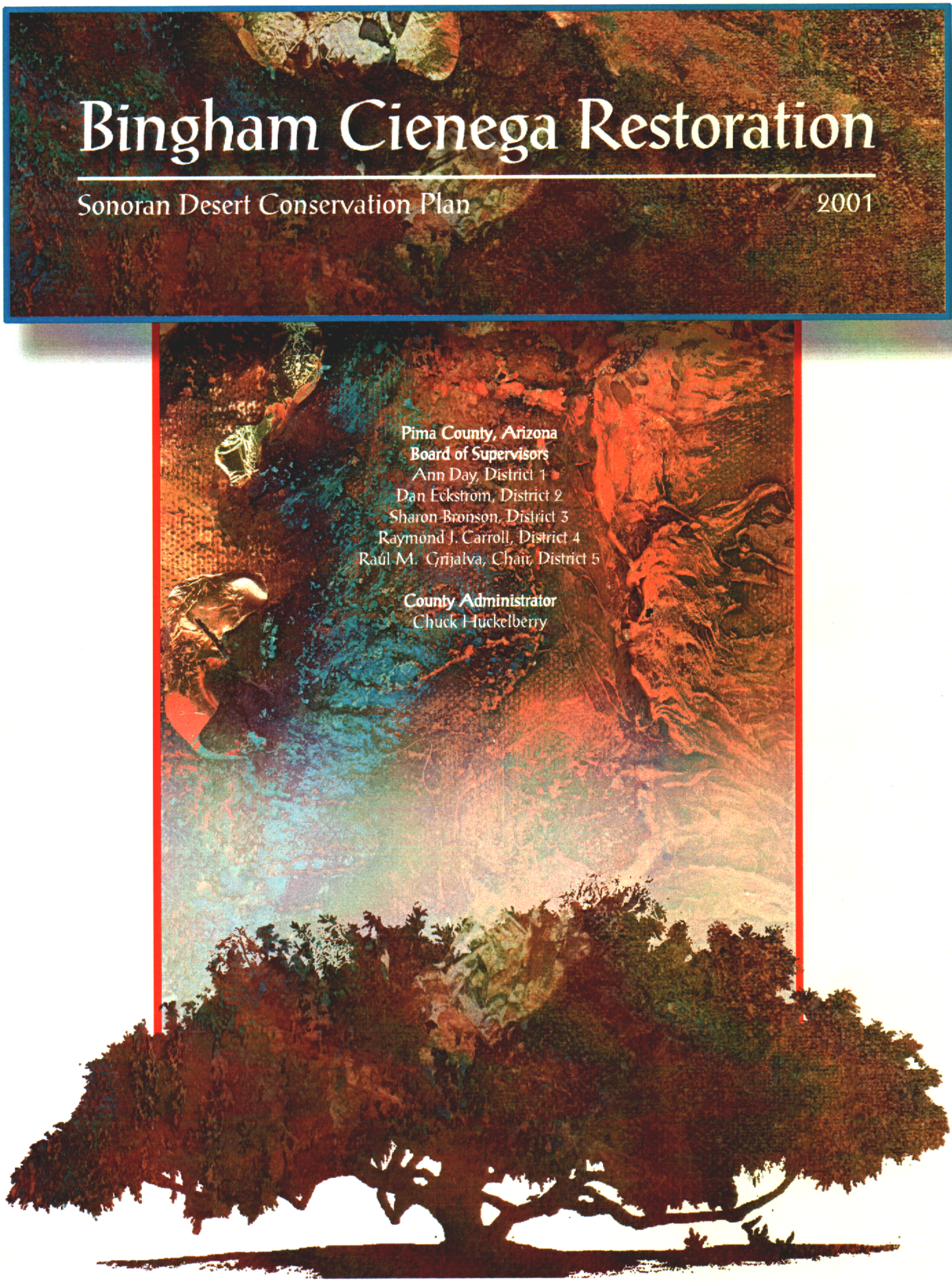
DRAFT

Bingham Cienega Restoration

Sonoran Desert Conservation Plan 2001



Pima County, Arizona
Board of Supervisors
Ann Day, District 1
Dan Eckstrom, District 2
Sharon Bronson, District 3
Raymond J. Carroll, District 4
Raúl M. Grijalva, Chair, District 5

County Administrator
Chuck Huckelberry

MEMORANDUM

Date: October 22, 2001

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Bingham Cienega Riparian Restoration Project**

Background

Today under separate cover I forwarded a study entitled *Biological Values of the West Branch of the Santa Cruz River* which proposes to conserve the West Branch of the Santa Cruz River as a part of the larger Paseo de las Iglesias project, and as a cornerstone of a more extensive effort at ecological restoration involving the mesic corridors of Pima County. The attached study is an example of riparian restoration efforts in another part of Eastern Pima County: the San Pedro River.

The *Bingham Cienega Riparian Restoration Project* is a three year project that resulted from the award of an $84,000 grant to restore sacaton grassland, riparian trees and mesquite to about half the 50 acres of fallow agricultural fields at the Bingham Cienega. The extensive report memorializes the completion of the fifteen project tasks and establishes a model for future restoration projects carried out under the Sonoran Desert Conservation Plan.

The Bingham Cienega

Surveys of the Bingham Cienega area from 1879 by the General Land Office indicate that dense, shrubby willows were found in and near the cienega, while sacaton grasslands, deciduous riparian forests and mesquite bosques were found outside the cienega. Around the turn of the century, the area was cleared for agriculture and modified hydrologically through ditching and berming.

In 1989, Pima County purchased around 300 acres including the cienega. After the dam was breached the wetland re-established over the abandoned fields. The Pima County Flood Control District has a 25 year management agreement with The Nature Conservancy, who formulated the revegetation concepts carried out in this project. The fifteen tasks described within are:

- Task 1: Obtain permits
- Task 2: Revegetation and monitoring plans
- Task 3: Install irrigation system
- Task 4: Planting site preparation and maintenance

Task 5:	Grow-out grasses, shrubs, and trees
Task 6:	Plant native grasses
Task 7:	Plant native trees and shrubs
Task 8:	Install electrical fencing and graze cows for mesquite propagation
Task 9:	Irrigation management and monitoring
Task 10:	Ground water depth and precipitation
Task 11:	Monitoring revegetation success
Task 12:	Monitoring bird use of restoration area
Task 13:	Dissemination of project information
Task 14:	Draft semi-annual progress reports
Task 15:	Draft final report.

Goals, Objectives and Tasks

The overriding restoration goals for the project were to (1) establish a diversity of riparian habitats in the fields, which, in turn, will support a greater number of invertebrate, reptile, mammal and bird species; and (2) plant species in areas where the depth-to-groundwater and soil moisture are sufficient to maintain them once established.

The project objectives were to (1) promote the long term re-establishment of deciduous riparian woodland, sacaton grassland and mesquite woodland in the abandoned agricultural fields; and (2) develop practical techniques for promoting establishment of native plants that either do not require irrigation or that require only infrequent irrigation.

Perhaps most useful to future riparian projects under the Sonoran Desert Conservation Plan are the sections of the study dedicated to implementing the restoration plan (tasks 4 through 9) and implementing the monitoring plan (tasks 10 through 12). The study measures and reports the effect of various actions on survivorship, flowering and growth of vegetation, including actions such as irrigation, mowing versus mulching, pot size, depth-to-groundwater, and thinning of areas.

The results of species surveys in different restoration areas at different times of the year also provide an indication of activity that will become more commonplace under the inventory, research and monitoring functions of the Sonoran Desert Conservation Plan.

Conclusion

The sophistication of the *Bingham Cienega Riparian Restoration Project* bodes well for future riparian restoration projects carried out by Pima County staff and partners from the science community under the Sonoran Desert Conservation Plan.

Attachment

Arizona Water Protection Fund
Final Report

Bingham Cienega Riparian Restoration Project
Grant No: 97-040 WPF

September 30, 2001

Photo by Harold Malde

The Arizona Water Protection Fund Commission has funded a portion of this project. The views or findings represented in this deliverable are the Grantee's and do not necessarily represent those of the Commission nor the Arizona Department of Water Resources. This project is also funded by the Fish and Wildlife Service Partners for Wildlife Program, the Wallace Research Foundation, Pima County Flood Control District and by private donations to The Nature Conservancy.

The Project Managers would like to acknowledge the following individuals and organizations for their help and apologize for inadvertently omitting any of the many contributors to this many-faceted project.

Rod Held, the Water Protection Fund project manager for his professional guidance.

Elizabeth Hill, Julia Fonseca and Tom Helfrich of Pima County Flood Control District as our partners in progress.

Kim Fox and Dave Gori, Dana Backer, Steve Huckett, Jorja Foster, Becky and Jason Ekstein, Daniel Baker, Dave Harris, Lynn Richards, Linda Wallace-Gray and Jennifer Lloyd as TNC employees who were leaders in getting the job done.

Jack Kelly and Family, Faron Bingham and Family, and the Manuel Medina Family as Redington area residents who helped because they cherish the Cienega, and Cascabel Community members Jim and Pat Corbett, Jack and Norma Hughes, and Debbie Hawkins and Chet Phillips for their work and advice. And a nod to William and Char Johnson for financial support.

Tucson Audubon Society and the University of Arizona Volunteers:
Melody Kehl, Peggy Wong, Linda Figueroa, Will Turner, Bob Shank, Larry Liese, Nancy Herriman, Pricilla Titus, Ingrid Balsa, Julie Conley, Michelle Steg, Tom Slawson, Darius Simmons, Kristin Johnson, Mica, Mick Reed, Roy Stewart

Tom Butler - fencebuilder

Michael Baker, Ed Blanchard, Doug Newton, and all the Volunteers for Outdoor Arizona (in all those fields!)

Marty Kroll at the Willcox-San Simon Natural Resource Conservation Service and Mark Pater of the Tucson USDA Plant Materials Center helped technically and the Supervisors and co-operators of the Redington Natural Resource Conservation District supported us and helpfully shared the Americorps National Civilian Conservation Corps

Russ Houghey of Arizona Game and Fish contributed saplings and Marty Jaekle of US Fish and Wildlife Service granted financial and technical support; Bernie Jilka of Coronado Heights Nursery and Gary Maskerinec of Wildlands Restoration supplied plants and seeds from local sources and Rural Education Alternative for Children (REACH), Recycle America, Tri-Community Resource Center, and the University of Arizona Conservation Biology Class, Pima County Summer Intern Program planted and maintained those plants.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Bingham Cienega lies along the banks of the San Pedro River, which has received substantial local, national and international attention. In 1978, The Nature Conservancy's Arizona Natural Heritage Program identified Bingham Cienega as one of Arizona's rarest natural features. In a 1988 Arizona Natural Areas Study, the Arizona State Parks Board identified and ranked Bingham Cienega as the 9th most significant site out of over 300 sites proposed for natural area protection in Arizona. In 1989 the Pima County Flood Control District (PCFCD) purchased the Cienega and entered into a 25- year management agreement with The Nature Conservancy (TNC).

SITE DESCRIPTION AND HISTORIC NATURAL CONDITIONS

The San Pedro and environs was designated as one of The Nature Conservancy's "Last Great Places" because it represents one of the last great relatively intact surviving ecosystems. As one of the longest undammed watersheds remaining in the American Southwest, the San Pedro River stretches 140 miles from northern Sonora, Mexico to its confluence with the Gila River. The North American Free Trade Agreement's scientific expert team for the Commission for Environmental Cooperation found that as many as four to five million neo-tropical bird migrants utilize it as their main Western flight corridor between Central and North America. Nearly half of North American birds have been sighted there, and the American Bird Conservancy recognized it as a Globally Important Bird Area. Some of America's rarest forest types line its banks, principally Fremont cottonwood-Gooding willow forest and mesquite bosques. It also supports the highest number of mammal species in North America.

Bingham Cienega is situated in the Central Basin of the San Pedro. The Central Basin presents the rare sight of a nearly unfragmented landscape with no significant development and a very low human population density (a few hundred) between the fifty-five or so miles separating the towns of Benson-Pomerene and San Manuel-Mammoth. It also connects the Rincon-Catalina mountain complex with the Winchesters and Galiuros. Mountain lion, black bear, bighorn sheep, mule and whitetail deer, gray fox, coatimundi and ringtail cats among others traverse these ranges. Wildlife corridors such as nearby Buehman and Redfield Canyons connect these "sky islands, increasing the possibility of recolonization should a species become locally extinct and permitting gene flow between populations in connected habitats.

Bingham Cienega is a spring-fed marsh. Rock outcrops from the Catalina Core Complex in the main channel just north of the mouth of Edgar Canyon force underflow to rise up and become streamflow (Agenbroad, 1967). The shallow water table created by the influence of this same block of consolidated sediments is also thought to be responsible for generating outflow at the spring location. Bingham Cienega and adjacent agricultural fields occur on the pre-entrenchment flood plain of the San Pedro and are 4 meters above the active channel. Flooding in 1983 or 1993 did not erode the site.

An analysis of 1879 General Land Office surveys of the Preserve and vicinity (Fonseca, 1994) indicates that historically moister areas in and near the cienega included dense, shrubby willows. Sacaton grasslands, deciduous riparian forests and mesquite bosques lay outside the cienega. Pollen analyses show woody riparian vegetation increased during late historic periods, coincident with decreased fire frequency (Davis, 1994). Bingham Cienega is now a lotic system supporting extensive stands of cattails, bullrush and other obligate wetland plants (Stromberg, 1993). Besides the wetland, mesquite bosque, palustrine wooded swamp and cottonwood-willow riparian forest are on site. Sacaton grass persists along riparian forest edges or in understory. The adjacent floodplain is dominated by riparian species, especially mesquite and salt cedar as well as Fremont cottonwood, Gooding willow, Arizona walnut and velvet ash. The surrounding upland plant communities are Sonoran desert scrub dominated by mesquite, saguaro and cholla cacti species.

Sites like Bingham with perennial flow and diverse riparian habitats are critically important as stepping stones for migratory birds in the intermittent middle and lower San Pedro. Cottonwood-willow forests support the highest densities of birds in the Southwest, and mesquite bosques the second highest, and both support diverse assemblages of invertebrates, reptiles and mammals (Ohmart and Anderson, 1986). In Arizona 90% of streamside wetlands have disappeared. In cienega wetlands the losses are estimated to be closer to 95% (Hendrickson, 1984). The remaining are threatened by increased water demands on streamflow and ground-water sources. Despite their small area, over 70% of all species inhabiting this semi-arid region as well as migratory species depend on these systems (Naiman et al, 1993).

CHANGES TO SYSTEM RESULTING IN NEED FOR RESTORATION

Around the turn of the century approximately 70 acres at Bingham Cienega were modified hydrologically by ditching and berming the cienega wetland, and the entire area was cleared for agriculture. These fields are like the thousands of acres of floodplain habitat, especially mesquite bosques and sacaton grasslands that were cleared and farmed along the San Pedro. The loss of sacaton grassland is especially notable: over 95% of sacaton grassland habitat in Arizona has been lost over the last century (Humphrey, 1960). Historically sacaton grasslands formed extensive stands along riparian areas within the semiarid grasslands. It has now been replaced by mesquite due largely to fire suppression and declining water tables. Initial site recovery began in 1989 when Pima County purchased about 300 acres including the cienega and surrounding agricultural fields from the Kelly Family, who currently reside on a 15 acre conservation easement in-holding. Pima County stopped farming and livestock operations and breached the dam, allowing the wetland to reestablish over the abandoned fields. Areal extent and hydrology of the cienega has somewhat stabilized at about 28 acres.

Before 1890, the San Pedro flowed slowly in a shallow narrow channel through marshy environments. San Pedro entrenchment occurred around the turn of the century with a series of large floods. This was apparently due to a variety of causes including climactic changes, timber harvesting, fire suppression, overgrazing, draining of swamps, beaver extirpation and earthquake. Today only isolated pieces of the once extensive marshlands persist; commonly attributed to the arroyo cutting episode, and more recently to groundwater development in the form of pumping for agricultural, municipal and industrial uses which has lowered water tables and diminished the water supply necessary to maintain wetland habitats.

RESTORATION OPPORTUNITIES, CHALLENGES, APPROACHES

Part of the opportunity at Bingham Cienega is the potential for local restoration of the lost character of the San Pedro, which historically included sacaton meadows. Since cienega vegetation often occurs in zones or bands that reflect gradients of water availability, The Nature Conservancy conducted a "Preliminary Vegetation and Hydrological Analyses for Bingham Cienega" (Baird et al, 1997). The purpose of the study was to relate hydrologic gradient across the agricultural fields to spatial distribution of dominant cienega plant species. Three planting areas were identified to support a different historic riparian community type: deciduous riparian woodland, sacaton grassland and mesquite woodland. The entire upland terrace portion of Bingham Cienega was found to be hydrologically suitable for the restoration of sacaton grassland. If successful, such an effort might provide a model for other recovering areas and abandoned agricultural fields along the length of the San Pedro Valley where sacaton dominated historically.

The conditions that allow the opportunity for riparian deciduous woodland and sacaton grassland restoration are the same ones that make it such a challenge. The lesson of ecology is that all systems and their parts are connected. Bingham is effectively an island in the threatened hydrologic system of the San Pedro. The lack of floods and overbank inundation due to floodplain entrenchment, and which are required to move seeds into sediment, have prevented recruitment and reestablishment of native species. Additional inputs of moisture after germination appear to be an important factor in seedling survivorship (Aldon, 1975). Competition with exotic weeds including Johnson grass and bermuda which dominate the fields are inhibiting factors as well. Sacaton is also adapted to fire of appropriate timing and periodicity (Bock and Bock, 1986). Any controlled burning must match historical timing and intensity of wild fires, as well as be feasible within surrounding environmental and social conditions.

Bingham Cienega Natural Preserve attracts attention for its beautiful, unique and important location and habitat type. It is also interesting for its riparian restoration possibilities. It presents all the opportunities and challenges that constitute the dreams and nightmares of the ecological restoration concept.

ARIZONA WATER PROTECTION FUND

In order to implement the revegetation concepts The Nature Conservancy had, funding sources were investigated. The Arizona Water Protection Fund Grant 97-040 was obtained in 1997. The Contract and six Semi-Annual Progress reports, detailing each year's activities, are on file with TNC as well as AWPF.

This grant contained 15 tasks, which are 100% complete. These tasks, listed in **Table 1**, formed the basis for the grant activities and deliverables as well as the context for the semi-annual reports. The June 2001 seeding of mixed native grass species and this September 2001 final report were the last deliverables due.

TABLE 1. PROJECT TASKS	
Task 1	Obtain Required Permits
Task 2	Revegetation And Monitoring Plans
Task 3	Install Irrigation System
Task 4	Planting Site Preparation And Maintenance
Task 5	Grow-Out Grasses, Shrubs, And Trees
Task 6	Plant Native Grasses
Task 7	Plant Native Trees And Shrubs
Task 8	Install Electrical Fencing And Graze Cows For Mesquite Propagation
Task 9	Irrigation Management And Maintenance
Task 10	Ground Water Depth And Precipitation
Task 11	Monitoring Revegetation Success
Task 12	Monitoring Bird Use Of Restoration Area
Task 13	Dissemination Of Project Information
Task 14	Six Semi-Annual Progress Reports
Task 15	Final Report

RESTORATION GOALS AND OBJECTIVES

Our management objective at Bingham Cienega Natural Preserve is to restore native vegetation to the abandoned agricultural fields, thereby increasing the density and diversity of native plant and animal species.

Competition with exotic weeds and reduced water availability at the soil surface have prevented deciduous riparian trees and shrubs and sacaton from re-establishing at the Preserve, despite the fact that the depth-to-groundwater profile is adequate to maintain these riparian species once established. These same factors have also limited natural re-establishment of native vegetation at other sites where surface hydrologic regimes and native plant communities have been altered.

An active restoration effort is being undertaken at this site because the site is a key part of the overall natural community and the groundwater levels are high enough to support the species targeted for revegetation, once they are established. The site also has access to roads to bring in equipment and to a well, which can provide supplemental water to the young transplants. This project is on the pre-entrenchment banks adjacent to the current river channel. Results from this project will provide important new information applicable to similar situations in southeastern Arizona.

We have two overriding restoration goals for the fields:

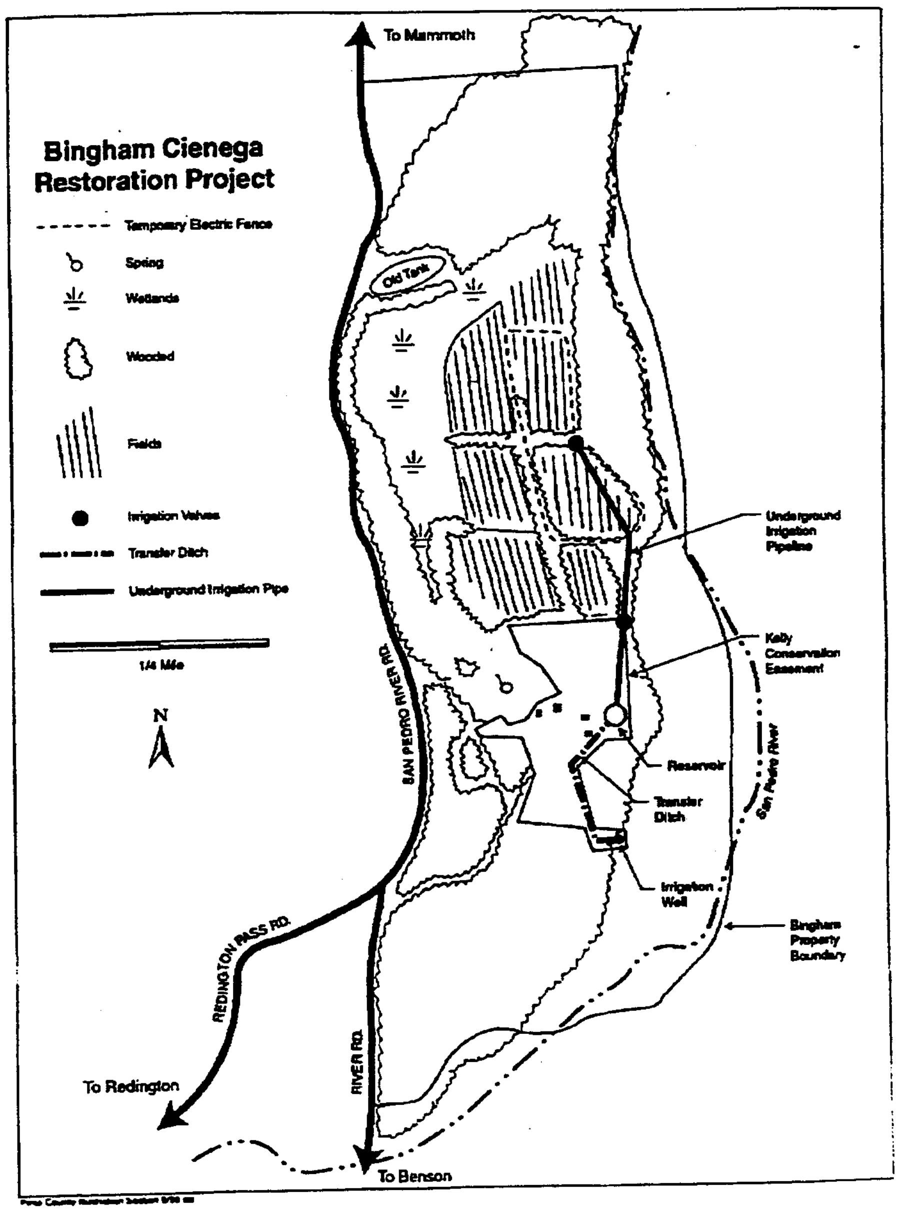
(1) To establish a diversity of riparian habitats in the fields, which, in turn, will support a greater number of invertebrate, reptile, mammal and bird species; and

(2) To plant species in areas where the depth-to-groundwater and soil moisture are sufficient to maintain them once established.

The project objectives are:

(1) To promote the long-term re-establishment of deciduous riparian woodland, sacaton grassland and mesquite woodland in the abandoned agricultural fields; and

(2) To develop practical techniques for promoting establishment of native plants that either do not require irrigation or that require only infrequent irrigation.



METHODOLOGY AND MONITORING OVERVIEW

Based on a site evaluation that included hydrology, geomorphology, soil analysis, and an inventory of existing plants, three planting areas were identified. Each was targeted to support a different riparian community type: deciduous riparian woodland, sacaton grassland, and mesquite woodland.

The general plan was to plant the woody or herbaceous species that are canopy dominants of each plant-community type. When these elements are established, they will promote the passive restoration of the related species in that plant community. We also planted a variety of other native grass seeds throughout the restoration area to ensure that there is a seed source for these species. We explored and evaluated methods, results, and costs for these restoration efforts to help plan future projects.

