Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Beal Riparian and Marsh Restoration Development & Monitoring Plan: Overview

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

March 2010

Lower Colorado River Multi-Species Conservation Program Steering Committee Members

Federal Participant Group

Bureau of Reclamation
U.S. Fish and Wildlife Service
National Park Service
Bureau of Land Management
Bureau of Indian Affairs
Western Area Power Administration

Arizona Participant Group

Arizona Department of Water Resources
Arizona Electric Power Cooperative, Inc.
Arizona Game and Fish Department
Arizona Power Authority
Central Arizona Water Conservation District
Cibola Valley Irrigation and Drainage District
City of Bullhead City
City of Lake Havasu City
City of Mesa
City of Somerton
City of Yuma
Electrical District No. 3, Pinal County, Arizona
Golden Shores Water Conservation District
Mohave County Water Authority
Mohave Valley Irrigation and Drainage District
Mohave Water Conservation District
North Gila Valley Irrigation and Drainage District
Town of Fredonia
Town of Thatcher
Town of Wickenburg
Salt River Project Agricultural Improvement and Power District
Unit "B" Irrigation and Drainage District
Wellton-Mohawk Irrigation and Drainage District
Yuma County Water Users' Association
Yuma Irrigation District
Yuma Mesa Irrigation and Drainage District

Other Interested Parties Participant Group

QuadState County Government Coalition
Desert Wildlife Unlimited

California Participant Group

California Department of Fish and Game
City of Needles
Coachella Valley Water District
Colorado River Board of California
Bard Water District
Imperial Irrigation District
Los Angeles Department of Water and Power
Palo Verde Irrigation District
San Diego County Water Authority
Southern California Edison Company
Southern California Public Power Authority
The Metropolitan Water District of Southern California

Nevada Participant Group

Colorado River Commission of Nevada
Nevada Department of Wildlife
Southern Nevada Water Authority
Colorado River Commission Power Users
Basic Water Company

Native American Participant Group

Hualapai Tribe
Colorado River Indian Tribes
The Cocopah Indian Tribe

Conservation Participant Group

Ducks Unlimited
Lower Colorado River RC&D Area, Inc.

Lower Colorado River Multi-Species Conservation Program

Beal Riparian and Marsh Restoration Development & Monitoring Plan: Overview

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

March 2010

Contents

Background 1
Introduction 2
Purpose 2
Location and Description 2
Land Ownership 2
Water 2
Agreements 3
Restoration Development Plan, Phase 1 3
    Introduction 3
    Materials 3
    Methods 4
    Results 6
Restoration Development, Phase 2 8
    Introduction 8
    Materials 8
    Methods 9
    Results 10
    Planting 10
Restoration Development, Phase 3 11
    Introduction 11
    Materials 11
    Methods 11
    Results 11
    Discussion Phases 1, 2, and 3 11
Management Overview 16
    Introduction 16
    Land Manager 17
    Soil Management 17
    Water Management 17
    Vegetation Management 18
    Reports 19
Literature Cited 20

Appendices

Appendix A. Habitat Monitoring Results, 2004-2005 68
Methods 68
Data Analysis 69
Results 2004 Phase 1 70
Results 2005 Phase 1 and 2 71
Discussion 72
Literature Cited 74
Appendix B. Avian Post-Development Monitoring Results, 2005 86
Methods 86
Data Analysis 86
Results 87
Discussion 87
Literature Cited 89
Appendix C. Monitoring Plan 96
Introduction 96
Site Description 96
Purpose 97
Pre-Development Monitoring 97
Implementation and Habitat/Species Monitoring Goals 98
Implementation Monitoring 98
Habitat/Species Monitoring 100
Vegetation Classification 105
Reference Conditions 106
Monitoring Analysis and Evaluation 106
Data Collection and Analysis 107
Evaluation of Results and the Adaptive Management Program 107
Literature Cited 108

Acronyms and Abbreviations

ac	Acre
af	Acre Foot
ANOVA	Analysis Of Variance (statistical)
cm	Centimeter
CW	Cottonwood-Willow land cover type, as defined in the LCR MSCP HCP
EC	Electro-conductivity
gpm	Gallons per Minute
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
lb	Pound
L	Liter
LCR	Lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	Meter
mm	Millimeter
m^3	Cubic Meters
MNSW	MacNeill's Sootywing Skipper
mS/cm	Milli-Siemens per Centimeter
NWR	National Wildlife Refuge
P	Probability (statistical)
Reclamation	Bureau of Reclamation
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

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 U.S. Fish and Wildlife Service's (USFWS) Havasu National Wildlife Refuge (NWR) (Figure 1) (U.S. Fish and Wildlife Service 1999a, 1999b). This project began prior to the finalization of the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) and much of the work has been completed. Recently adopted reporting procedures and templates for the LCR MSCP include a Restoration Development Plan, followed by annual reports. This document adheres as closely as possible to the format for a Restoration Development Plan, but deviates when necessary.

The work accomplished to date includes all stages of development, from site preparation to results of soil testing, planting, irrigation, and habitat and species monitoring. Information on site preparation, planting, and irrigation is included in the main body of this report. Monitoring to collect baseline data began prior to the development of LCR MSCP monitoring protocols for vegetation, birds, and small mammals by utilizing existing, widely accepted protocols such as avian point counts, area searches, and established southwestern willow flycatchers survey protocol. Results of vegetation and species monitoring prior to 2006 are presented in appendices A and B, followed by a Monitoring Plan, Appendix C. Starting in Fiscal Year 2007, information on planting and changes to management or monitoring will follow the LCR MSCP Restoration Development Plan format. A description of work conducted each year, results of monitoring, and adaptive management recommendations will adhere to the annual report format.

In 2001, Beal Lake was dredged to create a refugia for native fish on Havasu NWR (Figure 1). The dredge material was distributed over adjacent areas to be planted at a later date with native riparian vegetation.

Site preparation on the riparian habitat area began in 2002. In addition to using cuttings and container plants, this project provided an opportunity to explore seeding, with the idea that simple seeding methods might produce acceptable results. For additional background information on this project, a previous report covering activities from 2001 to 2003 (Phase 1 of the project) entitled, *Beal Lake Habitat Restoration, April 2005*, is available on the LCR MSCP Web site.

During the development of the project, procedures used for planting, irrigation, and soil testing were documented. Phase 1 of the project was planted from 2003 to 2005 and resulted in 59.5 ac (24.1 ha) of Fremont cottonwood (*Populus fremontii*), Goodding's and coyote willow (*Salix gooddingii*, *S. exigua*), and screwbean and honey mesquite (*Prosopis pubescens* and *P. glandulosa* var. *torreyana)* (Bureau of Reclamation 2005). Phase 2 was planted from 2004 to 2005 and established an additional 47.9 ac (19.4 ha) of cottonwood and willow. Phase 3, originally planned to include 100 ac (40.5 ha) of honey and screwbean mesquite (*Prosopis glandulosa* var. *torreyana* and *P. pubescens*), was scaled back considerably (Figures 2, 3, and 4).

The project included the use of container plants grown in nurseries, cuttings and/or poles, and seeds. Although some screwbean mesquite was planted, much of it established naturally along with arrowweed (*Pluchea sericea)* and saltcedar (*Tamarix* spp.). Areas with saline soils were

planted with shrubs known to be more salt tolerant, such as *Atriplex* spp. (Jackson et al. 1990), as well as shrubs and groundcovers that could potentially be used in other restoration sites to prevent saltcedar encroachment. Details on the planting in each field can be found in Table 1.

1.0 Introduction

The LCR MSCP was finalized with the signing of a Record of Decision on April 4, 2005 (Lower Colorado River Multi-species Conservation Program 2004). The overall goal of the LCR MSCP is to develop and implement a plan that will:

- conserve habitat and work toward the recovery of threatened and endangered species, as well as reduce the likelihood of additional species being listed
- accommodate present water diversions and power production and optimize opportunities for future water and power development, to the extent consistent with the law
- provide the basis for incidental take authorizations

The Bureau of Reclamation is the implementing agency for the LCR MSCP and is interested in quantifying conditions that result in successful habitat restoration to improve efficiency and effectiveness in future projects. Because the Beal project was immediately available to Reclamation when the LCR MSCP began, it was included as an area to demonstrate restoration and management techniques.

Purpose

The project area has been planted with riparian vegetation and is now being managed for LCR MSCP covered species. This document and appendices will describe details of the planting, intended management activities, and results of the first two years of monitoring. As part of the LCR MSCP, the project continues to be used as a demonstration area for various methods and techniques used in riparian restoration and may be used for habitat creation credit, depending on results of management over the next few years.

Location and Description

The project is adjacent to Beal Lake, on Havasu National Wildlife Refuge, near Needles, California, and is within the historic floodplain of the lower Colorado River. It is within Reach 3 of the LCR MSCP planning area, between and approximately 0.5 miles (0.15 m) east of river miles 238 and 239 on the Arizona side of the LCR (Figure 1).

Land Ownership

The project is on lands owned and managed by the U.S. Fish and Wildlife Service.

Water

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). Colorado River water is diverted into Topock Marsh through two instrumented inlet canals. Havasu NWR's combined second- and third-priority entitlements of 37,339 acre-feet (af) (46,057,283 $m^{3)}$ per year consumptive use and 41,839 af (51,607,988 $m^{3)}$ per year diversionary right are being utilized to irrigate habitat restored during the project. The water for irrigation of the project is supplied from Topock Marsh.

Agreements

The project represents an ongoing partnership between the U.S. Fish and Wildlife Service's Havasu NWR and Reclamation. A Memorandum of Understanding (MOU) is being developed, which recognizes the USFWS's and Reclamation's commitment to work together to achieve common goals. If the decision is made to request habitat creation credit, a Land Use Agreement (LUA) will be drafted to secure the land and water to maintain the riparian habitat for the duration of the program under the LCR MSCP. It will also outline the rights and responsibilities of each partner for the duration of the LCR MSCP.

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 whether acreage credit will be applied under the LCR MSCP.

Restoration Development Plan, Phase 1

Introduction

This section describes site preparation, planting, and irrigation in Phase 1, which was largely completed in 2004 (Reclamation 2005). Methods and results describe the planting process, including infrastructure installation, site preparation, soil testing, planting, and irrigation. Methods and results of post-development monitoring of vegetation and LCR MSCP covered species are described in Appendices A, B, and C.

Materials

Seeds

Cottonwood and willow seeds were collected from various locations along the LCR (Tables 1 and 2; Figures 1 and 5) using a variety of methods, depending on site conditions. Near roads where trees could be easily accessed, they were collected using a dry-vacuum system equipped with an extended piece of PVC pipe to reach high branches. The electric vacuum was connected to a small gas generator (Figure 6). Seeds were vacuumed into mesh or cotton laundry bags placed inside of the dry-vacuum bucket. If trees were some distance from a road, a long pruning pole was used to cut small seed-laden branches from the trees. Seeds and/or seed pods were then either stripped from the branches or small branches were left intact with seeds still on them. All seeds and branches were transported and stored (in cloth bags) out of direct sunlight and placed on racks to dry the seeds and prevent mold and mildew. Because cottonwood and willow seeds are reported to be viable for only 1-5 weeks after maturity, depending on conditions (Stromberg 1993), seeds were collected directly from the trees and not from ground litter.

No information could be found in the literature regarding the best developmental stage to collect seed from the trees. Therefore, germination and viability testing of cottonwood and willow seeds were conducted to determine the developmental stage in which to collect seed in order to obtain the highest germination rates. Photographs of most seed stages were taken to assist in collection of seed in the future. Testing was also performed on different aged seeds to confirm the effects of seed age on germination rates. Tetrazolium absorption testing (Leist and Kramer 2003) was performed on cottonwood seeds and direct germination testing (due to the small size of the seed) was performed on willow seed by the Arizona Department of Agriculture's State Agricultural Laboratory in Phoenix.

In addition to cottonwood and willow seed, a more salt-tolerant seed mix was purchased from Granite Seed, Lehi, Utah, and planted in fields N and A, and the southern edges of J and E (Table 3) where soil salinities exceeded 2-4 mS/cm, the recommended soil electro-conductivity levels for cottonwood and willow (Tables 4 and 5). *Baccharis* sp., collected from the Pratt Restoration Site, near Yuma, Arizona (Raulston 2003), and *Baccharis* sp. collected from the Bill Williams River National Wildlife Refuge were also planted in areas with higher salinities). Parts of Field N were planted with screwbean mesquite (Wildland Seeds, Tempe, Arizona) and inland saltgrass (*Distichlis spicata*) (Granite Seed, Lehi, Utah). These seeds were mixed together and dispersed using two ATVs, with the first dragging a chain harrow behind it to break up the soil surface and the second pulling an EarthWay EV-N-Spred commercial seed spreader.

Container Plants

Container plants for Phase 1 (*P. fremontii*, *Salix exigua*, and *S. gooddingii*) were ordered from the nursery at the Colorado River Indian Tribes' (CRIT) 'Ahakhav Tribal Preserve in November 2002. All were grown in gallon-sized containers from cuttings collected on CRIT lands near Parker, Arizona, in December 2002 and January 2003. The plants ranged in height from 1 to 3 feet when planted between 28 May – 6 June 2003 and 21 January – 3 February 2004
In November 2004, approximately 2,200 gallon-sized cottonwoods from Mountain States Nursery were planted in a part of Field M that exhibited a low success rate with seed.

Methods

Site Preparation and Infrastructure Installation

Planning and design of the project, as well as clearing of existing vegetation, began in 2002. Sparse saltcedar and arrowweed were removed and the site was root-plowed to a depth of 1.5 ft (0.45 m) to remove saltcedar roots. The 59-ac (24-ha) site was then laser leveled and divided by berms into 17 individual fields in order to irrigate each field separately (Figures 2, 3, 4, and 7). On 15 January 2003, 6,000 lb (2,722 kg) of barley seed purchased from Fertizona, Buckeye, Arizona, was drilled in as a temporary cover crop on all fields to stabilize and condition soils and prevent weed infestation. A temporary sprinkler system was used to irrigate the cover crop from 18 March 2003 until 19 May 2003.

The permanent irrigation system included a water-cooled, variable speed, diesel-driven pump with a maximum flow rate of 9,000 gpm (42 m^3/minute) and a total lift of 10 ft (3 m) (Figure 8). A 1000-gallon (3,785-L) above-ground, double-walled, concrete diesel fuel storage tank was placed adjacent to the pump. Water is pumped from a small constructed pond between Beal Ditch, which runs adjacent to the east side of the site, and Topock Marsh. Water is transported to each field via 4,000 ft (1,219 m) of 24-in (60-cm) diameter bell and spigot casketed PVC pipe

(Figure 8 and 9). Two separate butterfly valves were installed to control irrigation to the two portions of irrigated area. Within each field, the 24-in (60-cm) diameter main was reduced to 18-in (46-cm) diameter and connected to 18-in (46-cm) diameter alfalfa valves. A concrete apron was poured around each valve and heavy rock was deposited to reduce erosion (Figure 10).

Soil Testing

Soil testing was conducted in 1999 as part of a general soil survey of Refuge lands on the lower Colorado River (Figure 11). Prior to construction, analysis of aerial photos indicated distinct differences in vegetation types and densities within the proposed planting area. Soil sampling was conducted in these areas in 2002 to determine whether this visual difference translated to soils higher in salts. Prior to planting, one soil sample per field or approximately one sample per 3.5 ac (1.4 ha) was taken for analysis of salinity, soil texture, and depth to groundwater. Soil samples were also collected in September 2003 to compare soil data with differences in growing patterns seen in the cover crops in some fields. For these later samples, nutrients, texture, and salinity were analyzed. A t-test was performed on each soil sample to determine differences in salinity between areas that had poor cover crop growth and areas where cover crops appeared healthy.

Sample size refers to number of individual holes from which soil was collected. All soils were collected with soil augers measuring 6 in by 4 in (16 cm by 10 cm) at three depths: 0-1 ft (0-0.3 m), 1-3 ft (0.3 m-0.9 m), and 3-5 ft (0.9 m-1.5 m) per sample. Analysis was performed at Reclamation's Lower Colorado Regional Laboratory in Boulder City, Nevada, according to the protocol of the U.S. Department of Agriculture's 1996 methods manual (USDA 1996). Soil salinity was reported as a measure of electro-conductivity (EC) in milli-Siemens per centimeter (mS/cm); texture was reported in percentages of sand, silt, and clay per sample. Sand was defined as particles between 0.5-2 mm, silt was between 0.002-0.05 mm, and clay was less than 0.002 mm (Kilmer 1982, USDA 1996).

Irrigation

Individual fields were flood irrigated according to species requirements, method of planting, and time of year planted. Areas seeded with cottonwood and willow were irrigated daily between 20 March 2003 and 19 May 2003 with a temporary pump and sprinkler system. Once germination was observed (Figure 12) and seedlings were established, these fields were irrigated once per week throughout the first growing season. Container plants and pole cuttings were irrigated once immediately following planting and then as needed through the growing season. Container plants and poles planted between October and February, regardless of species, were watered once immediately after planting and then not again until early spring.

Planting

Dates and methods of planting, species planted, weight of seed per field, and other details are in Table 1. A barley cover crop was disked into the soil a few weeks prior to dispersing cottonwood and willow seed in fields F, G, H, Q, K, and M. Hydroseeding was one method used for seeding. This method involves spraying a mix of seed, water, mulch (Conwed Fibers, Inc. pure wood fiber mulch) tackifier for adhesion, water, and fertilizer (16% Nitrogen, 20% Phosphate, 13% Sulfur) onto the wet surface of each field (Figure 13). Field M, 1.1 ha, was used to determine the feasibility of hydroseeding as a method to grow cottonwood from seed. The field was divided into seven areas of approximately 0.4 ac (0.16 ha) each. All combinations of the ingredients in the hydroseed mix were combined with 2.4 lb (1.1 kg) of cottonwood seed and sprayed onto the

field on 20 March 2003, immediately after irrigating. At the end of the growing season, all cottonwoods in each of the seven areas were counted.

Additional seed dispersal methods included the placement of seed-laden branches directly into wet soil in fields F, K, and Q to allow for gradual wind dispersal of the seeds over the fields (Figure 14). Loose seed collected by stripping seed and pods from branches was also dispersed by hand onto either wet soil or the water surface following flood irrigation.

At the end of the first growing season, the seeded areas were evaluated subjectively to determine whether the intended species had become established. Vegetation mapping through general observation of the seeded areas delineated the composition within discrete patches of each vegetation type and was used in determining which areas to replant. Patches of vegetation with only sparse cottonwood and willow or none at all were cleared and re-seeded with willow in May and June, 2004 (Table 1). In Field N, an L-shaped area was re-seeded in February 2005 with screwbean mesquite and inland saltgrass. The seeds were mixed together and dispersed using two ATVs, with the first dragging a chain harrow behind it to break up the soil surface and the second pulling an EarthWay EV-N-Spred commercial seed spreader purchased from Forestry Suppliers, Inc.

Approximately 15,000 cottonwoods and willows in 1-gallon containers were planted in fields B, D, E, J, and I approximately 1.5 m apart (Figure 15). These fields are along the outer edges of the site and were planted as a barrier against windborne seeds to help reduce the establishment of saltcedar in the seeded, inner fields. All container plants were planted using a two-seated tree planter (Tree Equipment Design, Inc., New Ringgold, PA) pulled behind a tractor (Figure 16). Mesquites from 1-gallon containers were also planted in the southern half of Field A because they are more tolerant of higher soil salinities (Jackson et al. 1990). Because the remaining container plants were not available from the nursery by June, fields C, L, P, and O were planted with a cover crop. Regreen, a sterile wheat-wheatgrass hybrid purchased from Seed Solutions, Denver, Colorado, was planted at a rate of 50 lb/ac.

Results

Site Preparation and Irrigation Infrastructure

The fields were leveled following construction of berms around each field. Two main roads were graveled to provide access to valves. The pump and all pipes and valves were installed in 2003. The permanent irrigation system began operation on 19 May 2003, and the fields have been flood irrigated since then.

Soil Testing

Soil results from data collected in 1999 (Figure 11) from the project area show a similar pattern as those from data collected in 2002 for this project (Table 4). Samples taken from the outer fields on the north and south sides of the site have significantly higher salinities than those from the inner fields. With few exceptions, higher ECs were found in soils collected at the surface. Samples collected from fields A and N had the highest ECs. For both sampling dates combined, and at all depths, soil salinities averaged 3.09 mS/cm and ranged from 0.42 to 25.7 mS/cm. After the cover crop was planted, differences were clearly visible in the growth patterns within fields C, G, H, K. and O. In these fields, the cover crop was growing well in some areas and little to no other vegetation had become established. Other areas had either no cover crop or other

vegetation growing at all, or vegetation was sparse and was being overtaken over by volunteer arrowweed or saltcedar. Additional soil testing was performed (Table 5) on samples taken within areas with well-established cover crops and areas with poorly established or no cover crops present. A t-test assuming equal variances ($\alpha = 0.05$, $n = 12$) determined no significant differences in EC ($P = 0.85$), nitrates ($P = 0.24$), organophosphates ($P = 0.32$), or ammonia ($P = 0.85$). There were also no textural differences observed; 90% of the soil samples were classified as sand. Soil samples taken from 0.3-0.9 m had EC values between 0.58 and 2.58 mS/cm, with higher values for soils taken from the surface.

Irrigation

The amount of water pumped with the temporary system between 20 March 2003 and 19 May 2003 was not quantified. Installation of the permanent pump was complete and flood irrigation of the fields began on 19 May 2003. Although irrigation amounts were not recorded monthly until 16 March 2004, the total amount of water used between 19 May 2003 and 16 March 2004 was 18 af/ac. Further information on the quantity of water used each month between March 2004 and December 2005, as well as the frequency of irrigation, is in tables 6 and 7.

Planting

Field M was surveyed on 12 December 2003 to determine the number of cottonwoods established from the hydroseeding test (Table 8). A total of 551 cottonwoods were counted, with the remaining areas in Field M covered with arrowweed. The highest number of cottonwoods was found in the treatment area sprayed with seed, mulch, fertilizer, and tackifier, and density generally decreased with increasing distance from the irrigation valve.

Results of germination testing with different aged seeds and developmental stages are shown in Table 9 and Figure 17. Differences between cottonwood and willow germination at the same stage of development (i.e., seed from pods collected unopened from trees or opened after collection) were evident: 58-78% of cottonwood seeds germinated at this stage versus 18-21% of willow seed. Cottonwood seed had the highest probability (98%) of germinating if collected just after pods began opening on the tree, and remained high (87%) even when pods were very brown and dry when collected from the tree. For willow, catkins that appeared yellowish in color, and had not opened on the tree, but opened after collection, had the highest germination rate (87%). Two stages of development were not tested for willow seed: seed collected from completely open pods with white fluff abundant, and seed that was dry and brown when collected.

Based on observations at the end of the growing season in 2003, none of the seeded fields developed into 100% cottonwood and willow. Cottonwood or willow established in approximately 38% of the 6.4 ha that were seeded using the various methods described. Results included mixtures of arrowweed and saltcedar, as well as other volunteer shrub and groundcover species. Vegetation maps, based on dominant vegetation types, were used to determine seeded areas requiring re-planting. Fields F, G, H, M, and Q contained patches of cottonwood and/or willow, which were left intact. Approximately half of fields H, Q, and M were cleared following the first growing season due to unsatisfactory qualitative results. Fields F and G had small, narrow bands of cottonwood and willow that were retained and all of Field K was replanted. Within fields A and N, hydroseeded native salt-tolerant shrubs (Table 3) and volunteer screwbean mesquites were interspersed with saltcedar and arrowweed. These two fields were left intact to determine which vegetation would eventually dominate.

Container plants approximately 12 ft (3.8 m) in height were observed during the first growing season, and growth was very uniform within species. During the second growing season, vegetative reproduction of coyote willow was observed within fields J, E, and I, and limited seed production was observed on some Goodding's willow, but not on cottonwoods. Monitoring results on survival, growth, density, and condition of these plants are reported in Appendix A.

Restoration Development, Phase 2

Introduction

This section describes restoration activities conducted between December 2003 and January 2005 in Phase 2. Areas in phases 1 and 2 were often re-planted when the first seeding or planting methods were not satisfactory. Because of this, some work included re-planting areas in Phase 1 at the same time as planting was occurring in Phase 2 (Table 1).

Phase 2 included several different demonstrations of restoration techniques. Some of the fields in Phase 2 are being planted using "natural" seed dispersal by creating proper conditions for germination using flood irrigation. These areas have been planted with a perimeter of cottonwood and willows, with a cover crop planted in the center. Once the perimeter trees mature and begin seeding (3-5 years), the cover crop will be removed and the center flood irrigated while the trees are dispersing seed.

Alternative containers other than the gallon-size typically used for growing cuttings in nurseries were used in Phase 2. These are small tubes (slips) that are considerably easier and faster to handle and transport, decreasing overall labor costs.

A nursery is being developed in Phase 2 to provide cuttings and seed for other restoration projects. These trees are from cuttings collected at several locations between Yuma, Arizona, and Needles, California, and from trees established from seed collected on the LCR. The purpose of this is to provide a genetically diverse nursery stock for use on the LCR.

Materials

Seeds, Poles and Container Plants

A mix (209 lb, 95 kg total weight) of *Atriplex polycarpa* (33%), *A. canescens* (33%), and *A. lentiformis* (33%) for moist areas, and a mix (5.0 kg total weight) for more xeric conditions of brittlebush (*Encelia farinose*) (50%) and globe mallow (*Sphaeralcea ambigua*) were purchased from Wild Seed, Inc., Tucson, Arizona.

Gallon-sized container plants of cottonwood, willow, and mesquites were ordered from Mountain States Nursery in December 2003. Cottonwood and willow trees were ordered from Bluejack Nursery, Brawley, California, in December 2004. Half of the trees of each species were grown in gallon-sized (3.8-L) pots and half were grown in 6 in by 2 in (15.4 cm by 5 cm) tubes (Figure 18) for ease of handling. Goodding's willow and Fremont cottonwood cuttings for these container plants were collected between December 2004 and May 2005 from Havasu, Cibola, and Imperial NWRs. All *S.* ex*igua* cuttings were taken from Havasu NWR.

In January 2005, a total of 3,169 poles comprising cottonwood and willow (numbers by species unknown) were cut from Havasu NWR's tree nursery. The poles were 3-5 feet (1-1.2 m) long and 1-4 in (3-10 cm) in diameter. Prior to planting, they were soaked in barrels of water for up to a week.

Methods

Site Preparation and Infrastructure Installation

Beginning in December 2003, all existing vegetation in Phase 2, mainly dense arrowweed and sparse saltcedar, was cleared and the site was raked to a depth of 0.45 m to remove saltcedar roots. In January 2004, the berms and access roads were built and in February 2004, irrigation lines were extended from Phase 1 into Phase 2. One alfalfa valve per field was installed, identical to those described for Phase 1.

Soil Testing

Soil samples were collected from two sampling sites and from three depths per sample: surface, 1-3 ft (0.3-1 m), and 3-5 ft (1-1.5 m) in each field in Phase 2. Following the same methods used in Phase 1, moisture content, salinity, nutrients, and textural classification were determined for each sample at Reclamation's Lower Colorado Regional Laboratory.

Irrigation

Irrigation for Phase 2 followed the same general schedule as that described for Phase 1 (Tables 6 and 7). Container plants and pole cuttings were irrigated once immediately following planting and then as needed through the growing season. Container plants and poles planted between October and February, regardless of species, were watered once immediately after planting and then not again until early spring. Once established, mesquites were irrigated less than cottonwood and willows.

Planting

A summary of the planting methods in each of the Phase 2 fields (Fields AA-MM) is in Table 1. By September 2004, patches of Regreen within fields along the south side (BB, DD, II, and MM) were not growing vigorously enough to keep non-native saltcedar and tumbleweed from becoming established. In November 2004, these areas were disked and planted with 1,563 screwbean mesquites from container plants.

Also in November 2004, 1,985 cottonwoods were planted in the northern half of Field AA and 1,015 were planted in an unsuccessfully seeded portion of Field M from Phase 1 (Table X). In January 2005, a total of 3,169, 2-3 ft (0.6-0.9 m) long poles, both cottonwood and willow, were planted approximately 5 feet (1.5 m) apart in 4-5 rows around the perimeters of Fields AA (southern half only), CC, HH, and LL. The last of the poles were planted in one row around the perimeter of Field GG. In February 2005, the brittlebush-globe mallow seed mix was distributed on the drier, sloped perimeters of fields BB, DD, and II at approximately 11 lbs/ac (12 kg/ha). The *Atriplex* spp. seed mix was spread around the previously planted mesquites at approximately 26 lbs/ac (29 kg/ha) except in Field MM, where it was distributed at approximately 8 lb/ac (9 kg/ha). Seed was planted using a chain harrow pulled behind an ATV to break up the soils, followed by a second ATV equipped with a seed spreader (EarthWay EV-N-SPRED Model 2050P Spreader).

In December of 2005, several rows of coyote willow and Fremont cottonwood (1,464 trees total) were added to the perimeter of Field LL using container plants from Bluejack Nursery, Brawley, California. In addition, Field GG was planted with approximately one-third coyote willow, one-third Goodding's willow, and one-third Fremont cottonwood (3,895 total trees), and Field KK was planted with 1,402 Fremont cottonwood. Only the southern half of Field JJ (1,152 total trees) was planted with trees due to high soil salinity in the northern half. The area closest to the irrigation valve was planted with *S. exigua* and the remaining with *S. gooddingii*.

Barley, a more salt-tolerant crop, was planted on the northern, more saline half of Field JJ and in the areas of fields BB, DD, II, and MM as an alternative to the Regreen. Wheat, which is less salt-tolerant, was planted in the centers of the less saline fields AA (southern half only) CC, HH, and LL (Rawson et al. 1988).

Results

Site Preparation and Infrastructure Installation

Testing of the pump and pipes was completed in May 2004. To prepare the soils for riparian vegetation, a cover crop of 2,500 lbs (1,134 kg) of Regreen was planted (by drilling) on 47.7 ac (19.3 ha) of Phase 2 (50 lb/ac or 58.8 kg/ha).

