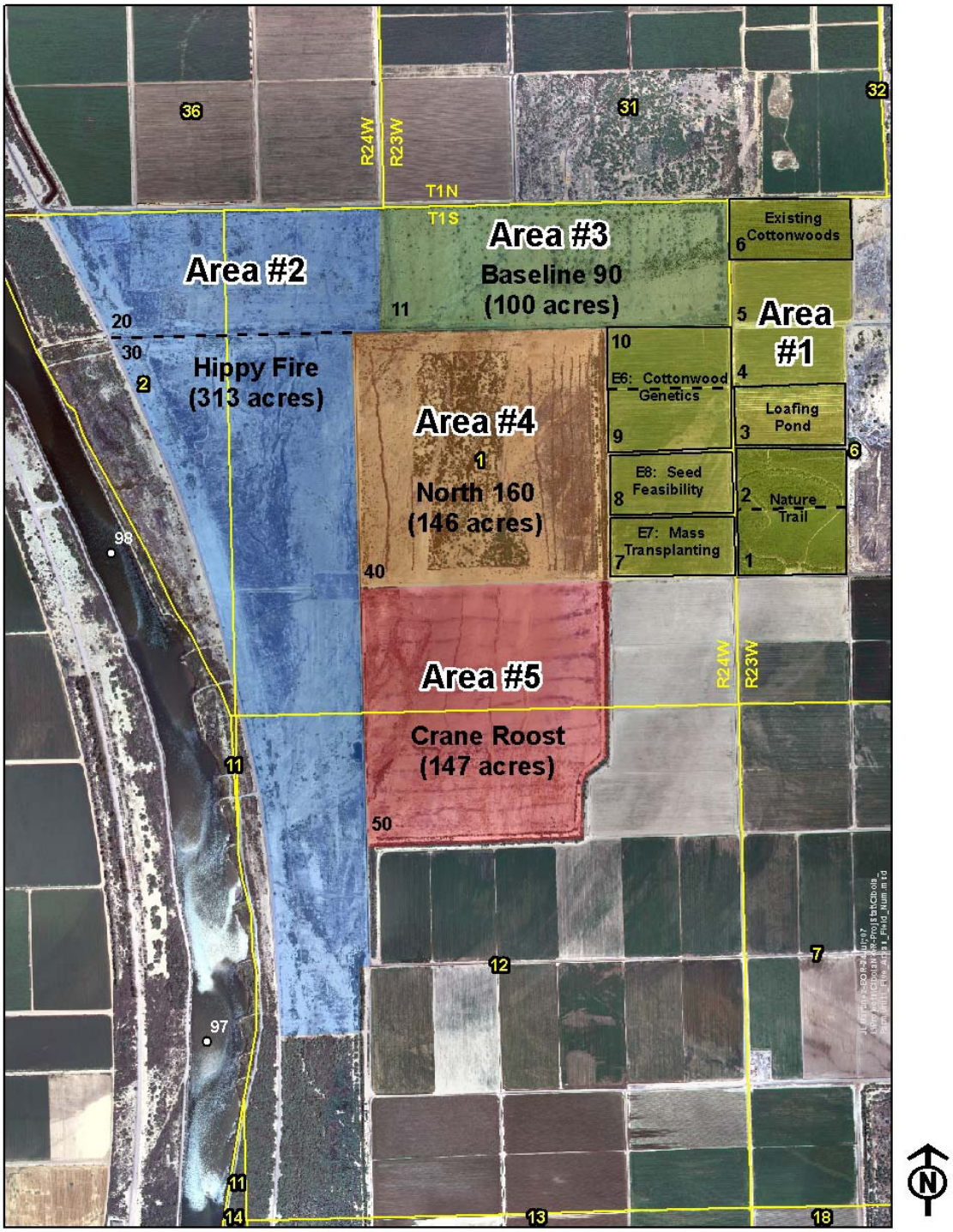
Cibola National Wildlife Refuge (NWR) consists of about 16,600 acres of land located along approximately 12 miles of the lower Colorado River in Arizona and California. Cibola NWR was established in 1964 as a refuge and breeding ground for migratory birds and other wildlife. The refuge is divided into six management units known as Unit 1, Unit 2, Unit 3, Unit 4, Unit 5, and Unit 6 (Figure 1).

Unit 1 is located on the northern end of the refuge in Arizona and encompasses approximately 4,100 acres, with approximately 1,000 acres dedicated to agriculture and 3,100 acres currently undeveloped. The Bureau of Reclamation (Reclamation) has previously partnered with Cibola NWR and currently has a number of established projects at Unit 1. These include previous habitat creation projects as well as research and demonstration projects. In 1999, the U.S. Fish and Wildlife Service (USFWS) and Reclamation planted the Cibola Corn Field/Nature Trail and established 34 acres of cottonwood-willow and mesquite land cover type within Unit 1. In 2002, the USFWS and Reclamation planted approximately 18 acres of cottonwood/willow in Unit 1 north of the Corn Field/Nature Trail.

Six fields of approximately 20 acres each in Unit 1 have been set aside for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) to conduct research and development projects. To date, four of the fields are occupied by three projects that have been fully or partially funded by the LCR MSCP. These include Work Task E6: Cottonwood Genetics Study, Work Task E7: Mass Transplanting Demonstration, and Work Task E8: Seed Feasibility Study. To the east of these projects are an additional two agricultural fields that are still in agricultural production. The six fields combined are currently included in a five-year land use agreement with USFWS to continue research activities on Unit 1 that expires in FY09.

The Cibola NWR Unit 1 Conservation Area (U1CA) incorporates the aforementioned existing projects and agricultural land as well as additional adjacent acreage into a single conservation area. Note that the Cibola NWR Unit 1 Conservation Area (about 900 acres) only includes a portion of the total area designated as Unit 1 by the Cibola National Wildlife Refuge (about 4100 acres).

Figure 1. The Cibola NWR Unit 1 Conservation Area



1.0 General Site Information

Cottonwood-willow land cover created within U1CA will be managed for the southwestern willow flycatcher (*Empidonax traillii extimus)* (SWFL), yellow-billed cuckoo (*Coccyzus americanus occidentalis*) (YBCU), and other species covered under the LCR MSCP. The creation of habitat includes both the establishment of native plants and the management of the vegetation and its structural type to meet performance standards for integrating seral stages of vegetation, moist soil, standing water, and open areas into mosaics of riparian vegetation.

Large habitat restoration sites such as U1CA are developed over a number of years and the restoration activities are divided into phases. The *Cibola NWR Unit 1 Conservation Area Restoration Development Plan: Overview* provides an overview of the restoration potential of the site as well as the projected phasing of development.

1.1 Location

The Cibola NWR Unit 1 Conservation Area consists of approximately 900 acres on Cibola NWR, located in Arizona between river miles 97 and 99 (Figure 2). The initial partnership for Cibola NWR Unit 1 Conservation Area includes Reclamation and the U.S. Fish and Wildlife Service, Cibola National Wildlife Refuge. The legal description of this area is as follows:

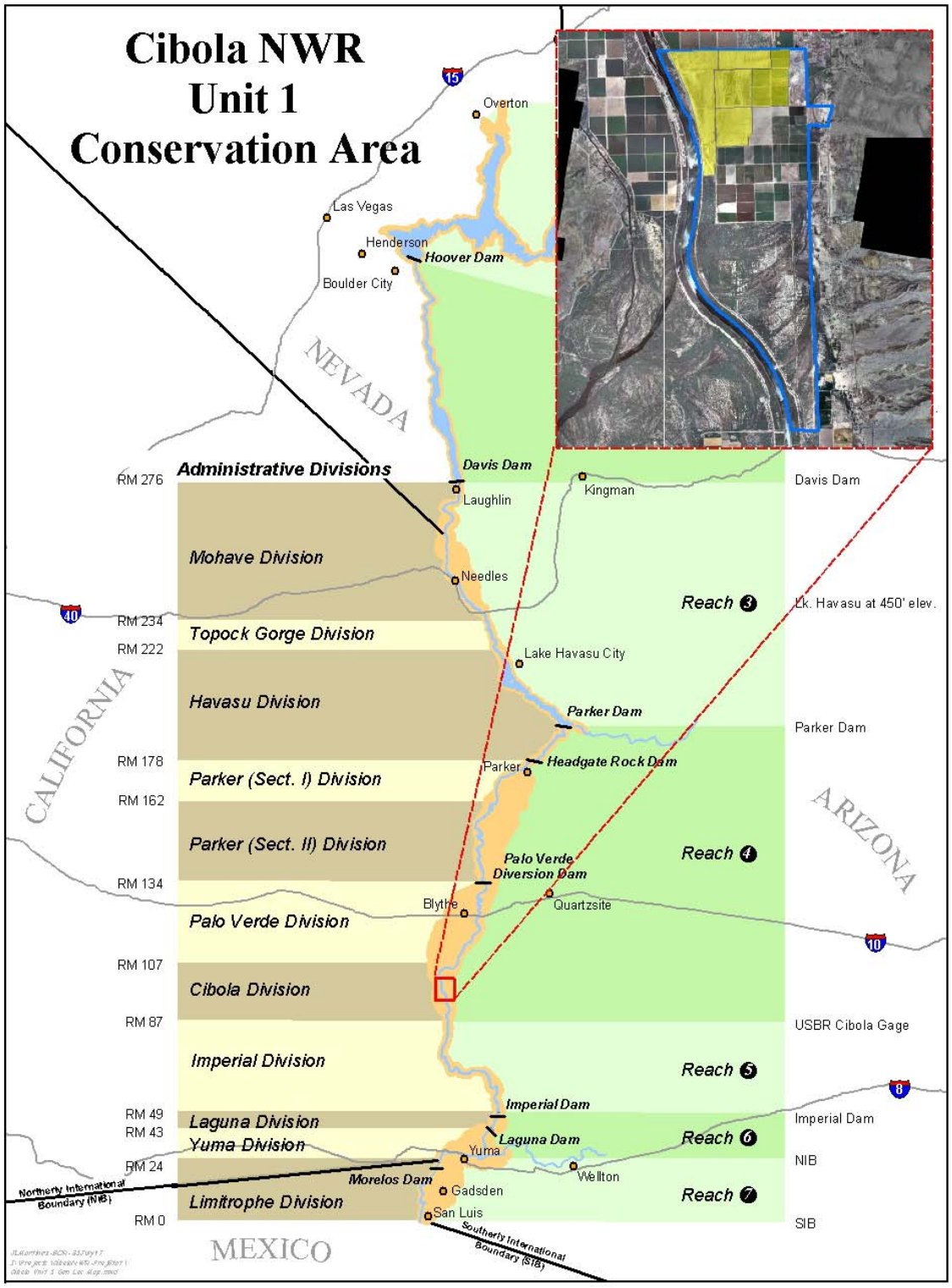
Township 1 South, Range 23 West, Gila and Salt River Base and Meridian, La Paz County, Arizona: Section 6, lots 4, 5, and 6;