There is an extensive monitoring program in place for each of the targeted restoration areas. The monitoring plan contains three components: a vegetation monitoring plan, a bird monitoring plan, and a groundwater-monitoring plan. Photopoints are a part of the vegetation monitoring.

OVERVIEW OF RESTORATION SITE AREA

Figure 1 is a black and white aerial photo with working field names of the site. The year that activities were conducted in the fields is summarized on **Figure 2** and listed in **Table 2**. These black and white aerial photographs will help explain the project's areas of activity

During active implementation of the Restoration Plan, we used the terms "Year-one" or "Year-two" field **(Table 2)** to reference where we were working.

Each "Year X field", depending on the groundwater levels and existing vegetation, has different Planting Areas (Riparian Woodland, Sacaton, and Mesquite Woodland) within its boundaries. These planting areas are shown on **Figure 3**.

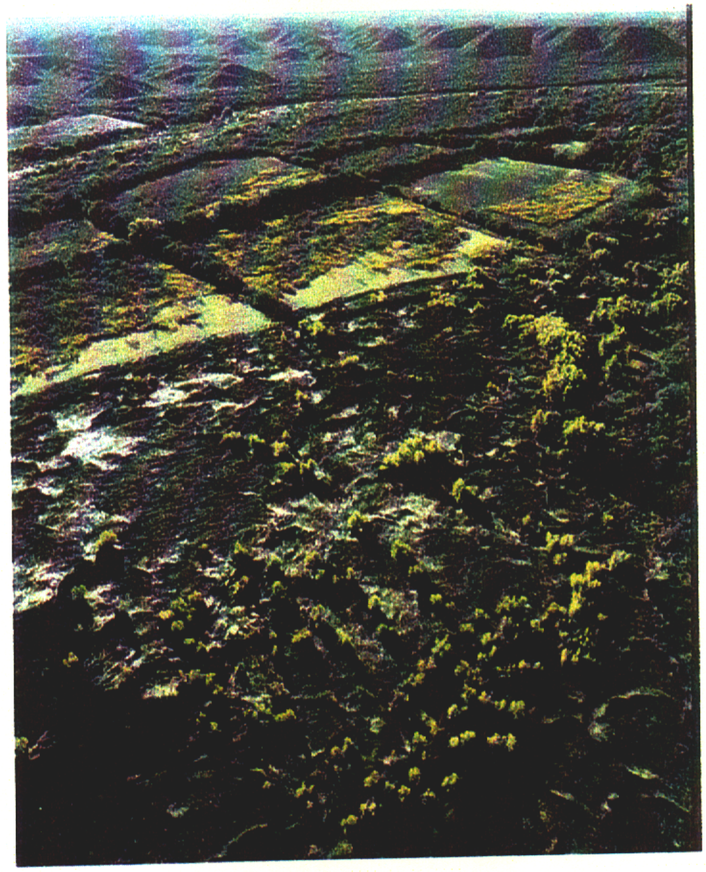


Photo bv Adriel Hiesev

Bingham Cienega Natural Preserve
Working Field Locations

FIGURE 1

Bingham Cienega Natural Preserve
Areas Of Vegetation Planted By Year

FIGURE 2

TABLE 2. ACTIVITIES CONDUCTED BY YEAR IN EACH FIELD
YEAR-ONE FIELD This field has three sections with differing activities. The western half (approximately five acres) was planted with deciduous tree saplings in autumns of 1998 and 1999. The eastern half was planted with sacaton grass seedlings in the summers of 1998 (five acres) and 2000 (one acre).
YEAR-TWO FIELD This field has three sections with differing activities. The largest section of this field is the five-acre sacaton area planted in 1999 and completed in 2000. West of the sacaton, in an elongated two acres with a bermuda sod, are trees and shrubs planted in 1998 and 1999. West of those trees and shrubs and into the eastern edge of the cienega are dormant poles planted January 2000 and February 2001. Additionally, there are dormant poles planted in 2001 across the cienega on its far western side.
YEAR-TWO FIELD EAST (mesquite field) This roughly two-acre area was planted in December 1999 with mesquite saplings and overseeded in 2001 with the native grass mix.
YEAR-THREE FIELD This is the northernmost restoration field (three acres) and was planted in sacaton in the summer of 2000. It now has a strong stand of sacaton bordered by the naturally occurring mesquite regeneration to the east and a very thick carpet of Bermuda to the west where we successfully introduced buttonbush in 1998 and 1999. Dormant willow poles were placed in the cienega edge west of the buttonbush in 2000 and 2001. This field has a lot of johnson grass on the north west side and gopher activity throughout. The spot-spray test area started in 2000 for Bermuda in the SW corner of this field stayed bare until late spring 2001 when a thick cover of sunflowers emerged.
YEAR- THREE FIELD EAST This is the largest of the old agricultural fields (about 12 acres) and is east of the northern 2000 sacaton/mesquite field. The canopy of naturally recruiting mesquite trees is very open in this area. It is rather savannah-like and we targeted the open spaces for seeding with other native perennial grasses. We mowed the annual weeds in May 2001 as the only preparation towards planting before the upcoming rainy season. Our goal was to minimize ground disturbance and use the new seed drill to plant through the litter and stubble. Predominant weeds were yellow starthistle, london rocket, and some wild oats and gaura. The previous two years had dense stands of sunflowers, but they were not present in noticeable amounts this summer.

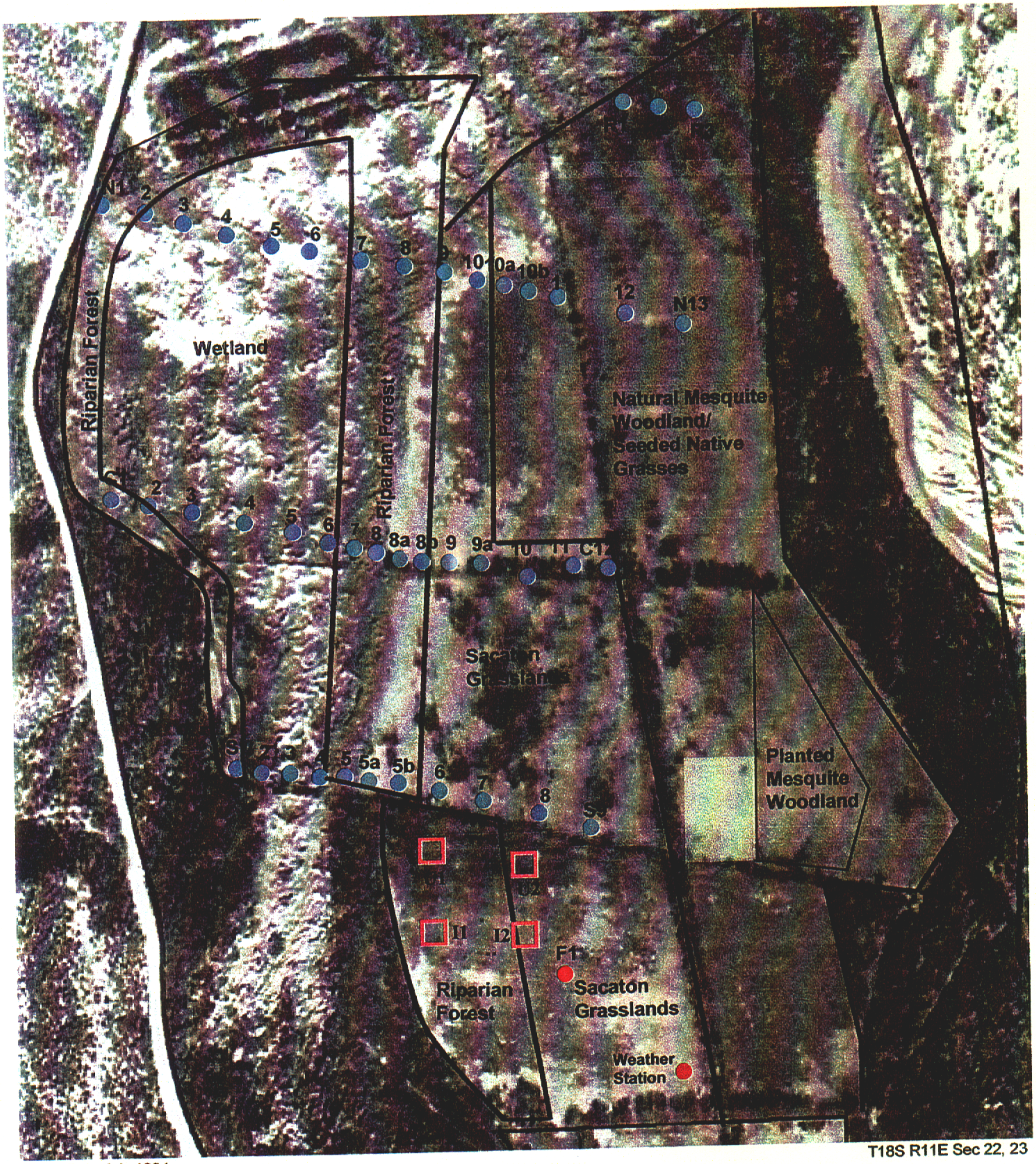


Photo Date July 1994

T18S R11E Sec 22, 23

BINGHAM CIENGEGA NATURAL PRESERVE

RESTORATION PLANTING AREAS

FIGURE 3

S2 Wetland Monitor Well and Identifier

Boundary of Restored Plant Community

N

Thinned Mesquite Test Plot

Irrigation and Depth to Water Test Plot

U=Unirrigated; I = Irrigated

OVERALL SITE PREPARATION (GRANT TASKS 1- 3)

Several overall project steps were taken to begin the restoration work. These steps effected all three planting areas. These general activities are reported here, and the more specific treatments for each of the three planting areas are detailed under separate headings for Riparian Woodland, Sacaton Grassland, and Mesquite Woodland.

PERMITS AND CLEARANCES

Pima County Flood Control District (PCFCD) obtained State Historical Preservation Office (SHPO) project clearance in February 1998 for activities that may impact historical resources. Permits were obtained from Arizona Department of Water Resources (ADWR) before the grant period for the installation of the observation wells for groundwater monitoring.

OVERALL SITE CONSIDERATIONS

In June of 1998, the vegetation, bird, groundwater, and photo monitoring plans were submitted as part of the earliest grant deliverables. These plans and the grant contract defined the scope of the work.

One of the restoration management techniques for which we have planned but not implemented during the grant period is the use of prescribed burning. The wetland cattail and willow area and some of the surrounding deciduous forest and mesquite bosque burned in a wildfire in late January of '00. There was a prescribed fire at the site in 1996.

Boundary fences were maintained or rebuilt during the duration of this grant to protect the restoration area from trespass cattle and people. Old interior fences are being removed. Feral pigs are also being trapped and dispatched.

INSTALL IRRIGATION SYSTEM

To help establish tree and grass transplants, the restoration plan calls for supplemental water. We decided to use the existing system designed for flood irrigation. It had fallen into disrepair. We refurbished some of its components that no longer functioned and replaced open ditches with PVC irrigation pipe for the final delivery to the fields.

In August of 1998, Gilbert Pump Company of Tucson, Arizona Public Service (APS), PCFDC, and TNC reinstalled a water delivery system from the shared irrigation well on the Kelly in-holding.

To meet project needs, we installed a 20hp Gould vertical turbine pump rated at 1,200 gpm and erected a new three-phase electrical panel to APS standards with a 460v fusible disconnect, 100 amp meter box, lightning resistor, and weather head. At the service panel, APS installed a new transformer, pole and lines, and a digital kWh display service meter. PCFCD entered into a three-year electrical supply agreement with APS. Jack Kelly and TNC kept a log of kWh used for the shared irrigation well.

The 8" discharge pipe from the pump was connected to an existing pipe that fed into a thousand-foot long cement ditch. TNC contracted locally to repair this ditch and the holding pond where it discharges. The sides of the ditch were shored up and cracks repaired. Cracks were patched again in 1999. The ditch was also routinely cleared of debris from falling leaves and limbs.

The holding pond was graded out and sealed with clay and graveled at the discharge area from the cement transfer ditch. It has held water well for most of the project period, but is leaking somewhat now in 2001. A metal screen was installed over the outlet pipe in the bottom of the pond to keep debris out of the 12" underground pipe that carries water from the pond to three risers located along the eastern side of the restoration fields. This screen can be cleaned semi-annually as needed. New valves were placed at the risers in 1998 and 2001 to prevent leaking. It is important to keep water pressure in the underground pipeline. Two new 12"x8" center tension hydrants were purchased and one was borrowed from J. Kelly. These are shut off valves and are installed on the risers.

Connected to the hydrants are 20-ft lengths of 8" solid Diamond Lite surface irrigation pipes that bring the water to the year-one, two, and three fields. When the pipe reaches the restoration areas, gated sections are opened to flood the furrows where grass or trees are planted.

IMPLEMENTING THE RESTORATION PLAN (GRANT TASKS 4 THROUGH 9)

To produce stock for the plantings, staff and volunteers gathered seeds of giant sacaton

(Sporobolis wrightii), sand dropseed (*Sporobolis cryptandrus)*, and sideoats gramma *(Bouteloua curtipendula)* grasses along with seeds from the deciduous trees buttonbush (*Cephalanthus occidentalis)*, ash *(Fraxinus velutina)*, walnut *(Juglans major)*, mesquite *(Prosopis velutina)*, and hackberry *(Celtus reticulata)* at the cienega in the fall of 1997. Sacaton and sideoats seeds were also collected in 1999. These grass seeds were all processed at the USDA Plant Materials Center in Tucson. Attempts to gather seeds from salt grass *(Distichlis stricta)*, knotgrass *(Paspalum distichum)*, and vine mesquite grass *(Panicum obtusum)* at the cienega were unsuccessful. The tree and cleaned grass seeds were sent to greenhouses for propagation. The sacaton seeds harvested in 2000 were only cleaned by stripping the seeds from the stems and then used in the 2001 direct-drill and broadcast planting of mixed grasses. We purchased native seeds, including vine mesquite, from a local collector if we could not locate them ourselves.

All of the old fields had some degree of mesquite regeneration as well as Bermuda grass (*Cynodon dactylon)*, bindweed (*Convolvulus arvensis*), Johnson grass *(Sorgum halapense)*, sunflowers (*Helianthus annuus)*, gaura (*Gaura parviflora)*, and other native and exotic, annual and perennial species. The fields were last worked for agriculture in 1987. We used different methods of site preparation within the three Planting Areas, and those will be detailed in each Planting Area report. In general, we should note that the site preparation is based on what the ground conditions are, what is being planted, and what post-planting treatments will be.

In the deciduous woodland and sacaton planting areas, we needed to eliminate naturally recruiting mesquite trees so that we could work the fields with a tractor. We tried removing mesquites by hand and mechanically. After the large plants were removed, the ground was loosened by disking and then furrowed to form the channels for irrigation.

After the fields were planted, they were mowed to control competition to the targeted species by exotic species. We also used Round Up to spot spray mostly Johnson grass. It was used monthly during the growing season in '99 and '00 in all the fields, and did not eliminate this species.

SACATON GRASSLAND PLANTING AREA

Thirteen acres were planted with sacaton using greenhouse-grown plants in two pot sizes. Most of the planting area was periodically irrigated but a portion was not irrigated for test purposes. Most plants were grown in 3" "honeycomb" paper cells, but some individuals were grown in 8.5" pots.

Site Preparation

In 1997, we removed mesquite saplings from an eight-acre area in the Year-one field by cutting them at ground level with a chain saw and loppers. We applied Garlon to the root crowns. In 1998, the area was planted. In early 1999, we decided a project of this scale needed to be done with machinery and that this preparation was inadequate. We found that many of those mesquites were not killed after a second application of herbicide, and the new shoots and the old stubs made working in the field with a tractor very difficult. We couldn't effectively mark irrigation furrows to keep them free of gopher activity or mow weeds because the trees were tearing up the tractor tires, a costly experience.

In January of 1999, we removed mesquites in the Year-two field by ripping and dozing them into piles. That proved a more efficient method of removal than cutting at ground level and treating with herbicide. We learned that debris piles need to be free of dirt and have more than six months drying time if burning is the sole method of disposal.

Ripping was not effective for Bermuda grass removal. Near the cienega, the extremely thick Bermuda sod in both Year-two and Year-three fields prevented us from planting sacaton. If we had had more preparation time and/or heavier equipment, we could have ripped and disked repeatedly, loosening the soil sufficiently to make furrows in which to plant sacaton seedlings.

We were not able to use broadscale application of herbicides to suppress Bermuda at this site. Local residents asked us not to apply herbicides beyond spot-spraying individual plants. We did not try removing Bermuda by spraying herbicides as a part of preparing the site for planting.

After the initial preparation of mesquite removal, we used a 2240 John Deere tractor to pull a disk to smooth the field and then a toolbar with three shovels to make furrows. We irrigated several days before transplanting and immediately after transplanting. The toolbar and shovels were also used to control weeds and keep the furrows clear of gopher activity so that we could water when the young plants needed it.

In the late summer of 1999, the northern half of Year-one field was mowed and then ripped and dozed. The northeastern quadrant of that field was slated for sacaton seedlings the following summer. It lay fallow over the winter and the following April was disked, furrowed, and irrigated in preparation for the Sacaton transplants.

The western third of Year-three field was also ripped and dozed to remove scattered mesquite trees in late 1999. The eastern half of that field was covered with a thick stand of naturally regenerating mesquites and we decided to change the original restoration plan that called for sacaton throughout this area. We felt that it was both cost-effective not to hire the heavy equipment to remove mesquites as well as site-sensitive to accept the naturally occurring mesquites and work around them. We hoped to slow down Bermuda and Johnson grass there by leaving the roots exposed to freezing temperatures over the winter, but that is an iffy proposition at best; it wasn't a particularly cold winter and the rhizomes can be stimulated by separating like this.

Grow-out seedlings for planting

In three years, approximately 62,000 sacaton seedlings were transplanted into roughly thirteen acres. We planned on using about 5,000 sacaton seedlings per acre. The first year, 500 sideoats and sand dropseed seedlings were also produced and planted.

Coronado Heights Nursery supplied 4,500 sacaton seedlings in '98. Most of these transplants were in 3"paper pots. Some were in larger pots to test survival of the different sizes.

The University of Arizona's Desert Legume Program grew-out over 20,000 mixed grasses in the summer of '98. Protocol included application of fertilizer and fungicide, in addition to careful irrigation and trimming of overgrown seedlings.

In the summer of 1999, volunteers from Intel and TNC staff completed a greenhouse at the San Pedro River Preserve (SPRP) in Dudleyville, north of the cienega. Volunteers for Outdoor Arizona (VOA) and TNC staff started grass seeds in nursery flats divided by paper into three-inch sections. 21, 000 sacaton seedlings were delivered to the cienega. We learned that over watering can lead to a fungus that covers the soil and kills the sacaton. When starting grass seedlings, monitor the amounts of water applied very carefully. We also had problems with an automated sprinkler system and under watered in the greenhouse. We fertilized with Miracle-Gro. If needed, we trimmed seedlings.

In 2000, 16,000 seedlings were delivered for the project. This year, we used a hand held vibrating seeder device that regulated the amount of seed placed in each of the pots. That eliminates the need to thin emergent seedlings in each pot. We tried adding soil from under mature plants at the cienega to the commercial potting mix to inoculate with naturally occurring soil mycorrhiza.

It took three staff people one full day to fill 15,000 paper pots in trays with soil and seeds and place them in the greenhouse. A larger group of volunteers gets the job done in a half day. Once the trays are in the greenhouse, watering and temperatures must be closely monitored. The seedlings were ready in about three or four weeks to leave the greenhouse for a two-week period of hardening off before transplanting. The trays could be stacked in a pickup bed and transported to the restoration site with no damage to the seedlings. They could also be held at the site in the paper pots/trays for another week or two, if watered daily and placed in the shade. They are better planted before becoming too rootbound.

Planting

We used both hand and mechanical transplanting techniques. A team of six works well for either technique.

By hand, a pole is used to make holes about one meter apart as you walk down the row. Carry the tray of plants down the row and drop off a seedling, still in the paper pot, at each hole. Go along the row and place each plant in a hole, with care given to the depth, and firm the soil around the roots. Deeper (crowns slightly covered) is better than too shallow placement. Plant well away from the furrow if you are going to be mechanically maintaining the field because the tractor and implements need space to work.

If using a tractor-drawn Holland transplanter, load the boxes with seedlings that are at least five inches long. This helps the mechanical clamp get a good grip on the seedling. Set the height carefully so the depth of planting is regulated. You will want one or two people walking behind the planter to check and correct the placement of the seedlings.

Planting into damp soil and irrigating immediately afterwards is very important.
As a general observation, sacaton transplanted in July has fared the best. There are other factors, such as seedling vigor and amount and timing of rainfall and irrigation and herbivory and soil variation and weed competition, obviously. Parts of the August 1998 planting are very healthy, as are plants from other years done in August, May and September.

The last grass planting was completed in June 2001 without growing and transplanting seedlings. We overseeded areas in the sacaton grassland and mesquite woodland with a mix of native perennial grasses. The purpose of this was to insure a seed source of a diversity of grasses in the restoration area.

Site maintenance - mowing and irrigating

We used a brush hog mower pulled behind the tractor to mow the fields. We wanted to keep competition by sunflowers, Johnson grass, and other species under control until the sacaton and trees became well established. In 1999 and 2000, during the warm season, we mowed about once a month. The exception to this regime was the 1998 sacaton in the Year-one field, which was only mowed once a year in June of 1999 and 2000 and not at all in 2001. The other fields have been mowed once in 2001 during May.

In about two acres of the Year-one field 1998 sacaton planting, we used mulch to suppress weeds. Because this was very labor intensive and because hauling costs were prohibitive, we did not repeat that in other areas. Mulch and litter generally promote healthy soil and suppress certain annuals, like sunflowers. We note that bermuda was not deterred for any length of time by mulching.

We created furrows to irrigate the plantings. In order to efficiently provide water to the plants, we had to periodically re-furrow to keep the channels clear of gopher digging and weeds. This also helped with weed control, and might have deterred gopher activity. We had to manage the solid and gated irrigation pipes that carried the water to the fields by moving them when we mowed.

Frequency of irrigation was an oft-debated activity. We wanted to give the sacaton a good start while we were actively restoring the area, while not encouraging exotic species that were more dependent on the supplemental water. The more we watered, after a point, the more we had to mow to suppress the weeds we brought up with the extra water.

Direct Seeding of Other Native Grass Species

In June of 2001 we completed this task by directly seeding another seven acres with mixed native grasses in the northeast part of the restoration area. We used the Truax range drill drawn by the 5410 John Deere tractor from the SPRP. Ground disturbance was kept to a minimum. We planted around the existing shrubs and young trees. Light seed was mixed with wood shavings and put in a separate box on the planter from the heavier seed.

An additional random three acres within the already established restoration plantings were hand broadcast with the same seed mix. We planted at about 14 pounds per acre. We will monitor results through photo points.

The seed, with the exception of the giant sacaton, was obtained from Wildlands Restoration of Tucson. It was gathered in the southern part of Arizona and was comprised of these species: cane beardgrass (*Andropogon barbinoides*), sideoats gramma (*Bouteloua curtipendula)*, Rothrock gramma (*Bouteloua rothrockii*), spiked pappus grass (*Papophorum mucronulatum*), Arizona cottontop (*Trichachne californica)*, small-flowered fesque (*Vulpia microstachya*), green sprangletop (*Leptochloa dubia*), plains bristlegrass (*Setaria macrostachya*), bottlebrush squirreltail (*Sitanion hystrix*), alkali sacaton (*Sporabolis airoides*), sand dropseed *(Sporabolis cryptandrus*), giant dropseed (*Sporabolis gigantaeus)*, giant sacaton (*Sporabolis wrightii*),and Indian wheat (*Plantago insularis)*.

The price per pound for this seed mix was eighteen dollars. For the area where we used the drill to plant, the cost-per-acre was $350.

RIPARIAN WOODLAND PLANTING AREA

Ten acres were planted with deciduous riparian trees and shrubs using dormant poles and containerized saplings. Target plants include Goodding willow (*Salix gooddingii)*, Fremont cottonwood *(Populus fremontii)*, netleaf hackberry (*Celtis reticulata)*, Arizona walnut (*Juglans major)*, velvet ash (*Fraxinus velutina)*, and buttonbush (*Cephalanthus occidentalis)*.