Soil Testing

Soil testing results are in Table 10 and the location of each sampling site is depicted in Figure 11. Salinity levels were similar to results from Phase 1: samples from fields on the northern and southern edges of the planting area had average soil salinities of 33 mS/cm and ranged from 1.59 to 99.1 mS/cm. Samples from the inner fields were well within recommended soil salinities for cottonwood and willow (Jackson et al. 1990, Briggs 1996). Salinities ranged from a low of 0.36 mS/cm in fields KK and LL to a high of 95.2 mS/cm in Field EE.

Irrigation

Tables 6 and 7 include the amount of water used to irrigate phases 1 and 2 as well as irrigation frequencies. Data on irrigation by month began in February 2004. The total amount of water diverted to the 107.3 ac (43 ha) project was 14.3 af/ac in 2004 and 13.1 af/ac in 2005.

Planting

Preliminary observations following planting indicated that saltgrass planted by seed had germinated and was spreading in Field N. Globe mallow and brittlebush seed planted on the slopes of fields MM, II, DD, and BB had also germinated. Observations of the container plants and poles indicated the majority survived the first few months after planting. Quantitative vegetation monitoring results including growth and condition of container plants and poles are reported in Appendix A.

Restoration Development, Phase 3

Introduction

Phase 3 of the project was originally planned as a multiple cell project with an extensive irrigation system. Revegetation with mainly mesquite was planned, with cottonwood, willow, and marsh in appropriate areas. Due to excessive costs of irrigation infrastructure and engineering as well as changing priorities with implementation of the LCR MSCP, this plan was not fully implemented. The area was, however, cleared of most non-native vegetation and arrowweed. Leaving the site cleared without replanting would result in re-establishment of saltcedar and arrowweed. Therefore an alternative, less extensive restoration plan was adopted.

Mesquite pods are a valuable food resource for many mammals and birds on the LCR (Rosenberg et al. 1991, pers. obs.). Coyote scat is composed largely of mesquite seeds from approximately August into fall on the LCR (pers. obs.). The seeds have a hard seed coat that requires scarifying in order to germinate, which can be accomplished by ingestion and excretion by animals. Although honey mesquite is present on Havasu NWR elsewhere and a few trees of this species have come in as volunteers in phases 1 and 2, screwbean mesquites dominate within the project area. Utilizing intact honey mesquite pods to re-vegetate Phase 3 is being investigated.

Materials

Approximately 250 lbs of honey mesquite seed pods were collected on the Colorado River Indian Tribes' Ahakhav Tribal Preserve in Parker, Arizona, between 18 and 29 July 2005.

Methods

Clearing of all vegetation (arrowweed, Bermudagrass, saltgrass, tumbleweed, saltcedar) except screwbean mesquite occurred during two periods, December 2003 and January/February 2005. No honey mesquite was documented within the area. After clearing, areas containing screwbean mesquites were documented with a Global Positioning System. On 29 July, four piles of intact honey mesquite seed pods weighing 44.4, 38.3, 90.3, and 74.6 lbs (20, 17, 41, and 34 kg) each were spread on the ground at four separate locations in Phase 3 in order to make them available for foraging wildlife.

Results

By 17 August 2005, most of the mesquite pods were no longer present where they were initially placed. Phase 3 will be monitored to determine whether honey mesquites seedlings are present.

Discussion Phases 1, 2, and 3

The purpose of this project was to examine as many factors as possible that are involved in restoration of riparian habitat. This included testing of irrigation and planting techniques as well as various planting materials. Random sampling to designate monitoring plots and transects did not result in a representative sample of the vegetation. Because of this, the project inadvertently

became a testing ground for monitoring methods as well. A stratified sampling method based on Anderson and Ohmart's (1984a) vegetation classification and structural types as described in the LCR MSCP Habitat Conservation Plan (LCR MSCP 2004) will be implemented in the future at Beal and elsewhere, when necessary. This will ensure that all land covers and structural types resulting from restoration will be documented and monitored (Tables 11 and 12).

The different planting methods, plant materials, and plant species used for this project resulted in high variation within and between fields. Patches of arrowweed and saltcedar, homogenous patches of cottonwood and/or willow, as well as mixed stands of cottonwood, willow, mesquite, saltcedar, arrowweed, *Atriplex* spp., and *Baccharis* spp. have produced a mosaic of land covers and structural types (Figures 19 and 20). Figure 21 shows vegetation and structural types that may result over time as the site is adaptively managed for SWFL and yellow-billed cuckoos (*Coccyzus americanus*).

Under the LCR MSCP, nurseries are being developed that will include trees from many locations on the LCR and if possible, trees planted from seed. These nurseries will be the source for cuttings and seeds used in future restoration projects on the LCR in order to maintain as much genetic diversity as possible. Many of the trees present on LCR NWRs are from the Bill Williams River NWR, including the original nursery at Havasu NWR. This is because prior to the LCR MSCP, source trees for collection were difficult to find elsewhere. Other trees have been purchased from the same nursery for many years, with the source reported to be the lower Gila River. In order to take advantage of possible genetic diversity within the LCR population, the 2004 contract for growing trees for the project specified plants would be collected from a variety of locations on the LCR. These trees were then used to develop a nursery on the project site.

Regreen was chosen as a cover crop because it can germinate and grow in hot temperatures, is sterile, drought tolerant, and forms a dense root structure to stabilize soils. Planting and maintaining a cover crop for one growing season prior to the native vegetation helps to decrease the possibility of planting when conditions for natives may not be ideal. The site may not be ready for planting when the pre-determined delivery date for the trees arrives. The trees may not be ready due to uncontrollable circumstances such as cool spring weather at the nursery location, requiring a later delivery. Overall, it is more likely the restoration project will be a success if those involved do not experience the pressure to plant that often occurs at the end of spring when various delays have pushed planting into the hot months of summer on the LCR.

Based on observations at Beal, establishing a cover crop prior to restoration has many advantages:

- Soils are held in place and weeds are controlled.
- Irrigation problems can be identified and repaired.
- The movement of water across the area can be observed prior to the trees being planted, avoiding patches that may not receive water due to elevation or textural differences in soils.
- Growth patterns of the cover crop can indicate problem areas and can help determine how and what to plant.

- Tilling in the cover crop adds organic matter and mulch to the soils, which helps reduce irrigation demands and conditions soils.
- Problems associated with delays in a project can be minimized significantly if a cover crop is in place, stabilizing the site and decreasing weed problems.

When planting gallon-sized container plants, much of the time and labor is spent unloading trees from the delivery truck, transporting them to the planting site, and loading them onto a tree planter. In order to decrease this handling time, half of the trees were grown in 6-inch tubes. Trays containing 98 tubes each can be handled easily by one person, decreasing the unloading, loading, and transporting considerably.

Cottonwood and willow container plants from commercial nurseries ordered by December can be ready for planting the following spring because they are grown from cuttings. Mesquites are started from seed and require one full growing season in the nursery prior to planting. If cut and placed into containers in December or January, the earliest that cottonwood and willow can be ready for planting is April, but if growing conditions are not favorable (i.e., cool spring temperatures, low light conditions) it can be later in the spring or early summer before the trees are ready to plant. If the trees are not ready for planting or if the site is not ready by 1 May, it is better to hold the trees over until the following year (late fall or early winter) due to the extremely high temperatures on the LCR from May to August. Even if the specific planting day is cooler, placing newly transplanted roots into soils that can reach well over 110°F (43°C) at the surface should be avoided. Tree purchasing contracts should be written to allow for this possibility.

Cottonwood and willow seeding is timed to coincide with flood events, which leave behind newly cleared, saturated, alluvial soil banks. Stromberg 1993, Shafroth et al. 1998, and Shafroth et al. 2002 consider this the ideal substrate for germination. On the Bill Williams River (BWR), seasonal floods resulted from heavy rainfall in late winter/early spring, whereas pre-dam flood events occurred on the LCR in the late spring and early summer from snow melt in the Rocky Mountains . Two different seeding periods associated with these seasonal flood regimes have been observed. Seeding times are also associated with latitude; the trees near Yuma, Arizona begin dispersing seeds earlier than those at Havasu NWR (pers. obs.; Table 2). Seed collection of cottonwood and Goodding's willow is therefore possible at different locations from March through July along the LCR and its tributaries (Figures 1 and 11; Tables 1 and 2). Patches of the earlier seeding trees from the BWR can be found along the LCR where cuttings or poles from the BWR have been used in restoration projects.

Along with phenology, information on seed development stages is reported in Figure 17 and Table 9. Based on the information from germination tests, the optimal period to collect seeds from Fremont cottonwood or Goodding's willow is, in general, just after catkins on the tree begin opening. In Goodding's willows, this occurred after some catkins on the tree had begun turning slightly yellow (88% germination). In cottonwoods there was no observable color change in pods. Once some pods opened on a tree, viability of all seeds collected from that tree was high (98%), even those from pods that had not opened yet. Data on *S. exigua* was not collected.

Storage conditions and incomplete drying of seeds prior to dispersal may be factors that affect germination and/or establishment of seedlings. Also, during flood irrigation, we observed seeds

being washed to the end of the field furthest from the valve, creating areas with low densities of seedlings. Keeping high numbers of seeds in place and evenly distributed until germination should lead to high densities of seedlings and less infestation of weeds. Flood irrigation may also contribute to improper drying prior to germination. The tackifier in the hydroseed mix helped somewhat to keep seeds from washing away during irrigation. Sticking cut branches into the soil and allowing seeds to remain on the branch until they dry and disperse naturally may result in a more even dispersal and a higher survival rate. Due to the difficulty in keeping cottonwood and willow seed from blowing away from the dispersal site, seeding methods often overlapped. Controlled experimentation (including controlled storage conditions), both in the laboratory and on site along the LCR is needed to determine the effect of these variables on seeding success.

Monitoring seedlings in the field is problematic; seedlings first appear as miniscule cotyledons that are very difficult to detect on the ground, while their roots can be an inch or more long (Moss 1938, Raulston pers. obs.). The ability to see newly germinated seeds was so limited that walking through fields had the potential to affect results. Once germination was confirmed through observation, monitoring was delayed until seedlings were more visible, generally 6-10 weeks after planting. High germination rates in the laboratory and an abundance of seed dispersed on site did not result in equally high cottonwood and willow sapling establishment. Patchy germination and growth allowed weeds to become established, whereas the larger container plants spaced 5-8 ft (1.3-2.4 m) apart shaded out most competition. However, the increased genetic variability and possible savings in time and labor are advantages to seeding that will continue to be explored.

Cottonwood and willow seeds are short-lived; if no results are seen within one week, replanting or changing techniques is warranted. Re-planting should be done prior to any undesirable vegetation becoming established in order to avoid the added expense of re-clearing the site. Seeds of other plants used in restoration as groundcover or to establish a shrub layer vary in the length of time seeds remain viable. Because of this delay in germination, determining the success of seeding some species may not be possible for the first few years after planting.

Soil testing for salinity should be approached in a progressive manner, beginning with field observations of vegetation and presence of salt on soil surfaces, followed by preliminary surveys of a few samples. If samples show high salinity levels and/or variability in salinity, further samples may be warranted. Briggs (1996) discusses soil sampling strategy in detail. Textures are also important and should be tested following the same approach as with salinity. Heavier clays can retain salts despite repeated irrigations, while sandy soils can be flushed (pers. obs.) A combination of sandy soils and moderate to low salinities at this restoration site were used to indicate where cottonwood and willows would likely succeed, whereas areas with heavier soils and/or high salinity were planted with mesquites or shrubs.

Testing soils for nutrients can be an added expense that may not be necessary. It was performed during this project when the cover crop in some fields began to show stress. Asplund and Gooch (1988) and personal communications with experts in the field (Pat Shafroth, USGS, Ft. Collins, CO) indicate that nutrients may not be a significant factor in natural establishment of cottonwood and willow from seed. Asplund and Gooch (1988) use the term “inorganic surface” to describe the alluvium where these species germinate. However, Marler et al. (2001) report a clear benefit to cottonwood and willow from elevated nutrient levels provided by treated effluent. It is

possible that these species will establish naturally with low nutrient levels, but may also benefit if nutrients are provided.

Soils at the project site were extremely sandy, which increased irrigation water demands and resulted in higher irrigation costs. Maintenance costs include fuel for the pump, which must operate longer due to the sandy soils, as well as the labor involved in operating the pump and managing irrigation valves.

In order to move irrigation water over the field as quickly as possible, laser leveling the fields after rather than prior to infrastructure installation is recommended. An inch or two rise in elevation or the accidental placement of a berm during construction can interrupt irrigation. Laser leveling will improve water movement, but winds can still move sandy soils around enough to disrupt the flow of water across a field; therefore, close monitoring of the irrigation during the first few weeks is recommended, especially if planting seeds.

When planting cottonwood and willow seed, soil moisture and seedling condition should be monitored. Weather during these months can be unpredictable and temperatures can change drastically throughout the day, sometimes bringing rain and cooler temperatures. As summer approaches, air and soil surface temperatures, as well as high winds, increase irrigation frequency requirements. If the soil surface is to be kept wet for seeding, these factors have to be closely monitored until germination and establishment of seedlings.

The sprinkler irrigation system was adequate for the cover crop of barley and Regreen, but may not have kept the soil surface wet enough for germination of cottonwood and willow seed. This irrigation method was also labor intensive, and had to be continually monitored for problems. Because pipes were placed over the berms that separated fields, as well as within the fields, the irrigation lines were continually coming apart and causing erosion. In addition, sprinkler heads often became clogged and/or malfunctioned. Once the permanent irrigation was in place, flood irrigation was relatively free from maintenance problems. This system, however, remains a time consuming activity because of the amount of time it takes water to move across the extremely sandy fields. We anticipate that the accumulation of organic mulch in the soil, namely leaves from deciduous cottonwood and willows, will increase over time. This, combined with an increase in shade as the trees grow, will increase the water holding capacity, stability, and nutrients of the soils (Brookbank 1997, Am. Hort. Soc 2000).

Exploration of irrigation methods that keep the soil surface wet without disturbing seed is ongoing. Irrigating with furrows, for example, has been used at other restoration sites (Raulston 2003) and in local farming operations, but would be difficult to maintain in sandy soils. Furrowing allows water within the furrows to saturate the berm between them, creating moist soil on the upper surface and sides of the berm without the disturbance standard flood irrigation causes. If the site is planted with a cover crop that is then tilled into the soil after a few seasons, furrows may maintain their shape long enough for plants to become established. This irrigation method needs further investigation for use in restoration.

A long-term goal of Reclamation’s restoration program is to decrease the re-establishment of saltcedar through preventive measures during site preparation and planting rather than through constant, expensive, and often unsuccessful maintenance. Most of the saltcedar that came in at

Beal after the initial clearing was evenly distributed and of the same size, which indicates it was from seed rather than re-sprouting. These small saltcedars were disked and the areas were replanted with cottonwood and willow from either seed or container plants. Container plants can successfully shade out these competitors (Figure 22), but it remains to be determined whether cottonwood and willow established from seed will out-compete the saltcedar. When clearing larger, established saltcedar, deep root removal to at least 18 in (0.46 m) is essential to remove saltcedar root balls below the surface (Taylor and McDaniel 1998, Taylor 1999). Re-sprouts from existing roots grow fast and can quickly shade out native container plants or seedlings.

Demonstrations are underway in Phase 2 to reduce saltcedar establishment by planting an outer perimeter of closely planted gallon-size (3.8-L) container plants or pole cuttings that serve to block wind-borne weed seeds from reaching the interior of the field. The interior will be protected with a cover crop until trees in the perimeter have matured (Figure 23). The interior of the field will be disked and flooded, then seeded by natural seed dispersal from the trees in the perimeter.

Although many projects have been undertaken on the LCR over the years, each restoration project on the LCR presents different challenges. Considerable variation in such factors as soil irrigation methods, water availability, and groundwater depths will be encountered over the 50-year period of the LCR MSCP. It is unlikely that any restoration site on the LCR will remain saltcedar-free and maintenance-free indefinitely, but steps can be taken to reduce associated costs and labor. Because conditions throughout the LCR can differ so much, the goal of each project should be well defined and discussed so that all partners are aware of the possibilities and limitations of each project.

Management Overview

Introduction

The project's location, soil type, and proximity to nearby habitat occupied by nesting southwestern willow flycatchers (SWFL) (Koronkiewicz et al. 2006) make it an ideal site to monitor and document restoration and habitat management techniques that may lead to the creation of SWFL and YBCU habitat, as well as habitat for other covered species. Conservation measures expected to benefit from the project include WILF1, WRBA2, WYBA3, CRCR2, YHCR2, LEBI1, YBCU1, ELOW1, GIFL1, GIWO1, VEFL1, BEVI1, YWAR1, SUTA1, and MNSW1.

The following section of this report will describe the methods proposed to manage and maintain cottonwood and willow structural types I-IV (CW Types I-IV) (Tables 11 and 12). Portions of the project will be monitored to correlate irrigation practices with the presence of moist soil or standing water conditions within designated SWFL Management Areas (Figure 24). The remaining areas will be managed for yellow-billed cuckoo, elf owl (*Micrathene whitneyi*), gilded flicker (*Colaptes chrysoides*), and other LCR MSCP covered species that use these habitat types. Many of these species have been documented nesting on Havasu NWR and/or the Bill Williams River NWR.

Land Manager

The U.S. Fish and Wildlife Service is responsible for overall management within Havasu NWR. If the site is selected to be managed throughout the duration of the program, the details of operations and maintenance of the project will be agreed upon between Reclamation and the USFWS under a Land and Water Use Agreement. Through FY09, the USFWS and Reclamation have entered into an Interagency Agreement in order for Reclamation to fund a full-time position at Havasu NWR. The duties of this position will include irrigation and maintenance of the project, as well as involvement in other Reclamation activities on the refuge. Reclamation will continue to monitor all aspects of the project, including the monitoring of covered species and their habitats, soil, water, and vegetation. Based on monitoring over the next three years, Reclamation will determine whether the project warrants inclusion as created habitat. If so, Reclamation will be responsible for ensuring the long-term operation and maintenance of the project throughout the 50-year term of the LCR MSCP.

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 roads are graveled and are located along the same corridors as the main irrigation lines (Figure 7). Other berms that were previously used as roads, but are not graveled, will be left undisturbed to gradually fill in with volunteer vegetation (Figures 2, 3, and 4). There are no roads in Phase 3.

Soil Management

Soil management will be implemented in conjunction with water management, with both aimed primarily at establishing SWFL habitat. Soils are composed mainly of sand, making it difficult to retain moisture. In order to create the proper microclimate, areas within dense habitat will be supplemented with plastic pools, which will act as a series of small lined ponds that should maintain moisture at the surface of the soil.

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. Because of the extremely sandy texture of the soils present, providing moist soil and/or standing water component within the habitat is difficult. Water moves over the fields very slowly and moisture is not retained at the surface for very long after irrigation. Over time, organic debris will build up in the soils and the tree canopy will increase, providing shade. Both of these factors may increase the retention of soil moisture throughout the project.

To provide the components necessary for SWFL habitat, two 6-ha blocks of habitat will be irrigated more frequently than the surrounding fields. In this way, a mosaic of vegetation including arrowweed, mesquite, cottonwood, and willow will be created. At the center of the site, in fields L and P, *S. exigua* planted around the irrigation valves has spread to form a dense patch of CW III and IV, with leakage from the valve providing ephemeral moist soil conditions. Directly adjacent to this, Field K has been repeatedly seeded with cottonwood and willow, but except for four trees that are now over 6.0 m tall, seeding was not successful there. To expand

the occasional moist patches in fields P and L to a larger area, a series of 30 plastic wading pools have been buried in Field K with the top of each pool just below the surface of the soil. During irrigation, the pools fill with water, sand, and organic debris and should remain wet longer than the surrounding sand.

The remaining project area will be irrigated to the extent necessary to keep the trees healthy and to prevent salts from building up in the soils. Monitoring of soil salinity, survival, condition of trees, and other habitat variables will be used to determine whether this irrigation schedule and management is appropriate. Details of monitoring can be found in the Beal Riparian and Marsh Monitoring Plan (Reclamation 2006a).

Vegetation Management

The overall management objective for the project is to create a dense mosaic of largely native vegetation with a diversity of structural types and the presence of moist soils. With planting mostly completed, vegetation management and irrigation practices together will be used to mimic flood-prone riparian habitat. Management of the project is intended to create the habitat targets depicted in Figure 21.

Vegetation planted is similar in composition to habitat found at sites occupied by LCR MSCP covered species elsewhere (Halterman 2006, SWCA 2006, Rosenberg et al. 1991, LCR MSCP 2004). With the highest water requirement, *S. exigua* was planted closest to irrigation valves in most fields and will continue to spread where conditions are favorable (high soil moisture and maximum sunlight). *Salix gooddingii* is planted next, further from the valve, and *P. fremontii* is planted at the greatest distance from the valve.

In December 2005, *S. exigua* from container plants were planted immediately around the pools (Figures 25 and 26) followed by *S. gooddingii* and *P. fremontii*. Fields K, H, L, P, and Q total approximately 6 ha and are designated as SWFL Area 1. In January and December 2005, the perimeters of fields AA, CC, HH, and LL were planted with cottonwood and willow poles and container plants, and a cover crop of wheat was planted in the centers of the fields (Figure 23).

In three to five years, when these trees begin to seed in abundance, the cover crop can be plowed in and the fields flooded to create conditions for natural seed germination. If successful, these fields would provide a new cohort of cottonwood and willow.

Within five years of the last planting (December 2005), SWFL Area 1 may require some minimal cutting, thinning, or pruning to ensure the continued presence of CW types III and IV. Without vegetation management, or any type of natural disturbance, the trees will mature into CW Type I and/or II. If no SWFLs have been detected in SWFL Area 1, the vegetation may be cut back more severely to “re-set” the habitat there to CW types V and VI (and eventually CW III and IV). If SWFLs are utilizing SWFL Area 1, management would include only irrigation, to the extent necessary to maintain the proper microclimate within the area. The structure of the vegetation in SWFL areas 1 and 2 may either be managed on a rotational basis, or, if SWFLs are utilizing both areas, by selective, patchy cutting during the non-breeding season to maintain the presence of CW III and IV.

Adjacent to the areas designated for SWFL management is approximately 16 ha of cottonwood and willow established from container plants and seeds. Over the next 5-10 years this habitat will continue to mature into CW types I and II and provide habitat for YBCU, SUTA, and other species. Except for irrigation to maintain the health of the vegetation, active maintenance will not be necessary in these areas unless there is a fire, disease severely damages the trees, or saltcedar begins to dominate the area. In these cases, the area will be re-planted. Increased irrigation to areas comprising earlier successional stages of vegetation adjacent to this mature habitat will provide a mosaic of vegetation types.

Reports

Annual reports will include results of monitoring and management activities. Subsequent reports may also include additional Restoration Development Plans that describe adaptive management activities resulting from monitoring results.

Literature Cited

AMERICAN HORTICULTURE SOCIETY. 2000. Gardening Manual. Kindersly Publishing Co. 420 pp.

ANDERSON, B.W. AND R.D. OHMART. 1976. Vegetation type maps of the lower Colorado River from Davis Dam to the southerly international boundary. Final Report to Bureau of Reclamation, Lower Colorado Regional Office, Boulder City, Nevada.

ANDERSON, B.W. AND R.D. OHMART. 1982. Re-vegetation for wildlife enhancement along the lower Colorado River. Report to Bureau of Reclamation, Lower Colorado Regional Office, Boulder City, Nevada.

ANDERSON, B.W. AND R.D. OHMART. 1984a. Lower Colorado River riparian methods of quantifying vegetation communities to prepare type maps—final report. Bureau of Reclamation, Lower Colorado Regional Office, Boulder City, Nevada.

ANDERSON, B.W. AND R.D. OHMART. 1984b. Vegetation management study for the enhancement of wildlife along the lower Colorado River. Submitted to Bureau of Reclamation, Lower Colorado Regional Office, Boulder City, Nevada.

ASPLUND, K.K. AND M.T. GOOCH. 1988. Geomorphology and distributional ecology of Fremont cottonwood (*Populus fremontii*) in a desert riparian canyon. Desert Plants:17-27.

BRIGGS, M.K. 1992. An evaluation of riparian re-vegetation efforts in Arizona. Thesis submitted to the School of Renewable Natural Resources, University of Arizona, Tucson, Arizona.

BRIGGS, M.K. 1996. Riparian ecosystem recovery in arid lands: strategies and references. University of Arizona Press. Tucson, Arizona. 160 pp.

BRIGGS, M.K. AND S. CORNELIUS. 1997. Opportunities for ecological improvements along the lower Colorado River and Delta, final report. Prepared for Defenders of Wildlife, Washington, D.C. and National Park Service, U.S.-Mexico Affairs Office, Las Cruces, New Mexico by The Sonoran Institute, Tucson, Arizona.

BROOKBANK, G. 1997. Desert Gardening. Fisher Publishing. 282 pp.

BUREAU OF RECLAMATION. 1992. Vegetation management study, lower Colorado River, Phase 1. Lower Colorado Regional Office, Boulder City, Nevada.

BUREAU OF RECLAMATION. 1998. Soil survey report, lower Colorado River re-vegetation program, Cibola, Havasu, and Imperial National Wildlife Refuges. Denver Technical Service Center, Denver, Colorado.

BUREAU OF RECLAMATION. 1999. Long-term restoration program for the historical southwestern willow flycatcher (*Empidonax traillii extimus*) habitat along the lower Colorado River. Lower Colorado Regional Office, Boulder City, Nevada.

BUREAU OF RECLAMATION. 2004. Lower Colorado River Multi-Species Conservation Program. Vol. I-IV. December 17, 2004. Bureau of Reclamation, Lower Colorado Regional Office, Boulder City, Nevada.

BUREAU OF RECLAMATION. 2005. Beal Lake Habitat Restoration, April 2005. Lower Colorado Regional Office, Boulder City, Nevada.

BUSCH, D.E. 1992. Analyses of the structure and function of lower Colorado River riparian plant communities. Dissertation submitted to the Department of Biological Sciences. University of Nevada, Las Vegas, Nevada.

BUSCH, D.E. AND S.D. SMITH. 1995. Mechanisms associated with decline of woody species in riparian ecosystems of the southwestern U.S. Ecological Monographs 65:347-370.

ELZINGA, C.L., D.W SALZER, J.W. WILLOUGHBY, AND J.P. GIBBS. 2001. Monitoring plant and animal populations. Malden, MA: Blackwell Science, Inc. 360 pp.

FENNER, P., W.W. BRADY, AND D.R. PATTON. 1984. Observations on seedlings of Fremont cottonwood. Desert Plants 6:55-58.

FRIEDMAN, J.M., M.L. SCOTT, AND W.M. LEWIS, JR. 1995. Restoration of riparian forest using irrigation, artificial disturbance and natural seedfall. Environmental Management 19:547-557.

GLENN, E., R. TANNER, S. MENDEZ, T. KEHRET, D. MOORE, J. GARCIA, AND C. VALDES. 1998. Growth rates, salt tolerance, and water use characteristics of native and invasive riparian plants from the delta of the Colorado River, Mexico. Journal of Arid Environments 40:281-294.

JACKSON, J., J.T. BALL, AND M.R. ROSE. 1990. Assessment of the salinity tolerance of eight Sonoran Desert riparian trees and shrubs. Submitted to Bureau of Reclamation, Lower Colorado Region, Yuma Projects Office, Yuma, Arizona by Biological Science Center, Desert Research Institute, University of Nevada, Reno, Nevada.

JOHNSON, R.L. 1965. Regenerating cottonwood from natural seedfall. Journal of Forestry January:33-36.

KERNEY, T.H. AND R.H. PEEBLES. 1951. Arizona Flora. University of California Press, Berkeley, CA. 1085 pp.

KILMER, V.J. 1982. Handbook of soils and climate in agriculture. CRC Press, Inc. Boca Raton, Florida.

LEIST, N. AND S. KRAMER. 2003. Working Sheets on Tetrazolium Testing Volume Agricultural, Vegetable and Horticultural Species. International Seed Testing Association, 1st Edition.

LOWER COLORADO RIVER MULTI-SPECIES CONSERVATION PROGRAM. 2004. Lower Colorado River Multi-Species Conservation Program, Volumes I-IV. Final. December 17.

MARLER, R.J., J.C. STROMBERG, AND D.T. PATTEN. 2001. Growth response of *Populus fremontii, Salix gooddingii*, and *Tamarix ramosissima* seedlings under different nitrogen and phosphorus concentrations. Journal of Arid Environments 49(1):133-146.

MOSS, E.H. 1938. Longevity of seed and establishment of seedlings in species of *Populus*. Botanical Gazette 99:529-542.

OHMART, R.D., W.O. DEASON, AND C. BURKE. 1977. A riparian case history: the Colorado River. Pp. 35-47 *in* R.R. Johnson and D.A. Jones (editors). Importance, preservation and management of riparian habitat: a symposium. USDA Forest Service Gen. Tech. Rep. RM-43, USDA Rocky Mountain Forest and Range Experimental Station, Ft. Collins, Colorado.

PERIMAN, R.D. AND J.F. KELLY. 2000. The dynamic environmental history of southwest willow flycatcher habitat: a survey of changing riparian conditions through time. Pp. 25-42 *in* D.M. Finch and S.H. Stoleson (editors). Status, ecology, and conservation of the southwestern willow flycatcher. Gen. Tech. Rep. RMRS-GTR-60. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah.

PINKNEY, F.C. 1992. Revegetation and enhancement of riparian communities along the lower Colorado River. Report submitted to Bureau of Reclamation, Lower Colorado Regional Office, Boulder City, Nevada.

POPE, D.P, J.H. BROCK, AND R.A. BACKHAUS. 1990. Vegetative propagation of key southwestern wood riparian species. Desert Plants 10(2):91-95.

RAULSTON, B.E. 2003. Habitat restoration on the lower Colorado River, demonstrations projects: 1995-2002. Bureau of Reclamation, Lower Colorado River Regional Office, Boulder City, Nevada.

RAWSON, H.M., R.A. RICHARDS, AND R. MUNNS. 1988. An examination of selection criteria for salt tolerance in wheat, barley and triticale genotypes. Australian Journal of Agricultural Research 39(5):759-772.

REICHENBACHER, F.W. 1984. Ecology and evolution of southwestern riparian plant communities. Desert Plants 6(1):14-22.

ROSENBERG, K.V., R.D. OHMART, W.C. HUNTER, AND B.W. ANDERSON. 1991. Birds of the lower Colorado River Valley. University of Arizona Press, Tucson, Arizona. 416 pp.