Township 1 South, Range 24 West: Section 1, lots 1 through 4, inclusive, S½NE¼, NW¼, SW¼, N½SE¼, and SW¼SE¼; Section 2, lot 1, lots 2 and 3 those portions lying east of the levee road;

Section 12, N½NW¼NE¼, SW¼NW¼NE¼, SE¼NW¼NE¼ excluding that portion lying east of the irrigation drain, NE¼NW¼, W½NW¼ excluding that portion lying west of the levee road, NW¼NW¼SW¼ excluding that portion lying west of the levee road, and NE¼NW¼SW¼.

This area comprises 906 acres.

Figure 2. Location of Cibola NWR Unit 1 Conservation Area



1.2 Land Ownership

The property is owned by the USFWS, who will dedicate land and water to Reclamation to develop and maintain native land cover types for the LCR MSCP. The property will be owned and managed by the USFWS.

1.3 Water Availability

Cibola NWR has second priority water rights. These include a diversionary entitlement of 27,000 acre-feet per year and a consumptive use entitlement of (diversion minus return flow) of 16,793 acre-feet per year. In addition, the refuge has a circulatory (circulation water with minimum consumptive use) water right of 7,500 acre-feet per year. The 900-acre Cibola NWR Unit 1 Conservation Area will have a maximum of 5,400 acre-feet per year (6 acre-feet per acre, per year) available when the conservation area has been fully developed.

1.4 Agreements

A Land Use Agreement for restoration activities has been finalized to secure the availability of land and water resources for the 50-year term of the program.

2.0 Current Year Habitat Creation Activities

2.1 Fiscal Year 2008 Planting

Proposed Planting

The purpose of Phase 1 is to create 102 acres of cottonwood-willow habitat in the Crane Roost on the Cibola NWR. A portion of the Crane Roost has a previously established cottonwood-willow cover type. Planting is scheduled for early March of 2009. A conceptual map and details of the planting design are contained in the *Cibola NWR Unit 1 Conservation Area Development Plan: Phase 1*.

Planted

Previously the Crane Roost was part of abandoned agricultural land. The fields were cleared and a grass cover crop was planted. The cover crop on the Crane Roost has been cultivated for the past two seasons to help condition soils. The grass cover crop was chosen for its ability to help leach salts from the finer textured soils that are present on the Crane Roost.

2.2 Irrigation

Method

Flood irrigation was used to water the cover crop and saturate the soils at the appropriate seasons to leach the salts through the soil column and provide favorable conditions for future land cover establishment. The cottonwood-willow land cover type when planted

will be irrigated in accordance with the schedule prepared by Reclamation. A crop consultant will be used to monitor the site and recommend slight irrigation regime changes.

2.3 Site Maintenance/Improvements

A number of irrigation turnouts were added to the irrigation infrastructure at the Crane Roost to allow for appropriate and effective water delivery to the fields. In addition, approximately 3.5 miles of roads were constructed or improved to provide planting access to the Crane Roost and other areas on the U1CA. Drainage infrastructure was also improved by deepening some of the adjacent drains (approximately 1.2 miles). More of these types of infrastructure improvements are expected as development of the site moves to subsequent phases.

2.4 Management of Existing Land Cover

Flood irrigation was also used on other previously established fields within the conservation area for regular watering to maintain healthy stands of trees and to promote growth. Additional measures were taken as necessary to maintain field borders, and herbicide and/or fertilizer were appropriately used when necessary.

Specifically in FY08, according to the prescription from the crop consultant, fertilizer was applied to the nature trail, the mass transplanting, and cottonwood genetics fields in May 2008. A grass-specific herbicide was applied to the fields where the seed feasibility study and cottonwood genetics study were being conducted to reduce weed competition.

Crop Consultants

A local crop consultant was used to provide irrigation scheduling, soil analysis, and plant analysis. Fields at the nature trail were to be checked weekly throughout FY08. Field observations were made for soil moisture depletion, water holding capacity, plant available water, and general appearance of plant growth and vigor. Additionally, soil and plant samples were taken from each field to be tested for complete analysis of nutrient content.

2.5 Restoration Research and Demonstration

A number of previously established long-term research and demonstration projects are ongoing on the U1CA in Area 1 as depicted in Figure 1. The projects are described in greater detail in their respective work plans. If available, research updates will be periodically presented in these annual reports for projects in the U1CA; however, for more detailed information on these projects, please refer to the specific research reports for these projects.

Cottonwood Genetics

This research project is designed by Northern Arizona University (NAU) to determine the relative levels of genetic diversity in remaining stands of Fremont cottonwood across the

Southwest, and investigate the influence of this genetic diversity and local genetic adaptations on community diversity in the context of habitat restoration. The expression of these genetic adaptations may manifest in trees possessing superior traits with respect to growth, reproduction, survival, and the habitat quality they influence. NAU was awarded a cooperative agreement and contributed matching funds from a National Science Foundation grant to undertake these investigations. The project includes genetically screening remaining stocks of Fremont cottonwood trees in stands throughout the Southwest and selecting genetically distinct trees, representative of these locations, to be planted in an experimental garden with a replicated design. The experimental garden will be monitored to observe how these genetic differences may be expressed in terms of growth, reproduction, and survival in a typical restoration site, and genetic traits that influence superior habitat quality (including those that may support LCR MSCP covered species). These genetic traits will likely be important for long-term survival and for maintaining habitat quality and health throughout the life of the program. Recent results shed light on a number of research questions posed by this study:

1. Large-scale Riparian Restoration: (How) do home-site factors affect restoration success?

Survivorship studies on a 6,400-tree restoration common garden at the Cibola National Wildlife Reserve in Southern Arizona reveal that some genotypes survived at higher rates than others. However, when investigating the collection-site climate (temperature and precipitation) characteristics of each genotype in comparison to the climate of the common garden site, no specific patterns emerged. These results challenge the local climate adaptation model for choosing local genotypes in riparian restoration. Preliminary results also suggest that additional investigation is needed to determine the importance of genetic mixing for preserving riparian species, especially those that are under strong selection pressure through human influences and global climate change.

2. What is the importance of genetic diversity and structure of a foundation riparian forest tree, the Fremont cottonwood (*Populus fremontii*)?

Riparian habitats, centers of biodiversity in the Southwest, are in steady decline from ongoing climate change and human impact. Preserving foundation riparian species is critical for the maintenance of streamside communities and their numerous ecosystem services. Recent studies of *Populus* indicate that genetic diversity drives biodiversity in southwestern riparian ecosystems. However, no studies have investigated genetic diversity and structure of any single *Populus* species throughout its range. Using 243 loci derived from amplified fragment length polymorphisms (AFLPs), we investigated population genetic diversity and structure in *Populus fremontii*. At the species level, we found relatively high levels of total genetic variation (HT = 0.301) and structure (GST = 0.48). At the within-population level we found highly variable levels of genetic diversity (HS ranged from 0.060 to 0.209). Hierarchical analysis of genetic variation showed structuring at the regional and among population levels (ΦRT= 0.350, ΦPR=0.273), but most variation was harbored within populations (ΦPT = 0.527, $P < 0.001$). At a landscape scale, *P. fremontii* shows high levels of genetic variation and structure, which

may be important for the maintenance and preservation of riparian ecosystems and associated communities. Results suggest that populations of *P. fremontii* are highly structured across the Southwest, suggesting that genetic variation may be an important consideration when choosing trees for maximum fitness and adaptability, and therefore restoration success.

Seed Feasibility

Through a series of laboratory and field experiments, this study will document the necessary steps involved in using seed to create dense mosaics of native riparian land covers. Steps in the process include seed collection, storage, treatment, planting, germination, and seedling growth and survival. Using seeds in lieu of, or in conjunction with, cuttings may be feasible if it involves less labor, is more cost effective, or preserves the genetic diversity of the riparian habitat created under the LCR MSCP. The amount of nonnative to native vegetation resulting from using seed for restoration will also be an important factor in determining the feasibility of this method.