There are 5 acres in year-one field planted in '98 and '99 to ash, buttonbush, walnut, and hackberry. Year-two field has about three acres planted to ash and buttonbush saplings in '98 and '99 and dormant poles of willow and cottonwood in '01. Year-three field has about an acre of buttonbush saplings planted in both '98 and '99 and an acre of dormant poles done in '00 and '01. The depth to groundwater indicated by the observation wells guided where which species of tree was planted.

Site Preparation

The original tree area in the southwest quadrant of the Year-one field was prepared in the same manner as the first grassland restoration area; naturally occurring mesquites were cut at the soil surface and treated with an herbicide. Furrows or borders were then marked into the soil so that supplemental water could be provided.

The following year, 1999, saw us following a different protocol. We contracted to have an operator rip and doze the woody vegetation around the trees planted in '98 and in the area we would be planting in '99. This made it possible to use the tractor and implements to work the fields.

The first step towards field preparation was to mow. Next, the dozer knifed the woody vegetation to break out the root system. Then, the remains were dozed out of the work area and into a pile where they could be burned later when dry or left to rot. Next, the tractor and disk were used to level the soil and further clean up the area. There needs to be some soil moisture present to then mark the furrows with the drawbar and shovels and to dig the holes for the saplings. If we needed to wet the area before creating the holes, it was necessary to temporarily lay down irrigation pipe, apply water, wait several days and remove the pipe and furrow and drill as needed. With luck and timing, rainfall events can be utilized for this part of the soil preparation. We used an auger powered off the tractor to make the holes for transplanting the containerized trees. Irrigation pipe was laid to the furrows.

The buttonbush saplings transplanted in Year-two and Year-three fields were not irrigated. Holes were augured near the wetland's edge and no furrows were made. No site preparation was necessary for the dormant pole plantings.

Grow-out saplings and harvest poles

Coronado Heights Nursery of Tucson provided container stock grown from seeds collected at the cienega for the restoration project. They supplied the 1,500 buttonbush, ash, walnut, and hackberry containerized saplings.

The trees were delivered to the site in November of 1998 and 1999. They averaged two feet in height and were in 4X4xX14 inch plastic containers, which we returned to the nursery after planting the saplings. Containerized saplings were watered daily until planted.

Over 600 dormant poles of willow and cottonwood were cut in January of 2000 at the San Pedro River Preserve. Volunteers and staff bundled the roughly six foot long, average two-inch diameter poles for transport to the cienega in five-gallon buckets of water. They were stored for a week with the bases submerged in water before planting.

In February of 2001, 300 average four-foot long willow poles were harvested at SPRP and transported with their bases in buckets of water and planted the same day.

Planting

When transplanting saplings, we worked in damp soil. The containers were placed in the field by the holes, which were next to furrows. A shovel was used to make sure the holes were clear and to help set the dirt around the newly transplanted saplings. Keeping the rootballs intact as the trees were planted was tricky and important. If the site is prepped, a volunteer team of 20 can plant about 600 trees in a day. We varied the distance between trees (from 8 to 10') although we had to plant in lines to provide supplemental water.

The dormant poles were all planted in late winter at the edge of and within the cienega proper. Water levels were at or just below the surface of the root zone of the cattails. We opened holes about one foot deep with a digging bar and then pushed the poles into and through these holes to a depth of at least 18".

The relatively small size of the poles made it easier to handle them. A team of less than twenty volunteers handled the larger 2000 event in one day, and the second planting in 2001 was done in less than half a day with about ten volunteers and two staff members.

Site maintenance and irrigation

The transplanted saplings were irrigated during the dry summer months on a monthly basis in 1999 and 2000. They were also watered during the cool season if needed. The weeds between the furrows were mowed mechanically and by hand around the trees. The furrows were re-marked to insure delivery of the irrigation waters.

The gopher cages installed on selected trees planted in 1998 were removed in early 2001. We found that the chicken-wire cylindrical cages helped prevent herbivory. However, we also found that the labor costs of manufacture, installation, and removal were high. It was better to produce and plant enough specimens to accommodate some loss. A positive aspect to losing plants from the furrows is that it helps the site move away from a cultivated mode and appear more natural.

Three interesting things occurred to the poles planted in mid-January of 2000. They were unintentionally burned two weeks after being planted. The fire was quick and hot and carried by the thick mat of dead cattail. Subsequently, the poles were heaved up four to six inches by the freezing of the bare, wet soil. This was plainly visible by looking at the unburned bark area below the blackened bark and above the soil surface a month or so after the fire. Then, the water levels in the cienega dropped drastically that spring and summer because of drought, and almost every pole died because the roots were unable to follow the receding water table. The poles planted in 2001 have not had these stresses and are doing well.

MESQUITE WOODLAND PLANTING AREA

In the old fields farthest from the wetlands, natural recruitment of mesquite (*Prosopis velutina)* is extensive. The adjacent unfarmed areas are mesquite and hackberry dominated forest. The natural recruitment in the different abandoned fields is variable.

One area within that section of deeper groundwater levels remained bare and some areas were extremely dense. We tried propagating mesquites in an empty two-acre area by fencing in cattle and feeding them beans and also by planting saplings with limited irrigation. We also thinned and pruned a one-acre area of mesquites. In portions of the more open mesquite forest we seeded grasses.

Site preparation

In 1998, we unsuccessfully attempted to propagate mesquites in a two-acre area by fencing in cattle and feeding them mesquite beans. We did not succeed because the animals we used were not handled well. We needed stock that was more accustomed to being confined and we needed to provide more feed in the form of supplemental hay in addition to the beans. This is probably a viable method of starting mesquites, but we have no data from this project to support it.

After our attempt to use cattle to propagate mesquite failed, we decided to try a new technique being used to introduce saplings into areas where supplemental irrigation is unavailable. In the late fall of 1999, we mowed the Russian thistle and then disked and bordered in Year-two field East. The borders allowed us to flood irrigate the area to dampen the soil so that we could make holes for the saplings. We used the posthole-sized auger attached to the tractor to prepare larger holes in a very random pattern within borders rather than along furrows.

Grow out saplings

Arizona Game and Fish propagated about 350 mesquite trees, which they donated and delivered in December of 1999. They used 6" X 30" PVC tubes as planters. The long container is to help get the roots down to deeper groundwater levels.

Plant

One TNC staff member transplanted the trees over several days. The soil was damp but dry enough to use the tractor. After a bordered section was planted, it was flood irrigated.

Maintenance and irrigation

We amended our protocol for this method because of the extremely dry conditions at the time. Originally, we were to water the augured holes once before and once at the time of transplant and then provide no further irrigation. We irrigated the area twice in early 2000 because it was the driest winter in over 100 years and we did not want to lose all the trees. Costs were less than the average $260 per acre because we did not irrigate often.

IMPLEMENTING THE MONITORING PLAN (TASKS 10 THROUGH 12)

Since most of the restoration methods used in this project were either new (and evolving based on experience at the site) or developed in areas with different temperature and rainfall regimes, our objective was to evaluate their effectiveness locally by monitoring the survivorship and growth of transplanted individuals. This information combined with cost estimates for the various methods will permit us to articulate a set of recommendations for restoring the woody and herbaceous dominants of three floodplain community types--sacaton grassland, broadleaf riparian forest, and mesquite bosque--into abandoned agricultural fields. As previously outlined, the various restoration methods used included: low vs. high impact techniques for field preparation; planting sacaton seedlings grown in two pots sizes under two irrigation scenarios (periodic vs no irrigation); pole plantings of cottonwood and willow and container planting of ash and other woody species; caging plants to exclude gophers; suppressing weeds through use of mulching, mowing and localized herbicide application; thinning naturally-recruited mesquite saplings to increase growth; and transplanting mesquite saplings grown in tubes that encourage tap-root formation.

SACATON PLANTING AREA

Results from an earlier restoration study at TNC's Patagonia-Sonoita Creek Preserve (PSCP) indicated that supplemental watering increased survivorship of greenhouse-grown sacaton seedlings only slightly: 96% of irrigated seedlings grown in 14" pots survived their first growing season compared to 90% of un-irrigated seedlings (Gori et al. 1997). It was more cost-effective not to irrigate sacaton seedlings grown in 14" pots when the expense of setting up, operating, and maintaining the irrigation system was factored in. The following summer we compared the survivorship of un-irrigated plants grown in 14" vs. 8.5" pots over the first growing season. Plants grown in the larger pots survived better (96% survivorship vs. 76%), however, plants in the smaller pots could be planted, grown and transplanted more efficiently and the cost of soil and pots were less on a per plant basis, making use of the 8.5" pot size more cost-effective overall.

Bingham Cienega is 1200 ft lower in elevation than Patagonia, average daily temperatures are warmer, and Bingham receives less annual precipitation. Thus, it is unclear whether irrigation is required to sustain high survivorship of sacaton in 8.5" or 3" pots at this and other low-elevation sites.

In addition, different methods of field preparation, planting, irrigation and weed control were used in the Year-1 and Year-2 fields. A comparison of sacaton survivorship and growth in the two fields will indicate how plants responded to these different techniques and will assist in the evaluation of their overall costs and benefits.

Thus, the monitoring objectives were:

1) to estimate the percent survivorship and growth of sacaton plants grown in 3" pots over two growing seasons in the Year-1 and Year-2 fields; and

2) to estimate and compare the percent survivorship and growth of irrigated vs. un-irrigated sacaton plants grown in 8.5" and 3" pots at two groundwater depths (ca. 1 meter vs. 2 meters) over two growing seasons.

METHODS

To address the first objective, 123 plants in the Year-1 Field were randomly selected in August 1998 soon after planting using a stratified random design. This sampling design ensures that plants growing throughout the field (i.e., at all groundwater depths) were represented in the sample. Seventy-six of these plants occurred in areas that were periodically mowed to control weeds, whereas 47 plants occurred in areas that were mulched plus mowed. Mowing consisted of using a power mower that cut weeds between furrows whereas a rough-grade mulch was placed in furrows and around plants in the mulching treatment. The entire field was spot-treated with herbicide to control Johnson grass. Selected plants were permanently marked with a numbered metal tag and flagged; the tag was anchored to the ground near the plant using a 4" nail. The planting row and distance along the row were both recorded to assist in relocation of flags, tags, and plants. Plant height and basal diameter were measured when plants were initially tagged. Survivorship, presence of flowering, height, and basal diameter were re-measured in November, 1998, after the first growing season and November, 1999, after the second growing season. Plant height was measured as the distance from the ground to the highest leaf using a meter stick while basal diameter was measured with calipers. Seventy-eight plants in the Year-2 field were randomly selected (again using a stratified random design), measured, flagged and marked with a numbered tag in August 1999 soon after planting. These individuals were relocated and re-measured in November 1999 after the first growing season and in November, 2000, after the second growing season. Tagged plants in the Year-1 and Year-2 fields are hereafter referred to as "field plants".

To address the second monitoring objective, four 10 m x 20 m plots were established in the Year-1 Field; two plots were irrigated on the same schedule as the Year-1 Field, the other two were un-irrigated. Irrigated and un-irrigated plots were paired spatially with one pair located at ca. 1 meter depth-to-groundwater and the other at ca. 2 meters depth-to-groundwater **(Figure 3)**. **Table 3** shows the number of plants by pot size in each of the four plots. Seedlings from the different pot sizes were distributed randomly within plots. That is, planting locations (1 m apart) within each row were randomly assigned to plants grown in either 8.5" or 3" pots with the restriction that an equal number of plants of both pot sizes had to occur in each row. Plants were permanently tagged at the time of planting (July-August, 1998) and their location (row and distance along the row) was recorded. Height and basal diameter of plants were also measured at this time. Survivorship, flowering, height and basal diameter were re-measured in November, 1998 and 1999.

Table 3. The number of plants by pot size in each of the four plots.

	Plot Abbreviation	Pot Size 3"	8.5"	Total Number Plants
Unirrigated-1m depth-to-ground water	U1	151	112	263
Unirrigated-2m depth-to-ground water	U2	130	113	243
Irrigated-1m depth-to-ground water	I1	137	117	254
Irrigated-2m depth-to-ground water	I2	138	120	258
TOTALS		556	462	1018

RESULTS AND DISCUSSION

Field Plants

In the Year-1 field (Field 1), survivorship from planting (August, 1998; T1) to the end of the first growing season (November 1998; T2) was 95.1% despite a delay in the establishment of the irrigation system and the affinity of gophers for sacaton seedlings growing in moister soils (see below). The flowering frequency was 27.4% which seems high given that plants were 2-3 months old at time of planting, had a limited growing season under field conditions and may have been stressed due to transplanting **(Table 4)**. By the end of the second growing season (November 1999; T3) survivorship had dropped to 69.1% whereas flowering increased to 61.2%. The mean diameter and height of plants at T1, T2, and T3 as well as the mean diameter-growth and mean height-growth between T1-T2, T2-T3, and T1-T3 are summarized in **Table 4**. On average, plants increased in height and basal diameter over both growing seasons.

Since the weed control treatments were fully implemented shortly after T2, their effects on sacaton survivorship and growth were evaluated between T2 and T3. Mowing vs. mulching plus mowing had no differential effect on the survivorship and growth of plants **(Table 5)**. However, the frequency of flowering was significantly higher for plants in the mowed treatment compared to those in the mulched plus mowed. Interestingly, plants in the mowed treatment were taller at the end of the first growing season (T2), but this difference disappeared by the end of the second growing season (T3) and there was no significant difference between treatments in the mean height-growth over the second growing season (T2-T3; **Table 5**). Thus, mulching appears to contribute little to survivorship and growth of sacaton beyond what mowing is already doing. This result is surprising since mulching is known to increase soil moisture, enhance microbial and soil invertebrate activity, and inhibit weed growth. Bermuda grass, however, had little problem growing up through the mulch and we could detect little difference in its density between mowed and mulched plus mowed areas. In addition, mowed weeds were left laying around plants resulting in the build-up of a mulch layer over time in both areas.

Given the cost of hauling mulch to the site and distributing it around plants, we recommend that mulching not be used in future sacaton restoration projects of this kind.

*Table 4. Comparison of sacaton survivorship, flowering, mean size and growth in Year-1 and Year-2 fields (Field 1 and Field 2, respectively) after one (T2) and two growing seasons (T3); standard deviations are given in parentheses. X^2-tests and t-tests were used for statistical comparisons; significance levels are indicated (NS = not signifcant, $p > 0.05$; ** = $p < 0.005$).*

Dependent Variable	FIELD 1	FIELD 2	Statistical Significance
Number Surviving T2	117	64	
Number Surviving T3	85	55	
Survivorship T2 (%)	95.1	78.2	**
Survivorship T1-T3 (%)	69.1	70.5	NS
Flowering at T2 (%)	27.4	4.9	**
Flowering at T3 (%)	61.2	14.3	**
Mean Diameter (cm) T1	2.3 (1.3)	3.4 (1.4)	**
Mean Diameter (cm) T2	3.0 (1.5)	5.6 (2.0)	**
Mean Diameter (cm) T3	6.2 (3.8)	9.3 (3.2	**
Mean Diameter-Growth (cm) T1-T2	0.7 (1.8)	2.0 (1.9)	**
Mean Diameter-Growth (cm) T1-T3	4.2 (4.5)	3.2 (4.7)	NS
Mean Height (cm) T1	24.3 (6.8)	12.6 (4.7)	**
Mean Height (cm) T2	38.1 (14.4)	30.5 (9.7)	**
Mean Height (cm) T3	74.7 (25.3)	44.2 (10.1)	**
Mean Height-Growth (cm) T1-T2	17.3 (17.0)	17.8 (10.6)	NS
Mean Height-Growth (cm) T1-T3	48.0 (26.2)	18.7 (22.7)	**

Preparation of the Year-2 field (Field 2) included deep "ripping" and removal of all mesquite stumps before planting. This made it possible for the field to receive repeated, post-planting weed treatments including mowing and spot-application of herbicide from a tractor. Survivorship over the first growing season was 82.1% whereas flowering frequency was 4.9%; both were significantly lower than values observed in Field 1 **(Table 4)**. This lower survivorship may be due to a number of factors unique to Field 2 including the mechanical planting of seedlings, planting seedlings on the top of rows which increases soil drying, and periodic remarking of the field to maintain irrigation. The mean diameter of plants going into the ground was greater in Field 2 compared to Field 1 as was the mean diameter growth over the first growing season (T1-T2). In contrast, the mean height of transplanted plants was less in Field 1 than in Field 2 and this difference persisted at T2. However, there was no significant difference in the mean height-growth over the first growing season between the two fields **(Table 4)**.

By the end of the second growing season, sacaton survivorship had dropped to 70.5% in Field 2, but was equal to sacaton survivorship in Field 1. The flowering frequency increased to 14.3% but was still significantly lower than for plants in Field 1. Mean diameter of sacaton in Field 2 remained significantly greater than that in Field 1 at T3 but there was no difference in diameter-growth between plants in the two fields over two growing seasons (T1-T3). Furthermore, plants remained shorter in height on average in Field 2 and mean height growth was significantly lower in Field 2 over the two growing seasons than in Field 1. These differences in flowering, diameter, height, and height-growth may be due to a number of factors including differences in the physical and biological characteristics of the fields themselves, the time/year of planting, the condition of plants at the time of transplanting, the density of seedlings in pots (i.e. greater for Field 2 plants), where plants were planted (i.e., on top of rows vs. in furrows adjacent to rows); and the manner in which the fields were prepared, maintained, and treated for weeds. Since we set the study up as monitoring study rather than as a replicated field experiment it is impossible to disentangle the effects of these factors on sacaton survivorship and growth. However, after two growing seasons survivorship was equivalent in the two fields. Thus, our recommendations for field preparation and weed control for future restoration efforts will be based on a comparison of costs in the two fields.

*Table 5. Effect of Treatment (Mowing versus Mulching Plus Mowing) on survivorship, flowering and growth of sacaton in Field 1. Measurements were taken after planting in August 1998 (T1), November 1998 (T2) and November 1999 (T3). Standard deviations are given in parentheses. Significant levels are indicated. (NS = not significant; * = p < 0.01).*

Dependent Variable	Mowing	Mulching + Mowing	Statistical Significance
Survivorship T2 to T3(%)	70.0	76.6	NS
Flowering at T3(%)	73.5	44.4	*
Mean Diameter (cm) T2	3.0 (1.6)	2.9 (1.2)	NS
Mean Diameter (cm) T3	4.3 (1.8)	5.4 (2.7)	NS
Mean Diameter-Growth (cm) T2-T3	3.2 (4.0)	2.8 (2.6)	NS
Mean Diameter-Growth (cm) T1-T3	4.0 (4.7)	4.8 (3.6)	NS
Mean Height (cm) T2	41.0 (15.1)	33.9 (12.3)	*
Mean Height (cm) T3	73.1 (23.5)	76.8 (27.8)	NS
Mean Height-Growth (cm) T2-T3	32.6 (23.7)	41.6 (25.1)	NS
Mean Height-Growth (cm) T1-T3	46.8 (26.5)	53.9 (25.3)	NS

Experimental Plots

During the first growing season, irrigation had no apparent effect on survivorship or flowering of plants from small or large pots at 1 meter depth-to-ground water **(Table 6)**. However, at 2 meters depth-to-ground water, survivorship was significantly greater for irrigated plants grown in small pots (3") than for unirrigated ones **(Figure 3; Table 6)**.

Irrigation increased the growth rate of plants grown in small pots at 2 meters depth-to-ground water as it did for plants grown in large pots (8.5") at both 1-meter and 2-meters depth-to-ground water **(Figure 3; Table 6)**.

*Table 6. Effect of irrigation on survivorship, flowering and mean growth of sacaton in plots over the first growing season as a function of pot size and depth-to-groundwater. Survivorship and flowering comparisons were performed using X^2 tests; all other comparisons were performed using t-tests. Significance levels are indicated (NS = non significant, p > 0.05; * = p < 0.05; and ** = p < 0.001).*

	Depth-to-Ground Water	Small (3") Pots		Statistical	Large (8.5") Pots		Statistical
		Irrigated	Unirrigated	Significance	Irrigated	Unirrigated	Significance
Survivorship (%)	1 meter	86.9	83.4	NS	75.2	85.7	0.05
Flowering (%)	1 meter	38.7	42.9	NS	36.4	43.8	NS
Mean Growth Diameter (cm)	1 meter	1.2 (0.9)	1.0 (1.1)	NS	1.7 (0.9)	1.1 (1.4)	**
Mean Growth Height (cm)	1 meter	11.9 (13.9)	12.3 (21.1)	NS	8.7 (12.2)	11.8 (11.6)	0.08
Survivorship (%)	2 meter	96.4	86.9	0.01	93.3	85.0	0.06
Flowering (%)	2 meter	39.9	49.6	NS	52.7	44.8	NS
Mean Growth Diameter (cm)	2 meter	16.4 (12.2)	0.4 (1.2)	**	13.6 (12.4)	1.0 (2.8)	**
Mean Growth Height (cm)	2 meter	5.1 (3.0)	14.8 (11.6)	**	4.7 (3.1)	9.2 (10.1)	**

Unfortunately, the irrigated plot at 1-meter depth-to-groundwater was mistakenly plowed during preparation for deciduous tree planting so we are unable to report the effects of irrigation at 1 meter for the second growing season. Other comparisons (i.e., pot size and depth-to-groundwater) were also affected. Although irrigation occurred only during the first growing season (August 1998 to October 1998), irrigated plants in both pot sizes had significantly higher survivorship and greater growth in height than unirrigated plants did at 2 meters depth-to-groundwater **(Table 7)**. Thus, irrigation during the first year resulted in higher survivorship at the end of the first growing season and continued to influence (increase) survivorship in the second year although plants received no additional irrigation after October 1998. At 2 meters depth-to-groundwater, survivorship of irrigated plants in small pots was 81.2% compared to 33.6% for unirrigated plants (p<0.005). Similarly, survivorship of irrigated plants in large pots was 79.5% compared to 27.1% for unirrigated plants (p<0.005). Irrigated plants in both sized pots showed significantly greater growth in height during the second growing season and from the time of planting (August 1998) than did unirrigated plants **(Table 7)**. However, irrigation had no effect on the frequency of flowering or diameter growth. Thus, irrigation, even if it occurs only during the first growing season substantially increased sacaton survivorship and growth.

*Table 7. Effect of irrigation on survivorship, flowering and mean growth of sacaton in plots over several time periods as a function of pot size and depth-to-groundwater. Significance levels are indicated (NS = not significant, p > 0.05; ** = p < 0.005).*

Dependent Variable	Depth-to-Ground Water	Small (3") Pots Irrigated	Small (3") Pots Unirrigated	Statistical Significance	Large (8.5") Pots Irrigated	Large (8.5") Pots Unirrigated	Statistical Significance
Survivorship T2 to T3(%)	1 meter	↑	11.2	NA	↑	18.3	NA
Flowering at T3(%)	1 meter		57.1	NA		58.8	NA
Mean Diameter-Growth (cm) T2-T3	1 meter	Plot	2.6(4.1)	NA	Plot	1.3(2.4)	NA
Mean Diameter-Growth (cm) T1-T3	1 meter	Lost	3.5(4.1)	NA	Lost	2.4(2.7)	NA
Mean Height-Growth (cm) T2-T3	1 meter		15.2(18.1)	NA		6.7(20.5)	NA
Mean Height-Growth (cm) T1-T3	1 meter	↓	25.9(23.4)	NA	↓	17.2(24.2)	NA
Survivorship T2 to T3(%)	2 meter	81.2	33.6	**	79.5	27.1	**
Flowering at T3(%)	2 meter	73.2	50.0	NS	68.5	47.8	NS
Mean Diameter-Growth (cm) T2-T3	2 meter	1.5(2.9)	1.8(2.4)	NS	1.2(3.5)	-0.01(5.9)	NS
Mean Diameter-Growth (cm) T1-T3	2 meter	3.2(3.2)	2.1(2.6)	NS	3.4(3.8)	1.8(2.9)	NS
Mean Height-Growth (cm) T2-T3	2 meter	41.2(20.2)	22.8(14.9)	**	36.8(21.5)	19.5(22.7)	**
Mean Height-Growth (cm) T1-T3	2 meter	57.7(20.6)	36.6(17.1)	**	51.4(23.9)	32.0(22.0)	**

Over the first growing season, pot size (3" versus 8.5") had no apparent effect on survivorship or flowering for unirrigated plants **(Table 8)**. However, for irrigated plants at 1 meter depth-to-ground water, those initially grown in small pots had significantly greater survivorship but lower mean diameter growth than plants grown in large pots. This result for survivorship is somewhat surprising since at Patagonia Sonoita Creek Preserve, plants grown in large pots had higher survivorship and grew faster than those in smaller pots presumably because of their larger, better developed root systems at transplanting. Plants grown in large pots which received irrigation at 2 meters depth-to-ground water, had a higher flowering frequency than plants grown in small pots. **Table 8** summarizes the effects of pot size.