SCOTT, M.L., P.B. SHAFROTH, AND G.T. AUBLE. 1999. Responses of riparian cottonwoods to alluvial water table declines. Environmental Management 23:347-358.

SCOTT, M.L., G.C. LINES, AND G.T. AUBLE. 2000. Channel incision and patterns of cottonwood stress and mortality along the Mojave River, California. Journal of Arid Environments 44:399-414.

SHAFROTH, P.B., J.M. FRIEDMAN, AND L.S. ISCHINGER. 1995. Effects of salinity on establishment of Populus fremontii (cottonwood) and Tamarix ramosissima (saltcedar) in southwestern United States. Great Basin Naturalist 55:58-65.

SHAFROTH, P.B., G.T. AUBLE, J.C. STROMBERG, AND D.T. PATTEN. 1998. Establishment of woody riparian vegetation in relation to annual patterns of streamflow, Bill Williams River, Arizona. Wetlands 18(4):577-509.

SHAFROTH, P.B., J.C. STROMBERG, AND D.T. PATTEN. 2000. Woody riparian vegetation response to different alluvial water table regimes. Western North American Naturalist 60:66-75.

SHAFROTH, P.B., J. C. STROMBERG, AND D. T. PATTEN. 2002. Riparian vegetation response to altered disturbance and stress regimes. Ecological Applications 12(1):107-123.

STROMBERG, J.C. 1993. Fremont cottonwood-Goodding's willow riparian forests: a review of their ecology, threats, and recovery potential. Journal of the Arizona-Nevada Academy of Science 26(3):97-110.

STROMBERG, J.C. 1998. Dynamics of Fremont cottonwood (*Populus fremontii*) and saltcedar (*Tamarix chinensis*) populations along the San Pedro River, Arizona. Journal of Arid Environments 40:133-155.

STROMBERG, J., M. BRIGGS, C. GOURLEY, M. SCOTT, P. SHAFROTH, AND L. STEVENS. 2004. Human alterations of riparian ecosystems. Pp. 99-126 *in* M.B. Baker Jr., P.F. Ffolliott, L.F. DeBano, and D.G. Neary (editors). Riparian areas of the southwestern United States: hydrology, ecology and management. CRC Press.

SWENSON, E.A. 1989. Progress in the understanding of how to reestablish native riparian plants in New Mexico. Pp. 144-150 *in* K. M. Mutz, D.J. Cooper, M.L. Scott, and L.K. Miller (tech. coords). Restoration, creation, and management of wetland and riparian ecosystems in the American West. A symposium of the Rocky Mountain Chapter of the Society of Wetland Scientists, Denver, Colorado.

SWENSON, E.A. AND C.L. MULLINS. 1985. Re-vegetating riparian trees in southwestern floodplains. Pp. 135-138 *in* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Ffolliot, and R.H. Hamre (tech. coords). Ecosystems and their management: reconciling conflicting uses. USDA Forest Service Gen. Tech. Rep. RM-120, Fort Collins, Colorado.

TAYLOR, J.P. 1999. Soil disturbance, flood management, and riparian woody plant establishment in the Rio Grande floodplain. Wetlands 9(2):1-13.

TAYLOR, J.P. AND K.C. MCDANIEL. 1998. Restoration of saltcedar (Tamarix sp.) infested floodplains on the Bosque del Apache National Wildlife Refuge. Weed Tech.12:345-352.

U.S. DEPARTMENT OF AGRICULTURE. 1996. Soil survey laboratory methods manual. U.S. Department of Agriculture, soil survey investigations report no. 42, version 3.0. Natural Resource Conservation Service, Lincoln, Nebraska.

U. S. FISH AND WILDLIFE SERVICE. 1999a. Environmental Assessment, Proposed Beal Lake Improvement Project, Havasu NWR, January 1999. Needles, California.

U.S. FISH AND WILDLIFE SERVICE. 1999b. Memorandum, Environmental Assessment for Beal Lake Improvement Project, February 3, 1999, Arizona. Ecological Services Field Office, Phoenix, Arizona.

WYCKOFF, G.W. AND J.C. ZASADA. 2007. Available at http://nsl.fs.fed.us/wpsm/populus.pdf

ZASADA, J.C., D.A. DOUGLAS AND W. BUECHLER. 2007. Available at http://nsl.fs.fed.us/wpsm/Salix.pdf

Table 1-1. Beal Lake Restoration Phase 1; Phase 1 Total Acres = 59.6

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
A	5.1	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a		3.3-4.8	460.0
		Hydroseed	24Apr03	*Baccharis sarothroides*	16&17Dec02	BWRNWR-Kohen Ranch	<6	10	n/a	0-1' = 25.7	2.2 - 3.7	458.9
				Baccharis spp.	"	"	>10	(see Seed		1-3' = 8.09		
				Bebbia juncea aspera	23Dec02	Pratt Reveg-Yuma, AZ	>20	Info Table		3-5' = 4.45		
				Atriplex lentiformis	Purchased	Granite Seed	unk.	for % of				
				A. canascens	"	1697 W. 2100 North	unk.	each spp.)				
				A. polycarpa	"	Lehi, UT 84043	unk.					
				Phacelia campanularia	"		unk.					
				Encelia farinosa	"							
				(see Table 2 for details)								
B	2.4	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a		3.3-4.8	460.0
		Container Plants	28May-	2,195	Purchased	CRIT Ahakhav Tribal Nursery	unk.	n/a	n/a	0-1' = 2.58	3.1-4.6	459.8
			5Jun03	*Populus fremontii*		Parker, AZ				1-3' = 2.04		
										3-5' = 0.95		
C	3.6	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 2.74	3.3-4.8	460.0
		covercrop	June 2003	Regreen™	purchased	Seed Solutions, Denver, CO		1000lb		1-3' = 1.11		
		container plants	21Jan-3Feb	3900 *P. fremontii*	purchased	CRIT Ahakhav Tribal Nursery	n/a			3-5' = 1.42		
			2004	200 *S. exigua*	purchased	Parker, AZ	n/a			(Averaged)		
D	5.4	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a		3.3-4.8	460.0
		container plants	28May-	# Trees present after 1st growing season:	Purchased	CRIT Ahakhav Tribal Nursery	n/a	n/a	n/a	0-1' = 4.26	2.0-3.5	458.7
			5-Jun-03	*3561 Salix gooddingii*	"	Parker, AZ				1-3' = 3.28		
			21Jan-3Feb	652 *P. fremontii*	"	"				3-5 ' = 1.60		
			2004		"	"						
E	3.9	covercrop	15Jan2003	Solum Barley		Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 4.46	3.3-4.8	460.0
		Hydroseed	24Apr03	*Baccharis sarathroides*	16&17Dec02	BWRNWR-Kohen Ranch	<6	5.12	n/a	1-3' = 1.91	2.8-4.3	459.5
		(SW edge only)		*Baccharis* spp.	"	"	>10			3-5 ' = 1.65		
				Bebbia juncea aspera	23Dec02	Pratt Reveg-Yuma, AZ	>20					
				Atriplex lentiformis	Purchased	Granite Seed	unk.					
				A. canascens	"	1697 W. 2100 North	unk.					
				A. polycarpa	"	Lehi, UT 84043	unk.					

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
				Phacelia campanularia	"		unk.					
				Encelia farinosa	"							
		container plants	28May-	2000 *Salix exigua*	Purchased	CRIT Ahakhav Tribal Nursery	unk.	n/a	n/a		2.8-4.3	
			5Jun03	100 *Populus fremontii*		(cuttings collected locally)						
						Parker, AZ						
		container plants	21&22Apr04	272 *Prosopis pubescens*	Purchased	" "						
F	4.1	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 2.65	3.3-4.8	460.0
		Hydroseeded	3Apr03	*Populus fremontii*	26Mar03	HNWR, Pintail Slough area	+10			1-3' = 2.57	2.6-4.1	459.3
				S. gooddingii	27Mar03	Yuma, AZ, along Gila R., Pratt	<10	20		3-5' = 2.19		
				S. gooddingii	1Apr03	BWRNWR	7					
				S. gooddingii	2Apr03	BWRNWR	10					
				S. gooddingii	2Apr03	CRIT Ahakhav Preserve	1					
				P. fremontii	2Apr03	BWRNWR	1					
				S. gooddingii								
		Branches	24Jun03		17Jun03	HNWR, between LCR & Levy Rd	24		638			
		Hand seeded	20 May04	*S. gooddingii*	17May04	HNWR, between LCR & Levy Rd	12	15	n/a			
		(spread on surface of wet soil)										
G	1.0	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 3.49	3.3-4.8	460.0
		Hydroseeded	3Apr03	*S. gooddingii*	27Mar03	Yuma, AZ, along Gila R., Pratt	<10	5		1-3' = 0.98	3.3-4.8	460.0
		(experimental field)								3-5' = 1.24		
				S. gooddingii	1Apr03	BWRNWR	7			(averaged)		
				P. fremontii	2Apr03	BWRNWR	10					
				S.gooddingii	2Apr03	BWRNWR	1					
			1Aug03		24Jul03	Lake Mohave, 6 Mile Cove	6	6	n/a			
H	2.7	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 1.32	3.3-4.8	460.0

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
		Hydroseeding	10Apr03	S. gooddingii	8Apr03	BWRNWR	unk.	8	n/a	1-3' = 1.46	2.9-4.4	459.6
		(only NE 1/3 field, 1ac, hydroseeded)			9Apr03	Yuma, AZ-Navajo Bridge on road	<10			3-5' = 1.34		
						to Betty's Kitchen&Pratt Site				(averaged)		
				P. fremontii	7&8Apr03	L. Mohave, RV Park	<10	2.5				
		Hand Seeded	25Apr03	*S. gooddingii*	18&22Apr03	BWRNWR	<5	2	n/a			
		(seed spread on	19Jun03	*S. gooddingii*	17Jun03	HNWR, Between Levy Road and LCR	24	unk.	unknown			
		surface of receding			18Jun03	L.Mohave, Pot Cove	6	unk.	unknown			
		water)										
		Hand seeded	4June04	*S. gooddingii*	30May-3June	HNWR, Between Levy Road and LCR	12	13	n/a			
		(spread on surface			2004							
		of wet soil)										
I	4.3	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 8.99	3.3-4.8	460.0
		container plants	28May-	2,500 *S. gooddingii*	Purchased	CRIT Ahakhav Tribal Nursery	unkwn	n/a	n/a	1-3' = 2.20	1.8-3.3	458.5
			5Jun03	1,500 *S. exigua*		(cuttings collected locally)				3-5' = 1.29		
						Parker, AZ						
J	3.6	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 7.03	3.3-4.8	460.0
		container plants	28May-	3,200 *S. exigua*	Purchased	CRIT Ahakhav Tribal Nursery	unk.	n/a	n/a	1-3' = 3.36	1.8-3.3	458.5
			5Jun03			(cuttings collected locally)				3-5' = 2.34		
						Parker, AZ						
K	2.5	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 2.06	3.3-4.8	460.0
		Hydroseeding	10Apr03	*S. gooddingii*	8Apr03	BWRNWR	unk.	16	n/a	1-3' = 2.42	2.8-4.3	459.5
		(onlyNE1/3field, 1ac,			9Apr03	Yuma, AZ-Navajo Bridge on road	<10			3-5' = 1.34		
		hydroseeded)				to Betty's Kitchen&Pratt Site						
				P. fremontii	8Apr03	L. Mohave, RV Park	<10	5				
		Hand-seeded										
		(seed spread on	24Apr03	*S. gooddingii*	18&22Apr03	BWRNWR	<5	2				
		surface of receding										
		water)										

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
		Hand-seeded	19Jun03	*S. gooddingii*	17Jun03	HNWR, Between Levy Road and LCR	24	unk.	unk.			
		Branches			18Jun03	L.Mohave, Pot Cove	6	unk.	unk.			
		Hand seeded	4June2004	*S. gooddingii*	30May-3June	HNWR, Between Levy Road and LCR	12	13	n/a			
		(spread on surface										
		of wet soil)										
		Installation of pools for moist soil/standing water	Dec 05									
		(28 pools total, 9 large, 19 small)										
		Container Plants planted	Dec 05	*822 S. exigua*	Dec 05	Blue Jack Nursery, Brawley, CA						
				789 S. gooddingii								
				232 P. fremontii								
L	4.2	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 3.20	3.3-4.8	460.0
		covercrop	Jun-03	Regreen™	purchased	Seed Solutions, Denver, CO		50lb/ac		1-3' = 1.75		
				# Trees present after 2nd growing season:	purchased	CRIT Nursery, Parker, AZ				3-5' = 0.89		
		Container Plants	21Jan-3Feb04	1944 *S. exigua*								
				1215 *S. gooddingii*								
				292 *P. fremontii*								
M	2.6	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 3.77	3.3-4.8	460.0
		Hydroseed	20Mar03	*P. fremontii*	17Mar03	HNWR, Nursery	7	2.4	n/a	1-3' = 3.95	2.7-4.2	459.4
					18Mar03	BWRNWR (gate to 1st river crossing)	10			3-5' = 3.12		
					19Mar03	BWRNWR, Mineral Wash	11					
						BWRNWR(Dwnstrm of Mineral Wash)	5					
						BWRNWR, Kohen Ranch	2					
		Hand seeded	4June04	*S. gooddingii*	30May-3June	HNWR, Between Levy Road and LCR	12	13	n/a			
		(spread on surface			2004							
		of wet soil)										
		container plants	16Nov04	1015 *Populus fremontii*		Mountain Sates Nursery, Litchfield Park, AZ						
										0-1' = 11.77		

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
N	6.2	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	1-3' = 33.2	3.3-4.8	460.0
		Hydroseeded	20Mar03	*Baccharis sarathroides*	16&17Dec02	BWRNWR-Kohen Ranch	<6	223.1	n/a	3-5' = 41.4	2.1-3.6	458.8
				Baccharis spp.	"	"	>10					
				Bebbia juncea aspera	23Dec02	Pratt Reveg-Yuma, AZ	>20					
				Atriplex lentiformis	Purchased	Granite Seed	unk.					
				A. canascens	"	1697 W. 2100 North	unk.					
				A. polycarpa	"	Lehi, UT 84043	unk.					
				Phacelia campanularia	"		unk.					
				Encelia farinosa	"		unk.					
				(see Table 2 for details)								
		Seeded	2Feb2005	*Prosopis pubescens*		Wild Seed, Inc., Tempe, Arizona	unk.	3 lbs				
				Distichlis spicata		Granite Seed, Lehi, UT	unk.	30 lbs				
O	2.5	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 1.17	3.3-4.8	460.0
		container plants	21&22 Apr04	# Trees present after first growing season:	purchased	CRIT nursery				1-3' = 1.2		
				719 P. fremontii						3-5' = 1.63		
				1306 S. gooddingii								
				280 S. exigua								
P	2.6	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 5.35	3.3-4.8	460.0
		container plants	21&22 Apr04	# Trees present after first growing season:	purchased	CRIT nursery				1-3' = 4.04		
				456 P. fremontii						3-5' = 2.49		
				2102 S. gooddingii								
				298 S. exigua								
Q	2.9	covercrop	15Jan2003	Solum Barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	0-1' = 2.61	3.3-4.8	460.0
							unk.	8		1-3' = 0.61	3.0-4.5	459.7
		Hydroseeding	10Apr03	*S. gooddingii*	8Apr03	BWRNWR	<10			3-5' = 1.08		
		(onlyNE1/3field, 1ac,			9Apr03	Yuma, AZ-Navajo Bridge on road						
		hydroseeded)		*P. fremontii*		to Betty's Kitchen&Pratt Site	<10	2.5				
		Hand Seeded-seed on surface of receding water	25Apr03	*S. gooddingii*	18&22Apr03	BWRNWR	<5					

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
		Branches-seeding branches stuck into ground	12Jun03	*S. gooddingii*	11Jun03	L. Mohave, Pot Cove	6		251			
		then flooded			12Jun03	HNWR, betwn Levy Rd.&LCR	4					
		Hand seeded	4June2004	*S. gooddingii*	30May-3June	HNWR, betwn Levy Rd.&LCR	12	13	n/a			
		(spread on surface of wet soil										

Table 1-2. Beal Lake Restoration, Phase 2; Phase 2 Total Acres = 47.3; *NOTE: 3169 poles planted around perimeter of north 1/2 Field AA, and around perimeters of fields CC,HH, LL and GG. An exact count of poles per field not taken when planted. See updated monitoring data.

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
AA	3.9	Covercrop/ drilled seed	May04	Regreen™	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 0.91	See updated	458.7
				(Wheat-Wheatgrass hybrid)						1-3' = 0.44	monitoring	
										3-5' = 1.21	data for	
		container plants:	16Nov04	1985 *Populus fremontii*	n/a	Mountain States Nursery	n/a	n/a	n/a	(averaged)	water table	
		NW 1/2: 5'-6' centers									depths	
		Perimeter planting around southern half of field using portion	24-27Jan05	*P. fremontii & S. gooddingii*	508 - 18Jan05	Havasu NWR Nursery						
		of *3169 poles cut in Jan05,		(poles not separately	909 - 19Jan05	(Original Source of trees - BWRNWR)						
		5' centers, 3-4 rows		counted by spp.)	1245 - 20Jan05							
					507 - 21Jan05							
		Cover Crop, in center of CW/W perimeter, on S. half of field	Dec 2005	Wheat @ 60 lb/ac		Fertizona-Buckeye, Arizona		90lb				
BB	3.1	Covercrop/ drilled seed	May04	Regreen™	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 19.33		458.4
				(Wheat-Wheatgrass hybrid)						1-3' = 20.44		
										3-5' = 29.60		
		container plants:	17Nov04	349 *Prosopis pubescens*	n/a	Mountain States Nursery	unkn	n/a	n/a	(averaged)		
		Mesquites planted on outer										
		approx. 1/2 of field,										
		Hand Seeded around mesquites	15Feb05	*Atriplex polycarpa* (33%)	unkn.	Wildseed, Tucson, AZ	unkn	158 lbs	n/a			
				A. lentiformis (33%)								
				A. canescens (33%)								
		Hand Seeded around perimeter	15Feb05	*Encelia farinosa* (50%)	unkn.	Wildseed, Tucson, AZ	unkn	11 lbs	n/a			
				Sphaeralcea ambigua (50%)								

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
		Covercrop/seed drilled in inside 1/2 of field	Dec 05	Barley		Fertizona, Buckeye, AZ		100lb				
CC	3.6	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 4.71		458.8
				(Wheat-Wheatgrass hybrid)						1-3' = 1.10		
										3-5' = 1.20		
		Perimeter planting using portion	24-27 Jan05	*P. fremontii & S. goodingii*	508 - 18Jan05	Havasu NWR Nursery				(averaged)		
		of *3169 poles cut in Jan05,		(not separately	909 - 19Jan05	(Original Source of trees - BWRNWR)						
		5' centers, 3-4 rows		counted by spp.)	1245 - 20Jan05							
					507 - 21Jan05							
		Covercrop/seed drilled in inside 1/2 of field	Dec 05	wheat		Fertizona, Buckeye, AZ		160lbs				
DD	3.3	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 7.08		458.4
				(Wheat-Wheatgrass hybrid)						1-3' = 10.35		
										3-5' = 25.72		
		container plants:	17Nov04	303 *Prosopis pubescens*		Mountain States Nursery				(averaged)		
		Mesquites planted on outer										
		approx. 1/2 of field										
		Cover crop of Barley on inside 1/2 of field	Dec 2005	Barley		Fertizona, Buckeye, AZ						
		Hand Seeded around mesquites	15Feb05	*Atriplex polycarpa* (33%)	unkn.	Wildseed, Tucson, AZ	unkn	158 lbs	n/a			
		(158 lbs distributed around all mesquites in		*A. lentiformis* (33%)								
		BB, DD, II, and MM)		*A. canescens* (33%)								
		Hand Seeded around perimeter	15Feb05	*Encelia farinosa* (50%)	unkn.	Wildseed, Tucson, AZ	unkn	11 lbs	n/a			

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
		(11 lbs distributed around perimeter of fields		*Sphaeralcea ambigua* (50%)								
		BB,DD,II and MM)										
		Cover Crop	Dec05	Barley		Fertizona, Buckeye, AZ						
EE	4.7	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 64.45		458.5
				(Wheat-Wheatgrass hybrid)						1-3' = 24.63		
		No surviving regreen by May05,								3-5' = 26.83		
		some sc, mostly bare sand.								(averaged)		
		Demo marsh for Black Rail, planning/design in progress										
FF	2.5	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 0.64		459.4
										1-3' = 0.55		
		Regreen, arrowweed, some		(Wheat-Wheatgrass hybrid)						3-5' = 0.74		
		volunteer mesq.								(averaged)		
		Container Plants-nursery creation; trees at 20' spacing	Dec 05	*35 S. exigua,*	Dec 04-May05	BlueJack Nursery, cuttings from LCR						
		with cover crop of Barley		*65 S. goodingii*								
				102 P. fremontii								
GG	4.4	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 0.86		459.7
				(Wheat-Wheatgrass hybrid)						1-3' = 0.40		
										3-5' = 0.65		
		Perimeter planting using portion	24-27 Jan05	*P. fremontii & S. goodingii*	508 - 18Jan05		Havasu NWR Nursery			(averaged)		
		of *3169 poles cut in Jan05,		(planted poles not separately	909 - 19Jan05		(Original Source of trees - BWRNWR)					

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
		5' centers, 1 row around field		counted by spp)	1245 - 20Jan05							
					507 - 21Jan05							
		Note: perimeter planting discontinued, entire field planted		(3984 total trees)								
		with container plants	Dec 05	*P. fremontii 1831*	Dec-May 04/05	Cuttings from LCR, grown by BlueJack						
				S. goodingii 1370		Nursery, Brawley, CA						
				S. exigua 783								
HH	4.0	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 2.21		458.7
				(Wheat-Wheatgrass hybrid)						1-3' = 0.52		
										3-5' = 0.99		
		Perimeter planting using portion	24-27 Jan05	*P. fremontii & S. goodingii*	508 - 18Jan05	Havasu NWR Nursery				(averaged)		
		of *3169 poles cut in Jan05,			909 - 19Jan05	(Original Source of trees - BWRNWR)						
		5' centers, 3-4 rows			1245 - 20Jan05							
					507 - 21Jan05							
		Cover crop (in center, perimeter CW/W)	Dec 05	Wheat		Fertizona, Buckeye, AZ						
II	3.7	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 1.34		458.4
				(Wheat-Wheatgrass hybrid)						1-3' = 1.51		
										3-5' = 9.27		
		container plants:	17Nov04	678 P*rosopis pubescens*		Mountain States Nursery	unkn	n/a	n/a	(averaged)		
		Mesquites planted on SE ½ of field,										
		remaining area-arrowweed and regreen										
		to be mowed/disked asap,										
		then planted with wheat&barley Fall 05										

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
		Hand Seeded around mesquites	15Feb05	*Atriplex polycarpa* (33%)	unkn.	Wildseed, Tucson, AZ						
		(158 lbs distributed around all mesquites in		*A. lentiformis* (33%)								
		BB, DD, II, and MM)		*A. canescens* (33%)								
		Hand Seeded around perimeter	15Feb05	*Encelia farinosa* (50%)	unkn.	Wildseed, Tucson, AZ						
		(11 lbs distributed around perimeter of fields		*Sphaeralcea ambigua* (50%)								
		BB,DD,II and MM)										
		Cover crop		Barley		Fertizona, AZ						
JJ	2.5	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 3.94		459.5
				(Wheat-Wheatgrass hybrid)						1-3' = 6.79		
										3-5' = 13.38		
		Note:								(averaged)		
		adjacent marsh demo may affect										
		salinity, delay planting CW/W		Barley planted on Northern 1/2 of field								
				(1152 total trees)								
		Container Plants-S. half of field only	Dec 05	*S. goodingii 897, S. exigua 255*	Dec04-May05	BlueJack Nursery, Cuttings from LCR						
		Barley covercrop on Northern half of field						70 lb/ac				
KK	4.4	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 0.67		460.2
				(Wheat-Wheatgrass hybrid)						1-3' = 0.48		
										3-5' = 0.67		
		By May05-Tumbleweed/ arrowweed - Mow/disk					Havasu NWR Nursery			(averaged)		

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
		plant with CW/W perimeter in fall, barley/wheat					(Original Source of trees - BWRNWR)					
		in center until trees seed										
		Container Plants	Dec05	1402 *P. Fremontii*	Dec-May 04/05	Cuttings from LCR, grown by BlueJack						
						Nursery, Brawley, CA						
LL	3.6	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 0.85		458.2
				(Wheat-Wheatgrass hybrid)						1-3' =0.40		
										3-5' = 1.11		
		Perimeter planting using portion	24-27 Jan05	*P. fremontii & S. goodingii*		Havasu NWR Nursery				(averaged)		
		of *3169 poles cut in Jan05,		(not separately		(Original Source of trees - BWRNWR)						
		5' centers, 3-4 rows		counted d by spp)								
		Container Plants (Covercrop in center,	Dec 05	Total Trees = 1464	Dec-May 04/05	Cuttings from LCR, grown by BlueJack						
		cw/w perimeter)		Mix of SaEx, SaGo, PoFr:								
				# each species unknown		Nursery, Brawley, CA						
MM	3.6	Covercrop/seed drilled	May04	Regreen	purchased	Seed Solutions, Denver, CO		50lb/ac		0-1' = 2.99		459.0
				(Wheat-Wheatgrass hybrid)						1-3' = 3.68		
										3-5' = 8.03		
		container plants	17Nov04	233 *Prosopis pubescens*						(averaged)		
		Mesquites planted on NW										
		approx. 1/3 of field, remaining										
		area- arrowweed and regreen										
		to be mowed/disked asap,										
		then planted with wheat&barley in Fall 05										

Field	Acres	Planting Method/Current Status & Plans	Date Planted	Species	Date Collected or Cut	Plant Material Source Source	# Source Plants	Amount Seed (lbs)	# Branches	Soil EC mS/cm	Water Table Min-Max (ft)	Elev.
		Hand Seeded around mesquites	15Feb05	*Atriplex polycarpa* (33%)	unkn.	Wildseed, Tucson, AZ	unkn	158 lbs	n/a			
		(158 lbs distributed around all mesquites in		*A. lentiformis* (33%)								
		BB, DD, II, and MM)		*A. canescens* (33%)								
		and										
		Hand Seeded around perimeter	15Feb05	*Encelia farinosa* (50%)	unkn.	Wildseed, Tucson, AZ	unkn	11 lbs	n/a			
		(11 lbs distributed around perimeter of fields		*Sphaeralcea ambigua* (50%)								
		BB,DD,II and MM)										
		cover crop	Dec05	Barley				70 lb/ac				

Table 2. Seed Phenology: Bill Williams, Lower Colorado and Lower Gila Rivers

LOCATION	SPECIES	DATE	STATUS
Bill Williams River	Freemont cottonwood, *Populus fremontii*	6 Feb	Green seed clusters visible on trees
		3 Mar	Seed Dispersal begins
		19 Mar	Some trees still dispersing, some finished
		2 Apr	Most trees finished dispersing, a few still have seeds
		15 Apr	No seed dispersal observed
	Goodding's Willow, *Salix gooddingii*	31 Jan	Flower buds observed on trees
		3 Mar	Flowers present on female trees, most flowers on male trees still green and unopened, some are yellowish and open
		19 Mar	No seed dispersal yet, trees heavy with green clusters
		2 Apr	Many trees seeding
		15 Apr	Trees in full seed dispersal
		18 Apr	Seed declining, but still present
		23 Apr	Seed still present on few trees
Havasu NWR: tree nursery, cws in maintenance yard, mature trees near Pintail Slough	Fremont Cottonwood and Goodding's Willow	See dates above	Same phenology as BWR trees; all trees planted from cuttings taken from BWR
along Levy Rd.	Fremont Cottonwood	n/a	Cottonwoods associated with mainstem of LCR are not as accessible at HNWR, none collected
	Goodding's Willow	3 May	Willows heavy with all green seed capsules, no dispersal observed
		12 May	Mostly green seed pods, very little seed dispersal started on a few trees i.e. 1-2 capsules on catkin may be yellowish and dispersing seed, o seed collection
		17 May	Most trees still not seeding much, but a few are dispersing and approximately 20 lbs seed collected in one morning (amount includes chaff, leaves and debris as well)
		12-17 June	Full Seed Dispersal
Lake Mohave: Cottonwood Cove RV Park	Fremont Cottonwood	1-8 Apr	Full Seed dispersal from mature trees throughout RV park
	No willow present	N/A	
Pot Cove, AZ side	Goodding's Willow	11-18 June-	Seed collected 11-18 June, but seed present and abundant through July
6 Mile Cove, NV side	Goodding's Willow	24 July	Not many trees present, but all seeding
Yuma, AZ	Fremont Cottonwood	27 Mar	Lower Gila R. & Laguna Dam near BLM's Betty's Kitchen Rec. Area -abundant seed dispersal
YUMA, AZ	Goodding's Willow	27 Mar-9 April	Full seed dispersal

Table 3. Salt-tolerant Seed Mix (planted in Fields N, northern edge of A and southern edges of J and E)

Species	**Total (lbs)**	**% Total**
Baccharis sp.	0.60	0.4%
B. sarathoides	3.40	1.4%
Bebbia juncea aspera	0.45	0.2%
Atriplex lentiformis	67.40	28.0%
A. canascens	31.40	12.9%
A. polycarpa	37.20	15.3%
Phacelia campanularia	24.60	9.7%
Encelia farinosa	78.20	32.1%
Total	**243.25**	**100.0%**

Table 4. Bureau of Reclamation, Lower Colorado Regional Laboratory, Beal Lake soils: Complete Report , Dates Sampled: 12/03/02 & 12/12/02, Samples Received: 12/05/02 & 12/16/02, Samples Analyzed: 02/18/03