Germination Trials

During 2008, three additional germination trials were completed for frozen Fremont cottonwood, Goodding's willow, and coyote willow seed collected on the LCR during April 2006. Results indicate viability of over 80% for at least 27 months after collection. Therefore, it appears that long-term seed viability under freezer storage conditions should not be considered a limitation for the use of native seed for direct seeding and revegetation on the LCR.

Monitoring of 2007 Cottonwood-Willow Test Plots

Vegetation and water content monitoring continued for cottonwood-willow study plots seeded at Cibola National Wildlife Refuge in May 2007. Additionally, two distinct irrigation regimes were implemented. Half of the study plots received approximately 7 cm of water once per week, whereas the other plots received approximately 21 cm of water once per three weeks. In addition to large-scale monitoring of plant cover and establishment, individual cottonwood, willow, and saltcedar trees were tagged and monitored for the 2008 growing season, allowing survival and growth rate calculations for these species. Finally, trenches were excavated in the plots during October 2008 to monitor root growth through the soil profile.

Results for continued monitoring indicate an expansion of Fremont cottonwood crown and canopy cover as well as saltcedar crown and canopy cover. Monitoring of tagged trees has allowed documentation of superior growth rates of Fremont cottonwood over saltcedar under both irrigation regimes. Mortality was observed for both cottonwood and saltcedar at 6.4% and 4.2%, respectively. However, the average cottonwood growth rate was significantly greater than that of saltcedar. Finally, root systems were observed at depths greater than 1.5 meters below ground surface, indicating that seeded cottonwood likely utilized groundwater for at least a portion of the 2008 growing season (approximate depth to groundwater of 2 meters). Water content data to further evaluate this question are currently being processed.

2008 Goodding's Willow Test Plots

Sixteen additional small-scale study plots were implemented at Cibola National Wildlife Refuge to analyze the effectiveness of direct seeding Goodding's willow under reduced competition. Fremont cottonwood seed was not applied, and grass-specific herbicide was applied four times between May and July to control weed competition. Additionally, seeding rates were increased to approximately 140 pure live seed (PLS)/ft^2 (approximately 1400 PLS/m^2). Finally, hydroseeding of un-cleaned seed was compared with broadcast seeding of cleaned seed.

Goodding's willow establishment in the 2008 plots averaged 0.13% for broadcast seed and 0.95% for hydroseed. The relative Goodding's willow establishment compared to the 2007 cottonwood-willow study plots increased approximately 300% and 450% for broadcast and hydroseed methods, respectively. These data indicate that reduced competition increased plant establishment. However, the plant density was still low enough that the ratio of saltcedar to Goodding's willow was approximately 1.5:1. This is approximately equal to the ratio of saltcedar to cottonwood in the 2007 plots after the first growing season.

Results to date indicate continued monitoring is warranted to evaluate future competitive effects between saltcedar and Fremont cottonwood (2007 plots), and Goodding's willow (2008 plots).

Mass Transplanting

This project evaluates mass transplanting techniques for cottonwood and willow using commercially available mechanized transplanting equipment. To meet the requirement to create 5,940 acres of cottonwood-willow land cover type habitat, a significant number of native trees will need to be established each year. Mass transplanting is an approach used successfully by commercial growers. If mass transplanting of native species proves effective, it is expected to provide a useful cost-effective tool in the creation of future habitat.

Effectiveness of this technique has been established and is currently being used as a primary means for large-scale establishment of cottonwood-willow cover type for the LCR MSCP. For greater detail on this project, refer to the specific report for this technique demonstration. We are continuing to monitor the fields where these demonstrations took place to determine the long-term survival and growth of trees planted using this technique and at these high densities. Additional research has been conducted in these stands with respect to comparative arthropod use. These results are discussed in the Monitoring section of this report.

3.0 FY 2008 Monitoring

In 2008, monitoring was focused on pre-development, implementation, and species monitoring as outlined in the *Cibola NWR Unit 1 Conservation Area Restoration Development and Monitoring Plan* (Garnett and Calvert 2006). Pre-development

monitoring included avian area searches and acoustic bat monitoring. Implementation monitoring included soil sampling, vegetation monitoring, small mammal trapping, acoustic and capture bat surveys, intensive avian area searches, and avian mist-netting. Species-specific monitoring was conducted for the western yellow-billed cuckoo and southwestern willow flycatcher. The monitoring sections below are organized by resource type and include a combination of both pre-development and post-development monitoring.

3.1 Soils

Habitat creation is dependent on many factors, including soil salinity and nutrients, especially in a flood-irrigated environment where these elements can change over time. Soil samples were taken in early spring at the Nature Trail and Mass Transplanting areas of Unit 1.

Methods

One sample in each area was taken to determine soil moisture, pH, salinity, textural classification, and nutrients (including nitrates, ortho-phosphate, and ammonia). Soils were analyzed by an independent laboratory for the above stated parameters.

Results

The results from each sample point can be found in tables 1 and 2.

Table 1. Soil analysis of the Nature Trail sample

Nutrient	Results	Sufficiency Range[1]
Nitrate (NO_3-N) (ppm)	0.5	10.0-20.0
Phosphorus (PO4-P) (Olsen Method) ppm	3.4	10.0-20.0
Potassium (ppm)	181.0	80.0-180.0
Magnesium (ppm)	454.7	40.0-125.0
Calcium (ppm)	3983.0	300.0-600.0
Sodium (ppm)	370.8	100.0-200.0
pH	7.8	6.5-7.5
Ece (dS/cm(2))	0.8	2.00-4.00
Saturation (SP%)	55.1	30-70%
ESP (%)	6.3	1.0-5.0
Iron (ppm)	10.7	2.5-5.0
Manganese (ppm)	4.2	2.0-3.5
Zinc (ppm)	1.1	1.00-3.00
Copper (ppm)	1.0	0.3-0.5

1. Sufficiency Range provided by Stanworth Crop Consultants

Table 2. Soil analysis of the Mass Transplanting sample

Nutrient	Results	Sufficiency Range[1]
Nitrate (NO_3-N) (ppm)	1.8	10.0-20.0
Phosphorus (PO4-P) (Olsen Method) ppm	5.0	10.0-20.0
Potassium (ppm)	133.0	80.0-180.0
Magnesium (ppm)	347.8	40.0-125.0
Calcium (ppm)	3399.0	300.0-600.0
Sodium (ppm)	292.0	100.0-200.0
pH	7.8	6.5-7.5
Ece (dS/cm(2))	0.9	2.00-4.00
Saturation (SP%)	47.1	30-70%
ESP (%)	5.9	1.0-5.0
Iron (ppm)	11.4	2.5-5.0
Manganese (ppm)	2.3	2.0-3.5
Zinc (ppm)	1.7	1.00-3.00
Copper (ppm)	0.6	0.3-0.5

1. Sufficiency Range provided by Stanworth Crop Consultants

Discussion

Soil sample parameters were considered adequate for good establishment of native riparian trees, with the exception of nitrogen, phosphorus, and pH. Fertilizer recommendations included an application of a blend of UN-32 and 10-34-0.