After the second growing season, there were no significant differences in performance due to pot size **(Table 9)**. Plants started in smaller pots survived and grew as well as plants in larger pots did over the winter and during the second growing season (T2-T3) in unirrigated plots and the remaining irrigated one. In addition, the difference in flowering that was evident after the first growing season at 2 meters depth-to-groundwater disappeared by the end of the second growing season. Although plants in 8.5" pots may have longer better-developed roots at transplanting, keeping these roots intact when removing plants from pots is difficult compared to the 3.0" paper pots, which were planted <u>with</u> the sacaton seedlings (without disturbing roots).

*Table 8. Effect of pot size (3" vs. 8.5") on survivorship, flowering, and growth of sacaton in plots over the first growing season as a function of depth-to-groundwater and irrigation. Survivorship and flowering comparisons were performed using X^2 tests; all other comparisons were performed using t-tests. Significance levels are indicated (NS = non significant, $p > 0.05$; * = $p < 0.05$; and ** = $p < 0.001$).*

Depth-to-		Irrigated		Statistical	Unirrigated		Statistical
Ground Water	Dependent Variable	Small (3")	Large (8.5")	Significance	Small (3")	Large (8.5")	Significance
1 m	Survivorship (%)	86.9	75.2	*	83.4	85.7	NS
1 m	Flowering (%)	38.7	36.4	NS	42.9	43.8	NS
1 m	Mean Growth Diameter (cm) T1-T2	1.2 (0.9)	1.7 (0.9)	**	1.0 (1.1)	1.1 (1.4)	NS
1 m	Mean Growth Height (cm) T1-T2	11.9 (13.0)	8.7 (12.2)	NS	12.3 (21.1)	11.8 (11.6)	NS
2m	Survivorship (%)	96.4	93.3	NS	86.9	85	NS
2m	Flowering (%)	39.9	52.7	*	49.6	44.8	NS
2m	Mean Growth Diameter (cm) T1-T2	16.4 (12.2)	13.6 (12.4)	NS	0.4 (1.2)	1.0 (2.8)	NS
2m	Mean Growth Height (cm) T1-T2	5.1 (3.0)	4.7 (3.1)	NS	14.8 (11.6)	9.2 (10.1)	**

*Table 9. Effect of pot size (3" vs 8.5") on survivorship, flowering and growth of sacaton in plots over several time periods as a function of depth-to-ground water and irrigation. Significance levels are indicated (NS = not significant, $p > 0.05$; ** = $p < 0.005$).*

Depth-to-		Irrigated		Statistical	Unirrigated		Statistical
Ground Water	Dependent Variable	Small (3")	Large (8.5")	Significance	Small (3")	Large (8.5")	Significance
1 m	Survivorship T2 to T3(%)	↑	↑		11.2	18.3	NS
1 m	Flowering at T3(%)				57.1	58.8	NS
1 m	Mean Diameter-Growth (cm) T2-T3	Plot	Plot		2.6 (4.1)	1.3 (2.4)	NS
1 m	Mean Diameter-Growth (cm) T1-T3	Lost	Lost		3.5 (4.1)	2.4 (2.7)	NS
1 m	Mean Height-Growth (cm) T2-T3				15.2 (18.1)	6.7 (20.5)	NS
1 m	Mean Height-Growth (cm) T1-T3	↓	↓		25.9 (23.4)	17.2 (24.2)	NS
2m	Survivorship T2 to T3(%)	81.2	79.5	NS	33.6	27.1	NS
2m	Flowering at T3(%)	73.2	68.5	NS	50.0	47.8	NS
2m	Mean Diameter-Growth (cm) T2-T3	1.5 (2.9)	1.2 (3.5)	NS	1.8 (2.4)	0.0 (5.9)	NS
2m	Mean Diameter-Growth (cm) T1-T3	3.2 (3.2)	3.4 (3.8)	NS	2.1 (2.6)	1.8 (2.9)	NS
2m	Mean Height-Growth (cm) T2-T3	41.2 (20.2)	36.8 (21.5)	NS	22.8 (14.9)	19.5 (22.7)	NS
2m	Mean Height-Growth (cm) T1-T3	57.7 (20.6)	51.4 (23.9)	NS	36.6 (17.1)	32.0 (22.0)	NS

Over the first growing season, depth-to-ground water had a significant effect on sacaton plants; that is, survivorship and mean diameter growth were both greater for plants grown at 2 meters depth-to-ground water than those at 1 meter depth-to-ground water **(Table 10)**. These results are surprising and suggest that some other factor besides depth-to-ground water is affecting survivorship and growth. We believe that this other factor is gophers. Their precise impact on growth parameters is unclear but while conducting the monitoring, plants were recorded as either "dead" when there was no longer any green photosynthetic tissue evident or "gone". We assume that the latter plants were taken by gophers since frequently there was evidence of gopher activity (i.e., tunnels, holes, castings) in the vicinity of where the plant should be (as indicated by the ID tag and flagging). If so, the impact of gophers (i.e., the proportion of plant "gone") was significantly greater at 1-meter than at 2-meters depth-to-ground water, which would explain the greater overall survivorship and growth of sacaton growing at 2 meters depth-to-ground water **(Table 11)**. There was no evidence that gophers preferred plants grown in large vs. small pots.

Although overall survivorship of plants in unirrigated plots decreased 60-70% after the first growing season, only plants started in small pots showed an effect of depth-to-groundwater on survivorship **(Table 12)**. At 2 meters depth-to-ground water survivorship was 33.6% compared to only 12.5% at 1-meter depth-to-ground water ($p < 0.005$). This result is counter-intuitive but is difficult to attribute unequivocally to soil moisture (i.e., depth-to-groundwater) because of the lack of replication of plots. Depth-to-ground water did not significantly affect any other variables.

*Table 10. Effect of depth-to-groundwater on survivorship, flowering, and growth of sacaton plants in plots over the first growing season. Survivorship and flowering comparisons were performed using X^2 tests; all other comparisons were performed using t-tests. Significance levels are indicated (NS = non significant, $p > 0.05$; ** = $p < 0.001$).*

	Depth-to-Ground Water		Statistical Significance
	1 m	2m	
Survivorship (%)	83.0	90.6	**
Flowering (%)	40.6	46.5	NS
Mean Growth Diameter (cm)	1.2 (1.1)	8.5 (11.7)	**
Mean Growth Height (cm)	11.3 (15.4)	8.2 (8.7)	**

Table 11. Comparison of dead versus gone (due to gophers) sacaton in plot over the first growing season as a function of depth-to-groundwater ($X^2 = 26.5$, $p < 0.001$).

Depth-to Ground Water	Dead	Gone	% Gone
1 m	12	76	86.4
2m	27	20	42.6

*Table 12. Effect of depth-to-groundwater on survivorship, flowering and mean growth of sacaton plants in unirrigated plots over several time periods. Standard deviations are given in parentheses. Significance levels are indicated (NS = not significant, p > 0.05; ** = p < 0.005).*

	SMALL (3")		Statistical	LARGE (8.5")		Statistical
Dependent Variable	1 meter	2 meter	Significance	1 meter	2 meter	Significance
Survivorship T2 to T3(%)	12.5	33.6	**	23.9	27.1	NS
Flowering at T3(%)	57.1	50.0	NS	58.8	47.8	NS
Mean Diameter-Growth (cm) T2-T3	2.6 (4.1)	1.8 (2.4)	NS	1.3 (2.4)	-0.01 (5.9)	NS
Mean Diameter-Growth (cm) T1-T3	3.5 (4.1)	2.1 (2.6)	NS	2.4 (2.7)	1.8 (2.9)	NS
Mean Height-Growth (cm) T2-T3	15.2 (18.1)	22.8 (14.9)	NS	6.7 (20.5)	19.5 (22.7)	NS
Mean Height-Growth (cm) T1-T3	25.9 (23.4)	36.6 (17.1)	NS	2.4 (2.7)	1.8 (2.9)	NS

RIPARIAN FOREST PLANTING AREA

The monitoring objectives were:

1) to estimate the percent survivorship of container-grown saplings by species from the time of transplanting until the beginning of the second growing season;

2) to estimate the frequency (occurrence) of herbivory on transplanted container plants over this time period;

3) to determine how gopher cages affect the survivorship and the occurrence of herbivory on Arizona ash; and

4) to determine the percent survivorship of cottonwood and willow poles from the time of planting until the end of the first growing season.

METHODS

In December, 1998, a sample of 130 netleaf hackberry, 117 velvet ash, 92 Arizona walnut and 64 buttonbush were randomly selected to determine survivorship. This was done by dividing the two planting areas into a series of 20 m wide strips and then selecting individuals within each strip using a random number coordinate system so that the number of individuals per strip was equal. Selected plants were marked with flags and permanent metal tags to facilitate relocation. Plants were revisited in April 1999, December 1999, and April 2000 to determine survival and the occurrence of any herbivore damage. Determining whether or not a tagged plant was dead or alive was based on the general appearance of photosynthetic tissues and of the stem when broken.

In addition, most of the container stock, except 50 ash plants, and all of the buttonbush were surrounded by gopher cages in an attempt to discourage predation. Gopher damage has been an important source of container sapling mortality in a floodplain restoration project at TNC's Consumnes River Preserve in California. We predicted that among container plants ash was the most palatable to herbivores so that a comparison of caged vs. uncaged individuals would result in a "generous" estimate of the impact of herbivores on unprotected plants.

In December 1999, cottonwood and willow poles were planted along the east edge of the cienega. Shortly after, a wildfire swept through the area severely damaging the recently planted poles. Of the 600 poles planted, only those that appeared least burnt and were firmly in the ground were tagged for monitoring purposes (n = 65). We were unable to identify them to species at that time, or obtain a sample of 50-100 poles per species as originally intended. In April 2000, we relocated plants and identified 19 tagged poles as cottonwoods and 41 as willows; one dead individual could not be identified to species and 4 tagged poles could not be relocated. At that time, we noted whether the plant was dead or alive (again based on the condition of the photosynthetic tissues or stem when broken) and whether there was evidence of leaf sprouting from the base of the plant or along the stem. Similar measurements were recorded when plants were resurveyed for a final time in November 2000.

RESULTS AND DISCUSSION

Container Plants

During the course of monitoring we were unable to locate all of the tagged saplings due to dense weed growth in the restoration area, natural loss of the tags and flags, and damage to plants by the tractor during weeding (and resulting tag loss). For sake of analysis, these missing individuals were considered dead unless they were located alive in a subsequent monitoring period. Summarizing the data in this way overestimates mortality since some missing plants were undoubtedly alive. However, if survivorship was calculated only on the basis of tagged plants that were found, mortality due to tractor damage during weeding would not be included in our estimate of survivorship. Weeding was an important part of the restoration effort, benefiting saplings by reducing the competition for light and water, and we wanted to include its cost to plant survivorship in the analysis.

Overall, velvet ash saplings survived best followed by Arizona walnut while netleaf hackberry and buttonbush had dramatically lower survivorship **(Table 13)**. A possible explanation for ash's better survivorship compared to hackberry and walnut is that it was planted closer to the cienega where the water table was higher and soil moisture greater, thereby reducing seasonal water stress. Like ash, buttonbush was also planted close to the cienega but its lower survivorship may be due to the fact that it was growing among dense, 8-feet tall sunflowers, which presumably reduced light and water availability.

We expected the mortality of saplings to be higher during the first monitoring period due to transplanting stress and a change in water availability but in general we did not observe this pattern. Considering all species together, survivorship was high during the first winter-non growing season (91.1%), was somewhat lower during the first growing season (88.3%) and essentially remained at this level during the next winter-non growing season (87.3%; **Table 13)**. The different species, however, diverged somewhat from this overall pattern. Velvet ash and Arizona walnut had uniformly high survivorship across monitoring periods although walnut survivorship declined somewhat from 95.2% to 90.1% between the first growing season (April 1999-December 1999) and the second winter/non-growing season (December 1999-March 2000). Buttonbush survived well during the first growing season (94.4%) but had lower survivorship during the winter-non growing seasons, especially the second one (84.3% and 72.5%, first and second non-growing season, respectively). In contrast, netleaf hackberry experienced greatest mortality during the first growing season (75%) and survived at higher rates during the non-growing seasons **(Table 13)**. Three of the 4 species experienced reduced survivorship in the second non-growing season compared to the first one. A possible explanation for this was that rainfall from October to April in 1999-2000 was substantially lower than for the previous year (1.1" vs. 6.3", respectively) which may have increased water stress on saplings during the second non-growing season.

Table 13. Survivorship and incidence of herbivory on deciduous trees and shrubs over three monitoring periods from December 1998 to April 2000.

	Netleaf Hackberry	Velvet Ash	Arizona Walnut	Buttonbush	All Species
Number of Plants Monitored	130	117	92	64	403
1st Winter Non-Growing Season December 1998-April 1999					
Number of Plants Surviving	120	108	85	54	367
% Survivorship	92.3%	92.3%	92.4%	84.3%	91.1%
% Herbivory	16.1%	18.9%	10.5%	59.3%	22.3%
% Mortality Due to Gophers	2.9%	2.3%	4.3%	3.3%	3.2%
1st Growing Season April 1999-December 1999					
Number of Plants Surviving	90	102	81	51	324
% Survivorship	75.0%	94.5%	95.2%	94.4%	88.3%
% Herbivory	1.1%	0.0%	0.0%	0.0%	0.3%
2nd Winter Non-Growing Season December 1999-April 2000					
Number of Plants Surviving	78	95	73	37	283
% Survivorship	86.7%	95.1%	90.1%	72.5%	87.3%
% Herbivory	2.6%	2.0%	13.7%	0.0%	4.9%
OVERALL					
December 1998-April 2000					
% Survivorship	60.0%	82.9%	80.2%	57.8%	70.2%

The different patterns of survivorship shown by the 4 species presumably reflect differences in their ability to deal with transplanting, altered watering regimes from greenhouse conditions, water stress during the growing season, the effects of herbivores including gophers, and the effects of non-native plant species competition. Unfortunately, we know of no other studies with comparative data to evaluate the generality of our survivorship results.

To estimate the impact of gophers, plants that were dead or missing were grouped into one of two categories: 1) dead due to gophers (evidence of mounds and tunnels close to the plant); or 2) dead (or missing) due to other factors. Mortality due to gophers was low for all species during the first winter/non-growing season **(Table 13)** and mortality was twice as likely to occur due to other factors (3.2% mortality due to gophers and 5.7% from other factors); 13.7% of living plants also had evidence of gopher activity around them during the first non-growing season. Interestingly, there was no evidence of gopher disturbance around living or dead plants during the first growing season or second non-growing season.

Aboveground herbivory on leaves and stems was also more frequent during the first non-growing season, ranging from 10.5% to 59.3%, and was virtually absent during the other monitoring periods except for Arizona walnut during the second non-growing season (13.7%; **Table 13**). Buttonbush was the hardest hit species during the first non-growing season presumably because they were uncaged and more palatable than the other species. The incidence of gopher-related mortality on buttonbush did not differ from other species, however, we noted a high level of activity (tracks and digging) by javelina and possibly feral pigs around buttonbush plants.

To test the effectiveness of herbivore cages, 50 velvet ash saplings without cages and 67 saplings with cages were tagged and monitored. For this analysis we did not consider missing plants as dead but simply excluded them from calculations after the last monitoring period they were recorded as alive. We did this for two reasons: 1) to ensure that mortality due to tractor damage was not included in estimates of the effect of caging on survivorship; and 2) because tag loss was potentially more likely for uncaged than for caged plants thereby biasing the results towards higher mortality among uncaged saplings. The latter is true because tags were placed in the ground (anchored by a nail) near uncaged plants as opposed to on the cages themselves, making them relatively easier to displace or bury.

Cages were clearly beneficial in reducing sapling mortality. The survival rate of caged ash saplings was significantly higher than uncaged ash in all three monitoring periods **(Table 14)**. From the time of planting, caged saplings had an overall survivorship of 98.5% compared to 79.5% for uncaged ones **(Table 14)**. Obvious gopher activity (such as casings, mounds and empty holes where plants had once been) occurred frequently around caged and uncaged plants during the first monitoring period (December 1998 to April 1999); gopher activity was significantly higher around uncaged saplings than caged ones **(Table 14)**. Gopher activity was not observed after the first winter-non-growing season, still caged plants had higher survivorship. Although quantitative growth measurements were not made, uncaged ash *appeared* taller and more robust than caged plants because apical and axillary meristems became tangled in the chicken-wire cages reducing plant growth. Balancing these results against the resources necessary to produce, install, and later remove cages from plants that have outgrown them, we have decided to discontinue caging saplings before transplanting them. If saplings die, we will replace them with new ones; replacement plants can be cheaply grown at the San Pedro River Preserve.

A fire swept through the cienega in January 2000 burning 28 tagged button-bush plants and leaving 23 unburned; no tagged ash, hackberry or walnut were burned in the fire. Three months after the burn (April 2000), 21 of the 28 burned plants had survived (75%) compared to 16 of 22 unburned plants (72.7% survivorship; $X^2 = 0.2$, 1 df, $p > 0.5$). Thus, the wildfire had no apparent effect on buttonbush survivorship shortly after the burn; longer term consequences of the fire were not monitored.

Table 14 . Survivorship, aboveground herbivory, and incidence of gopher activity for caged and uncaged velvet ash saplings over three monitoring periods (December 1998 to April 2000). Significant results are indicated with superscripts.

	Caged Ash	Uncaged Ash
December 1998-April 1999		
Number of Plants Monitored	67	50
Survivorship	100%^{a}	82%^{a}
Aboveground Herbivory	3.0%	4.9%
Gopher Activity	14.9%^{b}	24.4%^{b}
April 1999-December 1999		
Number of Plants Monitored	63	48
Survivorship	100%^{c}	85.4%^{c}
Aboveground Herbivory	0.0%	0.0%
Gopher Activity	0.0%	0.0%
December 1999-April 2000		
Number of Plants Monitored	63	44
Survivorship	98.4%	94.6%
Aboveground Herbivory	3.2%	0.0%
Gopher Activity	0.0%	0.0%
OVERALL		
December 1998-April 2000		
Number of Plants Considered	67	44
Survivorship	98.5%	0.0%

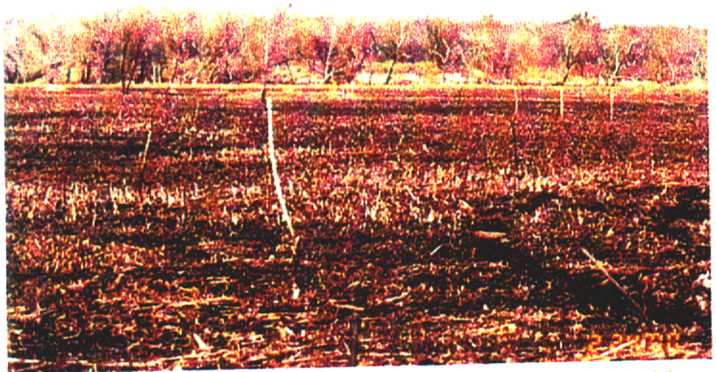
^{a} Fisher exact test, p=0.005

$^b X^2 = 18.0$, 1 df, $p < 0.001$

^{c} Fisher exact test, p=0.02

Cottonwood and Willow Poles

Although 84.2% of the tagged cottonwoods (n = 19) were burned in the fire, 94.7% survived the first 4 months after the burn (January 2000-April 2000). Among surviving cottonwoods, 44.4% re-sprouted along the stem, 23.3% re-sprouted from the base, and 23.3% failed to resprout but showed evidence of being rooted in the ground. Despite the promising early results, none of the tagged cottonwoods survived to the end of the first growing season (April 2000-November 2000); 6 individuals could not be relocated. Similarly, all of the tagged willows had some fire damage (n = 41) but survivorship was high (90.2%) in April 2000. Among surviving willows, 67.2% resprouted from the stem base, 8.1% resprouted along the stem, while 21.6% failed to resprout but showed evidence of rooting. However, by November 2000, only 1 of 26 relocated willows survived (3.8%); 15 tagged willows could not be relocated. Combining data for both species, only 2.6% of the poles were still surviving 13 months after planting.



It is impossible from the monitoring data to determine the cause of mortality but the wildfire appears to have been a contributing factor. The wildfire did not increase mortality rates after 3 months, i.e., April 2000 (Fisher exact test, $p = 0.42$) nor did it affect whether an individual re-sprouted or not (Fisher exact test, $p = 0.56$). However, 10 months after the fire, unburned poles appeared to survive at a higher rate than burned ones although the difference is only marginally significant **(Table 15)**. That is, 100% of the burned poles were dead by November 2000, compared to only 66.7% of the unburned poles. Other factors such as frost-heaving of the poles out of the ground in winter 2000 or drying of the cienega in summer 2000 may also have contributed to the high mortality rates.

Table 15. The number (and percent) of living and dead poles as a function of whether or not they were burned in a wildfire over two monitoring periods. The marginally significant statistical comparison is indicated by an asterisk (Fisher exact test, p = 0.077).

	Burned Poles	Unburned Poles
January 2000-April 2000		
Living	50 (92.6%)	5 (83.3%)
Dead	4 (7.4%)	1 (16.7%)
April 2000-November 2000		
Living	0	1 (33.3%) *
Dead	36 (100%)	2 (66.7%)

To obtain another estimate of survivorship, a complete census of the poles was conducted in November 2000. An additional 142 individuals were found: 132 could not be identified to species and were dead; 4 were cottonwoods, all dead; and 6 were willows, 1 was dead. All of the surviving saplings were growing in the northernmost end of the field near the spring source where soil moisture may be higher. Survivorship for both species, tagged and untagged, was 1%. This is extremely low suggesting that the wildfire and drought placed recently-planted poles under unusual physiological stress. In the future, planting poles later, that is in late winter-early spring rather than in December, may reduce the probability of frost-heaving so that poles remain in contact with the water table when they begin actively growing in the spring.

MESQUITE WOODLAND PLANTING AREA

We investigated two new techniques for mesquite restoration including (1) thinning "passively recruited" mesquite as a way to promote rapid growth and (2) planting mesquite saplings grown in 6" x 30" PVC pipe containers that promote tap root formation. In abandoned floodplain fields, "passively recruited" normally means recruitment facilitated by livestock eating, scarifying and spreading mesquite seeds. In this situation, mesquite germinates and grows at densities several times higher than in mature mesquite bosques or that occurs following floods in the active floodplain (Stromberg 1993; J. Stromberg, pers. comm.) Our hypothesis is that the unusually high sapling densities inhibit growth and regeneration of mature mesquite woodlands.

The container-grown mesquite were planted into a portion of the planting area with gypsum soils and limited passive recruitment. The original plan was to water these mesquite immediately before and after transplanting. However, the poor rainfall from October 1999 through September 2000 (i.e., only 5.1") required that the field be watered 2 additional times in early 2000. With input from Russ Haughey, Arizona Game and Fish Department, we are evaluating this tube planting technique as a way to re-establish woody riparian species in relatively dry sites with unpredictable, variable rainfall regimes and without supplemental irrigation.

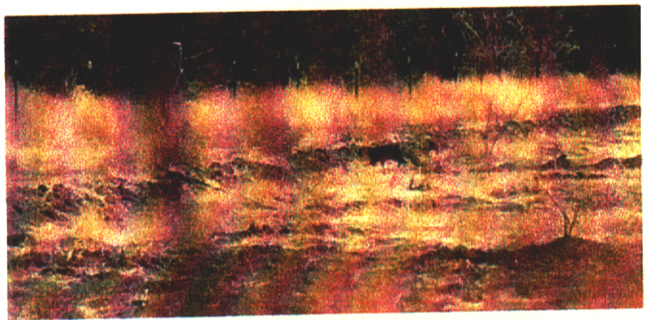
Thus, our monitoring objectives were:

1) to determine the survivorship of container-grown mesquite saplings from the time of transplanting until the end of the first growing season;

2) to determine the survivorship and growth rate of mesquite saplings in thinned vs. unthinned areas over two growing seasons so that the effect of thinning on both variables can be evaluated; and

3) to determine the effect of understory herbs, exotic and native, on sapling growth.

METHODS



To determine the survivorship of container-grown plants, a sample of 93 mesquite saplings were randomly selected from the planting area soon after they were transplanted. This was done by dividing the planting area into a series of strips and then selecting individuals within each strip using a coordinate system; coordinate values were generated from a random number table (Sokal and Rolf 1969). The number of individuals selected per strip was approximately equal across the planting area. Selected plants were marked with flags and permanent metal tags to facilitate relocation. Plants were relocated in May and November, 2000, and their survival status determined (i.e., dead or alive) based on the general appearance of their photosynthetic tissues and of their branches when broken.