Lab	Site	Sample	%	ECe	Textural Classification			
No.	No.	Depth (feet)	Saturation	mS/cm	% Sand	% Silt	% Clay	Laboratory Texture
022939	A	0 - 1	32.1	25.70	81.4	13.0	5.6	Loamy Sand
022940	A	1 - 3	33.5	8.09	96.3	1.6	2.1	Sand
022941	A	3 - 5	31.8	4.45	97.9	0.1	2.0	Sand
022942	B	0 - 1	29.0	2.58	90.9	6.3	2.8	Sand
022943	B	1 - 3	32.9	2.04	96.0	1.8	2.2	Sand
022944	B	3 - 5	31.9	0.95	97.4	0.7	1.9	Sand
022945	C	0 - 1	32.6	3.34	87.4	9.4	3.2	Sand
022946	C	1 - 3	32.1	0.73	96.8	1.2	2.0	Sand
022947	C	3 - 5	31.2	0.52	98.2	0.0	1.8	Sand
022948	C-2	0 - 1	32.2	3.01	94.4	2.4	3.2	Sand
022949	C-2	1 - 3	32.4	2.27	96.5	1.1	2.4	Sand
022950	C-2	3 - 5	31.9	2.10	95.9	1.9	2.2	Sand
022951	DD	0 - 1	31.9	4.26	86.6	8.1	5.3	Loamy Sand
022952	DD	1 - 3	31.8	3.28	96.4	0.8	2.8	Sand
022953	DD	3 - 5	32.6	1.60	97.0	0.8	2.2	Sand
022954	E	0 - 1	32.9	4.46	96.2	1.0	2.8	Sand
022955	E	1 - 3	32.6	1.91	97.7	0.0	2.3	Sand
022956	E	3 - 5	33.1	1.65	95.9	1.1	3.0	Sand
022957	F	0 - 1	32.2	2.65	93.2	3.8	3.0	Sand
022958	F	1 - 3	33.3	2.57	96.7	0.4	2.9	Sand
022959	F	3 - 5	34.3	2.19	96.8	0.8	2.4	Sand
022960	G	0 - 1	39.1	5.06	84.7	10.0	5.3	Loamy Sand
022961	G	1 - 3	33.1	0.79	97.0	0.8	2.2	Sand
022962	G	3 - 5	33.9	0.63	97.4	0.6	2.0	Sand
022963	H	0 - 1	30.2	1.38	94.3	3.4	2.3	Sand
022964	H	1 - 3	32.0	1.16	99.1	0.0	0.9	Sand
022965	H	3 - 5	33.3	1.08	96.6	0.7	2.7	Sand
022966	ii	0 - 1	31.5	8.99	96.9	0.3	2.8	Sand
022967	ii	1 - 3	31.9	2.20	97.3	0.3	2.4	Sand
022968	ii	3 - 5	30.3	1.29	97.8	0.2	2.0	Sand
022969	J	0 - 1	32.7	7.03	96.6	0.8	2.6	Sand
022970	J	1 - 3	31.8	3.36	97.8	0.6	1.6	Sand
022971	J	3 - 5	32.8	2.34	97.7	0.0	2.3	Sand
022972	Q	0 - 1	34.2	2.61	92.8	3.9	3.3	Sand
022973	Q	1 - 3	31.6	0.61	97.8	0.6	1.6	Sand
022974	Q	3 - 5	33.3	1.08	97.0	1.0	2.0	Sand
022975	K	0 - 1	27.5	5.10	94.5	4.0	1.5	Sand
022976	K	1 - 3	33.9	6.10	70.6	21.2	8.2	Sandy Loam
022977	K	3 - 5	30.0	1.76	98.0	0.9	1.1	Sand
022978	L	0 - 1	29.1	3.20	92.9	5.7	1.4	Sand
022979	L	1 - 3	32.6	1.75	94.3	3.8	1.9	Sand

022980	L	3 - 5	31.1	0.89	96.1	2.7	1.2	Sand
022981	M	0 - 1	31.6	3.77	97.3	1.6	1.1	Sand
022982	M	1 - 3	31.2	3.95	97.9	1.4	0.7	Sand
022983	M	3 - 5	33.7	3.12	97.4	2.6	0.0	Sand
022984	N	0 - 1	34.6	11.77	73.2	22.2	4.6	Sandy Loam
022985	N	1 - 3	33.2	19.40	87.6	9.8	2.6	Sand
022986	N	3 - 5	41.4	22.10	31.6	59.3	9.1	Silt Loam
022987	O	0 - 1	29.5	2.02	97.1	0.0	2.9	Sand
022988	O	1 - 3	31.4	2.34	97.7	0.0	2.3	Sand
022989	O	3 - 5	30.0	2.43	95.6	1.2	3.2	Sand
022990	P	0 - 1	29.7	5.35	91.9	4.2	3.9	Sand
022991	P	1 - 3	33.7	4.04	94.7	2.2	3.1	Sand
022992	P	3 - 5	31.6	2.49	97.4	0.2	2.4	Sand

UNITED STATES BUREAU OF RECLAMATION
LOWER COLORADO REGIONAL LABORATORY
** BEAL LAKE SOILS: Complete Report **

Date Sampled: 9/11/03
Samples Received: 9/11/03
Samples Analyzed: 12/18/03

Lab No.	Field No.	% Saturation	**ECe** mS/cm	**Nitrate** mg/kg dry soil	**Ortho-Phosphate** mg/kg dry soil	**Ammonia** mg/kg dry soil	**Textural Classification** %Sand	%Silt	%Clay	Laboratory Texture
031821	C1 North	29.0	3.84	8.92	0.03	0.46	74.7	19.0	6.3	Sandy Loam
031822	C2 N	31.4	0.79	2.18	0.08	0.17	96.1	2.2	1.7	Sand
031823	C3 N	32.3	1.90	6.31	0.08	0.31	94.1	4.1	1.8	Sand
031824	C1 South	28.3	0.75	3.29	0.08	0.20	94.2	4.1	1.7	Sand
031825	C2 S	30.4	0.66	4.83	0.08	0.29	97.3	1.7	1.0	Sand
031826	C3 S	29.7	1.14	5.44	0.19	0.12	97.5	1.3	1.2	Sand
031827	G1 North	33.2	0.94	2.72	0.10	0.35	92.6	4.8	2.6	Sand
031828	G2 N	33.2	0.80	3.84	0.06	0.21	97.3	1.9	0.8	Sand
031829	G3 N	32.0	1.26	5.22	0.05	0.10	96.6	2.3	1.1	Sand
031830	G1 South	48.5	4.47	4.26	0.06	0.61	5.0	82.1	12.9	Silt Loam
031831	G2 S	30.9	1.35	14.81	0.09	0.04	97.2	1.8	1.0	Sand
031832	G3 S	30.7	1.84	7.54	0.05	0.28	95.7	2.7	1.6	Sand
031833	H1 North	37.3	2.16	18.74	0.07	0.88	82.9	14.4	2.7	Loamy Sand
031834	H2 N	31.2	2.58	9.70	0.03	0.07	93.0	6.0	1.0	Sand
031835	H3 N	30.4	1.79	7.08	0.03	0.05	95.6	4.1	0.3	Sand
031836	H1 South	32.4	0.42	3.14	0.04	0.05	97.2	2.1	0.7	Sand
031837	H2 S	28.2	0.64	2.49	0.03	0.06	94.2	5.5	0.3	Sand
031838	H3 S	32.9	1.14	3.72	0.02	0.08	97.6	2.0	0.4	Sand
031839	K1 North	28.1	0.56	4.82	0.06	0.09	94.7	3.5	1.8	Sand
031840	K2 N	30.7	0.58	1.44	0.05	0.10	97.3	1.9	0.8	Sand
031841	K3 N	30.2	1.02	1.50	0.18	0.12	97.7	1.9	0.4	Sand
031842	K1 South	32.2	0.54	4.15	0.07	0.12	95.4	3.6	1.0	Sand
031843	K2 S	29.0	0.58	2.17	0.06	0.04	97.0	2.2	0.8	Sand
031844	K3 S	31.4	1.24	6.27	0.04	0.06	96.8	2.1	1.1	Sand
031845	O1 North	28.7	0.52	4.11	0.07	0.06	96.6	2.7	0.7	Sand
031846	O2 N	30.9	0.68	3.09	0.04	0.04	97.9	1.4	0.7	Sand
031847	O3 N	28.0	1.38	4.50	0.03	0.06	97.8	1.9	0.3	Sand
031848	O1 South	30.3	0.98	4.15	0.53	0.05	97.1	2.2	0.7	Sand
031849	O2 S	29.4	0.58	2.17	0.06	0.04	98.1	1.5	0.4	Sand
031850	O3 S	29.4	1.09	6.27	0.04	0.09	97.8	1.4	0.8	Sand

Table 6. Beal Irrigation Summary

May 19, 2003- March 16, 2004
(irrigation by month not recorded prior to March 16, 2004)
Total Acres = 59.6 (24.1 ha)
34, 611 gal x 10,000
1, 062 af (1,309,966 $m^{3)}$
17.8 af/ac (54,355 m^3/ha)

2004

Month	*Jan	*Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Gallons x 10,000	n/a	n/a	1413	4065	6374	11487	8907	9786	6217	0	1280	304
Acre Feet (af)	n/a	n/a	43.4	124.8	195.6	352.5	273.0	300.0	191.0	0.0	39.3	9.3
Acre Feet/Acre (af/ac)	n/a	n/a	0.4	1.2	1.8	3.3	2.5	2.8	1.8	0	0.4	0.1

Total Acres 2004 = 107.3 (43.4ha)
49,833 gal x 10,000
1529.3 af (1,886,376 $m^{3)}$
14.3 af/ac (43,465 m^3/ha)

2005

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Gallons x 10,000	854	306	2052	8986	5899	5536	6038	5976	5610	362	4277	1653
Acre Feet (af)	26.2	9.3	63.1	275	181	169.9	185	183	172	10.8	131.0	50.7
Acre Feet/Acre (af/ac)	0.2	0.1	0.6	2.6	1.7	1.6	1.7	1.7	1.6	0.1	1.2	0.5

Total Acres 2005 = 107.3 (43.4ha)
47549 gal x 10,000
1457.0 af 1797195 m^3
13.6 af/ac 41410 m^3/ha

Table 7. Fields were grouped for frequency of irrigation depending on species, planting dates, type of planting, and age of stands, D-s: Daily sprinkler irrigated, W-s: Weekly sprinkler, D: daily flood irrigation, W: weekly flood, M: Monthly flood, numbers indicate # irrigations/month, CW: Cottonwood &Willow, Cover Crops: Regreen, Barley and/or wheat, * indicates planting occurred that month.

2003 Irrigation Frequency														
Field	**Acres**	**Vegetation Type**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
A-Q	59.6	Cover Crop	*0	0	D-s									
C, L, O, P	12.9	Cover Crop				D-s	W	W	W					
M	2.6	CW/Seed			*D-s	D-s	W	W	W	W	W	0	0	0
F,G,H,K,Q	13.2	CW/Seed				*D-s	W	*D/W	W	*D/W	W	W	0	0
A, N	11.3	Salt-tolerant Shrubs/Seed				W-s	W	W	1	1	1	1	0	0
B,D,E,I,J	19.6	CW/Container Plants					*W	W	W	W	W	W	0	0
2004 Irrigation Frequency														
Field	**Acres**	**Vegetation Type**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
A, N	11.3	Salt-tolerant Shrubs/seed	0	1	1.5	1.5	2	1.5	2.5	1.5	0	1.5	0	0
C,L,O,P,	12.9	CW/Container plants, 1st yr		*1	2	*3	4	5	4	0	2	0	0	0
F,G,H,K,Q,	13.2	CW/Seed, 1st & 2nd yr	0	1	1.5	2	3	7	9	0	4	0	0	0
M	2.6	CW/Seed & CW/container plants	0	1	0	3	3	8	9	0	4	0	*1	1
B,D,E, I, J	19.6	CW/Container Plants, 2nd year	0	1	2	2.5	3.5	4	2.5	0	1.5	0	0	0
AA-MM	47.3	Cover Crop	W	W	W	W	*1.5	3	3	0	2	0	0	0
CC,FF,GG,HH,JJ,KK,LL	25	Cover Crop					*W	W	W	W	3	1	0	0
AA	3.9	Covercrop/Container Plants (1st yr)					*W	W	W	W	3	1	*1	0
BB,DD,II,MM	13.7	Covercrop/Mesquite					*W	W	W	W	2	0	*1	0
EE (cleared for wetland demo)	4.7	Not planted												

2005 Irrigation Frequency														
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	0	2	1	0.5	1.5	0	1	0	0	0
B,C,D,E,F,G,H,I,J,K,L,M,O, P,Q	48.3	CW (all +2 yrs)	0	0	0	2	1.5	1	1.5	1	1	0	0	0
AA,CC,HH,LL	15.1	CW (1st yr, container plants & poles)	*1	0	1	1	2.5	2	2	3	2	0	0	0
BB,DD,II,MM	13.7	Mesquite (2nd year)	0	0	1	1	1	1	0	1	1	0	0	0
FF, GG, JJ,KK	13.8	Cover Crop & CW container plants	0	1	1	1.5	1.5	1	0.5	0.5	0	0	0	0
EE	4.7	Not planted, high salts												

Table 8. Hydroseed Treatments, Field M

Treatment	# Cottonwoods
Seed Only	15
Seed+Fertilizer	5
Seed+Tackifier	13
Seed+Mulch	8
Seed+Fertilzer+Mulch	151
Seed+Fertilizer+Tackifier	177
Seed+Fertilizer+Tackifier+Mulch	182

Table 9. Seed Ages and Germination Test Results from Field Observations

Species	Developmental Stage	# Days Since Collection	% Germination
Cottonwood [1-5] *(Populus fremontii)*	1	9-10	56
	1	12-33	58
	2	9-10	78
	3 or 4	23	98
	3 or 4	17	58
	3	9-10	98
	4	9-10	90
	5	9-10	87
	3	17	58
	3	23	98
	3	12-33	58
Willow[1-4] (*Salix gooddingii*)	1	16-40	18
	2	15-36	21
	3	15-23	88
	4	15-22	99
	3-4	30-38	63
	3 (branches cut from tree, seeds remained on branch from 14-19 April, then sent to lab)	41-55	54

Cottonwood Developmental Stages:
[1]Seed pods collected green but known to have opened prior to testing . No ripe pods observed on tree.
[2]Very green pods, unopened at the time of collection, may or may not have opened prior to testing (78% viable). No ripe pods observed on tree.
[3]Seed pods opened slightly and/or at least one pod open on the cluster when collected-(98% viable).
[4]Seeds collected either as “fluff”; pods completely opened and dispersing from tree-(90% viable).
[5]Seed pods collected were brown, pods shells dry, some fluffy seed still present (87% viable).

Willow Developmental Stages:
[1]Pods/capsules collected green and known to have opened prior to testing (18% viable). No ripe pods seen on tree.
[2]Pods very green and unopened when collected from tree, may or may not have opened prior to testing (21% viable). No ripe pods seen on tree.
[3] Pods/capsules yellowish, but very few opened when collected from tree (88% viable).
[4]Completely open pods, fluff all over the catkin while still on tree (99% viable).

Table 10. Soil Sampling Results, 2004

UNITED STATES BUREAU OF RECLAMATION
LOWER COLORADO REGIONAL LABORATORY
** HAVASU NWR SOILS: Complete Report **
Date Sampled: 10/04/04 - 10/05/04
Samples Received: 10/06/04
Samples Analyzed: 02/04/05

Lab No.	Field No.	Depth (feet)	% Saturation	ECe (mS/cm)	Nitrate (mg/kg dry soil)	Ortho-Phosphate (mg/kg dry soil)	Ammonia (mg/kg dry soil)	Textural Classification			
								%Sand	%Silt	%Clay	Laboratory Texture
042102	AA1	1-3	29.2	0.48	2.39	0.05	0.05	97.8	1.0	1.2	Sand
042101	AA1	0-1	28.0	0.70	3.47	0.15	0.08	96.6	1.6	1.8	Sand
042103	AA1	3-5	28.7	1.32	2.13	0.04	0.04	98.0	0.8	1.2	Sand
042105	AA2	1-3	27.8	0.40	2.03	0.05	0.04	97.8	0.6	1.6	Sand
042106	AA2	3-5	28.8	1.10	2.17	0.03	0.06	98.0	0.7	1.3	Sand
042104	AA2	0-1	28.5	1.12	8.77	0.06	0.72	94.6	3.2	2.2	Sand
042107	BB1	0-1	29.9	37.4	3.74	0.39	2.03	79.2	16.0	4.8	Loamy Sand
042108	BB1	1-3	28.1	40.8	19.6	0.17	0.31	78.5	16.1	5.4	Loamy Sand
042109	BB1	3-5	34.5	58.0	6.11	0.14	0.19	39.3	54.2	6.5	Silt Loam
042111	BB2	1-3	29.8	0.87	2.63	0.04	0.06	97.1	1.3	1.6	Sand
042112	BB2	3-5	29.2	1.20	1.69	0.04	0.02	97.3	1.9	0.8	Sand
042110	BB2	0-1	30.0	1.25	2.66	0.09	0.09	92.0	5.8	2.2	Sand
042115	CC1	3-5	30.5	1.05	4.04	0.04	0.11	97.6	-0.8	3.2	Sand
042114	CC1	1-3	30.2	1.21	3.84	0.03	0.11	94.7	2.3	3.0	Sand
042113	CC1	0-1	32.2	8.04	13.0	0.07	0.59	89.8	7.7	2.5	Sand
042117	CC2	1-3	30.4	0.98	5.69	0.06	0.11	95.0	2.6	2.4	Sand
042118	CC2	3-5	32.7	1.34	6.05	0.04	0.23	97.6	-1.0	3.4	Sand
042116	CC2	0-1	30.2	1.39	2.35	0.14	0.27	91.2	5.8	3.0	Sand
042120	DD1	1-3	30.3	0.50	1.84	0.06	0.04	96.1	1.3	2.6	Sand
042121	DD1	3-5	31.4	1.14	2.21	0.16	0.07	97.0	0.6	2.4	Sand
042119	DD1	0-1	29.6	1.30	1.33	0.09	0.12	92.1	4.9	3.0	Sand

Lab No.	Field No.	Depth (feet)	% Saturation	ECe (mS/cm)	Nitrate (mg/kg dry soil)	Ortho-Phosphate (mg/kg dry soil)	Ammonia (mg/kg dry soil)	Textural Classification			
								%Sand	%Silt	%Clay	Laboratory Texture
042122	DD2	0-1	31.9	12.9	1.18	0.20	1.29	80.8	14.3	4.9	Loamy Sand
042123	DD2	1-3	27.4	20.2	14.3	0.12	0.40	63.5	29.9	6.6	Sandy Loam
042124	DD2	3-5	38.3	50.3	18.2	0.12	0.29	27.9	64.6	7.5	Silt Loam
042127	EE1	3-5	44.8	25.4	31.3	0.05	0.26	14.4	70.6	15.0	Silt Loam
042126	EE1	1-3	32.6	41.3	5.82	0.10	0.10	85.5	9.4	5.1	Loamy Sand
042125	EE1	0-1	31.1	99.1	22.3	0.26	0.19	79.4	11.7	8.9	Loamy Sand
042129	EE2	1-3	34.0	3.4	8.53	0.02	0.06	78.9	16.2	4.9	Loamy Sand
042130	EE2	3-5	48.4	4.92	22.6	0.03	0.17	3.6	72.6	23.8	Silt Loam
042128	EE2	0-1	35.3	21.9	12.4	0.05	0.11	62.7	28.8	8.5	Sandy Loam
042132	EE3	1-3	31.2	30.6	21.9	0.07	0.10	82.9	11.3	5.8	Loamy Sand
042133	EE3	3-5	46.3	34.7	32.3	0.08	0.29	10.8	77.6	11.6	Silt Loam
042131	EE3	0-1	34.2	41.6	32.4	0.05	0.13	74.3	19.7	6.0	Sandy Loam
042135	EE4	1-3	46.8	23.2	28.7	0.04	0.30	21.2	67.9	10.9	Silt Loam
042136	EE4	3-5	33.5	42.3	33.2	0.11	0.20	85.9	9.2	4.9	Loamy Sand
042134	EE4	0-1	34.4	95.2	64.7	0.29	0.61	70.0	21.4	8.6	Sandy Loam
042138	FF1	1-3	30.1	0.59	1.83	0.04	0.06	97.6	0.4	2.0	Sand
042139	FF1	3-5	30.3	0.68	2.82	0.03	0.05	98.2	-1.4	3.2	Sand
042137	FF1	0-1	31.3	0.74	5.79	0.03	0.12	96.4	1.2	2.4	Sand
042141	FF2	1-3	32.6	0.50	3.61	0.02	0.06	96.9	-0.6	3.7	Sand
042140	FF2	0-1	33.0	0.54	3.98	0.03	0.07	95.9	-0.2	4.3	Sand
042142	FF2	3-5	30.9	0.79	2.47	0.04	0.03	97.7	-0.1	2.4	Sand
042144	GG1	1-3	31.1	0.44	1.46	0.05	0.02	98.0	-1.2	3.2	Sand
042145	GG1	3-5	31.0	0.74	4.18	0.02	0.12	98.1	-0.4	2.3	Sand
042143	GG1	0-1	30.9	0.94	3.66	0.03	0.06	95.5	0.5	4.0	Sand
042147	GG2	1-3	30.3	0.36	1.00	0.05	0.04	97.6	-1.2	3.6	Sand
042148	GG2	3-5	30.8	0.57	2.29	0.02	0.03	98.0	-1.3	3.3	Sand
042146	GG2	0-1	31.2	0.77	5.99	0.06	0.10	97.2	-1.4	4.2	Sand

Table 10. Soil Sampling Results, 2004, Continued

Lab No.	Field No.	Depth (feet)	% Saturation	ECe (mS/cm)	Nitrate (mg/kg dry soil)	Ortho-Phosphate (mg/kg dry soil)	Ammonia (mg/kg dry soil)	Textural Classification			
								%Sand	%Silt	%Clay	Laboratory Texture
042150	HH1	1-3	30.7	0.40	2.06	0.04	0.04	98.1	0.7	1.2	Sand
042151	HH1	3-5	29.9	0.75	1.28	0.02	0.07	91.5	7.3	1.2	Sand
042149	HH1	0-1	31.5	1.04	8.86	0.10	0.07	93.4	3.4	3.2	Sand
042153	HH2	1-3	31.9	0.64	1.67	0.02	0.05	96.6	1.6	1.8	Sand
042154	HH2	3-5	31.3	1.22	3.47	0.03	0.07	97.2	1.1	1.7	Sand
042152	HH2	0-1	33.7	3.38	14.7	0.04	0.28	76.9	18.6	4.5	Loamy Sand
042155	II1	0-1	30.4	1.59	0.43	0.07	0.16	90.5	6.6	2.9	Sand
042156	II1	1-3	31.0	2.05	0.08	0.22	0.03	88.2	8.5	3.3	Sand
042157	II1	3-5	38.6	17.7	18.6	0.07	0.13	35.8	57.9	6.3	Silt Loam
042160	II2	3-5	30.7	0.82	0.96	0.03	0.03	96.3	1.8	1.9	Sand
042159	II2	1-3	28.5	0.97	2.58	0.07	0.04	77.4	18.6	4.0	Loamy Sand
042158	II2	0-1	30.8	1.09	0.72	0.08	0.10	90.8	6.1	3.1	Sand
042161	JJ1	0-1	34.3	6.63	5.05	0.10	0.35	77.1	15.6	7.3	Sandy Loam
042162	JJ1	1-3	32.4	13.0	3.73	0.02	0.04	92.1	4.5	3.4	Sand
042163	JJ1	3-5	35.4	25.6	8.32	0.04	0.07	41.7	50.8	7.5	Silt Loam
042165	JJ2	1-3	31.9	0.63	4.21	0.03	0.02	97.4	-0.5	3.1	Sand
042166	JJ2	3-5	31.0	1.16	1.54	0.03	0.05	97.6	-0.9	3.3	Sand
042164	JJ2	0-1	32.2	1.26	0.47	0.05	0.24	92.8	3.1	4.1	Sand
042168	KK1	1-3	31.2	0.36	2.66	0.05	0.02	98.0	-0.7	2.7	Sand
042167	KK1	0-1	29.6	0.54	1.58	0.04	0.06	96.5	1.1	2.4	Sand
042169	KK1	3-5	32.0	0.80	5.20	0.02	0.01	97.6	-0.3	2.7	Sand
042172	KK2	3-5	31.5	0.54	3.25	0.02	0.04	98.0	-0.6	2.6	Sand
042171	KK2	1-3	31.0	0.61	1.81	0.04	0.05	97.1	0.2	2.7	Sand
042170	KK2	0-1	33.0	0.81	1.32	0.08	0.13	92.9	3.7	3.4	Sand
042174	LL1	1-3	29.2	0.45	3.12	0.06	0.02	97.7	-0.3	2.6	Sand
042173	LL1	0-1	31.7	0.69	4.00	0.06	0.08	95.3	1.6	3.1	Sand

Lab No.	Field No.	Depth (feet)	% Saturation	ECe (mS/cm)	Nitrate (mg/kg dry soil)	Ortho-Phosphate (mg/kg dry soil)	Ammonia (mg/kg dry soil)	Textural Classification			
								%Sand	%Silt	%Clay	Laboratory Texture
042175	LL1	3-5	31.6	0.84	6.13	0.02	0.04	97.9	-0.4	2.5	Sand
042177	LL2	1-3	30.0	0.36	2.64	0.05	0.02	98.1	-0.1	2.0	Sand
042176	LL2	0-1	30.7	1.00	6.37	0.02	0.05	95.4	2.0	2.6	Sand
042178	LL2	3-5	30.8	1.38	5.88	0.02	0.04	98.3	-0.4	2.1	Sand
042179	MM1	0-1	29.4	4.70	35.0	0.12	0.41	78.8	16.6	4.6	Loamy Sand
042180	MM1	1-3	28.0	6.62	15.4	0.04	0.15	69.2	27.5	3.3	Sandy Loam
042181	MM1	3-5	37.8	15.0	3.31	0.08	0.06	34.3	59.0	6.7	Silt Loam
042183	MM2	1-3	27.6	0.74	2.14	0.06	0.02	80.6	16.9	2.5	Loamy Sand
042184	MM2	3-5	26.9	1.04	1.94	0.06	0.03	88.0	10.4	1.6	Sand
042182	MM2	0-1	26.6	1.28	2.52	0.04	0.03	79.4	17.4	3.2	Loamy Sand

Table 11. Habitat Types - Lower Colorado River

Habitat Type	Characteristics
Cottonwood-willow	*Salix gooddingii* and *Populus fremontii* (the latter usually in low densities) constituting at least 10% of total trees (remaining trees are usually saltcedar).
Saltcedar	*Tamarix* spp. constituting 80–100% of total trees.
Honey mesquite	*Prosopis glandulosa* constituting 90–100% of total trees.
Saltcedar–honey mesquite	*Prosopis glandulosa* constituting at least 10% of total trees; rarely found to constitute more than 40% of total trees.
Saltcedar–screwbean mesquite	*Prosopis pubescens* constituting at least 20% of total trees.
Arrowweed	*Pluchea sericea* constituting 90–100% of total vegetation in area.
Atriplex	*Atriplex lentiformis*, *A. canescens*, and/or *A. polycarpa* constituting 90–100% of total vegetation in area.
Source: Anderson and Ohmart 1984b.	

Table 12. Woody Riparian Structural Types – Lower Colorado River

Structural Type	Description of Vegetation
Type I	Mature stand with distinctive overstory more than 15 feet tall; intermediate class is 2–15 feet tall and understory is 0–2 feet tall.
Type II	Overstory is more than 15 feet tall and constitutes more than 50% of the trees; little or no intermediate class present.
Type III	Largest proportion of trees is 10–20 feet tall; few trees above 20 feet or below 5 feet tall.
Type IV	Few trees above 15 feet tall; 50% of the vegetation is 5–15 feet tall and 50% is 1–2 feet tall.
Type V	60–70% of the vegetation is 0–2 feet tall, the remainder is 5–15 feet tall.
Type VI	75–100% of the vegetation is 0–2 feet tall.
Source: Anderson and Ohmart 1984b.	

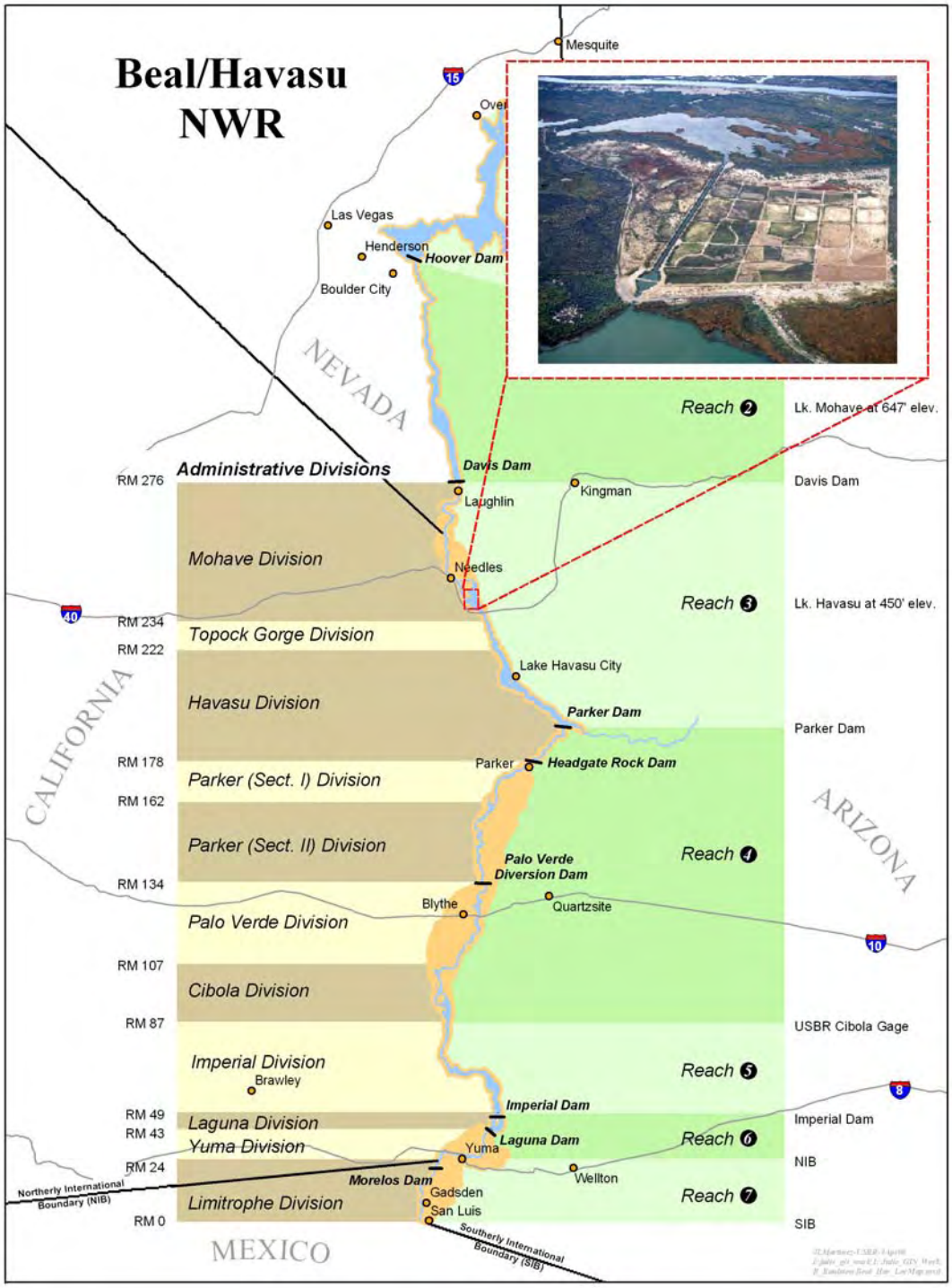


Figure 1. Beal Riparian Restoration Project site location with inset showing an aerial view of the areas planted; Beal Lake (top) and Topock Marsh (bottom).