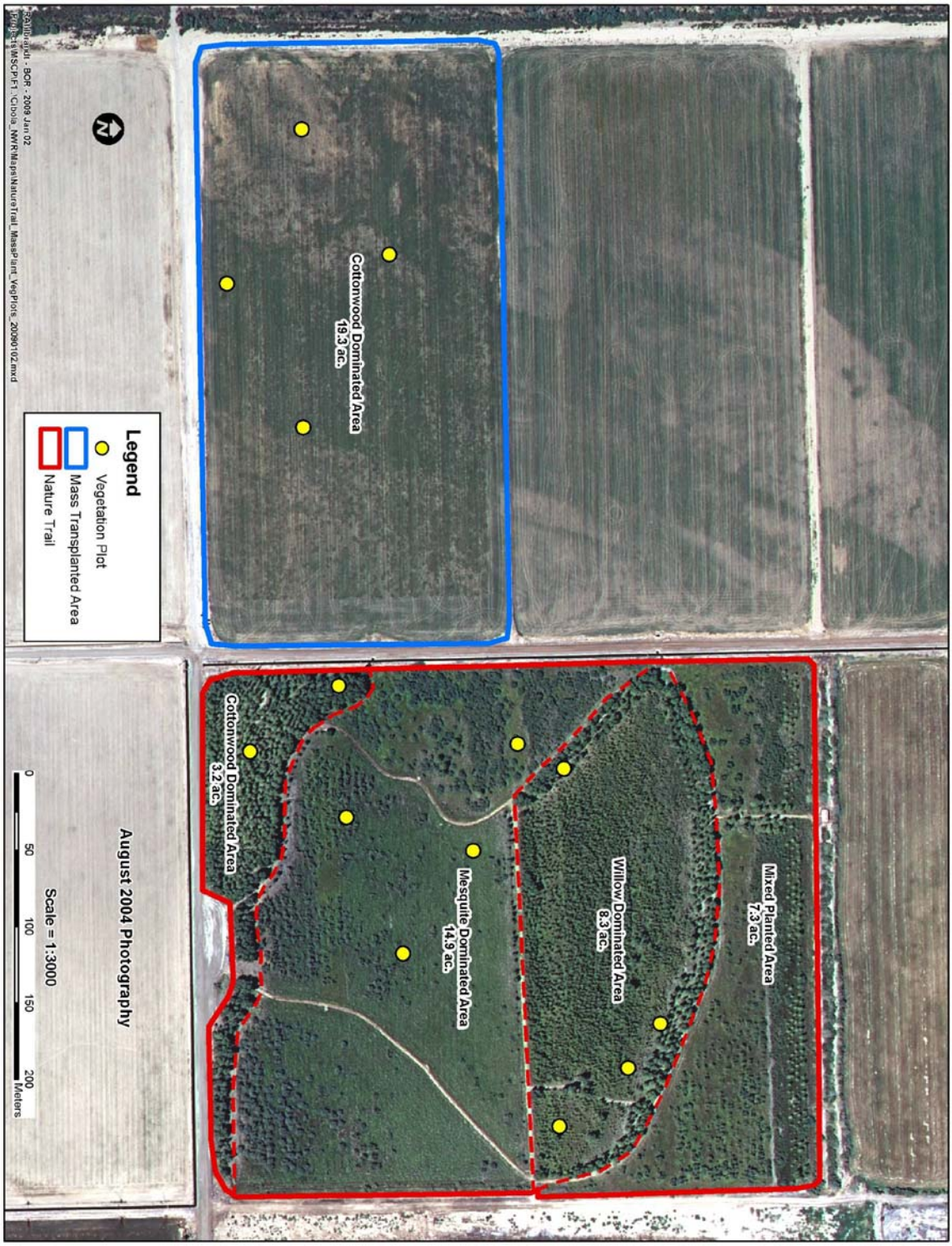
3.2 Vegetation

In 2008, vegetation was monitored using an updated protocol that was designed to characterize current plant community composition and structure, monitor changes in plant community composition and structure over time, and determine when vegetation components meet defined habitat criteria needed for accomplishment of LCR MSCP conservation measures.

Initial habitat creation efforts have been designed to provide information on potential habitat mosaics. In order to evaluate different planting mosaics, vegetation monitoring plots are being established using a stratified random sampling design. Permanent repeatable plots will be established within each habitat type to evaluate change in plant communities over time.

A total of 10 plots were established at the Nature Trail. Of these 10 plots, four were within the willow dominated area, four more were within the mesquite area, and two were established in the cottonwood area (Figure 3). Plots will be analyzed according to these three habitat types. Four plots were also established at the Mass Transplanted area. Three of these were in the half of the field that had high survivorship, and one plot was in the half that had very low survivorship. To get an adequate census of the successful area, only the three plots within that section were analyzed. All plots were chosen using a stratified random sample design.

Figure 3. Vegetation plots at the Nature Trail and Mass Transplanting areas



Methods

Overstory

Within a 26.3-foot (8.0-m) radius circle around plot center, every live tree measuring at least 4.5 feet (1.37 m) in height and 5.0 inches (12.7 cm) Diameter at Breast Height (DBH) was measured and recorded by species, total height, and DBH. Trees between 16.4 feet (5.0 m) and 26.3 feet (8.0 m) from plot center and at least 4.5 feet (1.37 m) in height and 3.1 to 4.9 inches (8.0-12.6 cm) DBH were tallied by species. Trees that branched below 4.5 feet (1.37 m) in height were considered separate individuals and were measured independently if they met the above criteria. The number of stems greater than 1.0 inches (2.5 cm) at DBH were estimated.

Shrubs and Intermediate Trees

Within a 16.4-foot (5.0-m) radius circle around plot center, all woody stem saplings and shrubs were recorded. Any individual at least 4.5 feet (1.37 m) in height and 3.1 inches (8.0 cm) DBH was measured and recorded by species, height, and DBH. Any stem at least 4.5 feet (1.37 m) in height but less than 3.1 inches (8.0 cm) DBH was tallied by species and DBH class.

DBH was recorded by size classes: Class 1 = <0.4 inches (<1 cm), Class 2 = 0.4-1.0 inches (1-2.5 cm), Class 3 = 1.1-2.2 inches (2.6-5.5 cm), and Class 4 = 2.3-3.1 inches (5.6-7.9 cm). No DBH was taken on trees less than 4.5 feet (1.37 m) in height; these were tallied by species only.

Ground Cover

The ground cover and herbaceous component of each site was estimated using the line-intercept method. Four 32.8-foot (10-m) lines were established from the center of each fixed plot in the four cardinal directions. The horizontal, linear length of each herbaceous plant that intercepts the transect line was measured and recorded by species. Areas along each transect that were covered by woody debris, bare ground, rock, or woody stem were measured and recorded as such.

Crown Closure

Crown closure, the measure of the horizontal canopy cover, was measured along the same line transects established to monitor ground cover. An estimate of canopy cover was made every 16.4 feet (5.0 m) using a spherical densitometer.

Total Vegetation Volume

Total vegetation volume (TVV) was measured to describe foliage height diversity by height class for each sample plot (Mills et al. 1991). Along the line transects established to monitor ground cover and crown closure, TVV was estimated every 16.4 feet (5.0 m) with a 7.5-meter survey rod extended through the canopy. TVV was estimated for each meter height class throughout the stand and for the entire site.

Results

Table 4 gives a summary of tree and shrub density (per acre), ground cover, and crown closure in all four habitat types. The Mass Transplanting area had the highest tree density

and groundcover. Groundcover in the Mass Transplanting area was dominated by Bermudagrass (*Cynodon dactylon*), while Johnsongrass (*Sorghum halepense*) was the dominant cover in the Nature Trail. The cottonwood area had the highest crown closure.

Table 4. Summary of tree density, groundcover, and crown closure for all habitat types. SE = standard error

Habitat Type	Number of Plots	*Tree Density*		*Ground Cover*		*Crown Closure*	
		Average	SE	Average	SE	Average	SE
Mass Transplanting	3	1850	362	90.2%	5.0%	41.1%	16.3%
CW III (willow)	4	635	56	83.5%	13.7%	50.4%	8.6%
Mesquite	4	528	155	84.6%	11.5%	54.9%	2.5%
CW II (cottonwood)	2	285	105	48.3%	13.0%	68.0%	5.9%
All Nature Trail Plots	10	522	75	76.9%	8.3%	55.7%	4.0%

Overstory

Within the 26.3-foot (8.0-m) plot center, density counts for overstory trees were found in all but the Mass Transplanted area (Table 5). The cottonwood area had the highest density of overstory trees. The average height and DBH for overstory trees can be found in Table 6.

Table 5. Density of overstory trees for each habitat type

Habitat	Number of Plots	Average Density	SE
CW III (Willow)	4	60	36
Mesquite	4	40	24
CW II (cottonwood)	2	210	30
All Nature Trail Veg Plots	10	82	27

Table 6. Height and DBH of overstory trees for each habitat type

Habitat	Number of Trees	Average Height (m)	SD	SE	Average DBH (cm)	SD	SE
CW III (willow)	12	12.0	1.6	0.5	22.7	7.5	2.2
Mesquite	8	5.8	3.7	1.3	28.6	4.4	1.6
CW II (cottonwood)	21	11.7	1.9	0.4	23.7	11.9	2.6
All Nature Trail Plots	41	10.6	3.0	0.5	24.4	9.7	1.5

Shrub and intermediate trees

For the 16.4-foot (5.0-m) plot, the average height and DBH of trees and shrubs at least 4.5 feet (1.37 m) in height and 3.1 inches (8.0 cm) in DBH are summarized in Table 7. Table 8 summarizes the average density of shrubs and trees per acre using the same plot. For the mesquite area, the shrub desert broom (*Baccharis sarothroides*) was the only species that met the criteria for measurements.

Table 7. Average height and DBH of larger shrubs and intermediate trees

Habitat Type	Number of Trees/shrubs	Average Height (m)	SE	Average DBH (cm)	SE
Mass Transplanting	11	8.7	0.1	9.9	0.4
CW III (willow)	1	5.1	N/A	10.5	N/A
Mesquite	12	2.9	0.2	11.7	1.6
All Nature Trail Plots	13	3.1	0.2	11.6	1.5

Table 8. Shrub and intermediate tree density

Habitat Type	Number of Plots	Average Tree Density	SE
Mass Transplanting	3	1850	362
CW III (Willow)	4	575	78
Mesquite	4	488	170
CW II (cottonwood)	2	75	75
All Nature Trail Plots	10	440	93

Total Vegetation Volume (TVV) and Species Composition

The TVV and species composition for the Mass Transplanting area can be found in figures 4 and 5. The TVV and species composition for the cottonwood area of the Nature Trail can be found in figures 6 and 7. The TVV and species composition for the willow area of the Nature Trail can be found in figures 8 and 9. The TVV and species composition for the mesquite area of the Nature Trail can be found in figures 10 and 11. The species composition using the TVV method for the entire Nature Trail can be found in Figure 12. The Johnsongrass and Bermuda grass were the dominant species at the lower meter layers, while the tree and shrub species accounted for the majority of the vegetation in the upper meter layers.

Figure 4.