To determine the effect of thinning, we measured the survivorship and growth rate of 58 mesquite saplings in the thinned area and 50 mesquite in an adjacent unthinned area **(Figure 3)**. Thinning was accomplished by cutting and treating mesquite stumps with herbicide (Garlon) so that adjacent individuals were 5-6 meters apart. This reduced the density of mesquite in the thinned area to 5.4 ± 2.0 plants/100m^2 compared to 26.8 ± 11.7 plants/100m^2 in the unthinned area. The former value is approximately 1.1-3.4 times the density of trees reported in the literature for mature mesquite woodland (Stromberg 1993). Plants from the two areas were randomly selected using the location coordinate system described above. Selected plants were tagged, flagged and measured in June, 1998, to characterize plants at the time of thinning, and re-measured in June, 1999, and May, 2000, to determine growth. Percent survivorship of mesquite saplings was determined by counting the number of dead and live plants using the descriptive criteria described above. Measurements on live plants included height, basal diameter, and shoot length for the current growing season (using 20 randomly selected stems/plant).

RESULTS AND DISCUSSION

Container Plants

In May 2000, 5 months after planting, survivorship of the mesquite saplings was 74.7% with 6 tagged individuals (6.5%) not relocated (**Table 16**). By October 2000, 10 months after planting, survivorship had dropped to 61.4% **(Table 16)**; 23 tagged individuals could not be relocated (25%). During both surveys, it was difficult to locate tagged plants, particularly dead individuals, because of the dense growth of Russian thistle (*Salsola iberica*) in the field. This suggests that the above survivorship figures are somewhat overestimated (high) since dead mesquite were less obvious among the weeds than living ones and therefore more likely to be missed. Assuming that all missing individuals were dead, a minimum estimate of survivorship would be 46.2% by October 2000. This is a much lower survival rate than observed for netleaf hackberry, velvet ash, Arizona walnut, and buttonbush over a 12-month period (December 1998 to December 1999; **Table 13**).

Table 16 . The number of mesquite saplings that were dead, alive, or of uncertain status at two census periods, April-May 2000 and September-October 2000.

	May 2000	September-October 2000
Number Located	87	70
Live	65	43
Dead	17	27
Uncertain	5	0
% Survivorship	74.7%	61.4%

The low survivorship of mesquite saplings was not entirely unexpected. The area had little natural recruitment before planting although it was adjacent to a site with dense stands of young mesquites (i.e., area of the mesquite thinning experiment) suggesting some soil difference between the two sites. As noted in the Restoration Plan, Don Walther, Crop Specialist for the USDA Natural Resources Conservation Service, took several soil cores from the planting area and identified a well developed gypsum layer close to the soil surface. Gypsum soils typically show poor and unequal permeability which may have resulted in reduced soil moistures across the planting area. This coupled with lower than average winter rainfall in 1999-2000 may have placed transplanted saplings under considerable water stress leading to higher mortality rates. However, even under the most conservative scenario, an estimated 133 trees had survived transplanting and were still alive 10 months later. Together with naturally recruited mesquites, the combined density of saplings in the planting area is now 914 individuals/ha, which is 1.8-5.7 times the density reported for mature woodlands in the literature. So if future mortality of saplings does not exceed 82%, there will be a sufficient number of trees for a high-quality mesquite woodland to develop on the site.

Thinning and Mesquite Growth

In June 1998, 2 months after thinning, there was no significant difference in the height, stem diameter and mean shoot length of trees growing in the thinned and unthinned areas **(Table 17)**. However, by May 2000, two years later, stem diameter was significantly greater for plants in the thinned area. The change in stem diameter was also significantly greater for trees in the thinned areas compared to the unthinned area in both 1999 and 2000. Between June 1998 and May 2000, individual trees in the thinned area increased an average of 2.52 cm in diameter compared to only 1.51 cm for trees in the unthinned area **(Table 18)**. Change in mean height and mean shoot length were similar in the two areas in both 1999 and 2000 and from 1998-2000. Only 3.6% of the tagged trees died during the course of the study: 3 in the thinned area and 1 in the unthinned area.

For all three monitoring periods, stem diameter was significantly correlated with tree height and mean shoot growth **(Table 19)**. However, diameter was a better predictor of height than of shoot length. That is, the percent of the variation in the dependent variable that was explained by stem diameter (i.e., the R^2-value) ranged from 35-50% for height and from 3-17% for shoot. When we were measuring trees we noticed that often trees that appeared less vigorous (i.e., fewer leaves, dead branches, open canopy) had longer shoot lengths but fewer shoots than more vigorous appearing individuals. This suggests that there may be a complex relationship between shoot length, shoot number, and vigor that makes mean shoot length or change in mean shoot length between years a poorer indicator of overall growth than change in basal diameter and height. The significant regression relationships, however, support our hypothesis that thinning mesquite trees to more natural densities accelerates growth and that increases in stem diameter will eventually lead to increases in height and shoot length for mesquites in the thinned area.

Table 17. Mesquite measurements including diameter (cm), height (m), and shoot length (cm) in thinned and unthinned areas in 1998, 1999, and 2000. T-tests were used in all comparisons of measurements; statistically significant comparisons are indicated by a letter, all others are non-significant. Sample size is given in parentheses.

		2000		1999		1998	
Diameter (cm)		Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
	Thinned	7.14 [a]	2.00 (58)	5.55	1.76 (58)	4.58	1.50 (58)
	Unthinned	6.04 [a]	1.69 (49)	5.00	1.69 (50)	4.48	1.57 (50)
Height (m)							
	Thinned	2.94	0.75 (56)	2.61	0.62 (58)	2.31	0.55 (58)
	Unthinned	2.95	0.60 (50)	2.53	0.56 (50)	2.19	0.50 (50)
Shoot Length (cm)							
	Thinned	30.76	12.35 (57)	26.95	13.17 (58)	20.01	8.6 (58)
	Unthinned	32.32	11.06 (50)	29.1	13.56 (50)	20.24	8.98 (50)

[a] t-test, $t = 1.31$, 105 df, $p < 0.005$

Table 18. Change in growth measurements for mesquites in thinned and unthinned areas between 1998, 1999, and 2000. Paired t-tests were used in all comparisons of growth change; statistically significant comparisons are indicated by a letter, all others are non-significant. Sample sizes are given in parentheses.

		Change from 98-99		Change from 99-00		Change from 98-00	
Diameter (cm)		Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
	Thin	0.97 [a]	0.53 (58)	1.53 [b]	1.12 (58)	2.52 [c]	1.15 (58)
	Unthinned	0.51 [a]	0.65 (50)	0.98 [b]	0.63 (49)	1.51 [c]	0.81 (49)
Height (m)							
	Thin	0.30	0.23 (58)	0.34	0.45 (56)	0.64	0.51 (56)
	Unthinned	0.33	0.24 (50)	0.42	0.23 (50)	0.76	0.33 (50)
Shoot Length (cm)							
	Thin	7.66	9.61 (58)	3.12	9.67 (58)	10.48	8.15 (58)
	Unthinned	9.74	7.80 (50)	3.33	6.88 (50)	13.04	6.95 (50)

Table 19. Summary statistics for regressions of mesquite basal diameter (dependent variable) on height and mean shoot length (dependent variables) including coefficient values, standard errors, R^2-values, sample size (N), and significance for 1998, 1999, and 2000. See text for further explanation.

Year	Dependent Variable	Independent Variable	Coefficient	Stnd Error	R^2	N	Significance
1998	Height	Stem Diameter	0.26	0.03	0.5	101	p < 0.001
	Mean Shoot Length	Stem Diameter	1.76	0.38	0.17		p < 0.001
1999	Height	Stem Diameter	0.24	0.03	0.46	101	p < 0.001
	Mean Shoot Length	Stem Diameter	0.81	0.42	0.03		p = 0.058
2000	Height	Stem Diameter	0.21	0.03	0.35	100	p < 0.001
	Mean Shoot Length	Stem Diameter	1.48	0.41	0.11		p = 0.001

We also investigated the effect of exotic herbs and grasses on mesquite growth. Because water, nutrients and light are potentially limiting, competition with exotic species including dense stands of bermuda grass may limit mesquite growth. To test this hypothesis we compared the size and growth of mesquite trees surrounded by high vs. low exotic ground cover. To quantify percent cover of grasses and forbs under each tagged tree, a 1.5 meter transect was run in each of the four cardinal directions starting at the tree trunk, and canopy cover by species was determined using a line-intercept method. A break of 5 cm or more in the vegetation was considered discontinuous cover and measured accordingly.

For sake of analysis, mesquite trees were divided into one of two groups: those with > 40% bermuda grass cover and those with < 40% bermuda grass cover. For a second set of tests, trees were grouped into those with >40% exotic, non-bermuda grass cover and those with < 40% exotic, non-bermuda grass cover. Comparison of these two sets of tests allows us to determine the relative effect of bermuda grass compared to other exotic species on mesquite growth. Other dominant exotics besides bermuda grass include common sunflower, russian thistle (*Salsola iberica*), and bindweed.

There was no difference in the cover of exotic grasses/herbs under trees in the thinned vs. unthinned area; mean cover of exotics in the thinned area was 38.6% vs. 38.0% in the unthinned area (t-test, t = 0.16, 106 df, p = 0.88). However, trees with high bermuda grass cover were significantly shorter, had smaller stem diameters and shorter mean shoot lengths than trees with low bermuda grass cover **(Table 20)**. The change in height and in stem diameter between 1998 and 1999 were also less for trees with high bermuda grass cover than for those with low bermuda grass cover but these differences were not statistically significant **(Table 21)**. In contrast, trees with high (>40%) non-bermuda grass cover were similar in height, diameter and mean shoot length to those with low, non-bermuda grass cover **(Table 22)**. Thus, abundant bermuda grass appears to depress mesquite growth rates while other exotic herbs and grasses have little effect. Weed control programs that specifically target bermuda grass may significantly enhance efforts to restore mesquite bosques and reduce time and resource costs by focusing on one vs. many exotic species.

Table 20. Comparison of mean height, diameter and shoot length (and standard deviations) for mesquites with low (< 40%) and high (> 40%) Bermuda grass cover under them. T-tests were used in all comparisons; t-values and sample sizes are given.

	Height 1999 (m)			Diameter 1999 (cm)			Shoot Length 1999 (cm)		
Bermuda Cover	Mean	Std. Dev.	p-value	Mean	Std. Dev.	p-value	Mean	Std. Dev.	p-value
High (n = 12)	2.20	0.44	0.009	4.3	1.2	0.002	23.2	4.9	0.005
Low (n = 96)	2.62	0.59		5.8	1.7		28.3	7.4	

Table 21. Comparison of change in height, diameter, and mean shoot length between 1998 and 1999 for mesquites with low (< 40%) and high (> 40%) Bermuda grass cover under them. T-tests were used in all comparisons; all comparisons were non-significant (NS).

	Height Change 98-99 (m)			Diameter Change 98-99 (cm)			Shoot Length Change 98-99 (cm)		
Bermuda Cover	Mean	Std. Dev.		Mean	Std. Dev.		Mean	Std. Dev.	
High (n = 12)	0.31	0.18	NS	0.7	0.4	NS	7.6	7	NS
Low (n = 96)	0.32	0.24		0.8	0.6		8.6	7.5	

Table 22. Comparison of mean height, diameter and shoot length (and standard deviations) for mesquites with low (< 40%) and high (> 40%) non-Bermuda grass cover under them. T-tests were used in all comparisons; t-values and sample sizes are given.

	Height 1999 (m)			Diameter 1999 (cm)			Shoot Length 1999 (cm)		
Non-Bermuda Cover	Mean	Std. Dev.	p-value	Mean	Std. Dev.	p-value	Mean	Std. Dev.	p-value
High (n = 36)	2.70	0.60	0.34	5.9	1.7	0.70	23.2	4.9	0.21
Low (n = 60)	2.60	0.60		5.7	1.6		28.3	7.4	

GROUNDWATER AND PRECIPITATION MONITORING

Hydrogeologic units in the vicinity of the Bingham Cienega include floodplain alluvium along the San Pedro River and its tributaries and the underlying Quiburis Formation. Bingham Cienega, underlain by floodplain alluvium, is located on the pre-entrenchment floodplain about 13 feet above the active channel of the San Pedro River. Floodplain alluvium is about 100 feet thick and about ¾ mile wide in the vicinity of Bingham Cienega. Groundwater in the highly transmissive floodplain alluvium supplies the majority of domestic and irrigation wells in the area. Depth to groundwater in the floodplain alluvium ranges from near surface adjacent to the Bingham Cienega to 29 feet below land surface at the Rhodes well, located ½ mile south-southwest from the cienega. The floodplain alluvium is underlain by basin fill, termed the Quiburis Formation (Agenbroad, 1967), which is comprised of moderately lithified sandstone, mudstone, and siltstone. Most of the groundwater in the valley occurs in the basin fill or regional aquifer. This deeper regional aquifer is confined throughout most of the eastern portion of the basin (Roberston, 1992). Water in the regional confined aquifer originates chiefly in the Galiuro Mountains; depths to water near the Bingham Cienega range from about 350 to 390 feet below land surface (Roberston, 1992).

Based on geologic, geomorphic, and water chemistry studies (Kenny, no date; Roberston, 1992; Pima Association of Governments, 2001), investigators have concluded that water discharging from the Bingham Cienega spring is derived from the floodplain aquifer rather than from the confined regional aquifer and consists most likely of San Pedro underflow augmented by inputs from several side canyons, including Buehman, Edgar, and Redfield.

Monitor Well Installation and Construction

Forty-five water-level monitor wells were installed at the Bingham Cienega Natural Preserve during 1993 through 1997. Monitor wells consist of hand-driven, 2-inch polyvinyl chloride (PVC) casing open at the bottom; total depths range from 5 to 15 feet. The majority of the monitor wells were installed in 1993 in conjunction with a TNC/UA cooperative study designed to obtain water level and vegetation information in an attempt to correlate plant distribution with hydrologic parameters (Baird, et al 1997). Additional monitor wells were installed in 1995 and 1997.

The monitor wells were installed in three west to east lines, or transects, identified as the North (N), Central (C), and South (S) transects. Monitor well locations and identifiers are shown on **Figure 4**. With some exceptions, wells are spaced at 30 meter intervals along each transect. The North transect is 200.9 meters north from the Central transect, which is 168.1 meters north from the South transect. Each well along each transect is numbered sequentially from the west, with the transect letter as the prefix. Therefore, N1 is the western-most well on the North transect, N2 is about 30 meters to the east of N1, and so on. Suffixes, such as N10a and N10b, indicate wells that were installed after 1993 between the original wells; distance between the suffixed wells and original wells ranges from 10 to 20 meters. Distance between wells and between transects is given in **Table 23**, which also gives total depth of the monitor wells as measured in 2000 (wells have silted in and total depth has decreased since installation).

An additional transect line, consisting of three wells (R1, R2, and R3) was installed in 1997 at the northern end of the study site. A monitor well designated Field 1 (F1) was installed in the southern-most sacaton grassland planting area (Year-One Field). In addition, two irrigation wells, Kelly Well and Rhodes well, have been utilized for water level measurements. The Kelly well is located at the Kelly residence just south from the cienega and supplies irrigation for restoration plantings. The Rhodes well is located across the San Pedro River Road about ½ mile south-southwest from the cienega.

Water Level, Precipitation, and Streamflow Data Collection

Water levels in monitor wells were monitored on a nearly monthly basis during the course of the study. Monthly water level measurements for 1997 through 2000, and for January through July 2001, are summarized in **Appendix A**. A positive number indicates depth of standing water (water above land surface in the well casing). A negative number indicates depth of water below land surface. There were occasions when staff resources were insufficient to conduct water level monitoring; therefore, a few months are missing. Gathering and entering data costs were about $700 a year.

A rain gage was installed in June 1998 in a field adjacent to the sacaton planting site. Jack Kelly, who lives adjacent to the Cienega, provided data from his rain gage for April, May, June, and July 1998, and for months when data could not be obtained from the sacaton field rain gage. Monthly precipitation for 1997 through July 2001 are summarized in **Table 24** and shown on **Figure 5**; these data are further discussed in a subsequent section of this report. Precipitation data from San Manuel were used as a substitute for site data for 1997 and for January through March 1998. Comparison of precipitation at San Manuel and at Bingham is shown on **Figure 6** and indicates similar trends, though the intensity may vary.

Stream flow data for the San Pedro River gage at Redington (# 09472050), located ¾-mile upstream from the study site, were obtained from the U.S. Geological Survey (http://water.usgs.gov/az/nwis/sw). Mean monthly flows at the Redington gage for 1997 through July 2001 are shown on **Figure 7**, which also shows precipitation at the site, for comparison purposes.

TABLE 23. DISTANCE BETWEEN MONITOR WELLS AND BETWEEN TRANSECTS, BINGHAM CIENEGA

NORTH TRANSECT	DISTANCE BETWEEN WELLS (meters)	TOTAL DEPTH (feet)
N1	0	
N2	30	4.7
N3	60	4.7
N4	90	4.6
N5	120	4.8
N6	150	2.7
N7	180	4.8
N8	210	4.4
N9	240	4.4
N10	270	4.4
N10a	285	5.5
N10b	300	4.8
N11	320	8.4
N12	370	8.5
N13	395	10.6

CENTRAL	DISTANCE BETWEEN WELLS (meters)	TOTAL DEPTH (feet)
C1	0	4.5
C2	30	3.8
C3	60	4
C4	90	3.2
C5	120	3
C6	150	3.4
C7	180	4.3
C8	210	4
C8a	230	3.7
C8b	245	3.6
C9	260	5
C9a	300	
C10	310	9
C11	340	9.3
C12	380	9

SOUTH TRANSECT	DISTANCE BETWEEN WELLS (meters)	TOTAL DEPTH (feet)
S1	0	4.5
S2	30	2.9
S3	60	3
S4	90	2.3
S5	120	2.7
S5a	130	3
S5b	140	3.9
S6	150	6
S7	190	7.7
S8	230	7.3
S9	270	9.8

R TRANSECT	DISTANCE BETWEEN WELLS (meters)	TOTAL DEPTH (feet)
R1	0	6
R2	25	9.5
R3	50	10

Distance Between Transects = 200.9 meters 168.1 meters

Hydrologic Zones and Plant Restoration Areas

Baird et al (1997) delineated hydrologic zones based on depth to water. The hydrologic zones run approximately north-south, parallel to the wetland, and were used to design the original restoration plan. The designated zones, based on depth to water, are 0 to 3 feet; 3 to 6 feet; 6 to 9 feet; and greater than 9 feet. The wetland, as designated by Baird et al (1997), is the area where standing water typically occurs **(Figure 4)**. The hydrologic zones used to guide the restoration plan, associated proposed planting zones, and the wetland are shown in **Figure 8**.

Actual on-the-ground plant community restoration areas are shown on **Figure 3**. The original restoration plan based on hydrologic zones delineated by depth to water was generally followed in determining plant community restoration areas. In increasing depth to water order, the three plant community restoration areas are: riparian woodland, sacaton grassland, and mesquite woodland. Within the riparian woodland restoration area, tree species were planted in zones corresponding to their water needs: willow at the edge of and within the wetland; buttonbush nearest the wetland; cottonwood; ash and walnut; and hackberry at increasing distance from the wetland.

As can be seen through inspection of **Figure 4**, 19 of the 45 monitor wells are located in the wetland. Except in times of sustained drought, water stands above land surface in the wetland. With the exception of some willow poles, restoration planting was not conducted in the wetland, although riparian trees (poles and container plantings) were planted on the edge of the wetland. Therefore, in the subsequent section providing analysis of water level data, the wetland wells are generally disregarded.

Hydrologic Evaluation

Hydrologic data, including water levels in monitor wells, precipitation, and streamflow, were evaluated to determine groundwater system response to climatic factors and to correlate plant survival and growth to water availability.

Water levels for 1997 through July 2001 for wells on the South, Central, and North transects are shown in **Figures 9 through 12**. Inspection of water levels for wetland monitor wells indicates that there were two periods of decreased water levels in the wetland during the grant period – June through December 1997 and April through mid-October 2000. There was also a brief drying of wetland wells in June 1999. During these two periods, surface water was generally not present in the cienega. Based on spring flow monitoring conducted in 1997, drying of the wetland may have corresponded to an 80% reduction in spring flow [spring flow was not monitored after 1997.] Jack Kelly, former owner of the property now residing adjacent to the cienega, recalls only two prior times when surface water flow in the cienega stopped: 1953-54 and 1975-76.

Water levels in upland wells show a different response in water levels than do wetland wells. Water levels in upland wells fell below the bottom of the casing in June through

December 1997 (similar response to wetland wells) with water levels recovering in early 1998. However, unlike the wetland wells, which retained water levels through 1998, water levels in upland wells generally indicated falling water levels through 1998 and early 1999. Some of the upland monitor wells show brief water level recovery during the 1999 monsoon season; however, water levels quickly returned to below the bottom of the casing and stayed there until the large rains in October 2000. Water levels in upland wells generally declined each month after October 2000 through July 2001. It is most unfortunate that monitor wells were insufficiently deep to capture the entire range of water level decline.

Inspection of precipitation data **(Table 24 and Figure 5)** indicates that precipitation was substantially below average for the months of March, July, and October 1997. Although these data are from San Manuel rather than from the site, the overall pattern of monthly precipitation at San Manuel and Bingham are similar **(Figure 6)**. Precipitation was substantially below average (none recorded) in April, May, and June of 1998 **(Figure 5)**. Precipitation was substantially below average in December 1998, a dry trend that continued through January, February, and March 1999. Although above average rainfall was recorded at Bingham in April 1999, the dry trend continued with below average precipitation in May and June. Monsoon season rainfall was decent in 1999 (average rainfall in July, August, and September), however, October, November, and December showed no recorded rainfall, a dry trend that continued until October 2000. Above average rainfall was recorded in October (nearly 8 inches recorded) and November 2000. Though December 2000 showed no recorded rainfall, rainfall was near average January through July 2001.

Table 24

MONTHLY PRECIPITATION DATA FOR BINGHAM CIENEGA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
1997	1.92	1.17	0	0.22	0.96	0.64	0.57	4.1	1.28	0.2	0.64	1.8	13.5
1998	0.31	4.22	2.11	0	0	0	2.5	3.12	2.25	1.37	1.16	0.52	17.56
1999	0.31	0	0.53	2.45	0	0.06	4.81	4.4	2.75	0	0	0	15.31
2000	0.35	0.03	0.75	0	0	2.05	0	1.94	0	7.72	1.36	0	14.2
2001	2.67	0.56	0.8	1.8	0.35	0.37	3.72	----	----	----	----	----	*10.27*

NOTE: 1997 and Jan through Mar 1998 are from San Manuel gage. Remainder of data are from Bingham

Average annual rainfall at San Manuel for the period from 1954 through 2000 was 14.15 inches. Annual rainfall recorded at Bingham was below this amount only for the year 1997. However, precipitation for 2000 would have been substantially below the annual average except for the unusually large rainfall in October.

In comparing precipitation at the site to water levels in the wetland and upland monitor wells, it is difficult to determine correlations based on the three-year rainfall record. If rainfall data from San Manuel is used, a 4 ½-year record is available, but definitive correlations are still difficult to make. It was dry in 2000; most of the monitor wells dried up in 2000. Precipitation was near average in 1997 (San Manuel), yet many of the monitor wells dried up. Rain was not recorded in April, May, and June 1998 (San Manuel), yet wetland wells retained their water levels, although upland monitor wells showed a decreasing trend in water level through 1998.