Figure 2. By Fall 2003, Phase 1 (outlined in red) was cleared, leveled, and separated into fields by with earthen berms. Beal Lake is at the top left corner of the photo and the irrigation reservoir is at the bottom right corner.

Figure 3. By Spring 2004, Phase 1 (outlined in red) was partially planted, Phase 2 (outlined in yellow) had been cleared, and Phase 3 (outlined in blue) had been partially cleared. Beal Lake is at the top and Topock Marsh at the bottom of the photo.

Figure 4. Aerial Photo of Beal Restoration Site, August 2006. Field Labels and Average Elevations (Black), Well Locations (Blue), and Irrigation Valves (Red).

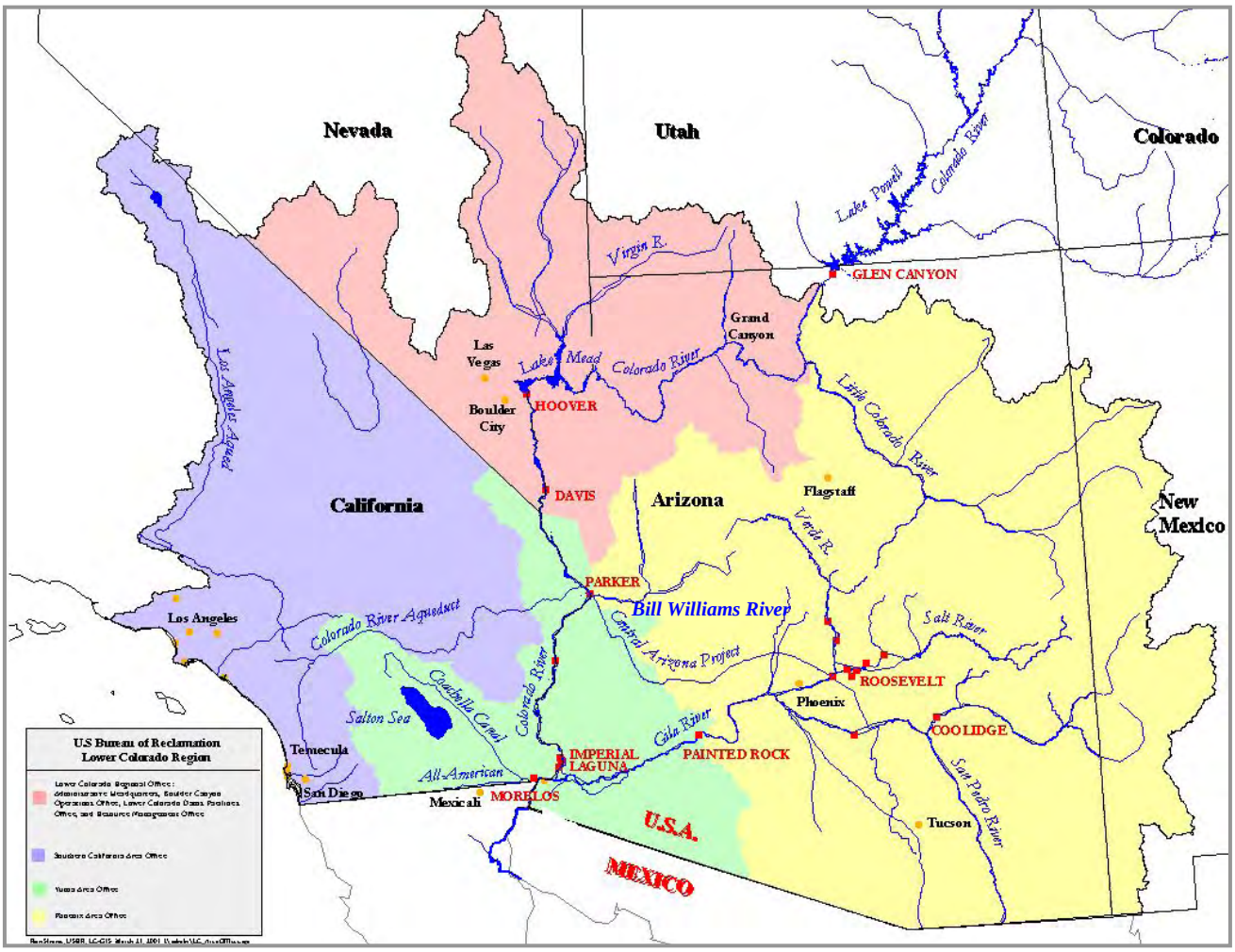


Figure 5. Seeding of cottonwood and willow occurs at various times from March–July on the lower Colorado River and its southernmost tributaries, the Bill Williams and Gila rivers.

Figure 6. Seed collecting with a dry vacuum modified with PVC pipe and operated with a small generator from the back of a pickup truck was used to reach seeds.

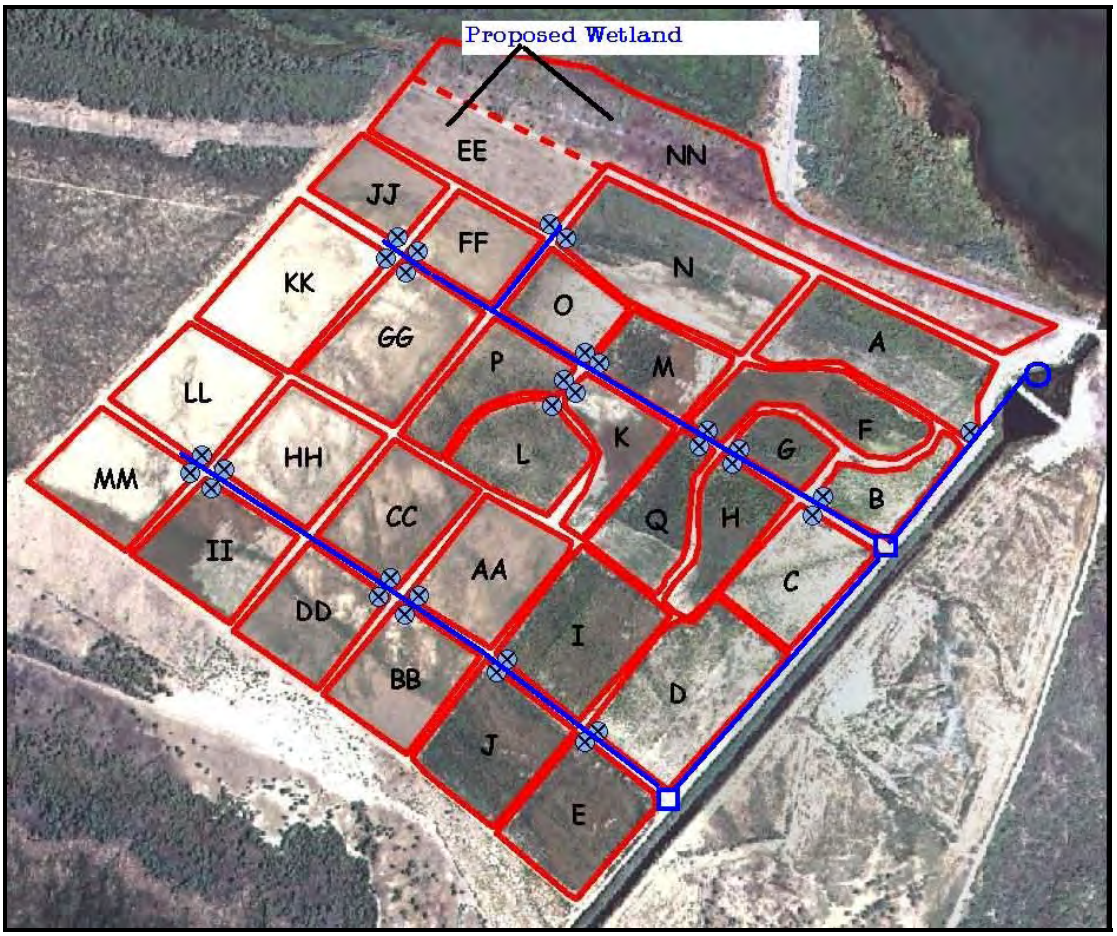


Figure 7. Irrigation infrastructure at Beal includes the pump (blue circle), 30 alfalfa valves (blue circles with Xs in center), 2 butterfly valves (blue diamonds), and approximately 5,000 linear feet of irrigation pipe (blue lines). Red lines are field borders (aerial photo taken August 2004).

Figure 8. The pump used to irrigate all fields is located at the NE corner of Phase 1, over the irrigation reservoir identified in Figure 1.

Figure 9. Installation of 4000 linear feet of irrigation pipe in Phase 1 was completed in April 2003.

Figure 10. Rock was placed around all alfalfa valves to prevent erosion. This partially open valve is surrounded by *Salix exigua* spread by vegetative growth of planted cuttings.

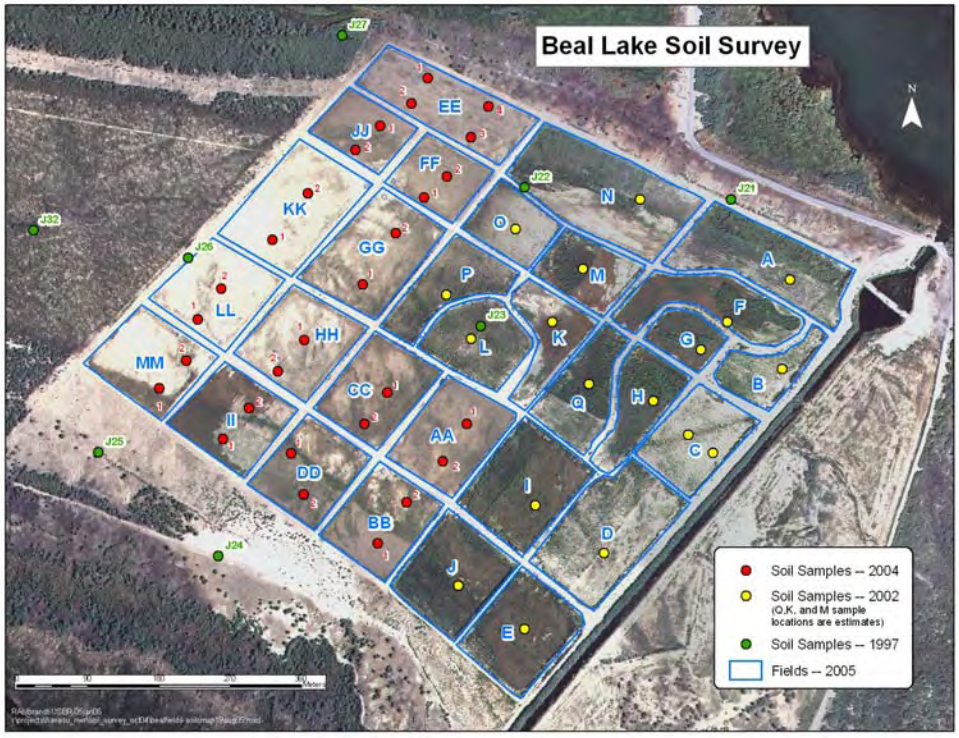


Figure 11. Yellow, red, and green circles represent soil sampling locations in phases 1 and 2 (aerial photo taken August 2004).

Figure 12. Miniscule seedlings germinating on the surface of the wet soil.

Figure 13. The hydroseed mixture was sprayed onto the wet field.

Figure 14. Branches with seeds still attached are placed directly into wet soil to mimic natural seed dispersal.

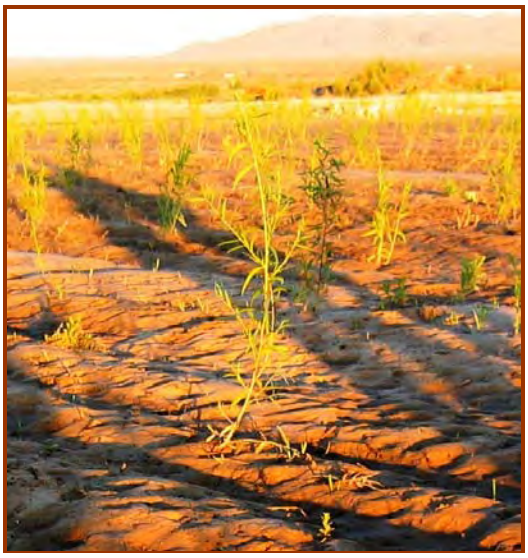


Figure 15. Newly planted willows from container plants are 1-3' tall when planted.

Figure 16. Typically 3000 container plants or poles per day can be planted using a tree planter pulled behind a tractor.

GOODDING'S WILLOW (*Salix gooddingii)*

DEVELOPMENTAL **DESCRIPTION OF DEVELOPMENTAL STAGE AND PHOTO**

STAGE		GERMINATION
1	All pods on tree very green and unopened when collected directly from tree.	21%
2	Pods were collected while completely green, none opened on tree, but opened later after collected.	18%
3	Pods were yellowish when collected, but not opened yet on tree. Opened after collected.	88%
4	Completely open pods, fluff abundant on catkin when collected from tree.	% N/A

GOODDING'S WILLOW (*Salix gooddingii)*		
DEVELOPMENTAL STAGE	**DESCRIPTION OF DEVELOPMENTAL STAGE AND PHOTO**	**% GERMINATION**
5	Few to no green pods remaining on tree, most seed dispersed, mostly brown, dry catkins with few seeds remaining. (Photo N/A)	% N/A
6.	Male Flower 	
FREMONT COTTONWOOD (*Populus fremontii*)		
1	Very green pods, none opened on tree when collected, unknown if seedpod opened prior to germination testing. 	78%
2	 Pods unopened when collected from tree, known to have opened 1 day later.	2003 results 56% 2004 results 58%
3	Slightly opened seed pods and/or at least one pod opened/slightly opened in cluster (photo not available)	98%
4	Seed collected fully open and fluffy or tree actively dispersing and pod opened after collection (photo not available)	90%
5	Seed collected when pods very brown and dry, all open when collected from tree (photo not available)	87%

Figure 18. Plastic growing tubes were used instead of gallon-sized containers to save space and labor.

Figure 19. Seeding in Field G resulted in a dense patch of Goodding's willow in the center of the field, surrounded by arrowweed and saltcedar.

Figure 20. Seeding in Field H resulted in dense cottonwood and Goodding's willow mixed with arrowweed and saltcedar throughout approximately half the field. The other half resulted in mostly arrowweed.

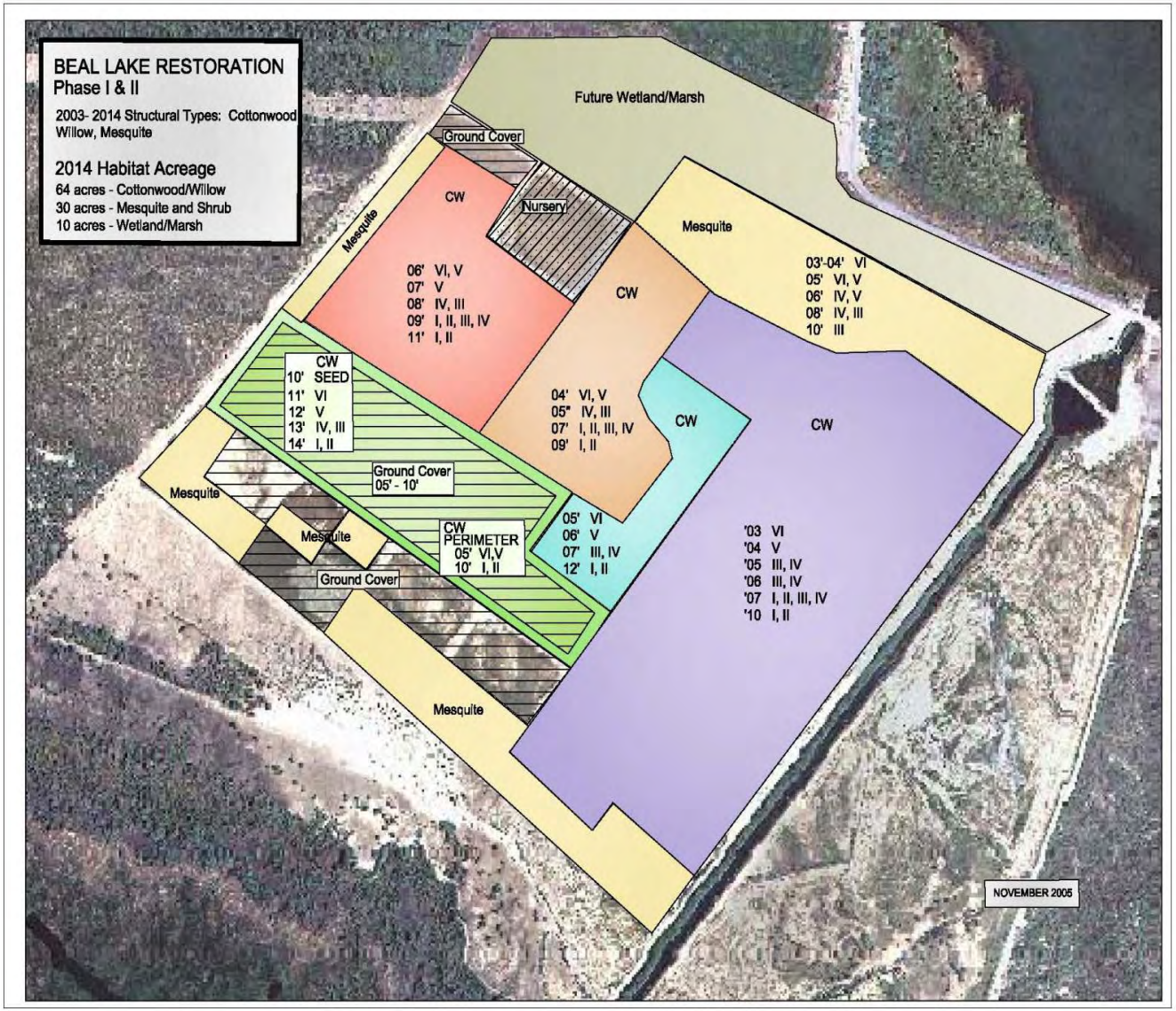


Figure 21. Targeted Habitat Types for the Beal Restoration Site.

Figure 22. Trees from gallon-sized container plants spaced approximately five feet apart successfully shade out weeds. These trees are in their first growing season.

Figure 23. Trees planted around the perimeter of the field will be the seed source for the center of field in 3-5 years.

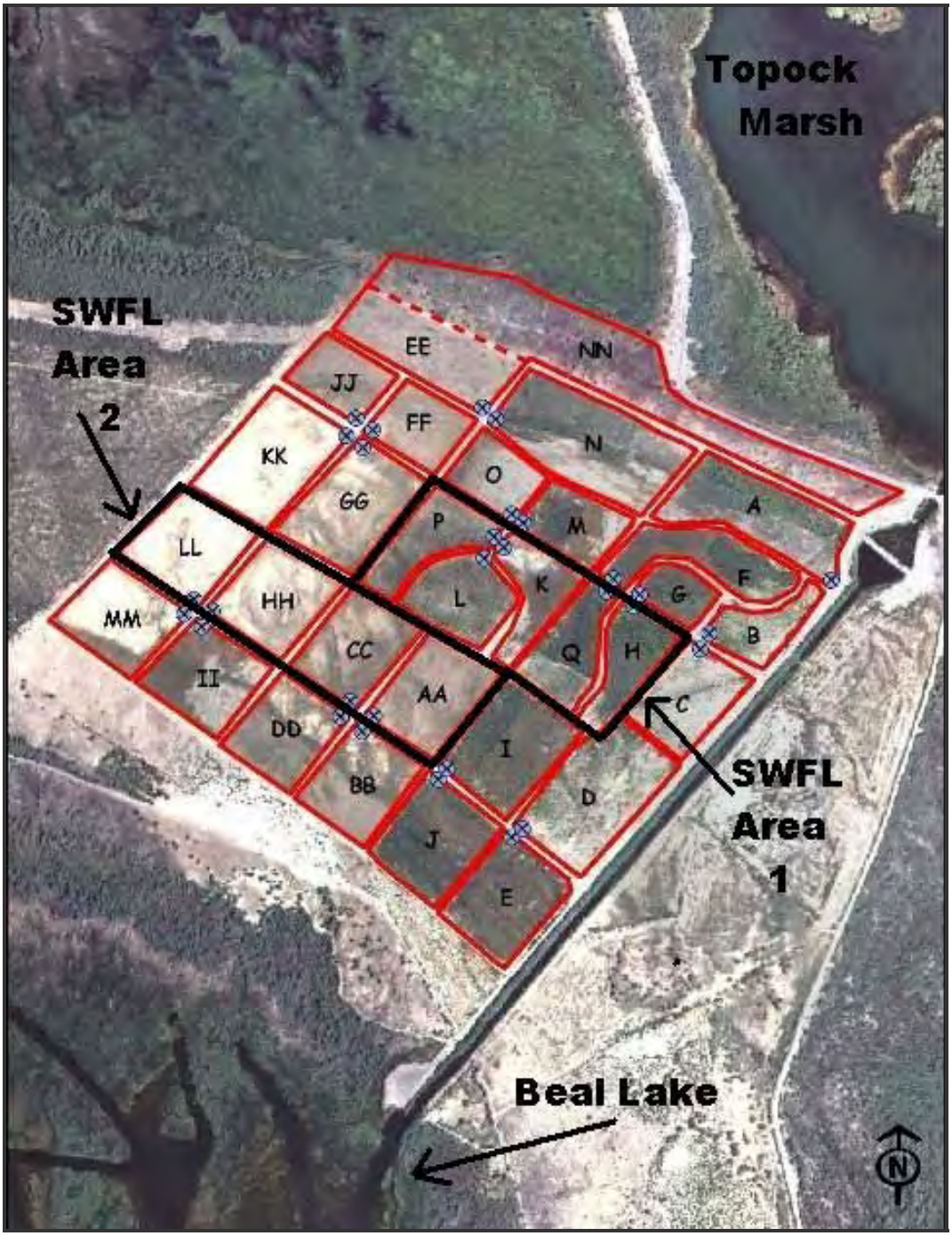


Figure 24. SWFL Management Areas 1 and 2.

Appendix A. Habitat Monitoring Results, 2004-2005

Methods

Vegetation monitoring was conducted in phases 1 and 2 during November and December of 2004 and 2005. Since the fields were planted or seeded in different years (2003, 2004, and 2005) they were in different stages of growth when monitored. Fields planted in 2003 were not monitored after the first growing season (Table A-1). No monitoring was conducted in Phase 3.

Diameter at Breast Height, Height and Survivorship

Fields that were planted using container plants or cuttings were monitored for height, diameter at breast height (DBH), and survivorship annually after the first two growing seasons (Table A-1). A total count of live and dead trees per species was conducted in each field. Only trees originally planted were counted (i.e., volunteers and root-sprouts were ignored). Diameter at breast height was measured at 4.5 ft (1.4 m) above the ground on the uphill side of the tree. Height and condition of every one hundredth tree were also measured. Height was measured using a telescoping survey rod and recorded to the nearest 0.3 ft (0.1 m). Diameter at breast height was measured using a metric steel diameter tape and recorded to the nearest 0.04 in (0.1 cm).

Fixed Radius Plots

Fixed radius plots were established in seeded areas after the first growing season. Fixed radius plots were established after the third growing season in fields planted with container plants or cuttings (Table A-1). These plots will be monitored annually through the sixth growing season, and every other year from the sixth through the tenth growing season. Plots were established using a simple random sampling design. The lengths of the two perimeter axes (x and y) of each field were measured. For each plot in each field, a random number generator was used to generate a coordinate (x, y) for the plot. In cases where generated coordinates resulted in location outside the field boundaries, the plot was moved to a place inside the field that was at least 16.4 ft (5.0 m) from the boundaries of the field. When one of the boundaries of a plot intersected the boundaries of an existing plot, the plot was rejected and new coordinates were chosen. One, 37.1 ft (11.3 m) fixed-radius plot was established per 1.0 ac (0.4 ha) in each field. The center of each plot was marked by a fence post and its Universal Transverse Mercator (UTM) coordinates were recorded using a handheld Garmin GPS unit.

Height, DBH, and species were recorded for all trees within the 37.1-ft (11.3-m) plot measuring at least 4.5 ft (1.4 m) in height and 5.0 in (12.7 cm) in DBH. Trees measuring at least 4.5 ft (1.4 m) in height and 3.1-5.0 in (8.0-12.7 cm) in DBH were tallied by species. Trees that were branched below 4.5 ft (1.4 m) were counted as two separate trees. Trees branched above 4.5 ft (1.4 m) were counted as one tree and the branch with the greatest DBH was measured. Trees were only counted if at least 50% of the base of the tree was located in the quadrant.

A sub-plot with a 16.4 ft (5.0 m radius) from the plot center was nested inside the 37.1 ft (11.3 m) radius plot. Height, DBH, and species were recorded for all stems within the 16.4 ft (5.0 m) plot measuring at least 4.5 ft (1.4 m) in height and 3.1 in (8.0 cm) in DBH. Single stems at least

4.5 ft (1.4 m) in height but less than 3.1 in (8.0 cm) in DBH were tallied by species and DBH class (<0.4 in (1.0 cm), 0.5-0.9 in (1.0-2.5 cm), 1.0-2.2 in (2.6-5.5 cm), and 2.3-3.0 in (5.6-7.9 cm)). Stems branched below 3.9 in (10.0 cm) were considered separate trees. Stems that were branched above 3.9 in (10.0 cm) were counted as one stem and the branch with the greatest DBH was measured. All branches that had a DBH of greater than 3.1 in (8.0 cm) were considered separate individuals whether they were branched above or below 13.9 in (10.0 cm). Stems were only counted if at least 50% of the base of the stem was located in the quadrant.

For all plots, height of trees and stems were measured using a telescoping survey rod and recorded to the nearest 0.3 ft (0.1 m). Diameter at breast height of trees and stems were measured using a metric steel diameter tape measured to the nearest 0.4 in (0.1 cm).

Herbaceous ground cover was estimated by sampling four 3.3 ft (1.0 m) square quadrants located 3.3 ft (1.0 m) from the plot center in each cardinal direction. Percent cover was estimated and recorded by species and substrate (i.e., bare ground, leaf litter, woody debris) in each quadrant. Woody stems less than 4.5 ft (1.4 m) in height that were located in the quadrant were tallied.

Vertical foliage was estimated 3.3 ft (1.0 m) from the plot center in each cardinal direction. The presence of live vegetation within a 3.9 in (10.0 cm) radius of a 24.6 ft (7.5 m) survey rod was recorded by species in 3.3 ft (1.0 m) intervals to a height of 24.6 ft (7.5 m). Dead vegetation was recorded in the same manner but not identified to species. Crown closure was estimated 3.3 ft (1.0 m) interval from the plot center in each cardinal direction using a spherical densiometer.

Data Analysis

Averages and standard errors were calculated for all parameters per species per planting technique on all fields. A single factor analysis of variance test was used to determine differences in density of saplings, shrubs, and woody understory, between species, and in percent of cover between cover types. When differences were detected, a Tukey multi-comparison test was conducted to see which means differed. A t-test assuming unequal variances was used to determine differences in density of sapling and shrubs, density of woody understory, and percent cover between fields that were seeded and fields that were planted with container plants. A t-test assuming unequal variances was used to determine differences of parameters between years.

Species richness, diversity, and evenness were calculated for sapling and shrubs per field for the sections of the site where fixed-radius plots were conducted. Species richness is defined as the total number of species present. 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:

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

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 5.0 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.

Sample sizes to accurately determine density for sapling and shrub species using simple random sampling was calculated using an equation from Elzinga et al. (2001). The equation used was for determining the necessary sample size for estimating a single population mean or a population total with a specified level of precision:

$$n=[Z_a][s]^2/[B]^2$$

where n = the sample size, Z_a = the standard normal coefficient for a 95% confidence interval, s = standard deviation, and B = the desired precision level expressed as half of the maximum acceptable confidence width (Elzinga et al. 2001). Sample sizes were calculated to determine feasibility of using a simple random sampling approach at this project. Precision levels of 20% and 30% were used to calculate sample size.

Results 2004 Phase 1

DBH, Height and Survivorship

Fremont cottonwood, coyote willow, screwbean mesquite, and Goodding's willow trees were measured for DBH and height on six fields (B, C, D, E, I, and J) (Table A-2). Annual growth could not be calculated because 2004 was the first year that trees in these fields were measured for height and DBH. Survivorship could not be calculated for these fields because number of trees planted was not known.

Fixed Radius Plots

Seven seeded fields (A, F, G, H, M, N, and Q) were monitored using fixed-radius plots. None of the plots contained trees that had a height and DBH range of overstory trees. None of the plots contained sapling species > 5.0 in (12.7 cm) DBH or shrub species > 3.1 in (8.0 cm) DBH; therefore, an average height of sapling and shrub species could not be obtained for 2004.