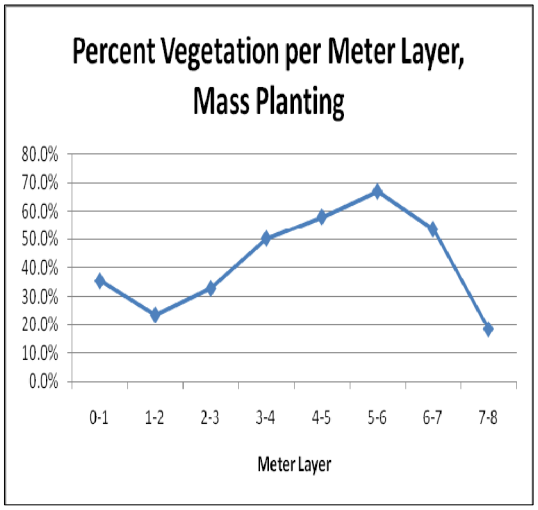
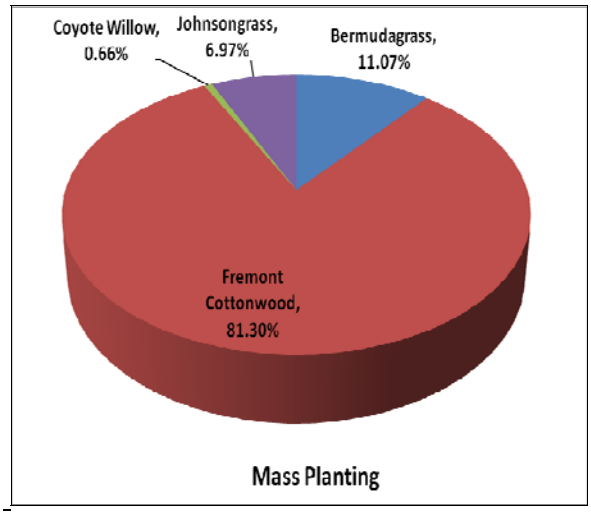


Figure 5. Species Composition



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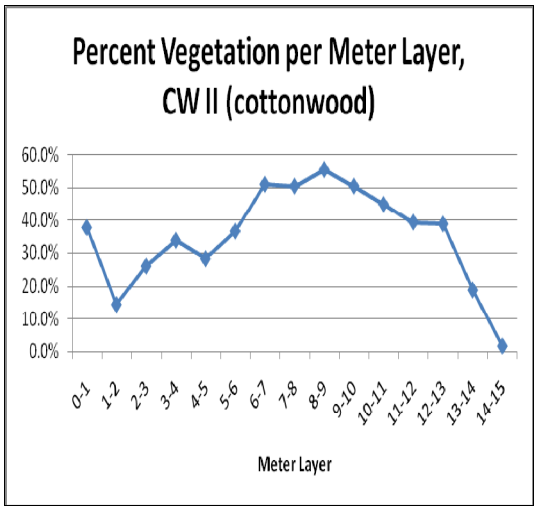
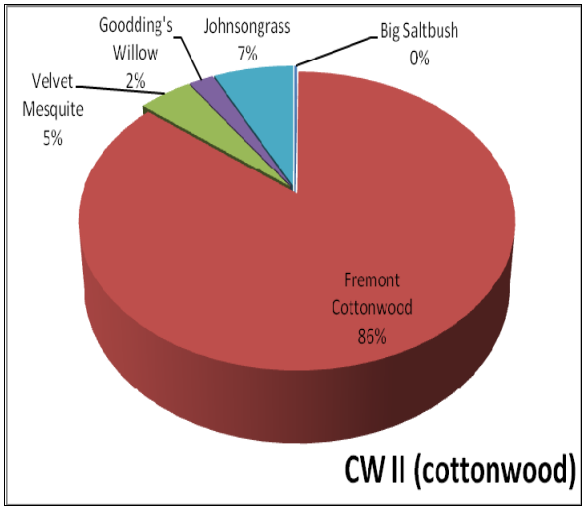


Figure 7. Species Composition



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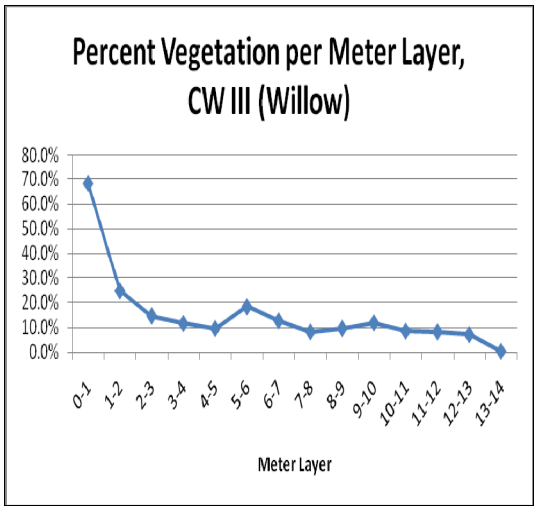


Figure 9. Species Composition

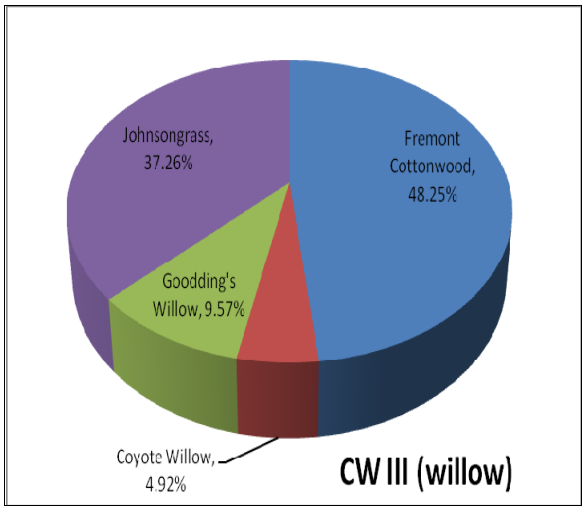


Figure 10.

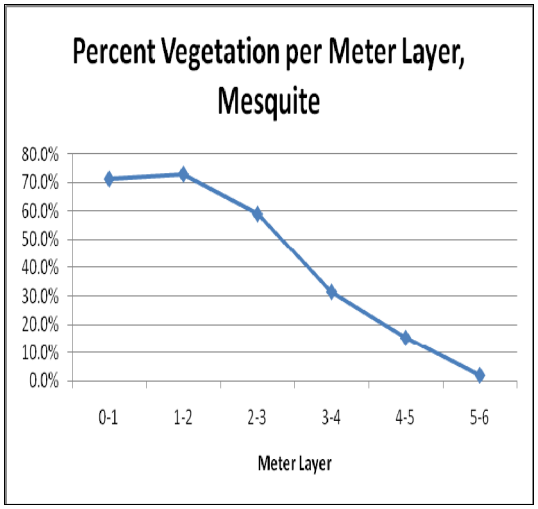


Figure 11. Species Compostion

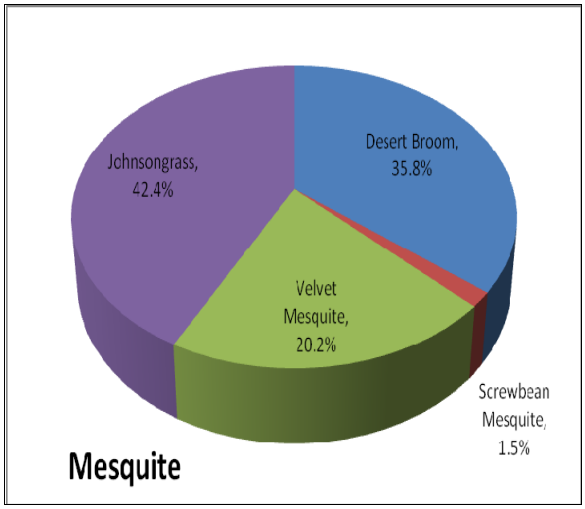
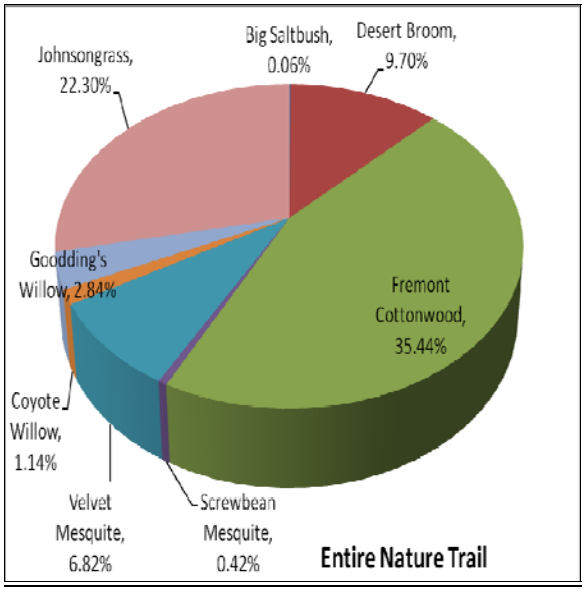


Figure 12.



Discussion

It should be noted that the velvet mesquite (*Prosopis velutina*) that was identified by the contractors had been thought to be honey mesquite (*Prosopis glandulosa*). Due to the possible misidentification of trees, a botanist was brought out to the site and it was decided that the trees in question may actually be hybrids of the two species. Further investigations will be done to confirm species identification. The successful section of the Mass Transplanting area had the highest density of trees because trees were planted in a higher density. It is suggested that an additional plot be established in the unsuccessful area allowing that area to be monitored separately from the successful area so that management recommendations can be made in the future. It is not surprising that when crown closure was higher, ground cover was lower. Most herbaceous plants need sunny areas to be able to grow more densely. The higher crown closure in the cottonwood area of the Nature Trail also correlates with the higher density of overstory trees compared to the other habitat types. There is a discrepancy between the average heights of overstory trees compared with the highest meter layers of the TVV measurements. This may be caused by the difficulty in estimating height in trees that are taller than 7 m. The high percentage of cottonwoods in the willow dominated area is caused by the locations where the random points landed. Most of the willow area is lined with cottonwoods. While four random points appeared to be adequate, half of these points landed in the area that was edged by cottonwoods. Because no random points landed within the center section of the willow area, it is suggested that one to two more points be added by stratifying the points to only include the center section. As more habitat data are collected from different covered species, more information may be obtained using the current protocol.