FIGURE 5. MONTHLY PRECIPITATION AT BINGHAM SITE

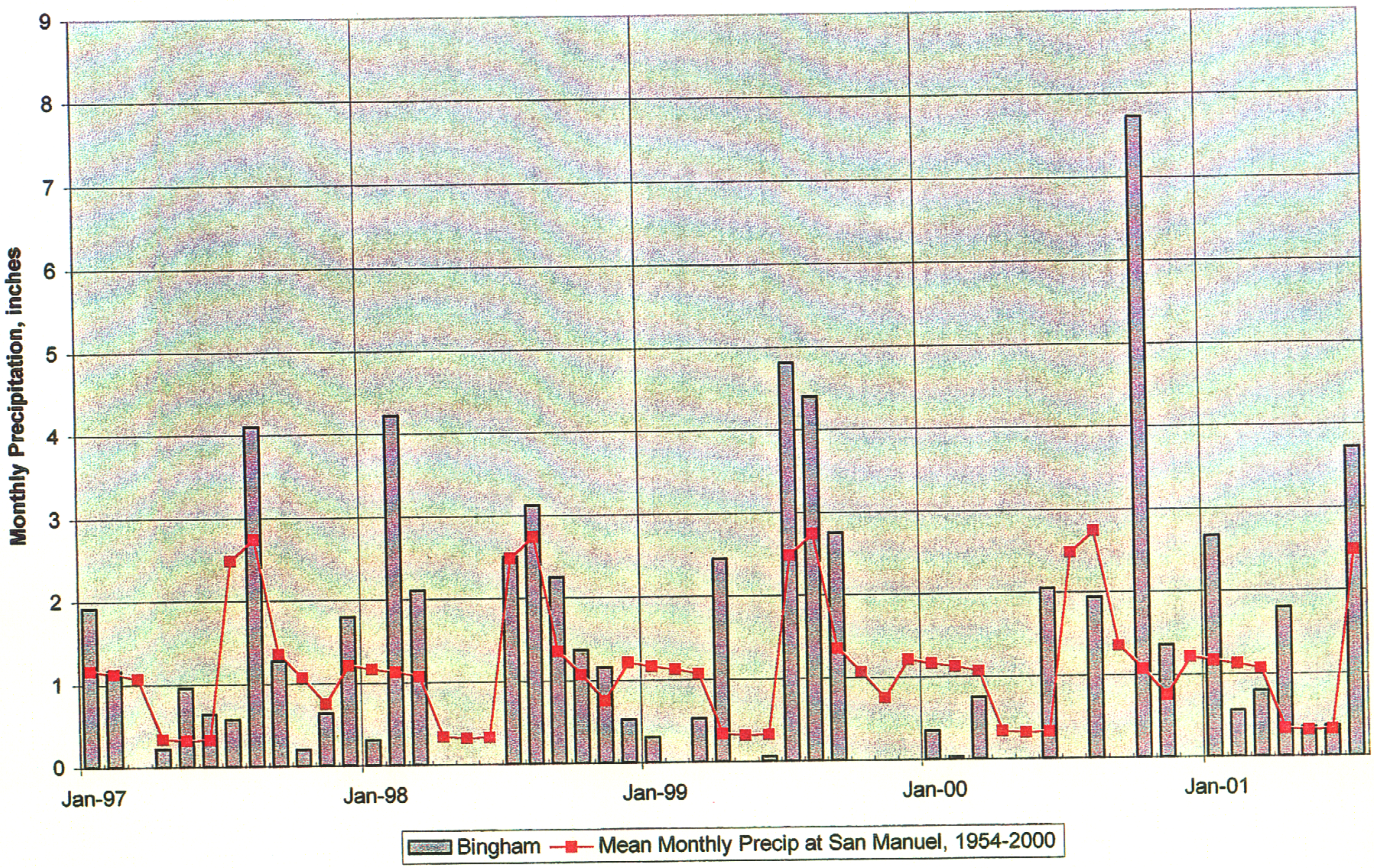


FIGURE 6. COMPARISON OF MONTHLY PRECIPITATION AT BINGHAM SITE AND AT SAN MANUEL

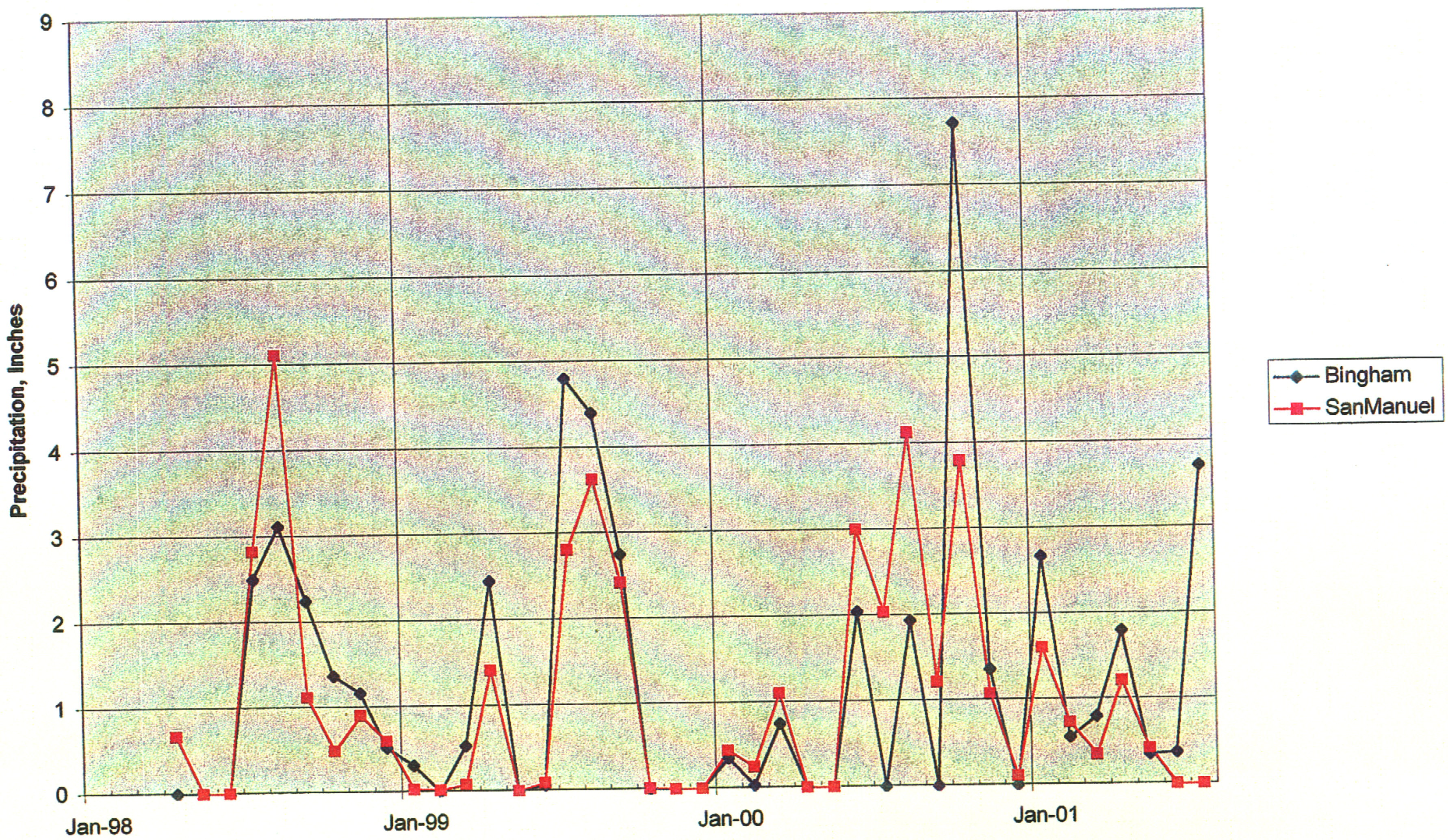
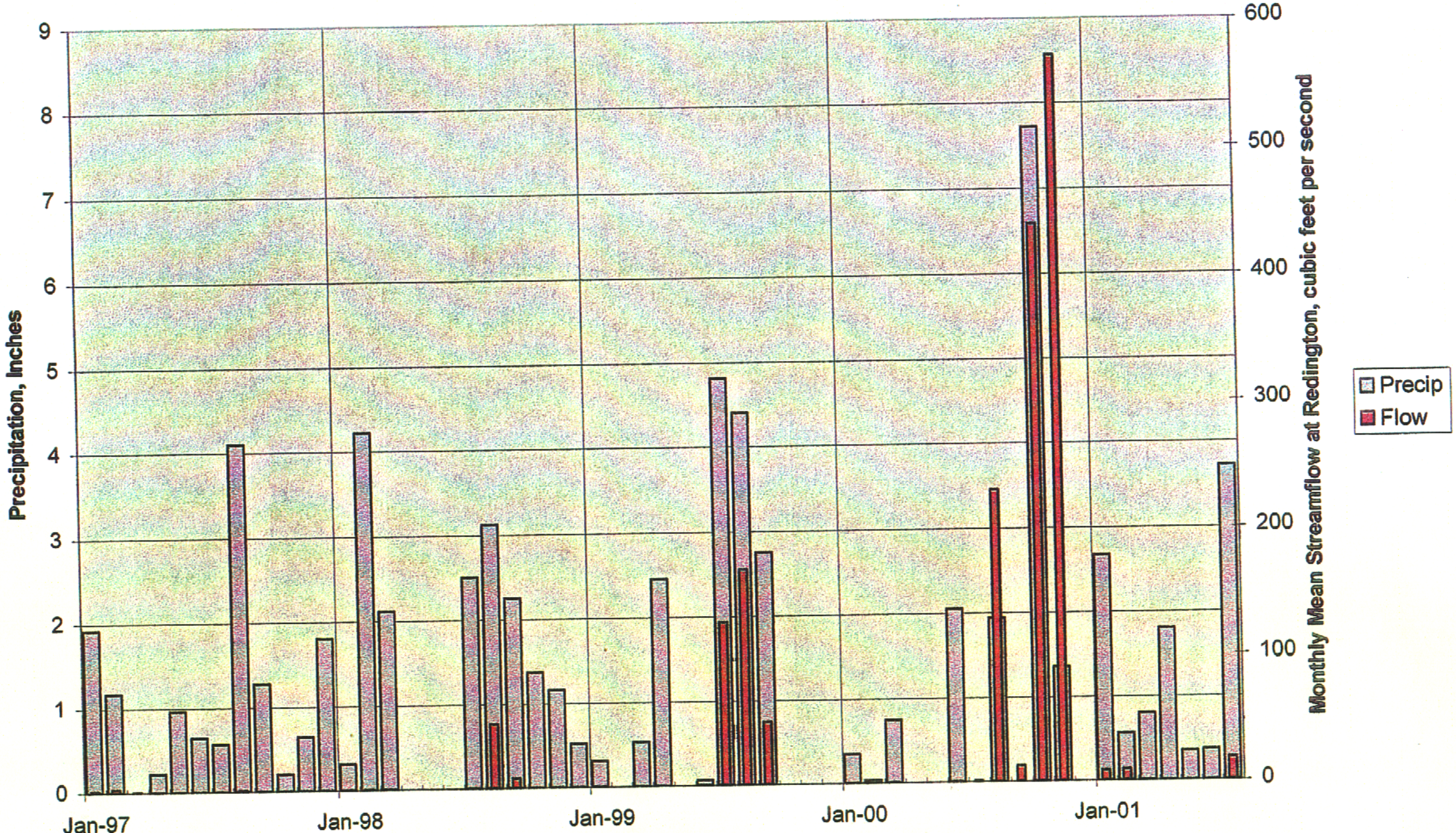
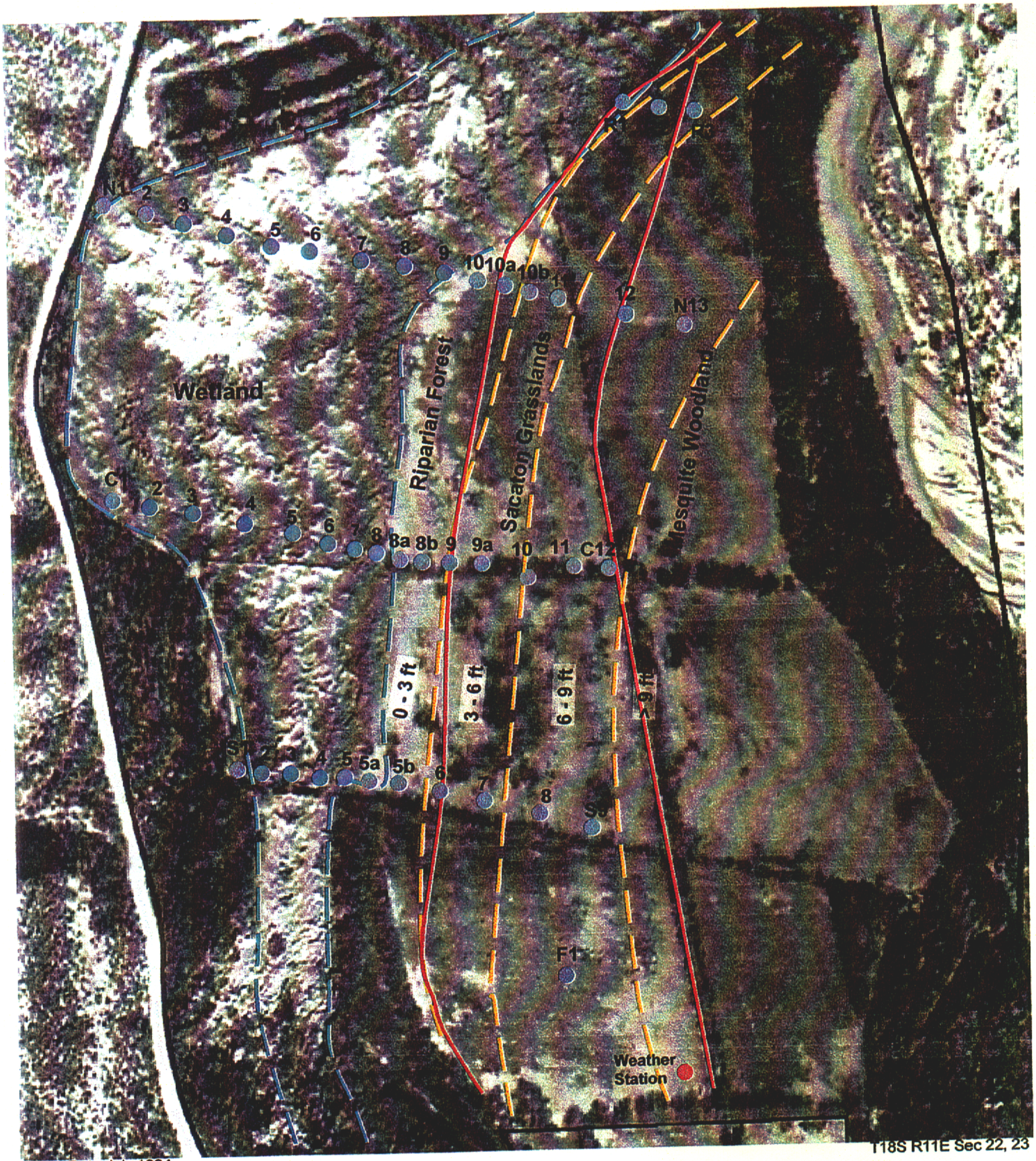


FIGURE 7. STREAMFLOW AT REDINGTON GAGE AND MONTLY PRECIPITATION AT BINGHAM SITE



Note: Precipitation data for 1997 and January through March 1998 are from San Manuel gage.



S2 Monitor Well and Identifier

Hydrologic Zone (Depth to Groundwater)