Total density of sapling and shrub species on the seven fields was 16,570/ac (41,424/ha) (Table A-3, Figure A-1). Total species richness of sapling and shrubs was 7.0 species. Species diversity was equal to 1.6 species of equal abundance on a scale of 0.0 to 7.0. A value of 7.0 would mean an equal number of individuals per species; as the value decreases the numbers of individuals per

species becomes increasingly unequal. Species evenness was 0.25 in species similarity on a scale of 0.0 to 1.0 (Table A-4). A value of 1.0 means proportions of species is similar and the value approaches zero as proportions of species becomes dissimilar. A higher density ($p < 0.05$) of arrowweed was detected than for other shrub and sapling species.

Seven woody species were present in the understory layer, with a total density of 63,500/ac (159,000/ha) (Table A-5, Figure A-2). A higher density ($p < 0.05$) of saltcedar and arrowweed was detected than for other woody understory species. Six types of cover made up the herbaceous ground layer (Table A-6, Figure A-3). A higher percentage of bare ground ($p < 0.05$) was detected than for other cover types.

Thirteen feet (4-m) layers of vertical foliage were present and comprised seven species, with the first meter layer containing the largest percentage 49% of vegetation (Table A-7).

Results 2005 Phase 1 and 2

DBH, Height and Survivorship

The mean height of Fremont cottonwood trees was greater ($p < 0.05$) in 2005 than in 2004 (Table A-8). Survivorship was calculated for fields C and D by species and for the Phase 2 cuttings (perimeter plantings). For field C, survivorship of Fremont cottonwood and coyote willow trees after the second growing season was 100% and 55.12%, respectively. For field D, survivorship of Fremont cottonwood, coyote willow, and Goodding's willow trees after the third growing season was 82%, 100%, and 94%, respectively. For the Phase 2, perimeter plantings of Fremont cottonwood and Goodding's willow trees combined survivorship after the first growing season was 74%. Survivorship could not be calculated for the other fields because the number planted was not known. The density of planted trees (Fremont cottonwood, coyote willow, and Goodding's willow) in B, E, I, and J did not decrease in density from 2004 to 2005. Annual growth was only calculated in fields that were measured in 2004, which included Phase 1 but not Phase 2.

Fixed Radius Plots

None of the plots contained trees that had a height and DBH range of overstory trees. None of the plots contained sapling < 5.0 in (12.7 cm) DBH or shrub species that had a DBH > 3.1 in (8.0 cm); therefore, an average height of saplings and shrub species could not be obtained for the 2005 season.

Total density of sapling and shrub species in the seven fields that were seeded was 12,528/ac (31,323/ha) (Table A-9, Figure A-4). Total density of sapling and shrub species in the four fields that were planted with container plants was 15,896/ac (39,740/ha) (Table A-9, Figure A-4). Total species richness of sapling and shrub species on the 11 fields was 9.00 species. Species diversity was equal to 2.38 species of equal abundance on a scale of 0.00 to 9.00. A value of 9.00 would mean an equal number of individuals per species; as the value decreases the number of individual per species becomes increasingly unequal. Evenness was 0.39 in species similarity on a scale of 0.00 to 1.00 (Table A-10). A higher density of arrowweed ($p < 0.05$) was detected than for other shrub and sapling species on the 11 fields.

There was a total of seven woody species present in the understory layer on the 11 fields where fixed radius plots were conducted. The total density was 66,200/ac (165,500/ha) (Table A-11,

Figure A-5). Six types of cover made up the herbaceous ground layer on the 11 fields where fixed radius plots were conducted (Table A-12, Figure A-6). Bare ground was present more ($p < 0.05$) than other ground cover, followed by leaf litter. The density of *Baccharis* spp. in the woody understory was greater ($p < 0.05$) in 2005 than in 2004.

Sixteen-feet (5-m layers) of vertical foliage, comprising six species, were present in the fields that were planted with potted plants. The first- and second-meter layer contained the highest percentage of vegetation, 32% and 28%, respectively (Table A-13). Sixteen feet (4-m layers) of vertical foliage, comprising eight species, were present in the fields that were seeded. The first and second-meter layer contained the highest percentage of vegetation, 33% and 16%, respectively (Table A-14).

No differences ($p > 0.05$) in density of saplings and shrub species, density of woody understory, and percent of cover were detected between areas planted with potted plants and seeded areas. The sample size needed for accurately determining density of all shrub and sapling species for 2005 is shown in Table A-16.

Discussion

Changes to the 2006 habitat monitoring protocol will be made based on results from 2004 and 2005 to make them consistent with protocols for other conservation areas. Survivorship could not be calculated in most of the fields because the actual numbers of trees were not counted when planted. Future efforts will involve counting trees when planted so survivorship can be determined.

The project is a demonstration that was designed to test various methods of creating habitat. This project is also being used to test various methods of vegetation monitoring at habitat creation projects. A stratified random sampling design at this project, as well as future projects, will produce more representative data than a simple random sampling design. Cottonwoods and willows in seeded sections survived in groups rather than being equally distributed across the fields. Thirty-three fixed-radius plots were sampled in 2005, a lower sample size than needed to accurately determine density for every species except arrowweed. Biologists calculated sample sizes (Elzinga et al. 2001) needed to accurately determine the mean density of shrubs and saplings per species if simple random sampling was conducted (Table A-16). It is not feasible to sample that number of fixed-radius plots. Therefore, future monitoring will use a stratified sampling method, which will reduce the sample size needed. The area will be stratified based on Anderson and Ohmart (1976, 1984) vegetative communities and structural types using annual aerial photos and ground-truthing. Each vegetative community and structural type will be represented for a clearer picture of the overall habitat created at the project.

The calculations for the fixed-radius plots in 2005 only represent 11 of the 26 fields, and may not be representative of the whole project. Some fields are still in the developmental stage, and others were only measured for height and DBH according to protocol. The seeded areas had less success than areas with container plants that left more open unshaded areas, possibly allowing for greater establishment of arrowweed. Two of the fields planted with container plants (E, J) had high mortality of coyote willows in 2004 (Table 2-3), resulting in areas dominated by arrowweed. Fields E, I, and J had high electro-conductivity (EC) values, which may also explain

high mortality and presence of arrowweed. When additional fields planted with container plants reach their third year of growth, calculations for fixed-radius plots will include more of the restored area making results more representative of the entire project.

Mortality of coyote willows in fields E and J in 2004 was high, but many coyote willows have vegetatively reproduced more than the other planted species. Therefore, density of coyote willows at the site has actually increased from 2004 to 2005 (Table A-15).

Arrowweed was the dominant species in the shrub and sapling population in 2004 (89%) and 2005 (79%), with the majority of plants having a DBH of < 0.4 in (1 cm). Arrowweed was the most abundant in areas where cottonwood or willow seed did not germinate, where there was a large mortality of planted trees, or along the edges of the field where no trees were planted. As the project matures, the tree species planted (cottonwoods, willows, and mesquites) should begin to shade out arrowweed.

Arrowweed and saltcedar were also the dominant species in the woody understory in 2004 and 2005; both species vegetatively reproduced. One of the goals of this project was to create functioning habitat with as little non-native vegetation encroachment as possible. Saltcedar was the only non-native woody species present at the site, and although it dominated the woody understory, it was present in low amounts in 2004 (6%) and 2005 (5%) in the sapling size class. The growth of arrowweed in areas where cottonwood, willow, and mesquite did not grow may be preventing saltcedar encroachment. Saltcedar encroachment is more problematic in seeded than in areas with potted plants. The fact that the potted areas were located on the outer edge of the project may be preventing saltcedar encroachment in the interior seeded portion of the site.

Noticeable differences in vegetation communities between the years include an increase of *Baccharis* spp. in the woody understory, a decrease in vegetation volume in the first-meter layer, and an increase in vegetation volume in the second-meter layer from 2004 to 2005. Vegetation volume in the higher meter layers should increase as the project matures.

Literature Cited

Bureau of Reclamation. 2004. Annual survivorship growth of restoration sites (unpublished report). Boulder City, Nevada.

Elzinga, C.L., D.W. Salzer, J.W. Willoughby, and J.P. Gibbs 2001. Monitoring plant and animal populations. Malden, MA: Blackwell Science, Inc. 360 pp.

Krebbs, C. 1989. Ecological methodology. Harper and Row, New York.

MacArthur, R.H. 1965. Patterns of species diversity. Biological Review 40:510-533.

Nur, N., S.L. Jones, and G.R.Guepel. 1999. A statistical guide to data analysis of avian monitoring programs. U.S. Department of the Interior, Fish and Wildlife Service, BTP-R60001-1999. Washington D.C.

Ohmart, R.D., B.W. Anderson, and W.C. Hunter. 1988. The ecology of the lower Colorado River from Davis Dam to the Mexico-United States International Border: A community profile. USDI Fish and Wildlife Service. Biological Report 85 (7.19).

Rosenberg, K.V., R. Ohmart, W. Hunter, and B. Anderson. 1991. Birds of the Lower Colorado River Valley. The University of Arizona Press, Tucson, Arizona.

Figure A-1. Relative abundance of sapling and shrub per species, Beal Lake Habitat Creation Project, Phase 1, 2004, Fields A, F, G, H, M, N, Q.

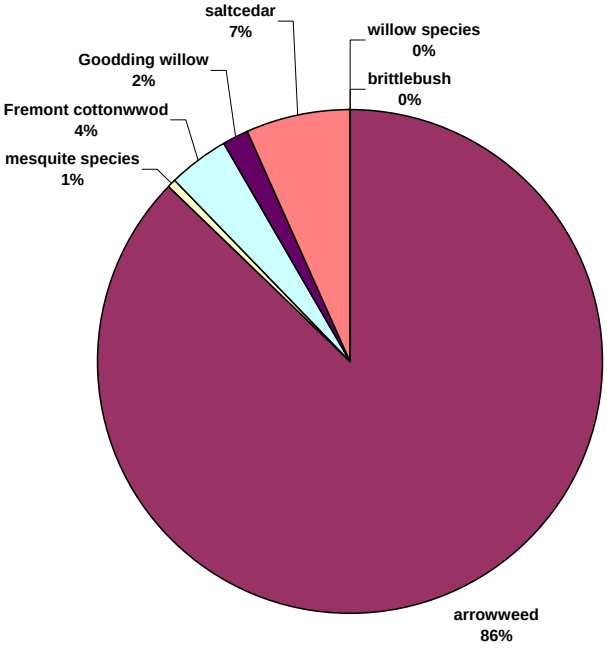


Figure A-2. Relative abundance of woody understory stems, per species, Beal Lake Habitat Creation Project, Phase 1, 2004, Fields A, F, G, H, M, N, Q.

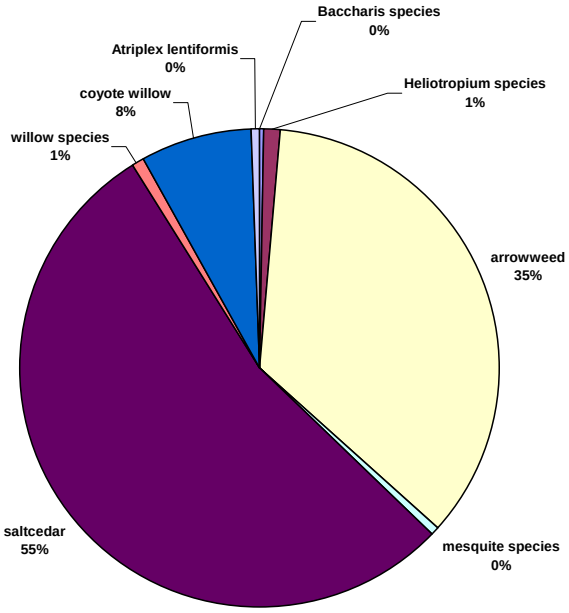


Figure 3. Percentage of herbaceous cover, per cover type, Beal Lake Habitat Creation Project, Phase 1, 2004, Fields, A, F, G, H, M, N, Q.

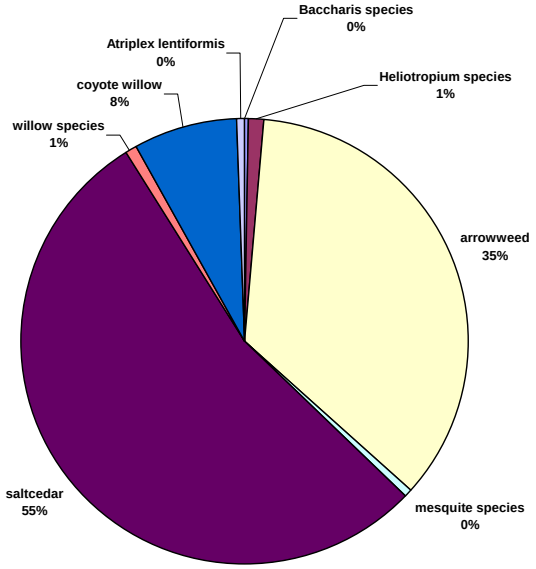


Figure 4. Relative abundance of sapling and shrubs per species, Beal Lake Habitat Creation Project, Phase 1, 2005, Fields A, F, G, H, M, N, Q, B, E, I, J.

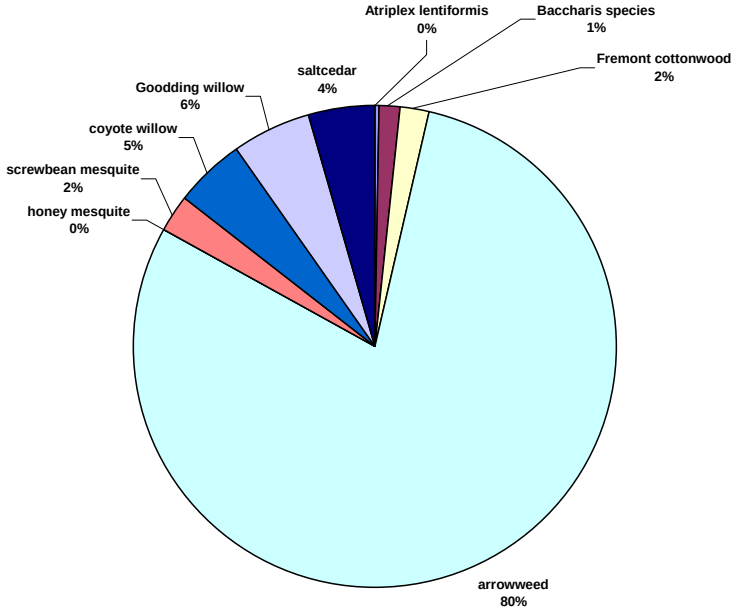


Figure 5. Relative abundance of woody understory stems, per species, Beal Lake Habitat Creation Project, Phase 1, 2005, Fields A, F, G, H, M, N, Q, B, E, I, J.

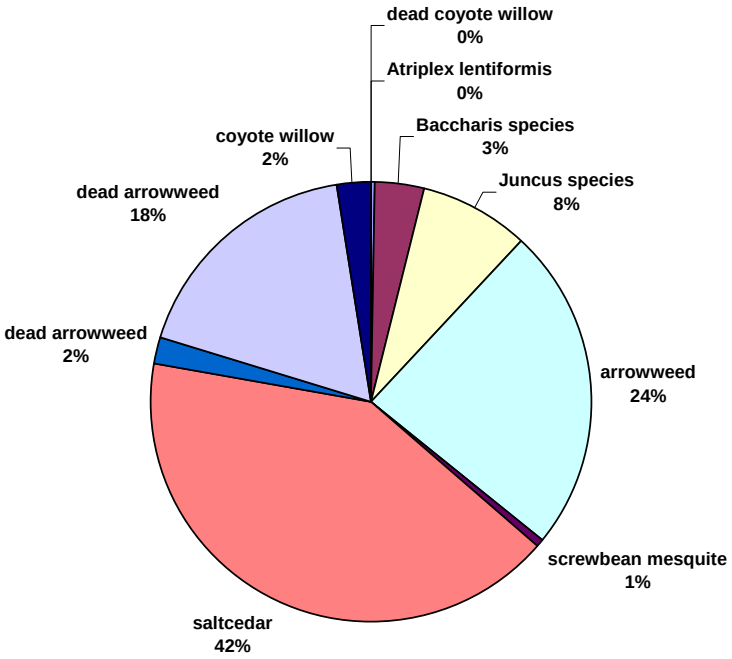


Figure 6. Percentage of cover, per cover type, Beal Lake Habitat Creation Project, 2005, Phase 1, Fields A, F, G, H, M, N, Q, B, E, I, J.

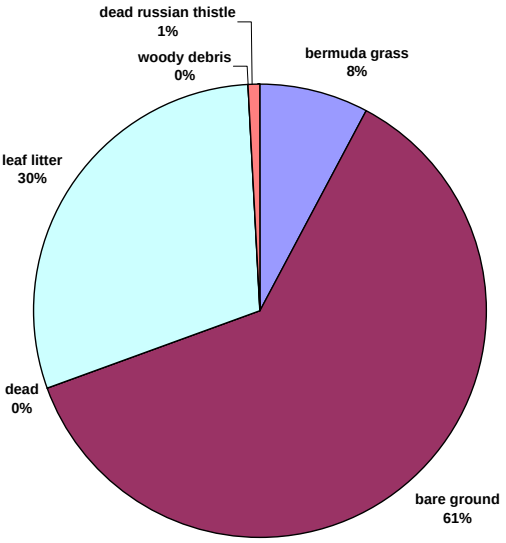


Table A-1. Monitoring method (survivorship and growth or fixed radius plots) conducted in each field in 2004 and 2005.

Field	Year	Monitoring method	Date planted	Planting technique	Growing season monitoring began
A	2004-2005	fixed radius plots	April 2003	hydroseeded	
B	2004	DBH, height and survivorship	May 2003	container plants	after 2nd
B	2005	fixed radius plots	May 2003		after 2nd
C	2004-2005	DBH, height and survivorship	January 2004	container plants	after 1st
D	2004-2005	DBH, height and survivorship	May 2003 Jan. 2004	container plants	after 2nd
E	2004	DBH, height and survivorship	May 2003 Jan. 2004	container plants	after 2nd
E	2005	fixed radius plots			after 3rd
F	2004-2005	fixed radius plots	April 2003	hydroseeded	after 2nd
G	2004-2005	fixed radius plots	April 2003	hydroseeded	after 2nd
H	2004-2005	fixed radius plots	April 2003	hydroseeded	after 2nd
I	2004	DBH, height and survivorship	May 2003	container plants	after 2nd
I	2005	fixed radius plots			after 3rd
J	2004	DBH, height and survivorship	May 2003	container plants	after 2nd
J	2005	fixed radius plots			after 3rd
M	2004-2005	fixed radius plots	March 2003	hydroseeded	after 2nd
N	2004-2005	fixed radius plots	March 2003	hydroseeded	after 2nd
O	2005	DBH, height and survivorship	April 2004	container plants	after 2nd
P	2005	DBH, height and survivorship	April 2004	container plants	after 2nd
Q	2004-2005	fixed radius plots	April 2003	hydroseeded	after 2nd
AA	2005	DBH, height and survivorship	Nov. 2004 Jan. 2005	container plants/cuttings	after 1st
BB	2005	DBH, height and survivorship	November 2004	container plants	after 1st
CC	2005	DBH, height and survivorship	January 2005	cuttings	after 1st
DD	2005	DBH, height and survivorship	November 2004	container plants	after 1st
GG	2005	DBH, height and survivorship	January 2005	cuttings	after 1st
HH	2005	DBH, height and survivorship	January 2005	cuttings	after 1st
II	2005	DBH, height and survivorship	November 2004	container plants	after 1st
MM	2005	DBH, height and survivorship	November 2004	container plants	after 1st

Table A-2. Average DBH and height of trees by species in fields that were measured for survivorship and growth, Beal Lake Habitat Creation Project, Phase 1, 2004 Fields B, C, D, E, I, J (potted areas).

Field	Species	DBH (cm)	Height (m)
		Average (Standard Error)	Average (Standard Error)
B	Fremont cottonwood	2.3 (0.3)	3.1 (0.2)
C	Fremont cottonwood	1.1 (0.1)	2.0 (0.1)
D	Fremont cottonwood	1.1 (0.1)	2.1 (0.1)
D	Goodding's willow	0.43 (0.1)	1.6 (0.2)
E	Fremont cottonwood	0.1 (0.0)	2.3 (0.1)
E	coyote willow	0.7 (0.2)	1.3 (0.1)
E	screwbean mesquite	-	2.2 (0.7)
I	Goodding's willow	1.4 (0.2)	2.4 (0.2)
I	coyote willow	1.0 (0.1)	2.9 (0.1)
J	coyote willow	0.7 (0.1)	1.8 (0.1)
All fields	Fremont cottonwood	1.35 (0.1)	2.3 (0.1)
All fields	Goodding's willow	1.34 (0.2)	2.4 (0.5)
All fields	screwbean mesquite	-	2.2 (0.7)
All fields	coyote willow	0.8 (0.1)	1.7 (0.1)

Table A-3. Average density (individuals per 78.5 m^2) of sapling and shrubs per species per size class, Beal Lake Habitat Creation Project, Phase 1, 2004, Fields A, F, G, H, M, N, Q (seeded areas).

Species	Size class DBH (cm)	Average density (Standard Error)
brittlebush	<1	0.7 (0.7)
arrowweed	<1	288.5 (76.6)
mesquite species	<1	0.9 (0.3)
mesquite species	1-2.5	3.6 (1.7)
Fremont cottonwood	<1	5.7 (3.0)
Fremont cottonwood	1-2.5	2.0 (1.8)
Fremont cottonwood	2.6-5.5	0.1 (0.1)
Goodding's willow	<1	5.1 (5.1)
willow species	<1	0.1 (0.1)
saltcedar	<1	18.3 (6.7)
dead arrowweed	<1	0.1 (0.1)
dead arrowweed	1-2.5	0.1 (0.1)
Total density of all species	all size classes	325.2 (104.1)
Total density of all species	<1	272.0 (102.6)
Total density of all species	1-2.5	10.6 (3.5)
Total density of all species	2.6-5.5	0.4 (0.3)

Table A-4. Species richness, diversity, and evenness of sapling and shrubs, Beal Lake Habitat Creation Project, Phase 1, 2004, Fields A, F, G, H, M, N, Q (seeded areas).

Field	Species richness (individuals)	Species diversity (species of equal abundance)	Species evenness (species similarity)	Maximum species diversity (species of equal abundance)
A	3.00	2.01	.64	3.00
F	5.00	1.32	.17	5.00
G	2.00	1.11	.15	2.00
H	3.00	2.39	.80	3.00
M	3.00	1.21	.17	3.00
N	4.00	1.68	.37	4.00
Q	2.00	1.31	.39	2.00
All fields	7.00	1.70	.25	7.00

Table A-5. Average density of woody understory stems (individuals per 1m^2), per species, Beal Lake Habitat Creation Project, Phase 1, 2004, Fields A, F, G, H, M, N, Q (seeded areas).

Species	Average (Standard Error)
Atriplex lentiformis	0.1 (0.1)
Baccharis species	0.1 (0.1)
Heliotropium species	0.2 (0.1)
arrowweed	5.6 (1.0)
mesquite species	0.1 (0.0)
saltcedar	8.6 (2.2)
coyote willow	1.2 (0.7)

Table A-6. Average herbaceous cover (percentage) and canopy cover (percentage), per species, Beal Lake Habitat Creation Project, Phase 1, 2004, Fields A, F, G, H, M, N, Q (seeded areas).

Cover Type	Average herbaceous % (Standard Error)	Average canopy cover % (Standard Error)
blue grama (*Bouteloua gracilis)*	1.00 (0.7)	
live grass species	0.1 (0.0)	
dead grass species	8.4 (3.3)	
dead Bermudagrass (*Cynodon dactylon*)	6.9 (2.6)	
bare ground	61.3 (6.7)	
leaf litter	10.9 (2.5)	3.0 (1.7)

Table A-7. Total Vegetation Volume by meter layer, per species, Beal Lake Habitat Creation Project, Phase 1, 2004, Fields A, F, G, H, M, N, Q (seeded areas).

Species	Meter layer (m)	Average (%) (Standard Error)
Atriplex lentiformis	0-1	0.4 (0.4)
Bermudagrass	0-1	6.1 (1.4)
Bermudagrass	1-2	0.7 (0.7)
Bermudagrass	2-3	0.3 (0.3)
arrowweed	0-1	16.7 (4.0)
arrowweed	1-2	4.4 (1.5)
Fremont cottonwood	0-1	1.9 (1.4)
Fremont cottonwood	1-2	2.7 (1.9)
Fremont cottonwood	2-3	2.7 (1.9)
Fremont cottonwood	3-4	0.1 (0.1)
screwbean mesquite	1-2	0.5 (0.5)
saltcedar	0-1	15.7 (3.4)
saltcedar	1-2	1.1 (0.8)
coyote willow	2-3	0.8 (0.8)
dead	0-1	0.3 (0.3)
Total vegetation	0-1	48.9 (5.5)
Total vegetation	1-2	9.3 (0.3)
Total vegetation	2-3	3.7 (2.0)
Total vegetation	3-4	0.1 (0.1)

Table A-8. Average DBH and height of trees by species in fields that were measured for survivorship and growth, Beal Lake Habitat Creation Project, Phase 1 and 2, 2005, Fields C, D, O, P, L, AA, BB, DD, MM, II.

Phase and method	Species	DBH (cm)		Height (m)	
		Average (Standard Error)	Average Growth	Average (Standard Error)	Average growth
Phase 1 potted	Fremont cottonwood	1.6 (0.1)	0.2	2.8 (0.1)	0.6
Phase 1 potted	Goodding's willow	1.6 (0.1)	0.2	2.1 (0.1)	--
Phase 1 potted	coyote willow	0.5 (0.1)	0.3	1.6 (0.2)	0.1
Phase 2 potted	Fremont cottonwood	0.8 (0.2)		1.7 (0.1)	
Phase 2 potted	screwbean mesquite	0.8 (0.1)		2.2 (0.1)	
Phase 2 cuttings	Fremont cottonwood	1.1 (0.2)		2.4 (0.2)	
Phase 2 cuttings	Goodding's willow	**		1.2 (0.1)	

** Trees not tall enough (>1.37 m) to record Diameter at Breast Height.

Table A-9. Average density (individuals per 78.5 m^2) of sapling and shrubs per species per size class, Beal Lake Habitat Creation Project, Phase 1, 2005, Fields A, F, G, H, M, N, Q (seeded areas) and B, E, I, J (potted areas) .

Method	Species	Size class DBH (cm)	Average Density (Standard Error)
Seeded	Atriplex lentiformis	<1	0.2 (0.2)
	Baccharis species	<1	6.5 (2.5)
	Baccharis species	1-2.5	0.1 (0.1)
	Fremont cottonwood	<1	2.3 (1.7)
	Fremont cottonwood	1-2.5	2.7 (1.3)
	Fremont cottonwood	2.6-5.5	1.8 (1.1)
	arrowweed	<1	200.4 (20.2)
	arrowweed	1-2.5	0.4 (0.3)
	honey mesquite	<1	0.3 (0.2)
	honey mesquite	1-2.5	0.1 (0.1)
	screwbean mesquite	<1	5.5 (1.9)
	screwbean mesquite	1-2.5	3.6 (0.5)
	screwbean mesquite	2.6-5.5	3.4 (0.5)
	Goodding's willow	<1	5.7 (3.7)
	Goodding's willow	1-2.5	1.4 (1.1)
	saltcedar	<1	11.6 (3.9)
	saltcedar	1-2.5	0.2 (0.2)
Potted	*Baccharis* species	<1	0.1 (0.1)
	arrowweed	<1	246.7 (121.1)
	arrowweed	1-2.5	10.9 (4.6)
	Fremont cottonwood	<1	0.3 (0.2)
	Fremont cottonwood	1-2.5	2.0 (1.3)
	Fremont cottonwood	2.6-5.5	1.5 (1.2)
	screwbean mesquite	<1	2.4 (0.5)
	screwbean mesquite	1-2.5	0.6 (0.3)
	screwbean mesquite	2.6-5.5	0.1 (0.1)
	coyote willow	<1	20.3 (8.3)
	coyote willow	1-2.5	10.2 (5.7)
	Goodding's willow	<1	3.6 (1.6)
	Goodding's willow	1-2.5	1.3 (0.8)
	Goodding's willow	2.6-5.5	0.1 (0.1)
	saltcedar	<1	11.9 (5.1)
All fields	Atriplex lentiformis	<1	0.7 (0.7)
	Baccharis species	<1	3.9 (1.6)
	Baccharis species	1-2.5	0.03 (0.03)
	Fremont cottonwood	<1	1.3 (0.9)
	Fremont cottonwood	1-2.5	2.3 (0.9)
	Fremont cottonwood	2.6-5.5	1.7 (0.8)
	arrowweed	<1	220.0 (18.2)
	arrowweed	1-2.5	5.1 (0.9)
	honey mesquite	<1	0.2 (0.1)
	honey mesquite	1-2.5	0.03 (0.03)
	screwbean mesquite	<1	4.3 (1.2)
	screwbean mesquite	1-2.5	1.5 (0.4)
	screwbean mesquite	2.6-5.5	1.3 (0.4)
	coyote willow	<1	8.9 (4.1)
	coyote willow	1-2.5	4.5 (2.7)
	Goodding's willow	<1	14.3 (3.2)
	Goodding's willow	1-2.5	1.4 (0.7)
	Goodding's willow	2.6-5.5	0.03 (0.03)
	saltcedar	<1	12.1 (3.3)
	saltcedar	1-2.5	0.09 (0.09)

Table A-10. Species richness, diversity, and evenness of sapling and shrubs, Beal Lake Habitat Creation Project, Phase 1, 2005, Fields A, F, G, H, M, N, Q (seeded areas) and B, E, I, J (potted areas).

Field	Species richness (individuals)	Species diversity (species of equal abundance)	Evenness (species similarity)	Maximum species diversity (species of equal abundance)
A	5.00	1.99	0.43	5.00
F	6.00	1.46	0.21	6.00
G	5.00	1.80	0.36	5.00
H	6.00	2.44	0.50	6.00
M	4.00	1.85	0.44	4.00
N	5.00	1.94	0.41	5.00
Q	5.00	2.88	0.66	5.00
B	3.00	2.61	0.87	3.00
E	4.00	1.42	0.25	4.00
I	5	1.85	.3840	5.00
J	6	2.02	.3922	6.00
Potted	7	1.97	.3474	7.00
Seeded	8	2.17	.3737	8.00
All fields	9	2.38	.3940	9.00

Table A-11. Average density of woody understory stems (individuals per 1 m^2), per species, Beal Lake Habitat Creation Project, Phase 1, 2005, Fields, A, F, G, H, M, N, Q (seeded areas) and B, E, I, J (potted areas).