3.3 Small Mammals

Presence/absence surveys were used in previous years to determine the presence of the Colorado River cotton rat (*Sigmodon arizonae plenus*) at the Nature Trail. No post-development trapping was conducted in Unit 1 in 2008 because no other areas had the appropriate habitat for colonization by cotton rats (dense tall grassy herbaceous understory). Trapping was conducted in 2007 and that data can be found in the report *Small Mammal Colonization at Habitat Creation Sites along the Lower Colorado River: 2007* (Calvert 2009). A population genetic study is currently collecting genetic samples of cotton rats throughout the LCR. Samples were collected at the Nature Trail in the fall of 2008, confirming the continued presence of the species. If potential habitat becomes available within the conservation area, surveys will be conducted in the future. The Nature Trail will be trapped periodically to confirm that cotton rats are still utilizing the area.

3.4 Bat Surveys

3.4.1 Acoustic Surveys

Methods

Up to 12 Anabat bat detectors were deployed two nights quarterly from dusk to dawn within a given habitat creation area for a total of four surveys (eight nights) per year. Bat detectors record the echolocation calls a bat makes as it passes by the detector. The minimum frequency, duration, and shape of each call is compared with reference calls to identify bats either to species or species group (Table 9). These calls are then converted into the number of minutes that each species/species group is recorded, which is then used to create activity indices. These indices are a proportion of bat minutes per species/species group divided by the total number of bat minutes. Two metrics are given in this report to characterize bat use of the riparian restoration and adjacent habitats: total number of bat minutes for the four covered and evaluation species, and indices of relative bat activity for all species/species groups. For a thorough overview of all bat activity within each habitat creation area see Broderick (in press).

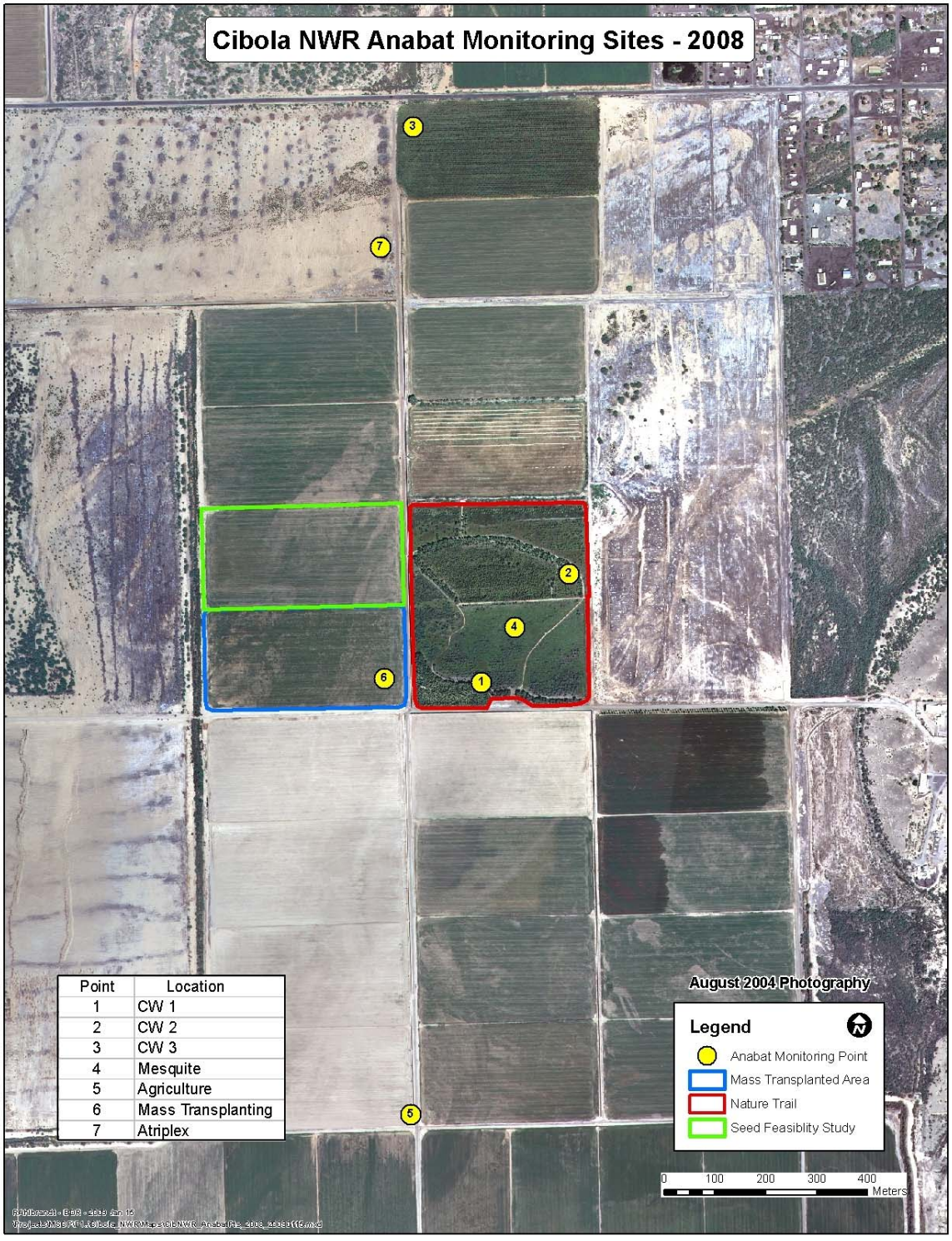
Table 9. All species and species groups for bats identified at habitat creation areas

Common Name	Scientific Name	Species Code
Individual Species		
Pallid bat	*Antrozous pallidus*	Anpa
Townsend's big-eared bat	*Corynorhinus townsendii*	Coto
Western red bat	*Lasiurus blossevillii*	Labl
Yellow bat	*Lasiurus xanthinus*	Laxn
California leaf-nosed bat	*Macrotus californicus*	Maca
Hoary bat	*Lasiurus cinereus*	Laci
Pocketed free-tailed bat	*Nyctinomops femorosaccus*	Nyfe
Big free-tailed bat	*Nyctinomops macrotis*	Nyma
Mastiff bat	*Eumops perotis*	Eupe
Western pipistrelle	*Parastrellus hesperus*	Pahe
Cave Myotis	*Myotis velifer*	Myve
Species Groups:		
20 Khz	Overlapping calls of Nyfe, Nyma, Laci, Tabr	
25-30 Khz	Overlapping calls of Epfu, Tabr, Anpa	
35 Khz	Various calls at 35 khz, primarily Anpa, Myve, Laxa	
40 Khz	Primarily Myve	
45-55 Khz	Overlapping calls of Myca, Myyu, and some Pahe	
Species included in the groups listed above:		
Big brown bat	*Eptesicus fuscus*	Epfu
Mexican free-tailed bat	*Tadarida brasiliensis*	Tabr
California myotis	*Myotis californicus*	Myca
Yuma myotis	*Myotis yumanensis*	Myyu

Results

Thirty detector nights were completed for seven monitoring sites at Unit 1. Two exploratory sites were an untreated site dominated by *Atriplex* spp., and the Mass Transplanting site. The other five long-term monitoring sites included three intermediate staged cottonwood-willow habitat types, one mesquite habitat type, and an agricultural field. See Figure 13 for detector locations. A total of 7,441 call files were obtained, edited, and identified to species or species group.

Figure 13. Locations of all acoustic bat monitoring sites at Cibola NWR Unit 1



There were 103 total minutes of bat activity for the four covered species, of which the California leaf-nosed bat was the most numerous. One western red bat minute was recorded in an agricultural field adjacent to the Nature Trail during July (Figure 14). No western yellow bat minutes were collected in any habitat during any sample period (Figure 15). No Townsend's big-eared bat minutes were collected (Figure 16). California leaf-nosed bats were more widely spread, with 13 minutes of bat activity obtained in the fall, 27 minutes in the spring, and 25 minutes in the summer all in the mature cottonwood and mesquite sites. Thirty-four minutes were obtained in the agriculture site in July, as well as one in spring and two in fall (Figure 17).

Figure 14.

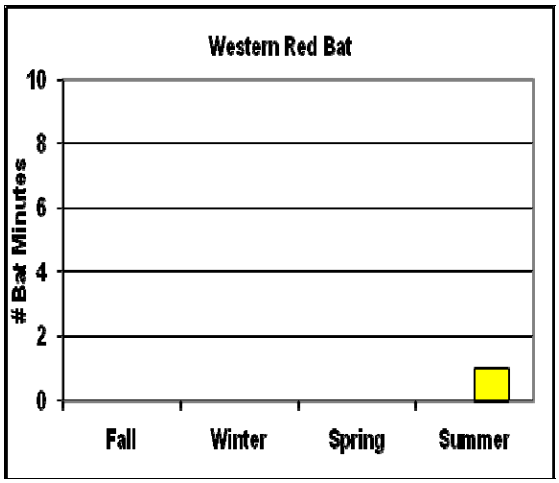


Figure 15.