Proposed Planting Areas

Wetland

N

BINGHAM CIENGEGA NATURAL PRESERVE

HYDROLOGIC ZONES AND ORIGINAL PROPOSED PLANTING AREAS

FIGURE 8

FIGURE 9. WATER LEVELS IN SOUTH TRANSECT WELLS

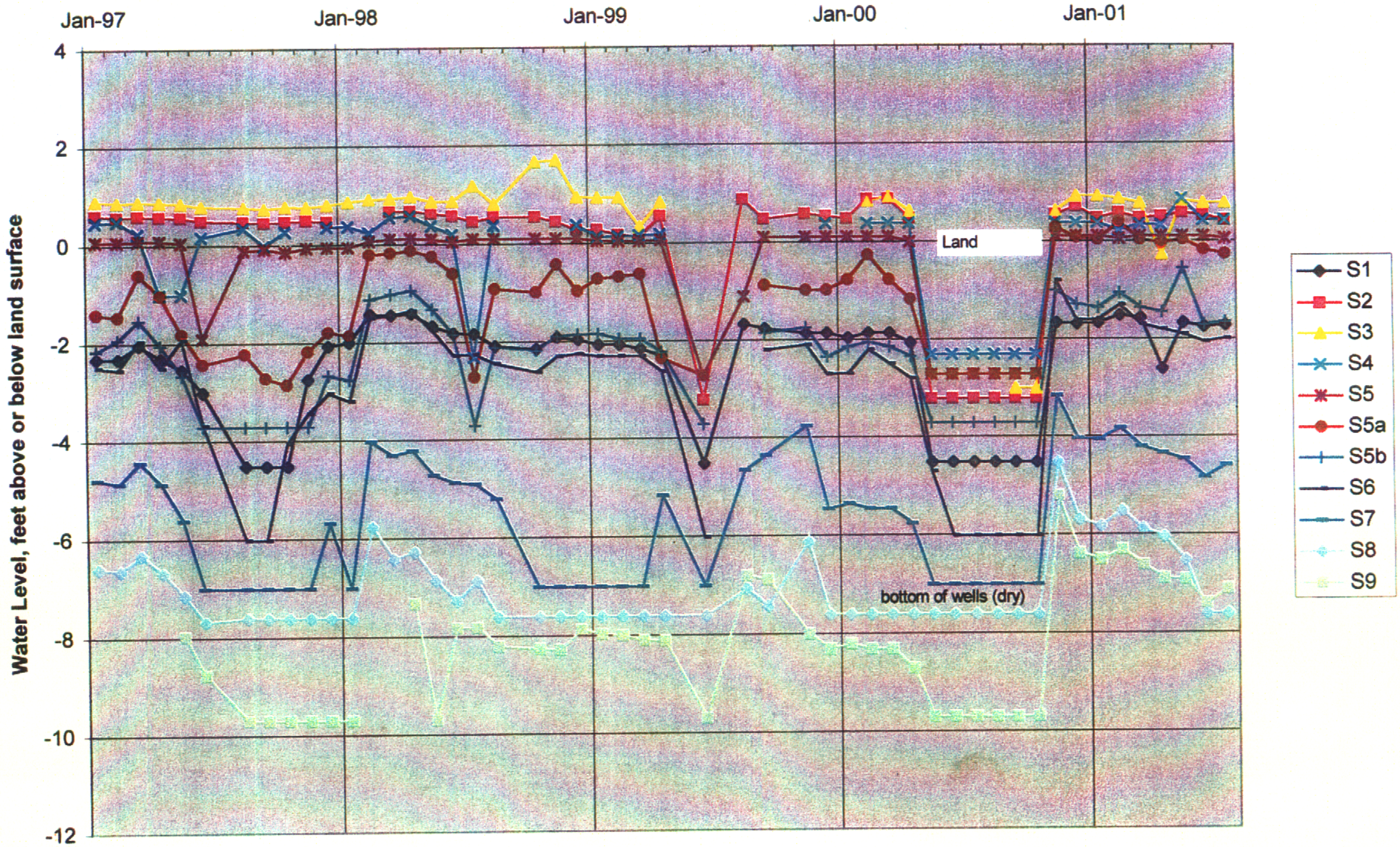


FIGURE 10. WATER LEVELS IN CENTRAL TRANSECT WELLS

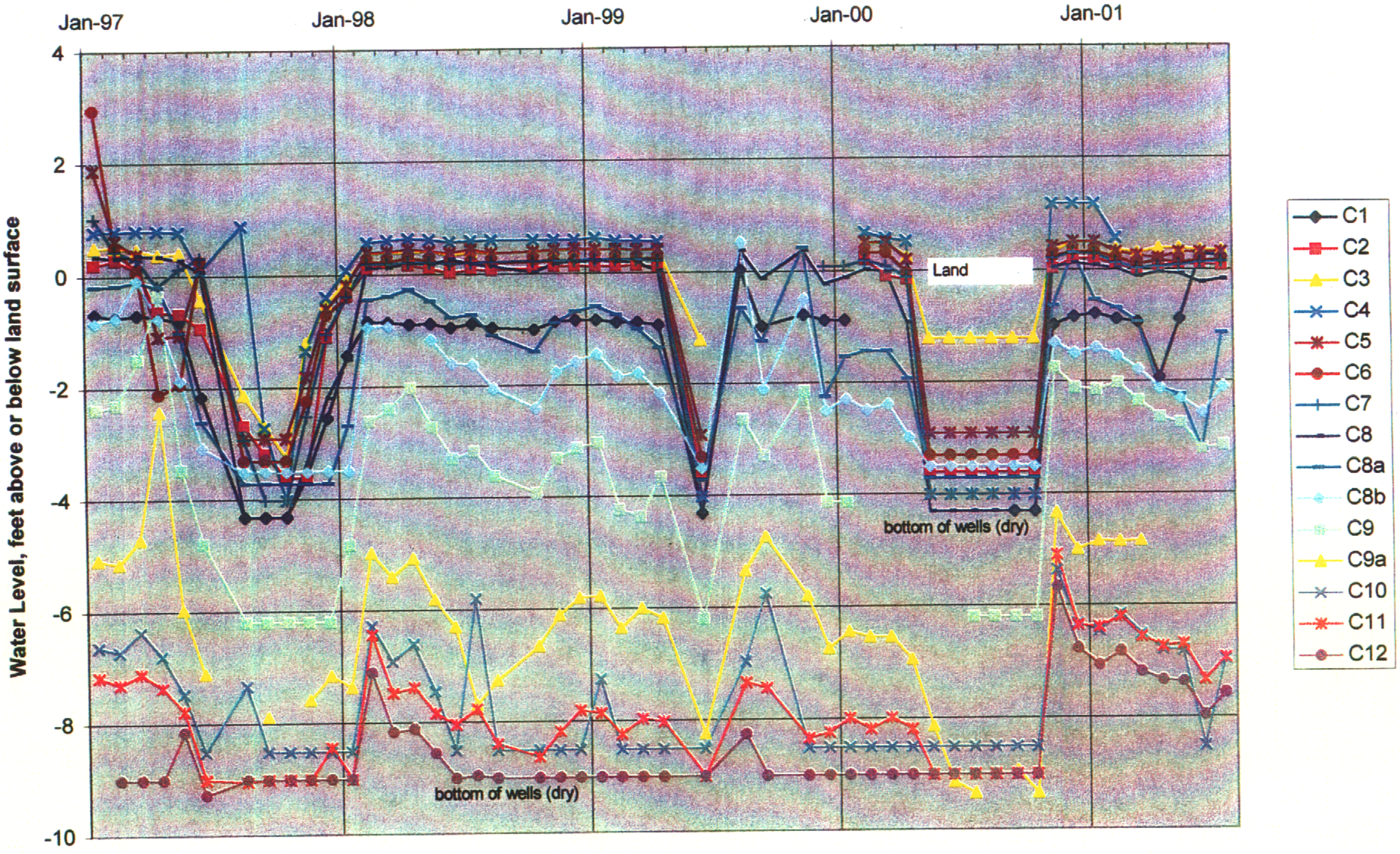


FIGURE 11. WATER LEVELS IN NORTH TRANSECT WELLS

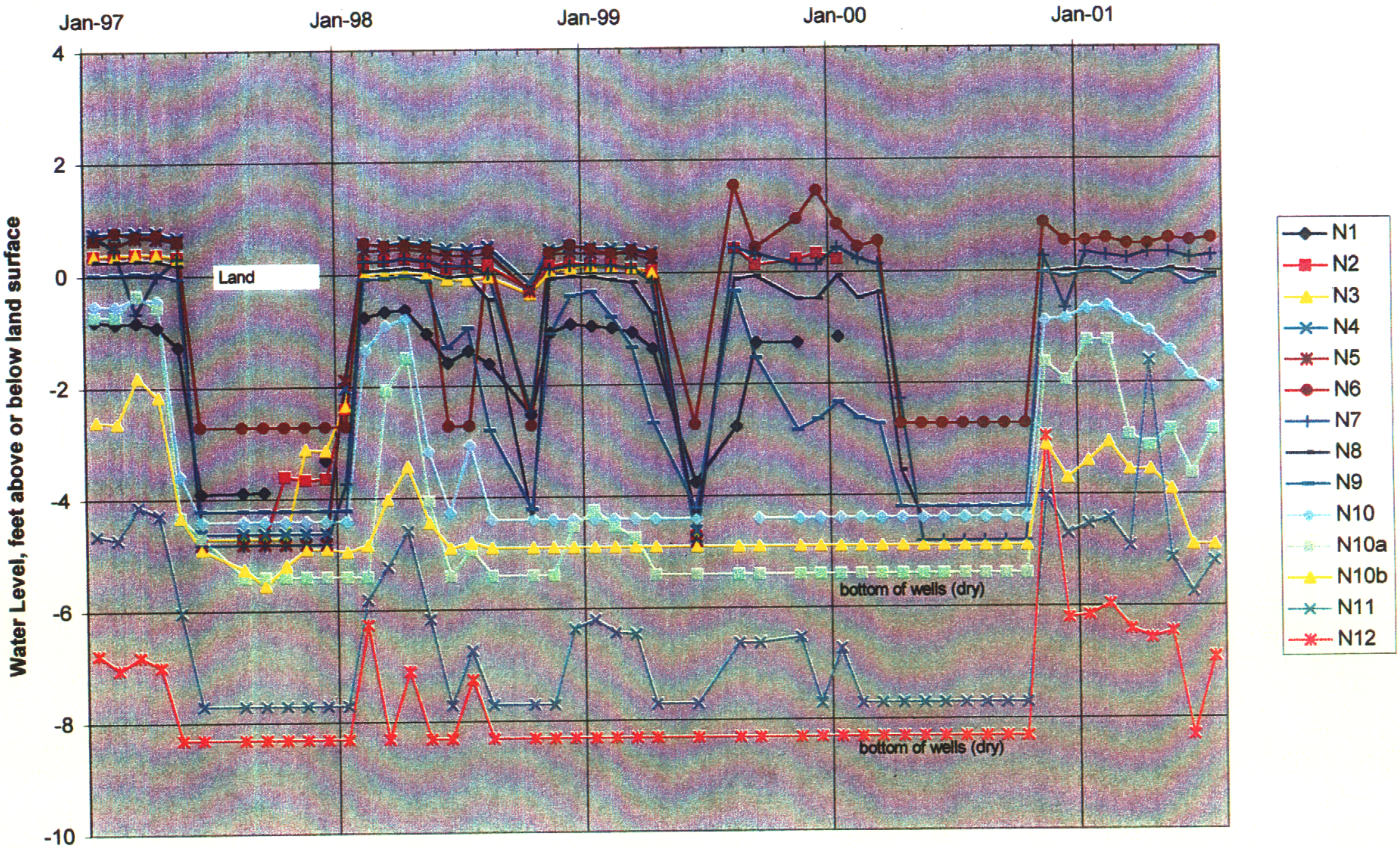
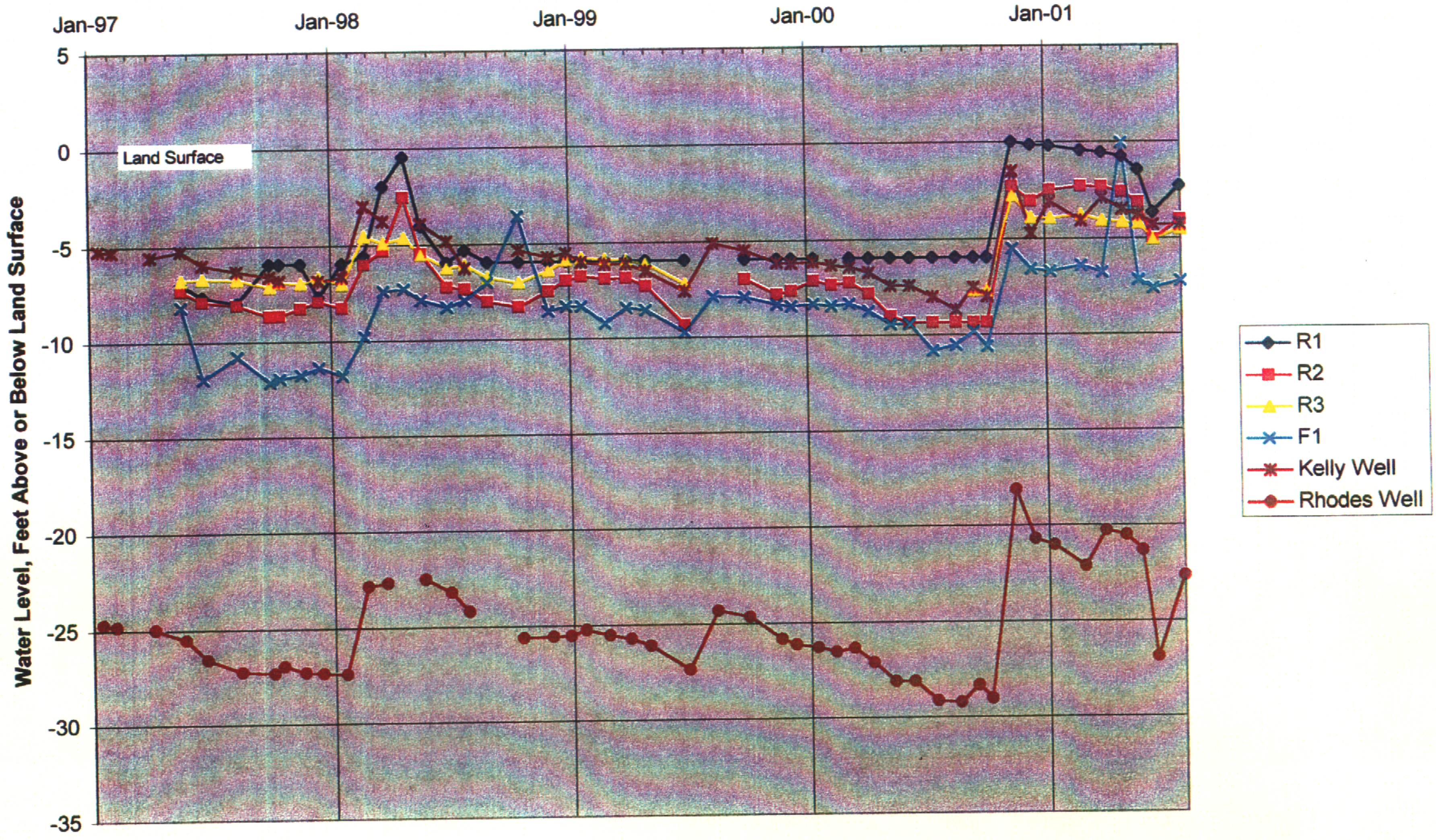


FIGURE 12. WATER LEVELS IN R TRANSECT AND IRRIGATION WELLS



Examination of streamflow records from the Redington gage compared to water levels in upland monitor wells indicates that water level recovery in July 1999 and October 2000 corresponded to large flows in the San Pedro River. However, water level recovery occurred in January/February 1998 without corresponding flow events recorded at the Redington gage. The water level record at the site is not sufficiently long to determine correlation between water levels in the alluvial aquifer (upland wells) and streamflow at Redington or precipitation at the site.

There may be a time lag between precipitation events and water level response – the time it takes groundwater to travel from the recharge area to the discharge area (in the case of the cienega spring) or to the monitor wells (in the case of the upland wells). The wetland contains a thick layer of heavy clay that impedes transmission of water between the wetland and the adjacent floodplain alluvium aquifer. Studies have indicated that source water for the Bingham spring is chiefly San Pedro subflow, with contributions from Buehman and Edgar Canyons; therefore, the recharge area for the cienega spring and the recharge area for the floodplain alluvium aquifer is probably the same. However, water level response in the upland monitor wells does not show the same response as in the wetland wells.

It would be reasonable to assume, given the highly transmissive nature of the floodplain alluvium, that water levels in the floodplain alluvium aquifer (i.e. upland monitor wells) are responsive to flood flows in the San Pedro River; whereas, discharge at Bingham spring is responsive to recharge at a more distant location, with corresponding lag time. However, the period of record for site-specific hydrologic data is not sufficiently long to definitely establish such correlations.

Depth to Groundwater in the Sacaton Planting Area

The areas of sacaton plantings with respect to location of monitor wells are shown on **Figure 3**. As an indication of water availability for sacaton plantings, average seasonal depth to groundwater in the upland monitor wells along each transect (with increasing distance from the wetland) is shown on **Figures 13, 14, and 15**. Seasonal average water levels are given in **Table 25**. The south and central transects are especially relevant, as these wells are nearest to the Year-one and Year-two agricultural fields. Unfortunately, monitor wells were completed with insufficient depth to capture the entire range of water levels; nearly all monitor wells go dry at some time during the period of record. Water levels represented for dry monitor wells is the bottom of the wells; therefore, depth to water is greater than indicated for dry wells. The total depth of the wells in some cases decreased during the grant period, due to silting of the well.

Inspection of **Figure 13** indicates that seasonal depth to water at S6, the farthest west area of sacaton plantings, ranged from 1.4 feet below land surface (bls) to more than 6 feet bls. Seasonal depth to water at S9, 120 meters east from S6 (and the farthest from the wetland) ranged from about 6 to greater than 10 feet bls. Based on the winter 2000/2001 seasonal average, groundwater at S9 was 4.6 deeper than at S6.

FIGURE 13. WATER LEVELS ACROSS THE SOUTH TRANSECT

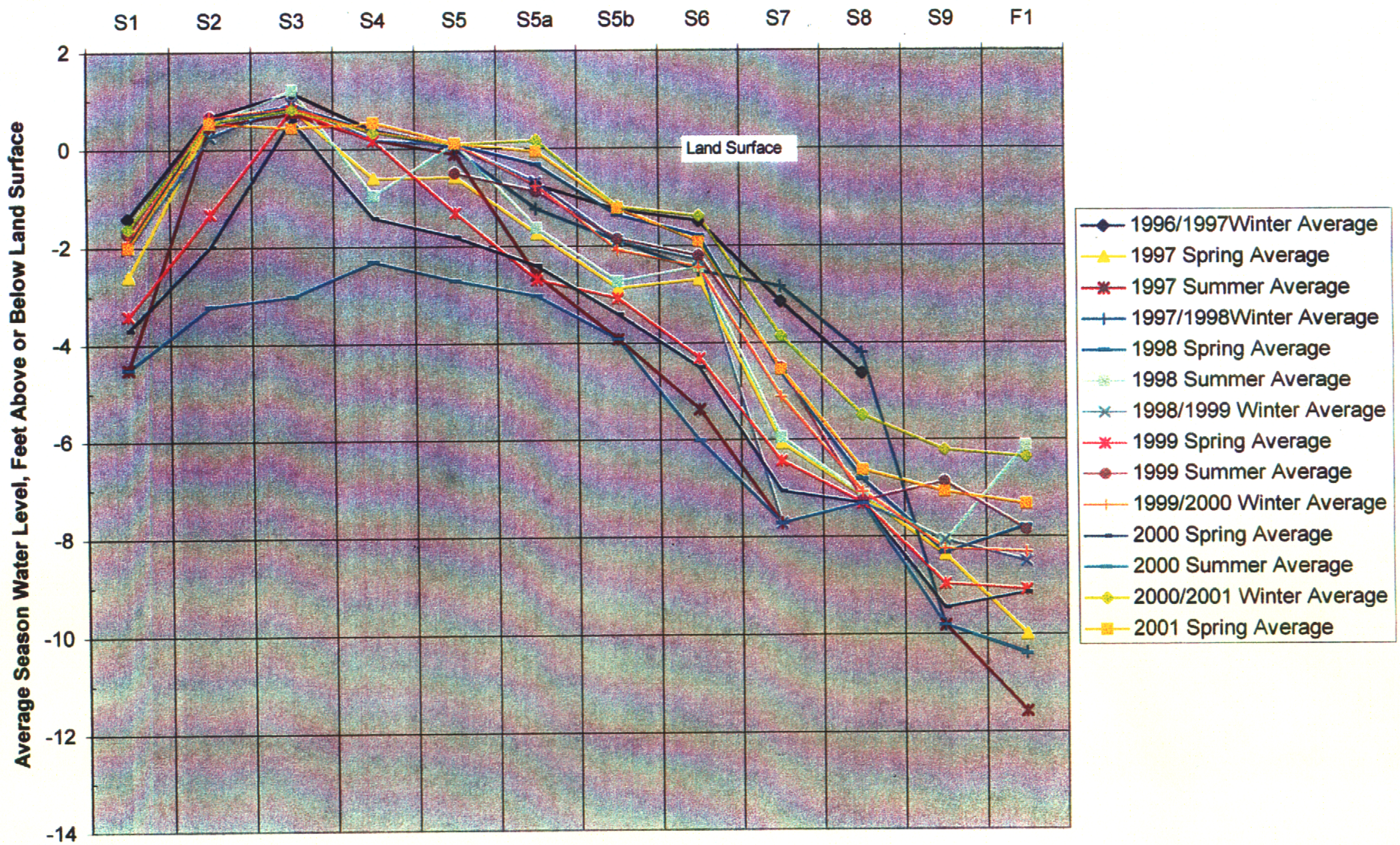


FIGURE 14. WATER LEVELS ACROSS THE CENTRAL TRANSECT

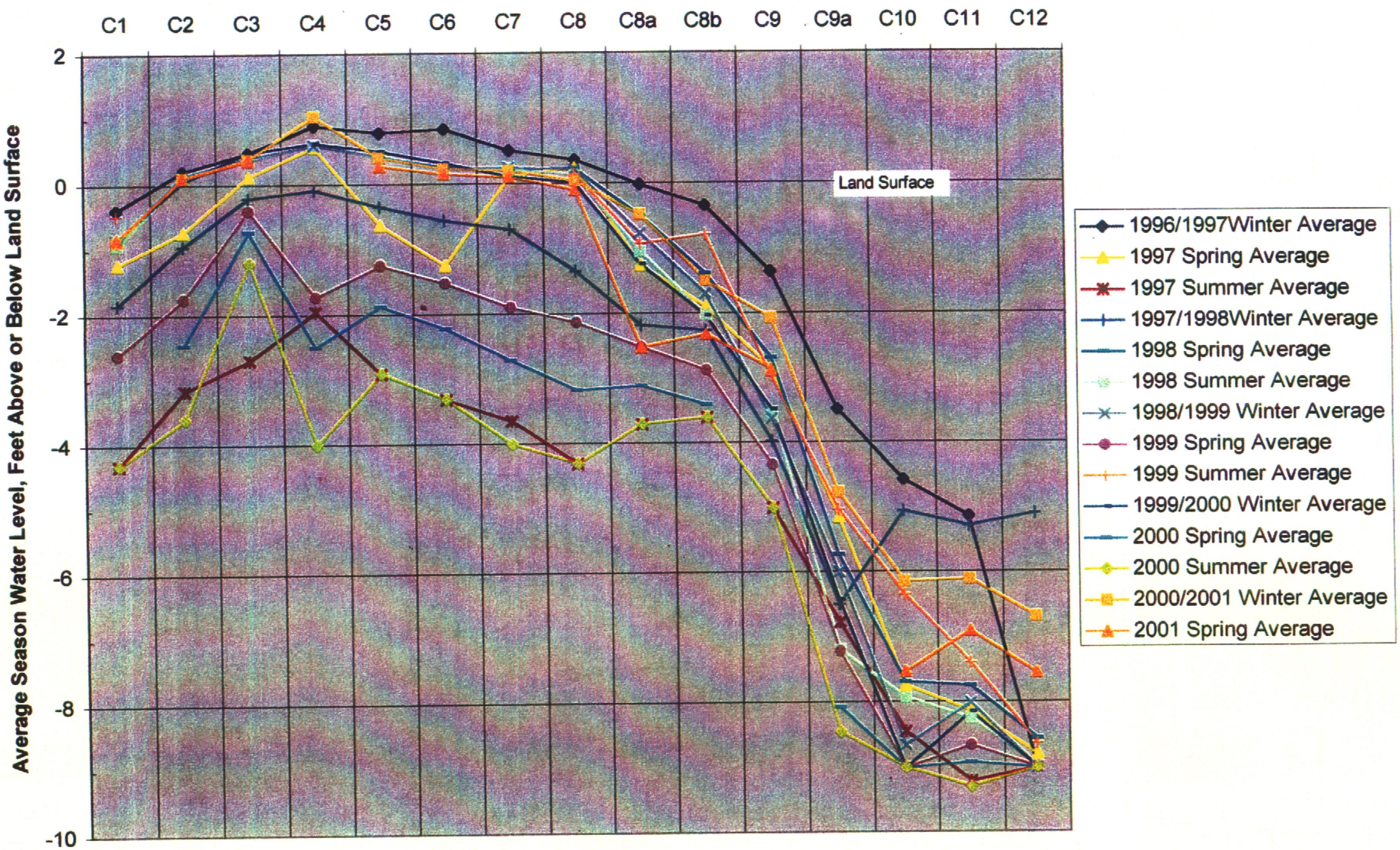


FIGURE 15. WATER LEVELS ACROSS THE NORTH TRANSECT

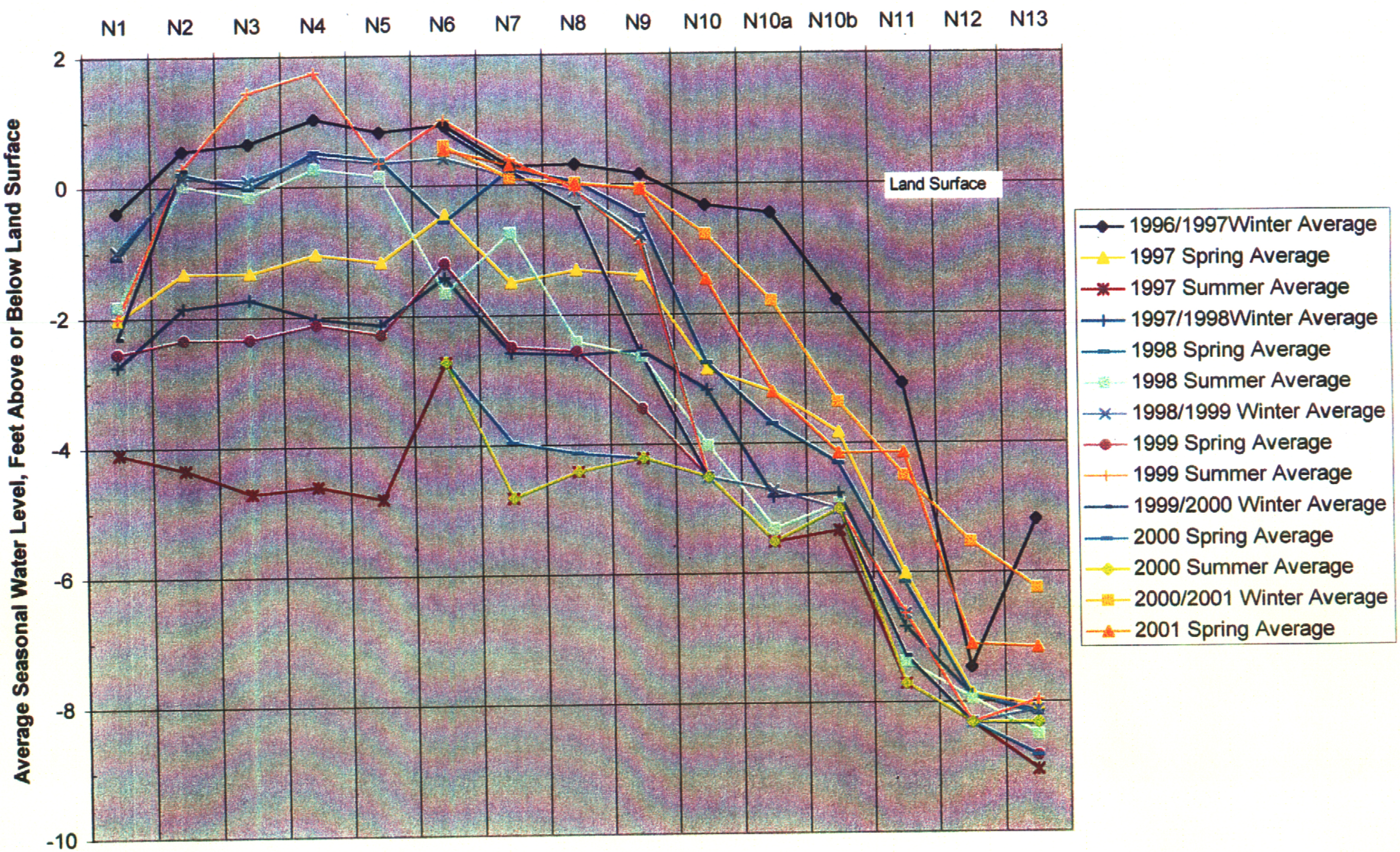


Table 25. Seasonal Average Water Levels in Monitor Wells

WELL NAME	1996/1997 Winter Average	1997 Spring Average	1997 Summer Average	1997/1998 Winter Average	1998 Spring Average	1998 Summer Average	1998/1999 Winter Average	1999 Spring Average	1999 Summer Average	1999/2000 Winter Average	2000 Spring Average	2000 Summer Average	2000/2001 Winter Average	2001 Spring Average
N1	-0.376	-2.017	-4.083	-2.736	-1.070	-1.817	-0.970	-2.540	-1.990	-2.293				
N2	0.564	-1.323	-4.333	-1.836	0.217	0.013	0.148	-2.330	0.290	0.273				
N3	0.669	-1.323	-4.700	-1.715	-0.012	-0.165	0.098	-2.335	1.450					
N4	1.040	-1.043	-4.600	-2.019	0.537	0.268	0.464	-2.110	1.750					
N5	0.831	-1.163	-4.800	-2.114	0.417	0.143	0.364	-2.270	0.360					
N6	0.942	-0.447	-2.700	-1.400	-0.550	-1.655	0.424	-1.180	1.010	0.857	-2.700	-2.700	0.621	0.555
N7	0.298	-1.488	-4.800	-2.560	0.250	-0.743	0.140	-2.475	0.400	0.230	-3.950	-4.800	0.110	0.317
N8	0.325	-1.303	-4.400	-2.602	0.068	-2.418	-0.082	-2.550	-0.075	-0.347	-4.115	-4.400	0.029	0.015
N9	0.168	-1.393	-4.200	-2.542	-0.468	-2.643	-0.764	-3.435	-0.910	-2.607	-4.200	-4.200	-0.061	-0.072
N10	-0.314	-2.843	-4.500	-3.150	-2.735	-4.022	-4.500	-4.500	-4.500	-4.500	-4.500	-4.500	-0.769	-1.448
N10a	-0.437	-3.197	-5.500	-4.812	-3.683	-5.310	-4.708	-5.500	-5.500	-5.500	-5.500	-5.500	-1.794	-3.197
N10b	-1.780	-3.827	-5.330	-4.760	-4.290	-4.933	-5.000	-5.000	-5.000	-5.000	-5.000	-5.000	-3.360	-4.150
N11	-3.065	-5.997	-7.700	-6.820	-6.133	-7.370	-6.614	-7.700	-6.610	-7.264	-7.700	-7.700	-4.502	-4.140
N12	-7.442	-7.860	-8.300	-7.888	-7.893	-7.947	-8.300	-8.300	-8.300	-8.300	-8.300	-8.300	-5.522	-7.100
N13	-5.170	-8.060	-9.037	-8.136	-8.180	-8.500	-8.106	-8.820	-7.955	-8.330	-8.813	-8.300	-6.236	-7.153
C1	-0.379	-1.217	-4.300	-1.830	-0.887	-0.930	-0.836	-2.605	-0.460	-0.827		-4.300	-0.860	-0.823
C2	0.215	-0.733	-3.150	-0.936	0.118	0.098	0.148	-1.740		0.065	-2.445	-3.600	0.121	0.105
C3	0.498	0.120	-2.688	-0.202	0.388	0.395	0.426	-0.395		0.505	-0.715	-1.200	0.403	0.375
C4	0.906	0.570	-1.940	-0.076	0.623	0.607	0.608	-1.715		0.640	-2.487	-4.000	1.040	
C5	0.796	-0.637	-2.900	-0.342	0.433	0.420	0.442	-1.235		0.520	-1.860	-2.900	0.416	0.287
C6	0.850	-1.250	-3.300	-0.558	0.263	0.230	0.248	-1.515		0.330	-2.207	-3.300	0.250	0.163
C7	0.517	0.105	-3.638	-0.695	0.228	0.235	0.258	-1.885		0.121	-2.702	-4.000	0.205	0.105
C8	0.371	0.255	-4.300	-1.339	0.238	0.138	0.222	-2.125	0.145	0.023	-3.168	-4.300	0.049	-0.095
C8a	-0.008	-1.262	-3.700	-2.173	-0.485	-1.052	-0.758	-2.610	-0.920	-1.227	-3.105	-3.700	-0.479	-2.515
C8b	-0.342	-1.898	-3.600	-2.255	-1.375	-2.022	-1.680	-2.875	-0.785	-2.027	-3.396	-3.600	-1.493	-2.316
C9	-1.355	-2.867	-5.000	-3.966	-2.683	-3.570	-3.616	-4.330	-2.965	-3.473		-5.000	-2.070	-2.860
C9a	-3.475	-5.160	-6.763	-6.490	-5.723	-7.197	-5.996	-7.205	-5.035	-6.410	-8.073	-8.455	-4.774	
C10	-4.569	-7.743	-8.438	-6.058	-7.673	-7.928	-8.648	-9.000	-6.340	-9.000	-9.000	-9.000	-6.149	-7.523
C11	-5.138	-8.137	-9.210	-6.278	-7.740	-8.257	-8.002	-8.655	-7.380	-8.140	-8.927	-9.300	-6.108	-6.907
C12	-9.000	-8.803	-9.000	-5.100	-8.550	-8.983	-9.000	-9.000	-8.625	-9.000	-9.000	-9.000	-6.684	-7.543
S1	-1.398	-2.603	-4.500	-1.920	-1.620	-2.010	-2.020	-3.395	-1.700	-1.870	-3.883	-4.500	-1.604	-1.997
S2	0.690	0.560	0.483	0.563	0.640	0.530	0.274	-1.320	0.690	0.680	-1.970	-3.200	0.570	0.550
S3	1.181	0.835	0.758	0.861	0.905	1.222	0.968	0.830		0.875	0.625	-3.000	0.825	0.442
S4	0.399	-0.598	0.213	0.395	0.398	-0.958	0.211	0.190		0.387	-1.405	-2.300	0.349	0.552
S5	0.095	-0.672	-0.095	0.019	0.105	0.115	0.084	-1.310	-0.485	0.117	-1.795	-2.700	0.105	0.115
S5a	-0.719	-1.738	-2.582	-1.221	-0.308	-1.627	-0.668	-2.670	-0.860	-0.737	-2.385	-3.000	0.173	-0.045
S5b	-1.245	-2.860	-3.900	-1.880	-1.353	-2.723	-1.890	-3.060	-1.840	-2.080	-3.380	-3.900	-1.196	-1.223
S6	-1.485	-2.688	-5.348	-2.503	-1.775	-2.425	-2.280	-4.305	-2.190	-2.427	-4.490	-6.000	-1.389	-1.905
S7	-3.132	-6.060	-7.700	-2.818	-4.593	-5.933	-7.700	-6.425	-4.500	-5.090	-7.050	-7.700	-3.848	-4.533
S8	-4.614	-7.170	-7.300	-4.188	-6.800	-7.157	-7.300	-7.300	-7.245	-7.064	-7.300	-7.300	-5.482	-6.620
S9		-8.370	-9.800	-9.800	-8.320	-8.100	-8.050	-8.960	-6.850	-8.230	-9.437	-9.800	-6.210	-7.067
R1		-7.265	-6.643	-3.663	-3.463	-3.530	-6.000	-6.000	-6.000	-6.000	-6.000	-6.000	-0.211	-1.905
R2		-7.560	-8.405	-7.105	-5.038	-7.815	-6.926	-8.355	-6.920	-7.367	-8.743	-9.500	-2.459	-3.575
R3		-6.705	-6.900	-6.000	-5.447	-6.593	-5.956	-6.625	-10.000	-10.000	-10.000	-8.825	-3.688	-4.453
F1		-9.995	-11.555	-10.363	-7.765	-6.122	-8.494	-9.070	-7.845	-8.307	-9.132	-10.390	-6.345	-7.330
IRRIGATION W	-3.218	-5.543	-6.523	-5.010	-4.320	-5.735	-5.838	-6.990	-5.250	-6.180	-7.117	-8.000	-1.600	-3.817
RHODES WELL	-15.819	-25.643	-27.120	-25.458	-22.780	-24.855	-25.458	-26.680	-24.445	-26.162	-27.730	-28.870	-11.570	-22.853

Notes:

All numbers are depth to water, feet above (positive number) or feet below (negative number) land surface.