Method	Species	Average Density (Standard Error)
Seeded	*Atriplex lentiformis*	0.01 (0.01)
	Baccharis species	0.9 (0.2)
	Juncus species	1.2 (0.67)
	arrowweed	3.1 (1.3)
	mesquite species	0.2 (0.1)
	saltcedar	9.2 (3.8)
	dead arrowweed	0.4 (0.2)
	dead saltcedar	4.4 (2.1)
Potted	*Atriplex lentiformis*	0.1 (0.03)
	Juncus species	0.6 (0.3)
	arrowweed	3.7 (0.3)
	mesquite species	0.2 (0.02)
	saltcedar	1.2 (0.2)
	coyote willow	0.8 (0.2)
	dead arrowweed	0.04 (0.02)
	dead coyote willow	0.02 (0,01)
All fields	*Atriplex lentiformis*	0.04 (0.03)
	Baccharis species	0.5 (0.1)
	Juncus species	1.8 (1.1)
	arrowweed	3.4 (0.2)
	mesquite species	0.1 (0.02)
	saltcedar	5.8 (2,3)
	coyote willow	0.3 (0.1)
	dead arrowweed	0.3 (0.1)
	dead saltcedar	2.5 (1.3)

Table A-12. Average herbaceous cover (percentage) and canopy cover (percentage), per species, Beal Lake Habitat Creation Project, 2005, Phase 1, Fields A, F, G, H, M, N, Q (seeded areas) and B, E, I, J (potted areas).

Method	Cover type	Average herbaceous % (Standard Error)	Average canopy cover % (Standard Error)
Seeded	Bermudagrass	13.0 (5.1)	30.4 (3.3)
	dead	0.03 (0.01)	
	bare ground	57.4 (5.2)	
	leaf litter	22.1 (3.2)	
	woody debris	0.1 (0.1)	
Potted	dead Russian thistle (*Salsola* sp.)	1.6 (0.7)	22.4 (3.1)
	dead	0.04 (0.02)	
	bare ground	61.0 (2.6)	
	leaf litter	37.0 (2.4)	
	woody debris	0.2 (0.1)	
All fields	Bermudagrass	7.5 (3.1)	28.9 (2.3)
	dead Russian thistle	0.7 (0.3)	
	dead	0.03	
	bare ground	59.15	
	leaf litter	28.46	
	woody debris	.11	

Table A-13. Total Vegetation Volume by meter layer, per species, Beal Lake Habitat Creation Project, Phase 1, 2005, Fields A, F, G, H, M, N, Q (seeded areas).

Species	Meter layer (m)	Average % volume (Standard Error)
Atriplex lentiformis	0-1	0.3 (0.3)
Baccharis species	0-1	4.2 (1.7)
Baccharis species	1-2	0.5 (0.3)
Bermudagrass	0-1	1.7 (0.7)
arrowweed	0-1	15.4 (2.9)
arrowweed	1-2	10.9 (2.3)
arrowweed	2-3	2.2 (0.9)
Fremont cottonwood	0-1	0.4 (0.4)
Fremont cottonwood	1-2	1.3 (1.1)
Fremont cottonwood	2-3	1.6 (0.8)
screwbean mesquite	0-1	2.1 (0.9)
screwbean mesquite	1-2	1.9 (0.7)
screwbean mesquite	2-3	2.2 (1.4)
screwbean mesquite	3-4	0.5 (0.4)
coyote willow	0-1	1.7 (1.2)
coyote willow	1-2	0.9 (0.7)
coyote willow	2-3	0.9 (0.6)
saltcedar	0-1	6.7 (1.9)
saltcedar	1-2	0.9 (0.8)
dead	0-1	0.1 (0.1)
Total vegetation	0-1	33.1 (3.8)
Total vegetation	1-2	16.1 (2.5)
Total vegetation	2-3	4.7 (1.6)
Total vegetation	3-4	0.5 (0.4)

Table A-14: Total Vegetation Volume by meter layer, per species, Beal Lake Habitat Creation Project, Phase 1, 2005, Fields B, E, I, J (potted areas).

Species	Meter layer (m)	Average % volume (Standard Error)
Juncus species	0-1	0.5 (0.5)
arrowweed	0-1	22.7 (4.3)
arrowweed	1-2	17.8 (3.9)
arrowweed	2-3	3.8 (1.6)
Fremont cottonwood	0-1	1.1 (0.8)
Fremont cottonwood	1-2	4.5 (2.4)
Fremont cottonwood	2-3	3.8 (2.0)
Fremont cottonwood	3-4	1.8 (1.8)
Fremont cottonwood	4-5	0.4 (0.4)
screwbean mesquite	0-1	0.4 (0.4)
screwbean mesquite	1-2	0.2 (0.2)
coyote willow	0-1	6.1 (2.3)
coyote willow	1-2	5.0 (1.7)
Goodding's willow	1-2	0.4 (0.4)
Goodding's willow	2-3	0.7 (0.7)
dead	0-1	1.4 (1.3)
Total vegetation	0-1	31.7 (4.6)
Total vegetation	1-2	27.7 (4.7)
Total vegetation	2-3	13.8 (2.6)
Total vegetation	3-4	1.8 (1.8)
Total vegetation	4-5	0.4 (0.4)

Table A-15: Density of trees (individuals per hectare) in fields B, E, I, J, Beal Lake Habitat Creation Project, Phase 1, 2004-2005.

Species	Density 2004	Density 2005
Fremont cottonwood	300	480
Goodding's willow	460	630
coyote willow	1040	3890
screwbean mesquite	44	400

Table A-16: Sample sizes needed to detect mean density of sapling and shrub per species for 2005 using simple random sampling.

Species	Sample size B=20%	Sample size B=30%
Atriplex lentiformis	3111	1353
Baccharis species	572	225
arrowweed	23	10
honey mesquite	1990	865
screwbean mesquite	164	73
Fremont cottonwood	507	227
coyote willow	747	332
Goodding's willow	663	295
saltcedar	807	358

Appendix B. Avian Post-Development Monitoring Results, 2005

Methods

Reclamation utilized a point-count protocol established by the Great Basin Bird Observatory (2003). Surveys were conducted on 19 May, 10 June, and 14 July 2005. Fourteen points were randomly chosen using satellite imagery of the study area. The points were located using a handheld Garmin (GPSMAP 76 S) GPS unit and marked with flagging to ensure surveying from the same point each time. Point-count stations were established in all three phases of the project: Phase 1 (PC station 1, 2, 5, 6, 9), Phase 2 (PC station 3, 4, 11, 10), and Phase 3 (PC station 7, 8, 12, 13, 14).

From each point, surveyors identified all birds either heard or seen. For all detections, distances were verified utilizing Bushnell Yardage Pro Legend range finders. All data were recorded on standardized data forms. Observations from greater than 328 ft (100 m) away were recorded as such. Points were surveyed for 10 minutes, separated into 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 from the birds. The first survey point started at sunrise and additional points were surveyed until 9 am. Time, wind speed, cloud coverage, and temperature were recorded at the beginning of each survey. All surveyors were experienced and trained in identifying birds in the desert Southwest.

Data Analysis

Data from birds observed beyond 328 ft (100 m) and recorded as flyovers were omitted from analysis. A single-factor ANOVA test was used to determine difference of mean relative abundance between survey dates and phases. A t-test assuming equal variances was used to determine difference of mean relative abundance between years. Species richness, diversity, and evenness were calculated. Species richness was calculated as total number of species present. A species diversity index provides more information about community composition than species richness, as it takes into account the relative abundance of different 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:

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

where S = number of species in the sample, and p_i is the proportion of all individuals belonging to the *i*th species. The transformation of H´ is given by $e^{H'}$, labeled as N_1 (MacArthur 1965). N_1 is used because it expresses diversity in terms of species, whereas H´ is expressed in bits. Species distribution is maximally even when $S = N_1$. Evenness expressed as $H'/H_{max} = H'/\mathrm{In}\ S$ is a measurement of how similar the abundance of different species are. Evenness is equal to 1.0

when there are similar proportions of all species. Community similarity between the three phases was measured with the Renkonen index (Percentage Similarity index):

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

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).

Marsh bird surveys have been conducted at Beal Lake, adjacent to the project, since 2001 by the University of Arizona as part of a study dealing with the effects of fire on Yuma clapper rails and California black rails (Courtney and Nadeau 2005). The number of marsh birds detected per species per year is in Table B-1.

Results

A mean of 87 individual birds, comprising 24 species, were detected at the project during the 2005 breeding season (Figure B-2, Table B-2). The three species that comprised approximately 50% of the population were the great-tailed grackle, song sparrow, and mourning dove (Figure B-2, Figure B-3). Refer to Table B-3 for a list of common names, scientific names, and American Ornithological Union (AOU) codes of species observed at the project. There was no difference ($p > 0.05$) for the mean of total individual birds and individual birds per species detected per year. There was no difference ($p > 0.05$) for the mean of total individual birds and individual birds per species detected per phase or per survey during the breeding season of 2006. Species richness was 24.00, ecological species diversity was 13.43, and evenness was 0.82 during the 2006 breeding season (Table B-2). Cumulative species diversity numbers from the 2006 season were similar to those from the 2005 season (species richness 20.00, ecological species diversity 12.18, and evenness 0.82). The percentage similarity index (Renkonen index) between the three phases was 0.20 during the breeding season of 2006.

Discussion

Two LCR MSCP covered avian species were detected: one Sonoran yellow warbler and one Arizona Bell’s vireo. Seven species listed in the LCR MSCP as sensitive, non-covered riparian species were present at the project: American kestrel, ash-throated flycatcher, blue grosbeak, common yellowthroat, Abert’s towhee, yellow-breasted chat, and lesser nighthawk. The Abert’s towhee is listed as a species of concern in the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004). Approximately 50% of the avian population comprised habitat generalists.

Reclamation biologists expect species composition to change with the development of future habitat and the maturation of existing habitat at the project. Biologists expected the lack of LCR MSCP covered species and other riparian obligate species due to the early stages of development. Biologists detected slight changes in species composition between years, but it is too early in the monitoring program to detect any trends. The importance of continually monitoring this project to see whether avian richness and diversity change as the project matures is vital 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).

There was a low percentage similarity index (Renkonen index) between each phase but the species diversity index was similar for each phase. Although the low percentage similarity index was expected, the similar species diversity for each phase was not. Reclamation biologists expected higher species diversity in Phase 1, which had been established for a year longer than the other two phases that have not yet been completed. Despite the low percentage similarity index between phases, there were no notable differences of number of birds detected for any species between phases. Diversity, evenness, and richness numbers from this project will be compared with these values from restored and non-restored areas along the LCR. These values will also be compared between years to see how species composition at the project changes over time. Refer to the report, *Avian Post-development Monitoring of Restoration Sites Along the Lower Colorado River, Breeding Season of 2005,* for comparisons between projects.

The project differs from previous habitat creation projects along the LCR due to its larger habitat size and the fact that it is adjacent to a constant water source. Comparison of avian monitoring data from the project to previous habitat creation projects will give insight to the factors that habitat size and a constant water source have in determining avian richness and diversity.

Tape playback surveys for the southwestern willow flycatcher (*Empidonax trailii extimus*) and the western yellow-billed cuckoo (*Coccyzus americanus occidentalis)* will be added in the 2006 breeding season. The development of habitat for the southwestern willow flycatcher is one of the goals of the project. McLeod et al. (2004) found that average canopy height and canopy closure was higher at southwestern willow flycatcher nesting sites (canopy height 17.1-51.8 ft (5.2-15.8 m), canopy closure 89.6-98.2 %)) than at non-nesting sites. It was also noted that vertical foliage density was greater in the upper strata of the canopy at nest sites than at non-nest sites. The average canopy height, canopy closure, and vertical foliage density above 3.3 ft (1.0 m) at the project is still relatively low in comparison. As the project matures, these parameters should increase. Monitoring for the southwestern willow flycatcher, as well as other LCR MSCP targeted species, will continue.

Literature Cited

Anderson, B.W., and R.D. Ohmart. 1976. Vegetation type maps of the lower Colorado River from Davis Dam to the southerly international boundary. Final Report. Boulder City, NV: Bureau of Reclamation, Lower Colorado Region.

Anderson, B.W., and R.D. Ohmart. 1984. Lower Colorado River riparian methods of quantifying vegetation communities to prepare type maps. Final report. Boulder City, NV: Bureau of Reclamation, Lower Colorado Region.

Bureau of Reclamation. 2005. Avian post development monitoring of restoration sites along the LCR breeding season 2005 (unpublished report). Boulder City, NV.

Bureau of Reclamation. 2005. Beal Lake Habitat Restoration Report. (unpublished report). Boulder City, NV.

Bureau of Reclamation. 2005. Beal Lake vegetation monitoring report along the LCR 2005 (unpublished report) Boulder City, NV.

Conway, C.J., and C.P. Nadeau. 2005. Effects of Fire on Yuma Clapper Rails and California Black Rails, 2004 Annual Report, Wildlife Research Report Number 2005-01. Arizona Cooperative Fish and Wildlife Research Unit, Tucson, Arizona.

Elliot, G., M. Chase, G. Geupel, and E. Cohen. 2004. Developing and Implementing and Adaptive Conservation Strategy: A guide for improving adaptive management and sharing the learning among conservation practitioners. Point Reyes Bird Observatory Conservation Science, Stinson Beach, CA.

Great Basin Bird Observatory. 2003. Nevada Bird Count. A habitat-based monitoring program for breeding birds of Nevada. Instruction package and protocol for point count surveys Available at http://www.gbbo.org/pdf/Instructions.2003.doc. Accessed Dec. 2004.

Lower Colorado River Multi-Species Conservation Program. 2004. Final Habitat Conservation Plan. Boulder City, NV.

MacArthur, R.H. 1965. Patterns of species diversity. Biological Review 40:510-533.

Nur, N., S.L Jones, and G.R. Geupel. 1999. A statistical guide to data analysis of avian monitoring programs. U.S. Department of the Interior, Fish and Wildlife Service, BTP-R6001-1999. Washington D.C.

Ralph, J.C., G. Guepel, P. Pyle, T.E. Martin, and D.F. SeSante. 1993. Handbook of field methods for monitoring landbirds. Gen. Tech. Rep. PSW-GTR-144. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. 41 pp.

Table B-1. Number of marsh birds detected at Beal Lake from 2001-2005, per species, per year.

Species	Year	Number detected per year
American coot	2001	15
	2002	21
	2003	18
	2004	0
	2005	0
Yuma clapper rail	2001	8
	2002	7
	2003	7
	2004	10
	2005	8
common moorhen	2001	0
	2002	0
	2003	6
	2004	12
	2005	8
least bittern	2001	8
	2002	0
	2003	7
	2004	8
	2005	18
pied-billed grebe	2001	2
	2002	9
	2003	25
	2004	15
	2005	15

Table B-2. Average number of individuals, species richness, ecological species diversity, and evenness for point count stations at the Beal Lake Habitat Creation Project, breeding season 2005.

Point Count Station	Average number of individuals	Cumulative Species Richness	Ecological Species Diversity	Evenness
1	2.67	5.00	4.76	0.97
2	8.33	8.00	6.1	0.87
3	8.67	8.00	6.72	0.92
4	5.33	9.00	6.65	0.86
5	4.67	8.00	5.88	0.91
6	6.00	9.00	7.86	0.94
7	6.00	7.00	5.47	0.84
8	3.00	4.00	3.46	0.90
9	5.00	9.00	7.58	0.92
10	5.00	6.00	4.11	0.79
11	3.00	5.00	4.33	0.91
12	10.50	9.00	6.29	0.84
13	9.00	8.00	5.86	0.85
14	9.50	9.00	6.57	0.86
Average	6.19	7.42	5.83	0.88
Phase 1	26.67	15.00	9.81	0.84
Phase 2	23.00	13.00	9.48	0.85
Phase 3	38.00	16.00	9.42	0.81
Cumulative	74.00	24.00	13.43	0.82

Table B-3. Scientific name, common name, and standard American Ornithological Union Codes of species detected at the Beal Lake Habitat Creation Project

Code	Common Name	Scientific Name
COMO	common moorhen	*Gallinula chloropus*
AMCO	American coot	*Fulica Americana*
AMKE	American kestrel	*Falco parverius*
MODO	mourning dove	*Zenaida macroura*
LENI	lesser nighthawk	*Chordeiles acutipennis*
ATFL	ash-throated flycatcher	*Myiarchus cinerascens*
WEKI	western kingbird	*Tyrannus verticalis*
BEVI	Bell's vireo	*Vireo belli*
NRWS	northern rough-winged swallow	*Stelgidopteryx serripennis*
BEWR	Bewick's wren	*Thryomanes bewickii*
BTGN	black-tailed gnatcatcher	*Polioptila melanura*
YWAR	yellow warbler	*Dendroica petechia*
COYE	common yellowthroat	*Geothypis 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*
BHCO	brown-headed cowbird	*Molothrus ater*
HOFI	house finch	*Carpodacus mexicanus*
KILL	killdeer	*Charadrius vociferus*

Figure B-1. Point Count Data Form.

NEVADA BIRD COUNT 2005 – Point Count Form

Great Basin Bird Observatory, 1755 E. Plumb Ln., Ste. 256, Reno, NV 89502
phone (775) 323-4226; email ammon@gbbo.org

Site #:_____-_____ - _____ **Surveyor:**_____ **Date:**____ - ____ - _____
Habitat/ transect # point # **Helper:**_____ month day year
UTMx:_____; **UTMy:**_____ **Start Time:** _____
Sky code: _____ **Wind code :** _____ **Temp (°F):** <30 30-50 50-70 70-90 90-110 >110

Time (0-3, 3-5, 5-10)	**Species Code**	**Species Full Name**	**Distance** (enter # individuals)				**Breeding Confirmed (Y/N) ***
			0-50 m	50-100 m	>100 m	Flyover	

* Nest, nesting material, copulating, carrying food, fledgling

TOTAL number of birds observed: _____

Incidental Sightings
(Seen/heard on the way to the point, after pointcount time limit, etc.)

Species Full Name	**Breeding Confirmed (Y/N) ***

ADDITIONAL COMMENTS

Figure B-2. Relative Abundance of Species, Beal Lake Habitat Creation Project, Breeding Season, 2005.

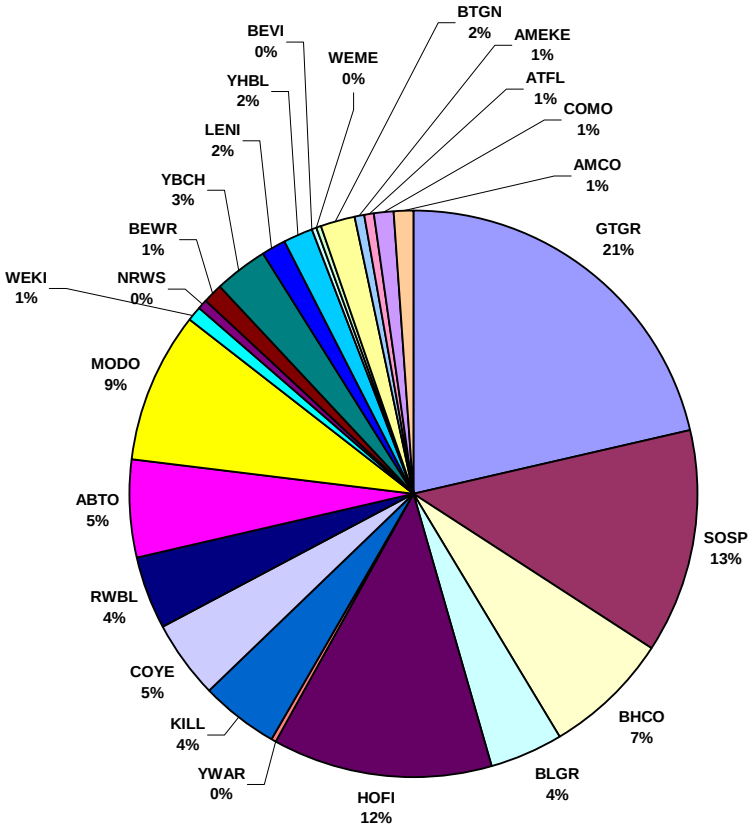
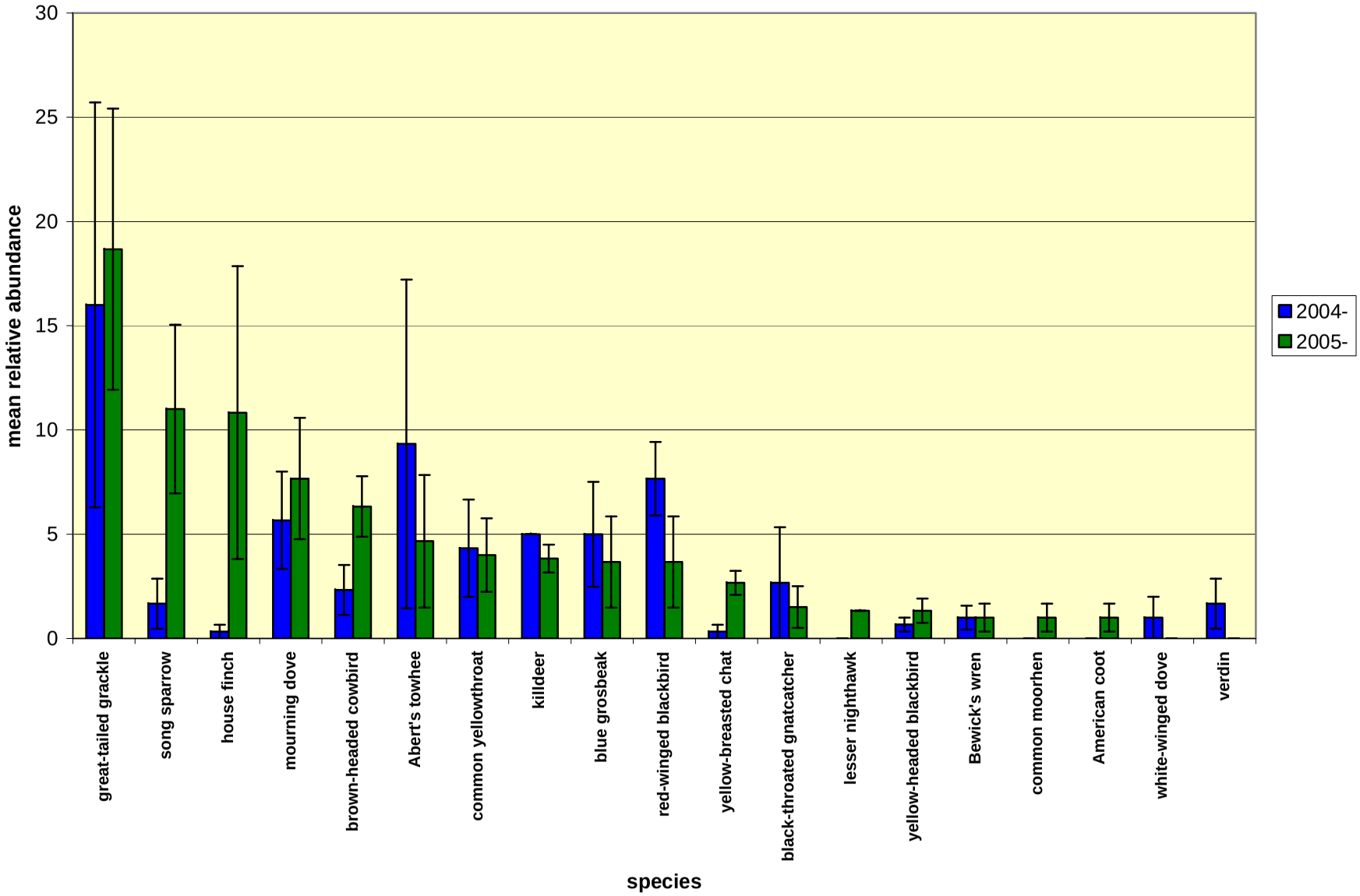


Figure B-3: Species with a mean relative abundance of >1 at the Beal Lake Habitat Creation Project, breeding season, 2004-2005.



Appendix C. Monitoring Plan

Introduction

Monitoring of habitat creation areas is critical to the adaptive management program. This process allows the LCR MSCP to analyze implementation activities, address the uncertainty inherent in a 50-year program, and respond appropriately. Monitoring will be conducted to evaluate that the restoration parameters established for each covered species habitat are being achieved, the habitat creation area develops as covered species habitat, and the habitat is being utilized by the covered species. Reported results on how the created habitat develops, relative to the restoration and management techniques employed, will be used to refine and/or develop future techniques. This should ensure that the most cost-effective and efficient approaches will be used at other habitat creation projects.

For the purposes of the LCR MSCP, initial conservation area monitoring plans will be based on elements described in the HCP (LCR MSCP 2004). A document describing the science and adaptive management plan strategies for the LCR MSCP is being developed.

Monitoring of the project will be structured into four schemes: 1) predevelopment, 2) implementation monitoring, 3) habitat/species monitoring, and 4) vegetation classification. Predevelopment monitoring is designed to establish what types of restoration activities may be conducted, establish baseline data for evaluating post development, and identify covered species currently inhabiting the project. Implementation monitoring will be conducted to determine whether the site was created as designed. Habitat/species monitoring will determine whether the site meets the established life history requirements necessary to provide habitat for the targeted covered species. The site will also be classified according to the Anderson and Ohmart vegetation classification system (1976, 1984). The goals for these monitoring techniques may be revised, depending on the adaptive management program results, science strategy, covered species requirements, and/or other management decisions in the future.

Site Description

The project was initiated in 2001 by Reclamation's Lower Colorado Regional Office in Boulder City, Nevada, in partnership with the U.S. Fish and Wildlife Service (USFWS), Havasu National Wildlife Refuge. The project is located adjacent to Beal Lake, on Havasu National Wildlife Refuge, near Needles, California, and is within the historic floodplain of the lower Colorado River. 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. The project is being used to test various riparian restoration methods and techniques for site preparation, planting, irrigation, monitoring, managing, and maintenance. Phase 1 of the project was planted from 2003 to 2005 and resulted in 59.5 ac (24.1 ha) of Fremont Cottonwood, Goodding's and coyote willow, and screwbean and honey mesquite land cover type. Phase 2 was planted from 2004 to 2005 and restored an additional 47.7 ac (19.4 ha) of cottonwood and willow land cover type. Phase 3, originally planned to include 100 ac (40.5 ha) of honey and screwbean mesquite, has now been scaled back considerably.

Purpose

The project is a demonstration site designed to evaluate riparian restoration techniques and the development of habitat for the southwestern willow flycatcher and other terrestrial and marsh species of concern. Scientifically designed monitoring studies will be conducted to determine whether different planting regimes and techniques succeeded in creating appropriate structural vegetative communities (Figure C-1) and provided habitat to LCR MSCP covered species. Scientifically designed monitoring studies will be conducted to quantify habitat characteristics (biotic and abiotic) that exist where covered species are detected. Results reported on how the created habitat develops, relative to the restoration and management techniques employed, will be used to refine and/or develop techniques for future larger-scale habitat creation projects. This monitoring plan, finalized in 2006, covers future monitoring as well as past efforts.

Pre-Development Monitoring

Pre-development monitoring is designed to establish what types of habitat creation activities may be conducted and obtain baseline data for evaluating habitat creation activities. Pre-development monitoring is divided into abiotic (soil features) and biotic (vegetation and covered species) factors. Pre-development monitoring took place once existing vegetation had been cleared and fields were leveled. Soil analysis was the only pre-development monitoring that took place at the project. Soil analysis was conducted to gather salinity and nutrient information to determine what species to plant in specific locations. Monitoring for small mammals took place in a non-developed area northeast of the project where a marsh construction project had been proposed to create black rail habitat; however, the marsh construction is no longer being considered.

The following pre-development monitoring occurred prior to project implementation:

- Abiotic Monitoring

    Soils

        LCR MSCP (2006) monitoring protocols were used.

        In Phase 1, one sample per field was taken in December 2002 after laser leveling each field but prior to tree planting.

        In Phase 2, two samples per field were taken in 2004 after laser leveling each field but prior to tree planting.

        The location for each sample per field was randomly chosen.

        Samples in each phase were analyzed for moisture, salinity, textural classification, depth to ground water, and nutrients, including nitrate, ortho-phosphate, and ammonia.

        Samples were taken with soil augers measuring 3.9 by 6.3 in (16 cm by 10 cm) at three depths (surface, 1 ft (0.3 m), 3 ft (0.9 m)).

        Samples were analyzed at Reclamation’s Lower Colorado Regional Laboratory in Boulder City, Nevada.

- Biotic Monitoring
    - Covered species monitoring
        - Small mammals

            LCR MSCP (2006) monitoring protocols were used.

            Presence and absence surveys for small mammals took place in the proposed marsh in April 2006 (Figure C-1). Three hundred trap nights (each trap set out for a night of trapping equals one trap night) were conducted.

            Traps were placed every 32.8 ft (10 m) along a parallel, linear transect of approximately 492 ft (150 m) in length. Transects were chosen using systematic random sampling. The first transect was chosen randomly and additional transects were placed every 32.8 ft (10 m) to 49.2 ft (15 m). Traps were placed in the habitat at sunset and checked at sunrise.

Implementation and Habitat/Species Monitoring Goals

Two types of monitoring will be conducted at the project: implementation monitoring and habitat/ species monitoring. Monitoring will be conducted to determine whether planting techniques were successful in creating designed habitat and whether covered species were utilizing the site. The project will be managed for the southwestern willow flycatcher, as well as other LCR MSCP covered species. Reference conditions for the southwestern willow flycatcher are based on conditions found during the southwestern willow flycatcher long-term life history studies conducted along the LCR (McLeod et al. 2005, Koronkiewicz et al. 2004).

Implementation Monitoring

Implementation monitoring was conducted to assess success of restoration techniques in terms of creating designed vegetation communities structural type defined by Anderson and Ohmart (1976, 1984; Figure C-1). Implementation monitoring was conducted to assess success of different hydroseeding treatments on field M. This type of monitoring quantifies change immediately after treatments and evaluates whether actions were implemented as prescribed. This monitoring is focused on the habitat (biotic) and conditions therein (abiotic).