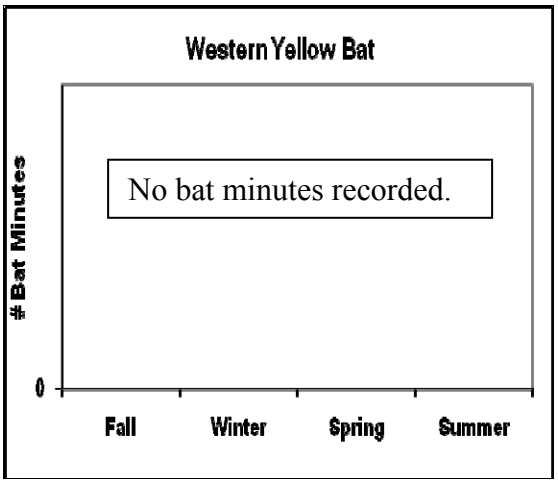


Figure 16.

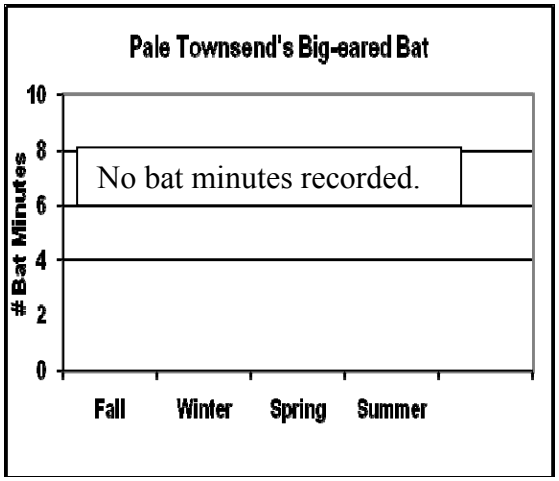
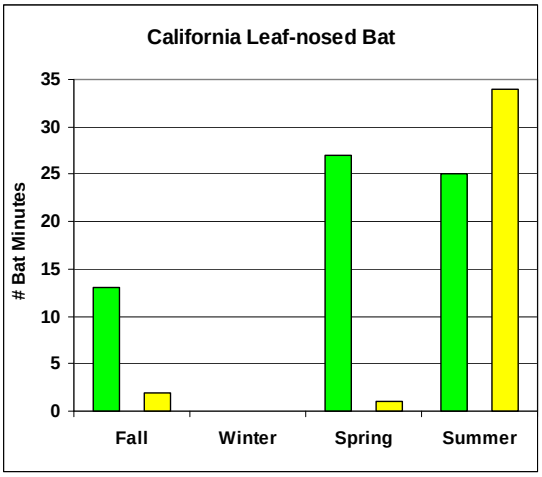


Figure 17.



Legend:

Restoration Sites

Agriculture

An index of relative bat activity was developed for the restoration and non-restoration sites (Table 10). Overall the bat assemblage was similar for both sites with the 45-55 KHz species group (mostly Yuma myotis and California myotis) being the dominant species group for both sites. The cave myotis was recorded much more often in restored areas. The California leaf-nosed bat (Maca) was the only covered species that was recorded in a restored habitat area, accounting for 3.9% of all activity. The western red bat was the only other covered species recorded in Unit 1, accounting for 0.1% of all activity in non-restoration areas.

Table 10. Index of activity for all species/species groups (MSCP species in bold)

Restoration Sites		Non Restoration Sites	
Species/Species Groups	**%**	**Species/Species Groups**	**%**
45-55 kHz	62.3	45-55 kHz	58.5
25-30 kHz	18.2	Pahe	20.1
Myve	9.5	25-30 kHz	14.3
Pahe	5.2	**Maca**	4.0
Maca	3.9	Nyfe	1.0
20 kHz	0.4	Myve	0.8
Nyfe	0.2	20 kHz	0.8
Labl	0.0	Eupe	0.4
Coto	0.0	**Labl**	0.1
Laxa	0.0	**Coto**	0.0
Eupe	0.0	**Laxa**	0.0
Laci	0.0	Laci	0.0

3.4.2 Capture Surveys

Methods

In 2008, the Nature Trail was the only area of Unit 1 where capture surveys occurred. Five surveys were conducted between April and September. Capture techniques included the use of mist nets and harp traps. The number and size of mist nets varied between sites depending on habitat in the site. Nets were 6 m (19.7 ft) and 12 m (39.4 ft) long and 2.6 m (8.5 ft) tall. Nets were set either as single nets or as stacked nets. At the Nature Trail, both a double-stacked and a triple-stacked net set were used. Harp traps were also used to capture bats. The harp trap is 1.8 m (6 ft) wide and has 4.2 m^2 (45 ft^2) of capture area.

Nets and traps were set up at the site where bats were most likely to be using an area as a flyway. Usually this involved natural corridors within a site that divided areas of habitat. At the Nature Trail, the entrance to the trail was trapped using a combination of mist nets and a harp trap. Farther down the trail, the triple-stacked set-up was set across the trail using 6-m long nets. One additional 12-m net was set on the western edge of the site where poles were already set up for avian mist-netting surveys.

Results

A total of 37 bats of six species were captured at the Nature Trail. The western yellow bat and California leaf-nosed bat were the only covered species captured. The hoary bat, which is an indicator species for tree roosting bats, was also captured (Table 11). All western yellow and hoary bats were captured in the triple high net set. A more thorough report of bat capture surveys can be found in Calvert (in press).

Table 11. Total captures for all five survey periods in 2008

Species	April	May	July	August	September	Total
Western yellow bat	0	0	0	2	0	2
California leaf-nosed bat	0	1	0	0	3	4
Hoary bat	0	0	0	0	2	2
California myotis	2	0	1	0	0	3
Pallid bat	2	8	1	0	2	13
Big brown bat	0	3	9	0	1	13
Total	4	12	11	2	8	37

Discussion

Beginning in April, the acoustic surveys study design was modified so that habitat preferences of covered bat species could be determined at habitat creation areas. The design now includes the deployment of three bat detectors within each habitat type being monitored within a habitat creation area. Because of the close proximity of the Cibola Valley Conservation and Wildlife Area to Cibola Unit 1, sampling for these two sites was combined. This also allowed for sufficient replicates of each habitat type. This will provide a total of three intermediate/mature stage cottonwood-willow sites, three young cottonwood-willow sites, and three agricultural sites.

Western yellow bats were not found acoustically, but were captured for the first time in 2008. Because the captures occurred in August, and were not found during any other capture survey, these may have been migrating individuals. Further acoustic and capture surveys will be conducted in 2009.

3.5 Avian Surveys

3.5.1 Area Search Avian Surveys

In 2007, a system-wide avian survey was implemented in order to develop a baseline inventory of bird populations within the LCR MSCP area (Bart and Manning 2008). Within this overall study plan, data for Cibola Unit 1 specifically has been summarized here. Complete data for the LCR and more detailed methods and results will be available in the report entitled, *System Monitoring for Riparian Obligate Avian Species (Work Task D6) and Avian Use of Restoration Sites (Work Task F2)* (GBBO in press).

Methods

Two types of surveys were used for avian monitoring based on the age of habitats at Unit 1. Rapid area search surveys were conducted on pre-development plots (Crane Roost area). This type of survey included two visits to each site and resulted in an index of relative abundance. Results of rapid area searches are reported here as an average of detections per survey. Intensive area search surveys were conducted on post-development plots (i.e., the Nature Trail and Mass Transplanted areas). Eight visits were made to each intensive area search plot and all bird activity was recorded. Data from intensive area searches resulted in an unbiased density estimate for breeding birds and an index of abundance for non-breeding birds. Due to the small numbers detected, breeding birds are reported as pairs per survey rather than densities.

Rapid area searches were conducted on the Crane Roost area because this area will be the next to be planted with riparian habitat. About 25% of the Crane Roost had already been planted by the Refuge and was included in the rapid area searches. Intensive area searches were conducted at both the Nature Trail and Mass Transplanted areas. The dates and times of all surveys in Unit 1 are found in Table 12.

Table 12. Areas, cover type, survey type, number of plots surveyed and dates of surveys

Area	Cover Type/Age	# Surveys, Type, # plots	Date Surveyed
Nature Trail	Cottonwood-willow and mesquite - 9 years	8 intensive area searches, 2 plots	7 May thru 30 June
Mass Transplanted	Cottonwood-willow- 4 years	8 intensive area searches, 1 plot	6 May thru 29 June
Crane Roost	Pre-development agriculture/some riparian	2 rapid area searches, 1 plot	30 April 18 June

Results

Pre-development monitoring. An average of 50 individuals were detected per survey at the Crane Roost. Twenty-five species were detected; the Abert's towhee (*Pipilo aberti*) and mourning dove (*Zenaida macroura*) were the most abundant. The majority of birds detected were not breeding at the Crane Roost. Most of the species detected were found in the area of the Crane Roost that had already been planted by the refuge with cottonwood, willow, and mesquite.

Post-development monitoring 2nd year of growth and older. There were 46 pairs of birds comprising 14 species that were detected breeding at these areas (Table 13). One LCR MSCP covered species, the yellow warbler (*Dendroica petechia sonorana*), was detected breeding at the Cibola Nature Trail. There were an average of 123 birds per survey detected at the Cibola Nature Trail and Mass Transplanting that were not breeding

at these areas (Table 14). The red-winged blackbird (*Agelaius phoeniceus*) and brown-headed cowbird (*Molothrus ater*) were categorized in the non-breeder category. The population of birds detected for these species could have comprised both breeders and non-breeders; however, conclusive evidence of breeding could not be obtained per individual.

Table 13. Number of breeding pairs detected during surveys, per species, at the Nature Trail and Mass Transplanting areas; breeding season 2008

Species	Number of Territories	Species	Number of Territories
Cibola Nature Trail		phainopepla	1
western kingbird	5	song sparrow	1
Abert's towhee	4	white-winged dove	1
blue grosbeak	4	verdin	1
Bullock's oriole	4	**Cibola Mass Planting**	
mourning dove	4	common yellowthroat	3
Sonoran yellow warbler	4	mourning dove	2
common yellowthroat	3	song sparrow	2
yellow-breasted chat	2	blue grosbeak	1
Anna's hummingbird	1	Bullock's oriole	1

Table 14. All Species Detected at Cibola Unit 1 (excluding flyovers and incidental detections)

Common Name	Scientific Name
American bittern	*Botaurus lentiginosus*
green heron	*Butorides virescens*
Gambel's quail	*Callipepla gambelii*
killdeer	*Charadrius vociferus*
white-winged dove	*Zenaida asiatica*
mourning dove	*Zenaida macroura*
great horned owl	*Bubo virginianus*
black-chinned hummingbird	*Archilocus alexandri*
Anna's hummingbird	*Calypte anna*
rufous hummingbird	*Selasphorus rufus*
belted kingfisher	*Megaceryle alcyon*
ladder-backed woodpecker	*Picoides scalaris*
olive-sided flycatcher	*Contopus cooperi*
western wood-pewee	*Contopus sordidulus*
willow flycatcher	*Empidonax trailii*
Pacific-slope flycatcher	*Empidonax difficilis*
black phoebe	*Sayornis nigricans*
Say's phoebe	*Sayornis saya*
ash-throated flycatcher	*Myiarchus cinerascens*
western kingbird	*Tyrannus verticalis*
Bell's vireo	*Vireo bellii*
Cassin's vireo	*Vireo cassinii*
warbling vireo	*Vireo gilvus*
verdin	*Auriparus flaviceps*
black-tailed gnatcatcher	*Polioptila melanura*
crissal thrasher	*Toxostoma crissale*
phainopepla	*Phainopepla nitens*
Lucy's warbler	*Vermivora luciae*
Sonoran yellow warbler	*Dendroica petechia sonorana*
yellow warbler	*Dendroica petechia*
Townsend's warbler	*Dendroica townsendi*
MacGillivray's warbler	*Oporornis tolmiei*
common yellowthroat	*Geothlypis trichas*
Wilson's warbler	*Wilsonia pusilla*
yellow-breasted chat	*Icteria virens auricollis*
western tanager	*Piranga ludoviciana*
Abert's towhee	*Pipilo aberti*
song sparrow	*Melospiza melodia*
blue grosbeak	*Passerina caerulea*
red-winged blackbird	*Agelaius phoeniceus*
western meadowlark	*Sturnella neglecta*
Brewer's blackbird	*Euphagus cyanocephalus*
great-tailed grackle	*Quiscalus mexicanus*
brown-headed cowbird	*Molothrus ater*
Bullock's oriole	*Icterus bullockii*
Scott's oriole	*Icterus parisorum*
house finch	*Carpodacus mexicanus*

3.5.2 Species Specific Avian Surveys

Species-specific surveys were conducted for the southwestern willow flycatcher and western yellow-billed cuckoo because their limited populations on the river make them difficult to detect during general avian surveys.

Southwestern willow flycatcher

Methods. Southwestern willow flycatchers were surveyed at the Nature Trail and Mass Transplanting areas using a tape/playback method to elicit responses, which would then determine the presence of the target species.

Results. Survey crews detected one willow flycatcher on 6 June. No willow flycatchers were detected during surveys after 14 June and breeding was not detected. The site was surveyed five times between May and July (McLeod and Koronkiewicz 2009).

Western Yellow-billed Cuckoo

Methods. Yellow-billed cuckoos were surveyed on five dates between 10 June 29 September 2008 at the Nature Trail (surveys included Mass Transplanted area) and the area of existing cottonwoods north of the Nature Trail. The surveys involved using a tape-playback method in which surveyors broadcast a recorded cuckoo call at predetermined intervals along a predetermined route within appropriate riparian habitat. Complete results of this monitoring effort are contained in the 2008 Yellow-billed Cuckoo Report (Halterman et al. 2009).

Results. Results from the presence/absence surveys of cuckoos are listed in Table 15. During five surveys, one individual was detected on 25 June. This bird was seen during the second survey at the site. It flew into a small mesquite after the first playback and sat quietly for about 1 minute, then flew out of site to the north. The bird was present and using the habitat during the early part of the season, but as this is the only detection in 2008, breeding was not likely.

Table 15. Dates of yellow-billed cuckoo detections

Site Name	Date / # of Cuckoos	Date/ # of Cuckoos	Date/ # of Cuckoos	Date/ # of Cuckoos	Date/ # of Cuckoos
Nature Trail	10 June/0	25 June/1	16 July/0	7 August/0	29 August/0
Existing cottonwoods	11 June/0	25 June/0	16 July/0	7 August/0	10 Sept/0

Discussion. Yellow-billed cuckoos nested at Cibola Valley Conservation and Wildlife Area (CVCWA) in 2008, which is less than three miles from the Nature Trail. The Nature Trail is smaller than the area at CVCWA, which may be one of the reasons cuckoos have yet to breed there. Cuckoos will continue to be surveyed in 2009.

3.3.3 Avian Mist-netting

A bird banding station has been in operation at the Nature Trail since 2002. Winter banding takes place from October to March and summer banding takes place from May to August. The data from these banding sessions will be inlcuded in a future report.

4.0 Established Land Cover & Habitat Credit

The process for Habitat Credit has not been finalized. Once the process is finalized, information in this section will be utilized to establish credit. The land cover is cottonwood-willow II and mesquite III, as defined by Anderson and Ohmart (1976, 1984). The cottonwood-willow II structure type is described as having one layer of vegetation with the bulk of the volume 6 m (20 ft) tall or more. Mesquite III is described as having one layer of vegetation with the bulk of the volume between 2 m and 6 m (6.5 to 20 ft) tall.

5.0 Adaptive Management Recommendations

The Nature Trail area was created as habitat for the southwestern willow flycatcher (Raulston 2003). No flycatchers have been found breeding within this area. Many of the willows in this section are showing signs of stress and stunted growth. The majority of the willows in this section are Goodding's willows. The very few coyote willows that are within the section have not grown or undergone vegetative reproduction as they do in newer habitat creation areas. It may be possible to cut down most of the trees, which would allow the healthy trees to stump sprout, and plant more coyote willow allowing the area to become more similar to a natural willow thicket.

Currently, little data exists on the microclimate parameters at the nature trail and other areas in U1CA to make recommendations for changes in irrigation management. Based on soil evaluations from a contracted crop consultant, fertilizer was applied to a number of the planted areas in U1CA. Both anecdotal and measured responses were reported in these areas in the season following the application. Reclamation staff reported positive wildlife response in terms of number and diversity of avifauna and NAU researchers measured positive responses in abundance and diversity of arthropods species. The positive responses in avifauna could be due to increases in forage base from the associated arthropod increases. Based on data from the previous year, this suggests that the application of fertilizer may have influenced tree vigor and in turn, influenced the trophic communities that are dependant upon them. This connection is not conclusive; however, additional fertilizer/arthropod interaction research appears (Bill Wiesenborn, LCR MSCP, pers. communication) to corroborate this theory. Fertilizer applications will continue on U1CA based on recommendations from the crop consultant.

Literature Cited

Bart J., and A Manning. 2008. Lower Colorado River Riparian Bird Surveys 2007. U.S. Geological Survey, Boise, ID.

Broderick, S. in press. Post-development bat monitoring of habitat creation areas along the lower Colorado River – 2008 acoustic surveys. Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Multi-Species Conservation Program, Boulder City, NV.

Calvert, A. 2009. Small mammal colonization at habitat creation sites along the lower Colorado River: 2007. Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Multi-Species Conservation Program, Boulder City, NV.

Calvert, A. in press. Post-development bat monitoring of habitat creation areas along the lower Colorado River – 2008 capture surveys. Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Multi-Species Conservation Program, Boulder City, NV.

Dodge, C. in press. Final report for the operation of two Monitoring Avian Production and Survivorship (MAPS) stations on the lower Colorado River, 2008 breeding season. Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Multi-Species Conservation Program, Boulder City, NV.

Garnett, G., and A. Calvert. 2006. Cibola NWR Unit 1 Conservation Area Restoration Development and Monitoring Plan. Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Multi-Species Conservation Program Office, Boulder City, NV.

Great Basin Bird Observatory. 2008. System Monitoring for Riparian Obligate Avian Species (Work Task D6) and Avian Use of Restoration Sites (Work Task F2). Lower Colorado River Multi-Species Conservation Program No. 07SF300004. Report submitted to Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Multi-Species Conservation Program, Boulder City, NV.

Halterman, M., E. Rose, S. McNeil, and D. Tracy. 2009. Yellow-billed cuckoo distribution, abundance and habitat use on the lower Colorado River and tributaries, 2008 Draft Annual Report. Submitted to Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Multi-Species Conservation Program, Boulder City, NV by Southern Sierra Research Station, Weldon, CA.

McLeod, M.A., and T.J. Koronkiewicz. 2009. Southwestern willow flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2008. Submitted to Bureau of Reclamation, Lower Colorado Region, Lower Colorado

River Multi-Species Conservation Program, Boulder City, NV by SWCA Environmental Consultants, Flagstaff, AZ. 153 pp.

Raulston, B. 2003. Habitat restoration on the lower Colorado River, demonstration projects: 1995-2002. Bureau of Reclamation, Lower Colorado Region, Boulder City, NV.