The results of this monitoring may:

- Determine whether each field has the appropriate vegetation community structural type (Anderson and Ohmart 1976, 1984) according to the original design of the project (Figure C-1).
- Determine survivorship of trees planted with potted plants and cuttings four weeks after trees produce buds and after the first two growing seasons.
- Determine the percent of hydroseeded and naturally seeded areas that had developed into cottonwood-willow habitat. Vegetation classifications will be created based on the percentage of dominant species observed.

- Determine the number of Fremont cottonwoods in each of the seven hydroseeding treatments in field M.
- Determine germination rate of Fremont cottonwood and Goodding's willow seeds in each developmental stage.
- Determine herbaceous species present in each area after the first growing season.
- Determine whether cover crop (REGREEN) remains viable.
- Determine whether the irrigation system adequately provides water to planted fields with an initial test of the system.
- Determine amount of water in acre-feet that was utilized per acre annually at the site.
- Determine whether soil is significantly different in seeded areas that produced different vegetation types or fields planted with potted plants that had different survivorship rates.
- Determine number of honey mesquite seedlings in Phase 3.
- Determine whether soil salinity levels in each field are low enough to support plant species in those fields.

- Abiotic Monitoring
  - Soil

    LCR MSCP (2006) monitoring protocols were used.

    One sample per field was taken in Phase 1 in September of 2003 for select fields (C, G, H, K, Q).

    Two samples per field were taken in Phase 1 and 2 in March 2006 at the same locations where the pre-development samples were taken.

    Samples in each phase were analyzed for moisture, salinity, textural classification, depth to ground water, and nutrients, including nitrate, ortho-phosphate, and ammonia.

    Samples were taken with soil augers measuring 3.9 by 6.3 in (16 cm by 10 cm) at three depths (surface, 1 ft (0.3 m), 3 ft (0.9 m)).

    Samples were analyzed at Reclamation's Lower Colorado Regional Laboratory in Boulder City, Nevada.

    Samples will be collected annually until the nutrient and salinity measurements are stable.
  - Irrigation

    Deliveries will be recorded as to time, quantity, and amount in acre feet.
  - Water depth

    Fourteen monitoring wells (piezometers) were installed at the site on 3 October 2005. One well per field was installed in four fields (E, D, C, A), four wells were installed in EE, and six wells were installed in NN.

    Groundwater table depth was measured in feet (meters) monthly from each well beginning in October 2005. Elevations for Beal Lake and Topock Marsh were measured monthly beginning in October 2005.

- Biotic Monitoring
    - Vegetation

        LCR MSCP (2006) monitoring protocols were used.

        Trees in fields K, FF, GG, JJ, KK, and LL were counted on 23 March 2006 to determine survivorship four weeks after dormancy break. These data will be used to guide initial management activities, such as water use and re-planting.

        The number of trees was counted in Field M on 12 December 2003, nine months after the site was hydroseeded.

        The percentage of area that had developed into cottonwood-willow habitat in the seeded fields was determined at the end of the first growing season (August 2003). Perimeters of the different vegetation types were mapped using points collected with a hand-held Corvalis GPS unit. Vegetation classifications were created based on the percentage of dominant species observed.

        Survivorship and growth of trees planted with pots or cuttings were measured after the first and second growing seasons during the dormancy period (October-January). For survivorship, every tree planted at the site was counted. For growth, 1% of all trees will be chosen randomly and measured for DBH, height, and condition index (Table C-2). One percent was calculated using an equation for determining the necessary sample size for estimating a single population mean, or a population total with a specified level of precision, based on variability of sample data collected (Elzinga et al. 2001). Percent cover was measured at random 3.3 foot (1.0 m) square plots in each transect to evaluate herbaceous and shrub plant component.

Habitat/Species Monitoring

Habitat/species monitoring is designed to determine whether the site is providing the habitat requirements needed for the targeted covered species, whether any covered species is utilizing the habitat, and whether there are differences in wildlife use of the habitat depending on planting design, composition, and watering regimes. All monitoring will be designed specifically for each phase and habitat type within that phase. The monitoring is divided into habitat and covered species; both sets of monitoring data will be incorporated for analysis.

The results of this monitoring may:

- Determine whether portions of cottonwood-willow structural types III-IV have become southwestern willow flycatcher habitat as determined by reference conditions listed below.
- Determine whether each field was the appropriate vegetation community structural type (Anderson and Ohmart, 1976, 1984) per year according to the original design of the project.

- Determine quantitative values for habitat characteristics such as canopy height, canopy closure, species density, species composition, basal area, herbaceous cover, mean soil moisture, mean diurnal temperature, mean diurnal relative humidity, and vertical foliage density.
- Determine whether habitat is being used by the southwestern willow flycatcher, or other LCR MSCP covered species.

- Habitat Monitoring
  - Abiotic Conditions

    Soil

    - LCR MSCP (2006) monitoring protocols will be used.
    - Samples will be analyzed for moisture, salinity, textural classification, depth to ground water, and nutrients, including nitrate, ortho-phosphate, and ammonia, until conditions are stable. When conditions become stable, samples will be analyzed every three to five years. If conditions change, samples will be analyzed annually until conditions become stable again.
    - Samples will be collected in the same locations as pre-development and implementation monitoring.
    - Soil moisture will be monitored 10 times during the breeding season (May-August) and once a month during August and September beginning in 2006. ThetaProbe ML2x soil moisture probes coupled to an HH2 Moisture Meter at microclimate locations will be used.
    - Soil moisture will be monitored twice a week during the breeding season in areas where targeted species (southwestern willow flycatcher and yellow-billed cuckoo) are confirmed nesting.
    - Soil moisture measurements will be recorded directly beneath the HOBO data logger and at estimated 1.6 ft (0.5-m) intervals from 1.6 ft (0.5) to 6.6 ft (2.0 m) in each cardinal direction for a total of 17 measurements per location.
    - Soil moisture measurements will be recorded for five years starting in April 2006. After five years, data will be examined and future monitoring decisions will be made.

    Water

    - Deliveries to each phase will be recorded and analyzed to determine whether the necessary amounts were delivered to grow the requisite habitat.

    Microclimate

    - LCR MSCP (2006) monitoring protocols will be used.
    - Temperature and relative humidity will be recorded utilizing HOBO H8 Pro data loggers made by Onset Computer Corporation in Pocasset, Massachusetts.

- HOBO data logger were placed at the site from March to October of 2006 at eight locations. Beginning in March 2007, data loggers will be placed at nine locations from March through October annually.
- Four locations were chosen in fields P, L, Q, and H where moist soil/standing water conditions are to be simulated during the breeding season for the purpose of managing for southwestern willow flycatchers. One location was selected per field in cottonwood willow habitat. One additional HOBO data logger will be placed in field K in willow habitat after trees complete their first growing season. More locations may be chosen in the future depending on how much acreage develops into southwestern willow flycatcher habitat. One HOBO data logger will be placed every 10 acres (4.0 ha) in southwestern willow flycatcher habitat.
- Four locations were chosen in cottonwood-willow vegetation type in the remainder of the site that is suitable habitat for yellow-billed cuckoos. Two locations were in cottonwood habitat and two in willow habitat. More locations may be chosen in the future depending on how much acreage develops into yellow-billed cuckoo habitat. One HOBO data logger will be placed every 10 acres (4.0 ha) in yellow-billed cuckoo habitat.
- Additional HOBO data loggers may be placed at the site in areas where southwestern willow flycatchers and yellow-billed cuckoos are detected nesting.
- Data will be recorded every 15 minutes and downloaded every 3 to 6 months.
- Data will be collected for five years beginning in March 2006. After five years, data will be examined and future monitoring decisions for microclimate will be made.

o Biotic Conditions

- Vegetation

LCR MSCP (2006) monitoring protocols will be used.

Hydroseeded and naturally seeded areas will be sampled annually after the first growing season (years 1 to 6), using a standardized protocol based on a nested sample design using fixed-radius plots. Fixed-radius plots will be measured at the end of the growing season to track growth and survival over time. Areas planted with potted plants or cuttings will be sampled annually after the third year of growth (years 3 to 6), based on a nested sample design using fixed-radius plots. In all areas, monitoring will occur every other year between years 6 and 10. After year 10, each site will be sampled every five years to monitor successional change through the LCR MSCP period. If a catastrophic disturbance (fire, flood, etc.) occurs to the

stand, post-disturbance monitoring will mimic the post-restoration monitoring regime.

Fixed-radius plots will be chosen using a stratified random sampling design. The strata will be divided using the Anderson and Ohmart vegetation classification system (Anderson and Ohmart, 1976, 1984). Sample size will be based on size of the area, species, and variation within the project.

Vegetation parameters monitored will include overstory trees, sapling, shrub, understory, herbaceous layer, vertical foliage density, and crown closure.

- Covered Species Monitoring
  - Neotropical Birds

    LCR MSCP (2006) monitoring protocols will be used.

    A standardized point-count protocol (GBBO 2003) was used from 2004 to 2006.

    Fourteen permanent points were established during the 2004 breeding season using a systematic random design in a grid format covering the whole site (Phase 1, Phase 2, and Phase 3). All points were located 820.2 ft (250 m) apart.

    Point counts were conducted at all points three times a year in 2004 and 2005 even though the whole site was not developed during those years. In 2006, point counts were conducted only at the previously set up permanent points in Phase 1 and 2.

    A double sampling approach using rapid and intensive area search surveys will be used to monitor avian species beginning during the breeding season of 2007. The project will be split into 23-ac (9-ha) plots and each area search plot on the project will be sampled at least one time in the last two weeks of May using the rapid area search protocol. Each plot will be surveyed for a maximum of two hours. A representative random sample of the 23-ac (9-ha) plots will be sampled in the months of May and June following the intensive area search protocol. Surveyors will find and map every individual bird's territory in the intensive plot to gather a complete census of birds. Intensive area search plots will be compared to rapid area search plots to determine a detectability ratio per species (Bart 2007).

    Standardized breeding and winter season banding/mist-netting (DeSante 2005) may be conducted, if conditions warrant.

    If covered species are observed, targeted species-specific surveys, nest searches, and banding/mist-netting may be conducted.
  - Cavity Nesting Birds

    Gilded flicker and Gila woodpecker will be surveyed as part of the neotropical bird monitoring. If gilded flicker and/or Gila woodpeckers are detected during the breeding season, nest searches and/or targeted

banding/mist-netting may be conducted for long-term use of site and refinement of habitat use.

- Southwestern Willow Flycatcher

  LCR MSCP (2006) monitoring protocols will be used.

  Standardized presence/absence surveys (Sogge et al. 1997, USFWS 2000) will be conducted beginning during the breeding season of 2006. A minimum of five surveys will be conducted beginning in May and ending in July. If a SWFL is detected after 15 June, and/or positive breeding evidence is identified, nest searches will be conducted to determine breeding status and use of habitat. If nests are found, they will be monitored according to Arizona Game and Fish Department protocol (Rourke et al. 1999). If nests are found, vegetation data will be collected around nests. If breeding populations of more than 10 birds are established, banding may be conducted for long-term use of site and refinement of habitat use.

  Surveys will be conducted annually during the breeding season for five years after their initiation. After five years, data will be examined and future monitoring decisions for southwestern willow flycatchers will be made.

- Yellow-billed Cuckoo

  LCR MSCP (2006) monitoring protocols will be used.

  Presence/absence tape play-back surveys for the yellow-billed cuckoo will be conducted when the project is mature enough to support suitable yellow-billed cuckoo habitat (Halterman and Johnson 2005). Three to five breeding surveys will be conducted from mid-June to late August. If yellow-billed cuckoos are present during the breeding season, nest searches will be conducted and targeted banding and mist-netting may be conducted for long-term use of site and refinement of habitat use.

  Surveys will be conducted annually during the breeding season for five years after their initiation. After five years, data will be examined and future monitoring decisions for the yellow-billed cuckoo will be made.

- Small Mammals

  LCR MSCP (2006) monitoring protocols will be used.

  Presence/absence surveys for small mammals will be conducted twice a year (spring and fall), beginning in the spring of 2006.

  Traps will be placed every 32.8 ft (10.0 m) along a parallel, linear transect of approximately 492.0 ft (150.0 m) in length. Transects will be chosen using systematic random sampling. The first transect will be chosen randomly, and additional transects will be placed every 32.8 ft (10.0 m) to 49.2 (15.0 m). Traps will be placed in the habitat at sunset and checked at sunrise.

  Presence/absence surveys will be conducted in the spring and fall with each survey period conducted for 250 trapping nights. After 500 trap nights have been conducted, an analysis of the data will be made to determine whether the trapping effort has been sufficient. If the curve

Presence/absence surveys will be conducted annually for the first five years. After the fifth year, data will be examined and future monitoring decisions will be made.

- Bats

  LCR MSCP (2006) monitoring protocols will be used.

  Presence-absence surveys for bat species will be conducted utilizing active and passive AnaBat surveys at least two days per season (spring, summer, winter, and fall), starting in the spring of 2007, and conducted annually for five years, according to protocol. All data will be recorded during the same moon phase. The preferred moon phase is new moon.

  One stationary AnaBat or Sonabat system will be installed in a central location. The initial location will be chosen based on suitable habitat for the covered bat species and ability to maximize data collected. The station will be established for at least five years, but may be moved to different locations throughout the site.

  Relative abundance will be analyzed by number of bats per species heard per call minute. A call minute indicates that a given species is present if it was recorded a least once within a one-minute block of time.

  After five years, data will be examined and future monitoring decisions for bat species will be made.

  Refer to Reclamation monitoring protocols (2006) for the complete bat monitoring protocol.

- Reptiles and Amphibians

  No monitoring will be conducted because no habitat for reptiles and amphibians will be restored or removed.

- MacNeill's Sootywing Skipper

  No monitoring will be conducted because no habitat for MacNeill's Sootywing Skipper will be restored.

Vegetation Classification

The Habitat Conservation Plan (LCR MSCP 2004) outlines the specific habitat acreage to be restored, utilizing the Anderson and Ohmart (1976, 1984) classification system. Reclamation will monitor created habitat using this classification system to accomplish this task. Reclamation will annually obtain aerial imagery of the site and create a vegetation community and structural type map for each phase of the project.

Reference Conditions

Reference conditions for the creation of southwestern willow flycatcher habitat will be based on long-term life history studies along the LCR (McLeod et al. 2005, Koronkiewicz et al. 2004). These variables may change depending on future analysis of the long-term life history studies currently being conducted. Variables that would be referenced include canopy height, canopy closure, vertical foliage density, mean soil moisture (% volume), mean diurnal temperature, mean maximum diurnal temperature, and mean diurnal relative humidity. These variables were chosen as there were statistically significant differences in use sites versus non-use sites at the southwestern willow flycatcher life history study sites conducted by SWCA, Inc. (McLeod et al. 2005, Koronkiewicz et al. 2004). Reference variables for southwestern willow flycatcher habitat are presented in Table C-1 and may change as future data refines these ranges.

Monitoring Analysis and Evaluation

Once the implementation and effectiveness monitoring data are analyzed, the results will be evaluated with two sets of management guidance criteria, thresholds and trigger points. These criteria will be used to evaluate all phases of implementation.

Thresholds

Thresholds signal that conditions are appropriate and to continue current management practices. The thresholds currently established are:

- Microclimate and vegetation conditions have been achieved for the reference conditions of southwestern willow flycatcher habitat in portions of cottonwood-willow III-IV.
- Fields are the vegetation community structure (Anderson and Ohmart 1976, 1984) that they were designed to be (Figure C-1).
- Successful germination of seeds in naturally seeded and hydroseeded areas occur.
- The project is being utilized by one or more covered avian species during the breeding season.
- The project is being utilized by the southwestern willow flycatcher.

Trigger Points

Trigger points signal the need to alter current management activities to achieve the conservation area goals of the habitat creation site or change goals for site. The trigger points currently established are:

- Low survivorship of trees planted with potted plants or cuttings.
- Cover crop is no longer viable.
- Low germination rate of seed in areas that were hydroseeded or naturally seeded.
- Soil salinity increases to thresholds above targeted plant tolerances.
- Non-native vegetation dominates particular areas of the project.
- Portions of cottonwood-willow III-IV are not providing habitat characteristics required by the southwestern willow flycatcher.

Data Collection and Analysis

All data collected will be entered into the long-term relational database that is being developed for the LCR MSCP. Analysis would be both qualitative and quantitative, depending on the data collected.

Evaluation of Results and the Adaptive Management Program

Data would be evaluated yearly to determine whether thresholds and /or trigger points are reached. An annual monitoring report will be written with summary results of all monitoring studies conducted that year.

Literature Cited

Anderson, B.W., and R.D. Ohmart. 1976. Vegetation type maps of the lower Colorado River from Davis Dam to the southerly international boundary. Final Report. Boulder City, NV: Bureau of Reclamation, Lower Colorado Region.

Anderson, B.W., and R.D. Ohmart. 1984. Lower Colorado River riparian methods of quantifying vegetation communities to prepare type maps. Final report. Boulder City, NV: Bureau of Reclamation, Lower Colorado Region.

Bart J. 2007. Lower Colorado River Riparian Bird Surveys. US Geological Survey, Boise, ID. Submitted to Lower Colorado Regional Office, Bureau of Reclamation. Boulder City, NV.

Anderson, B.W., and R.D. Ohmart. 1976. Vegetation type maps of the lower Colorado River from Davis Dam to the southerly international boundary. Final Report. Boulder City, NV: Bureau of Reclamation, Lower Colorado Region.

Anderson, B.W., and R.D. Ohmart. 1984. Lower Colorado River riparian methods of quantifying vegetation communities to prepare type maps. Final report. Boulder City, NV: Bureau of Reclamation, Lower Colorado Region.

Bart J. 2007. Lower Colorado River Riparian Bird Surveys. US Geological Survey, Boise, ID. Submitted to Lower Colorado Regional Office, Bureau of Reclamation. Boulder City, NV.

Colorado Indian River Tribes. 2006. Ahakhav Tribal Preserve Revegetation Research and Development Project. Colorado River Indian Tribes, ‘Ahakhav Tribal Preserve, Parker, AZ. Submitted Bureau of Reclamation.

Elzinga, C.L., D.W. Salzer, J.W. Willoughby, and J.P. Gibbs. 2001. Monitoring plant and animal populations. Malden, MA: Blackwell Science, Inc. 360 pp.

Great Basin Bird Observatory. 2003. Nevada Bird Count: A habitat-based monitoring program for breeding birds of Nevada. Available at http://www.gbbo.org

Halterman and Johnson. 2005. Western Yellow-billed Cuckoo Natural History Summary and Survey Methodology. Southern Sierra Research Station, Weldon, CA.

Koronkiewicz T.J, M.A. McLeod, B.T. Brown, and S.W. Carothers, 2004. Southwestern willow flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2004. Annual report submitted to Bureau of Reclamation, Boulder City, NV, by SWCA Environmental Consultants, Flagstaff AZ. 125 pp.

Lower Colorado River Multi-Species Conservation Program. 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan. Final. December 17. (J&S 00450.00.) Sacramento, CA.

McLeod, M.A., T.J. Koronkiewicz, B.T Brown, and S.W. Carothers, 2005. Southwestern willow flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2004. Annual report submitted to Bureau of Reclamation, Boulder City, NV, by SWCA Environmental Consultants, Flagstaff, AZ. 155 pp.

Nur, N., S.L. Jones, and G.R. Geupel. 1999. A statistical guide to data analysis of avian monitoring programs. U.S. Department of the Interior, Fish and Wildlife Service, BTP-R6001-1999, Washington, D.C.

Rourke, J.W., T.D. McCarthey, R.F. Davidson, and A.M. Santaniello. 1999. Southwestern willow flycatcher nest monitoring protocol. Nongame and Endangered Wildlife Program Technical Report 144. Arizona Game and Fish Department, Phoenix, Z.

Sogge, M.K., R.M. Marshall, S.J. Sferra, and T.J. Tidbits. 1997. A Southwestern willow flycatcher natural history summary and survey protocol. National Park Service Technical Report USGS/NAUCPRS/NRTR-97/12. 38 pp.

U.S. Fish and Wildlife Service. 2000. Southwestern Willow Flycatcher Protocol Revision 2000. Albuquerque, NM.

Table C-1. Reference variables for the creation of southwestern willow flycatcher habitat.

Canopy Height (M)	Average greater than 13.0 ft (4.0 m)
Canopy Closure (% total)	Greater than 70%
Vertical Foliage Density	Density greatest between 3.3-13.1 ft (1.0-4.0 m) above ground. This may change as additional analysis is completed.
Mean Soil Moisture (% volume)	Minimum of 17% Average of 23%
Mean Diurnal Temperature (Celsius)	Between 79°F (26° C) and 91°F (33° C)
Mean Maximum Diurnal Temperature (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% Average between 33% and 63%

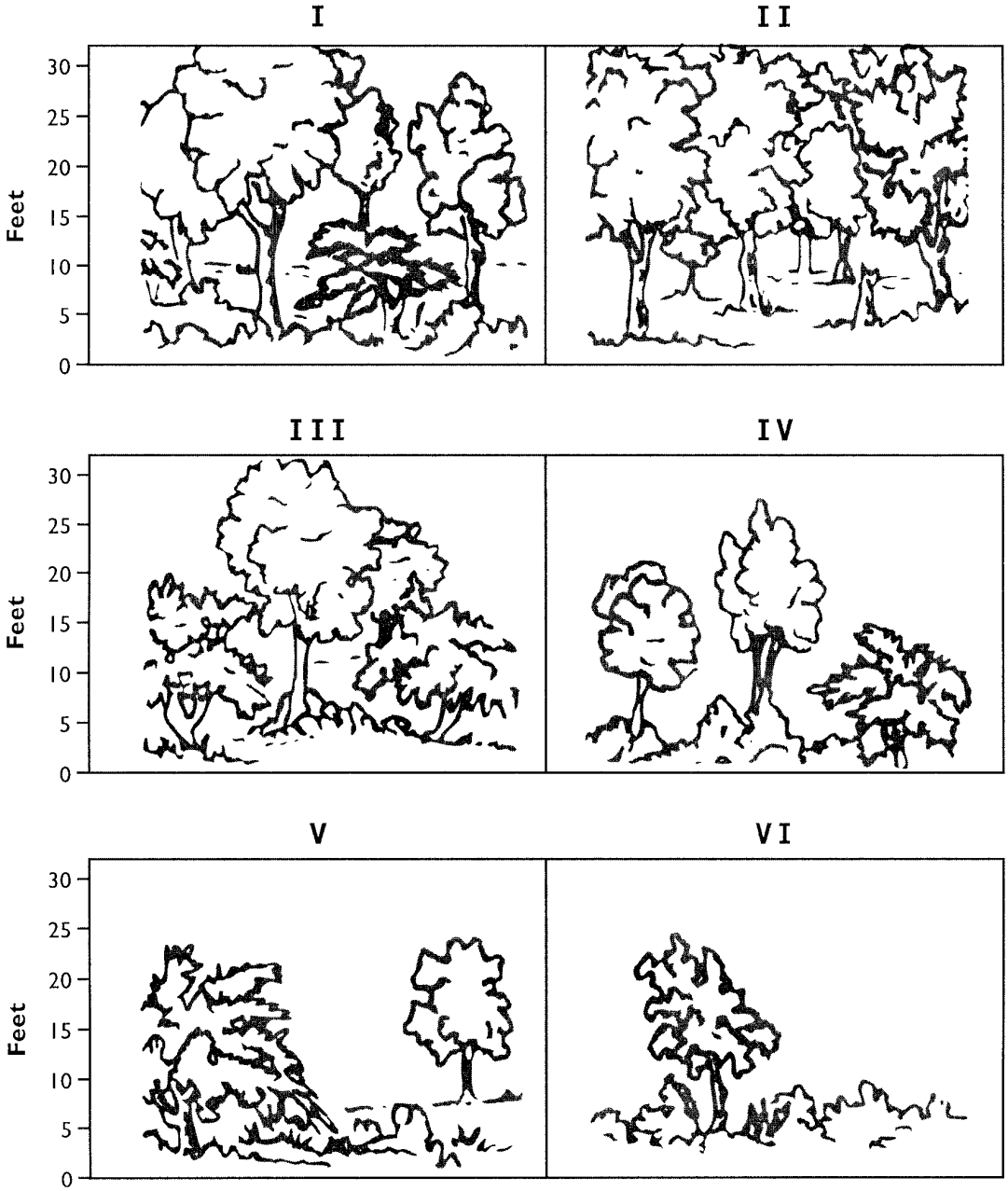
Table C-2. Tree Index of Condition.

Condition	Definition
Live	Trees appear in apparently good condition – leaves green, no symptoms of wilting, die-back, or chlorotic appearance of leaves
Stressed	Trees appear to be in generally poor condition – chlorotic leaves and leaf drop
Tip die-back	The main stem is in good condition; the most apical portions are in very poor condition exhibiting wilting and die-back symptoms
Basal sprouts	Main stem dead; new growth is initiated from stem base or root stock
Not found	Seedling not found during particular sampling period. If seedling not found in two consecutive periods, it is considered dead.
Apparently dead	General appearance of stem is dry and brittle; no live wood observed and no observable green foliage growth; re-sprouting still possible
Dead	Previously listed as apparently dead; tree in such poor condition that survival by re-sprouting is unlikely.

Table C-3. Vegetation Communities, Criteria, and Types (Anderson and Ohmart 1976, 1984).

Community Type	**Criteria**	**Vegetation Type**
Cottonwood /willow (CW)	*P. fremontii* and *S. gooddingii* constituting at least 10% of total trees	I, II, III, IV, V, VI
Salt cedar (SC)	*Tamarix chinesis* constituting 80-100% of total trees	I, II, III, IV, V, VI
Salt cedar/Honey mesquite (SH)	*P. glandulosa* constituting at least 10% of total trees	I, II, III, IV, V, VI
Salt cedar/Screwbean mesquite (SM)	*P. pubescens* constituting at least 20% of total trees	I, II, III, IV, V, VI
Honey mesquite (HM)	*P. glandulosa* constituting at least 90% of total trees	I, II, III, IV, V, VI
Arrowweed (AW)	*Tessaria sericea* constituting at least 90-100% of total vegetation area	I, II, III, IV, V, VI
Atriplex spp. (ATX)	*A. lentiformis*, *A. canescens*, and/or *A. polycarpa* constituting 90-100% of total vegetation in area	I, II, III, IV, V, VI

Table C-4. Vegetation Type



Adapted from Anderson and Ohmart (1984).

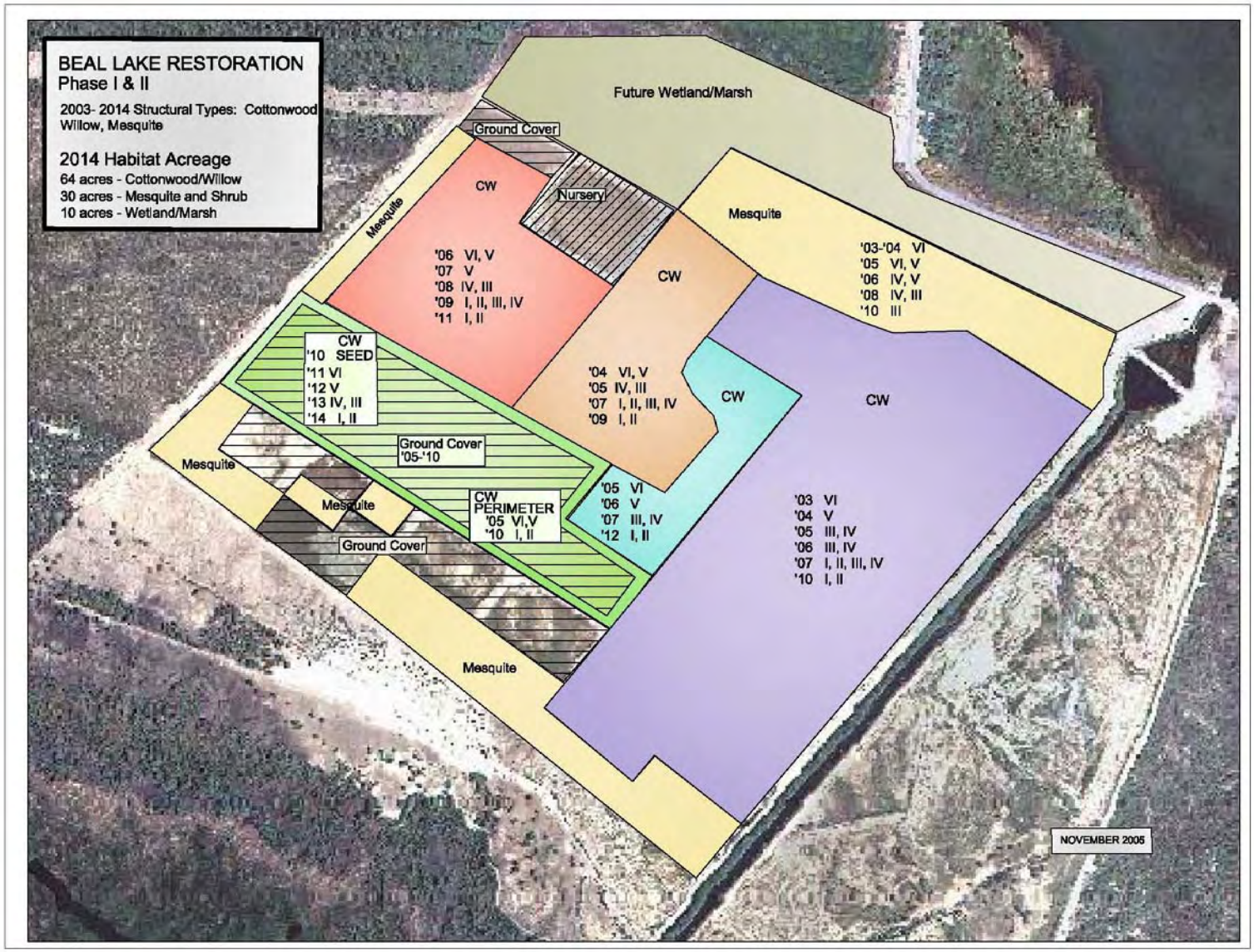



Figure C-1: Proposed vegetation communities and structural types at the Beal Lake Restoration Project from 2003-2014