Shaded cells are dry wells - total depth was substituted for depth to water

Blank cells represent no data available for the season (monitor well burned or unmeasureable)

Winter season = November, December, January, February, March

Spring season = April, May, June

Summer season = July, August, September, October

Inspection of **Figure 14** indicates that seasonal depth to water at C9, the farthest west area of sacaton plantings, ranged from 1.4 feet bls to greater than 5 feet bls. Seasonal depth to water at C12, 120 meters east from C9 (and the farthest from the wetland) ranged from 5.1 to greater than 9 feet bls. Based on the winter 2000/2001 seasonal average, groundwater at C12 was 4.7 feet deeper than at C9. Unfortunately, because most of the upland monitor wells went dry at some point during the monitoring period, the maximum depth to water is unknown.

Depth to Groundwater in the Riparian Woodland Planting Area

The areas of riparian woodland plantings with respect to location of monitor wells are shown on **Figure 3**. As indicated by inspection of **Figures 13, 14, and 15**, seasonal average depth to groundwater in the area of riparian woodland plantings ranged from a high of about 0.5 foot standing water to a low of greater than 3 feet bls. Depth to water increases to the north (from the south transect to the central to the north transect).

Depth to Groundwater in the Mesquite Woodland Area

There are no monitor wells located in areas of mesquite woodland plantings. However, monitor wells N12 and N13 are located in an area of natural mesquite woodland regeneration (native grasses have been planted in this area). Seasonal average depth to water in this area ranges from about 5 to greater than 8 feet bls.

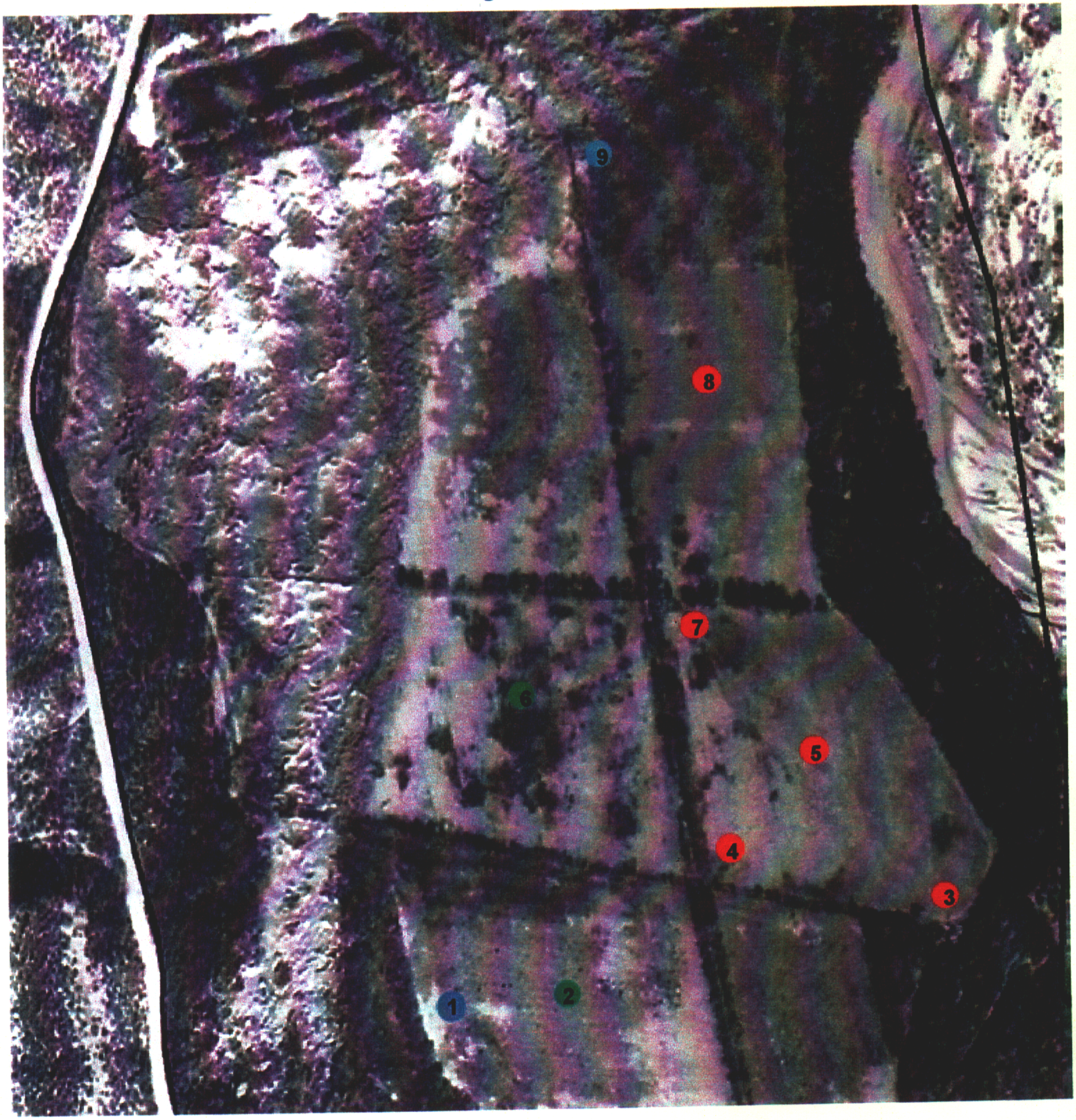
PHOTOGRAPHIC MONITORING

During the summer months of 1998, 1999, and 2000, repeat photography was taken at 9 monitoring points for a total of 27 views of the restoration area each year. Photo monitoring points are shown on **Figure 16**. Photomonitoring was used as a qualitative means for describing the three restoration planting areas (deciduous riparian woodland, mesquite woodland and sacaton grassland). All photos were digitally archived and original photographs are located in TNC's Tucson office. Comparison photos across years were enhanced and prepared using Adobe Photoshop and Pagemaker software. **Appendix B** contains a representative selection of the photo-monitoring.

BIRD USE MONITORING - RESTORATION AREA AND MATURE HABITATS

We monitored bird use of both the restoration areas and mature, undisturbed habitats as a way to evaluate the success of the restoration effort. We anticipated that the numbers and species of birds using mature mesquite woodland and

Bingham Cienega Natural Preserve
Monitoring Photo Points



Restoration Planting Areas	Photo Point Numbers
deciduous riparian woodlands	1,9
sacaton grassland	2,6
mesquite woodlands	3,4,5,7,8

FIGURE 16

deciduous riparian forest were different from the numbers and species using the agricultural fields. Furthermore, with the growth of restored vegetation in the fields, bird species in the mesquite and deciduous riparian planting areas should become increasingly different from those characteristic of pastures and abandoned agricultural fields and should come to resemble those in undisturbed, mature habitats. Bird use of the sacaton planting area is also expected to change as sacaton grassland becomes established and matures but there are no on-site comparisons that will allow us to predict how numbers and composition will change if the restoration effort is successful.

Thus, the monitoring objective was to determine the number of birds by species foraging in or traveling through the ten permanent monitoring stations and how these numbers and species changed through time. Since restoration and monitoring have only occurred over a 3-year period there has been little opportunity for change. So the following analyses will compare bird numbers and composition in the restoration areas and their corresponding mature habitats to document baseline conditions, that is similarities and differences in bird abundance and species composition between areas. The differences will allow us to predict how bird use will change with time if the restoration effort is successful.

METHODS

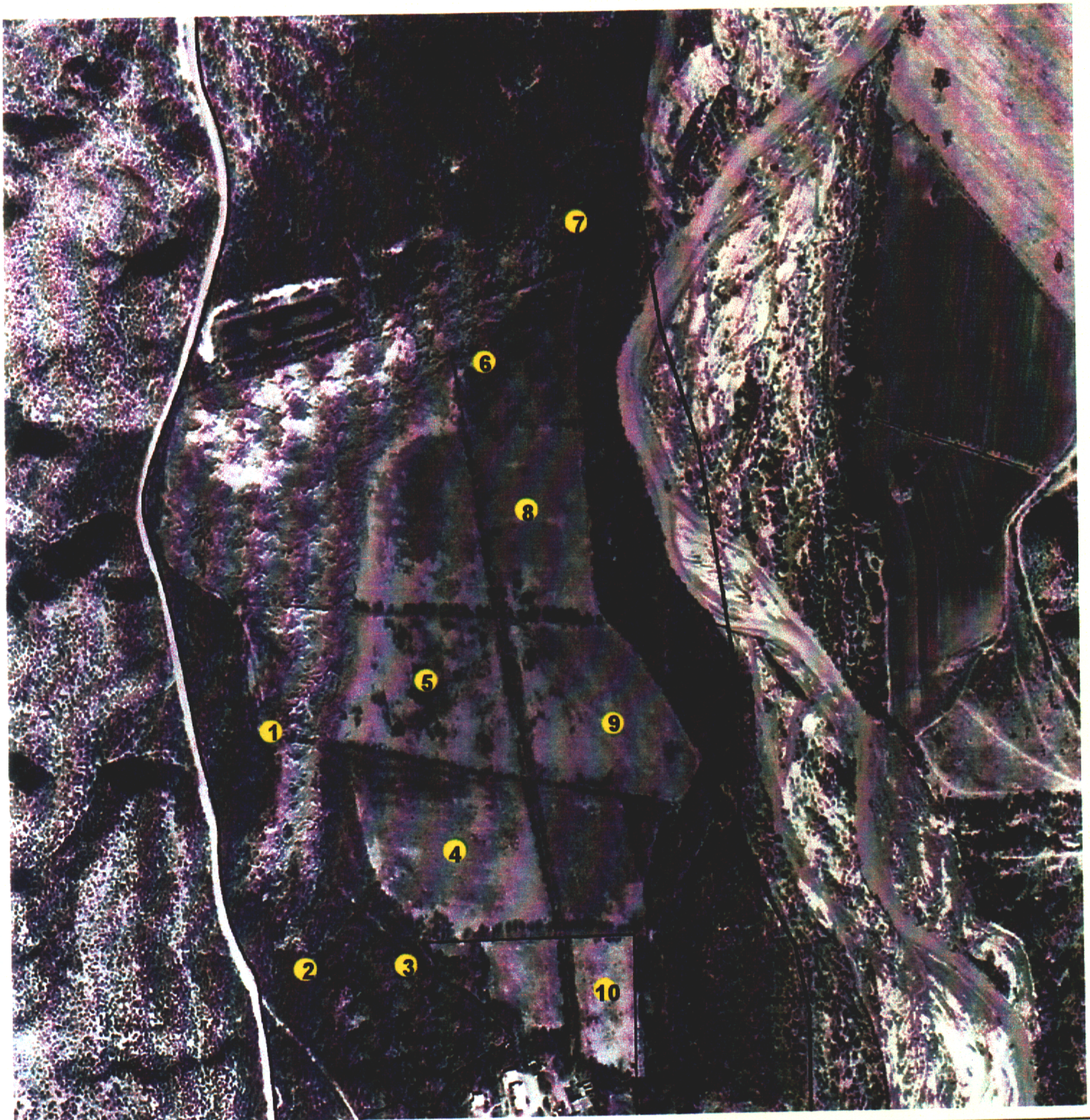
The monitoring stations were established in June, 1998: 4 stations were located in undisturbed riparian habitats (2 in mesquite bosque and 2 in riparian woodland) and 6 stations were placed in the agricultural fields. One of the 6 "field" stations is on land owned by Jack Kelly and not part of the restoration effort. Thus, it will remain a pasture and be a point of comparison for both the restoration areas and their corresponding mature habitats. The location of bird monitoring stations by habitat type or planting area are shown on **Figure 17**.

Four times a year (i.e., March, June, September, and December), at least two observers visited each station and recorded the number of birds observed or calling by species for a period of 6 minutes before moving to the next station. For calling birds we tried to determine their location so that birds in adjacent fields or habitats were not counted. Notes were also made on breeding or nesting behaviors observed at each station. Monitoring was conducted in the early morning when birds were most active.

To compare the composition of common species using control and restoration areas, all species with more than two individuals counted during a year for at least two out of 3 years were noted; separate lists were generated for the breeding (June) and non-breeding seasons (March, September, December) and for control and restoration areas.

Throughout the funding period, many volunteers from Tucson Audubon Society (TAS) and the University of Arizona (UA) assisted TNC staff with bird monitoring. The staff were well versed in the monitoring protocol but in most cases less experienced in bird identification than the TAS/UA volunteers. Furthermore, there was significant variation among volunteers in their ability to identify birds by sight and sound so that some of the

Bingham Cienega
Permanent Bird Monitoring Points



Station No	Station Habitat Type	Station No	Station Habitat Type
1	mature riparian woodland (control)	6	riparian woodland restoration area
2	mature mesquite bosque (control)	7	mature mesquite bosque (control)
3	mature riparian woodland (control)	8	mesquite bosque restoration area
4	sacaton grassland restoration area	9	mesquite bosque restoration area
5	sacaton grassland restoration area	10	Ag. Field (control)

FIGURE 17

between-survey differences in bird species and numbers can be attributed volunteer experience. Another factor affecting results is that the fields (restoration areas) were surrounded on 3- to 4-sides by hedge-rows of mature mesquite and hackberry trees. It was often difficult in well-vegetated fields to discern whether calls or songs were coming from the hedge-rows or from the field itself. This was especially true for secretive species like Bell's vireo and Yellow-breasted chat that were more often heard than seen. So the following results should be evaluated with these two *caveats* in mind. A complete list of birds that were sighted or heard at the preserve (including those recorded between monitoring stations) can be found in **Appendix C**.

RESULTS AND DISCUSSION

Sacaton Grassland Restoration Area and the Permanent Pasture

Over the 3-years period, bird counts during the breeding season (June) varied between years in the permanent pasture (field control station # 10) and in the restoration area, but the variation in counts was greater in the restoration area **(Figure 18)**. In the non-breeding season, between-year variation in bird abundance was again the rule, however, the amount of variation was somewhat greater in the permanent pasture **(Figure 19)**. This suggests that much of the variability in bird counts between census periods and years had little to do with our restoration effort since vegetation structure and cover was most constant in the permanent pasture yet bird abundance in the non-breeding season varied more there than in the restoration area. The most common visitors to both areas regardless of season were flocks of ground-foraging (i.e., Red-winged blackbird, Flicker) and/or seed-eating birds (i.e., goldfinch, sparrows, House finch, Cardinal, Mourning dove) who were using the restoration area and permanent pasture primarily as foraging areas **(Tables 26 and 27)**. The occurrence of these flocks at a monitoring station during a particular survey and their subsequent movements to another field were largely stochastic, hence the high degree of within- and between-survey variation in bird counts at the stations.

That being said, in 1998 and 1999, bird abundance in the permanent pasture during the non-breeding season was greater or equal to that in the restoration area whereas in 2000, abundance in the permanent pasture was less than in both sacaton fields. The switch in 2000 may be significant since by that year sacaton had been established for 1-2 growing seasons in the restoration area. Vegetation structure and cover were increasing in both sacaton fields but not in the permanent pasture so the two areas (restoration area vs. permanent pasture) were becoming more dissimilar over time. Thus, a greater dissimilarity in bird abundance and composition would be expected. This is borne out to a limited extent by a comparison of consistently common species in June **(Table 26)**. The permanent pasture and restoration area shared no species that were recorded as common for 2 or more years. However, House finch, Red-winged blackbird and Lesser goldfinch were recorded in large numbers in the permanent pasture in one year, i.e., 1999. In the non-breeding season, all common species recorded in the permanent pasture were also common in the restoration area and most species in both areas were ground-foragers and/or seed-eaters (in flocks) at least during the non-breeding season (i.e., Red-winged blackbird, Lesser goldfinch, White-crowned sparrow, House finch, Mourning dove, Flicker; **Table 27**). However, the number of common species was greater in the restoration area in both the breeding and non-breeding season presumably because of the increasing complexity and cover of vegetation there compared to the permanent pasture.

Figure 18. The number of birds counted during the breeding season (June) surveys in the permanent pasture (field control) and in the sacaton restoration area (Year-1 field, Year-2 field) between 1998 and 2000.

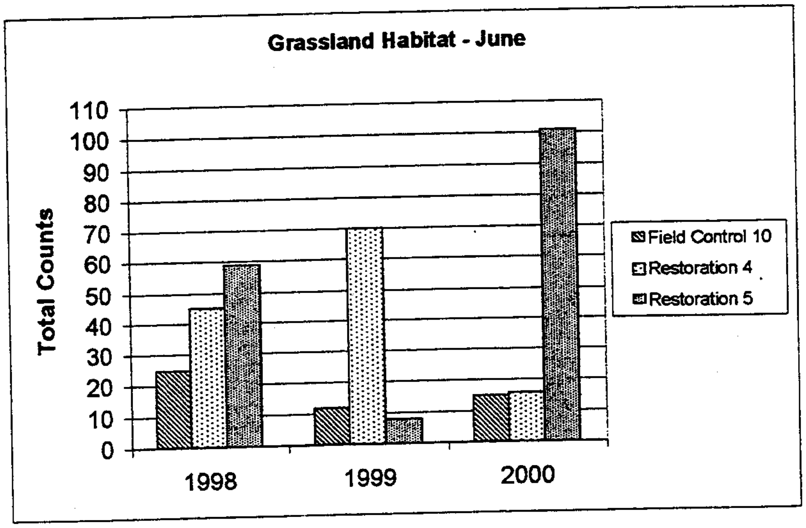


Figure 19. The number of birds counted during the non-breeding season surveys (March, September, December) in the permanent pasture (field control) and sacaton restoration area (Year-1 field, Year-2 field) between 1998 and 2000.

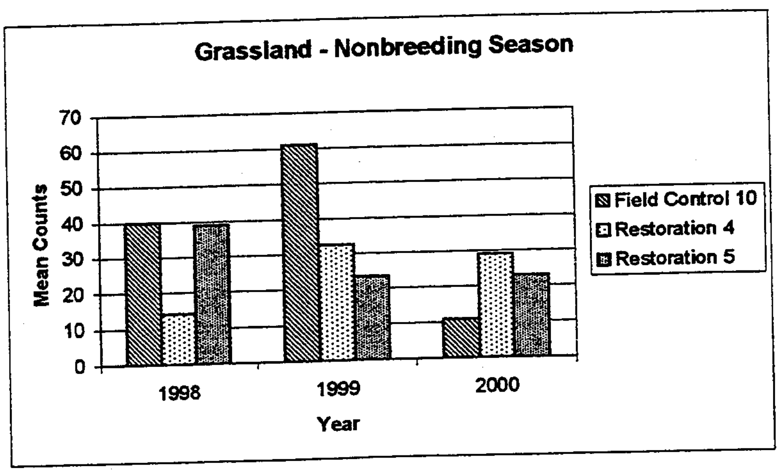


Table 26. Bird species recorded as common (n ≥ 2 individuals) for more than a single year during breeding season (June)surveys at monitoring stations located in a permanent pasture (Field Control) and in the sacaton restoration area (Year-1 and Year-2 Fields). Total counts for each species are given in parentheses; the number of years that the species was recorded as common is also given.

Control Station (n = 1)		Restoration Stations (n = 2)	
Number of Years	Species (Total No.'s)	Number of Years	Species (Total No.'s)
2	Vermilion flycatcher (4)	2	House finch (14)
2	Song sparrow (4)	2	Red-winged blackbird (26)
		2	Goldfinch (American, Lesser) (22)
		2	Mourning dove (17)

Table 27. Bird species recorded as common (n ≥ 2 individuals) for more than a single year during non-breeding season surveys (March, September, December) at monitoring stations located in a permanent pasture (Field Control) and in the sacaton restoration area (Year-1 Field, Year-2 Field) Total counts for each species are given in parentheses; the number of years that the species was recorded as common is also given.

Control Station (n = 1)		Restoration Stations (n = 2)	
Number of Years	Species (Total No.'s)	Number of Years	Species (Total No.'s)
2	Lesser goldfinch (6)	3	Goldfinch (American, Lesser) (67)
2	Red-winged blackbird (56)	2	Red-winged blackbird (46)
2	White-crowned sparrow (9)	3	Sparrows (White-crowned, Brewer's, Lincoln, others) (14)
2	Gila woodpecker (9)	2	Gila woodpecker (11)
2	House finch (41)	2	House finch (13)
2	Mourning dove (10)	2	Mourning dove (28)
2	Cardinal (4)	3	Cardinal (8)
		2	Abert's towhee (6)
		3	Song sparrow (14)
		2	Flicker (20)
		2	Vermilion flycatcher (15)

Mature Deciduous Riparian Forest and the Restoration Area

Total bird numbers remained relatively constant in June surveys over the 3-year period in mature riparian forest (controls) but was somewhat more variable in the restoration area **(Figure 20)**. That is, in 1998 bird numbers were 2-3 times greater in the restoration area than in mature forest but in 1999 and 2000, numbers were approximately equivalent in the two areas. In the non-breeding season, there was some variation in total counts in mature forest (i.e., a difference of no more than 12 birds between years) and somewhat more variation in the restoration area (i.e., a difference of no more than 20 birds between years). However, counts in the restoration area exceeded those in mature riparian forest in every year **(Figure 21)**.

In June surveys, mature riparian forest and the riparian restoration area shared 4 common species **(Table 28)**; half of these were more abundant in the mature forest (Song sparrow, Yellow-breasted chat) and half were more abundant in the restoration area (Mourning dove, Red-winged blackbird). The latter species are both predominantly ground-foragers. In addition, House finch and Brown-headed cowbirds were consistently common in the restoration area whereas two warbler species, Bell's vireo, and Gila woodpecker were consistently common in mature riparian forest. Presence of the warblers and Bell's vireo in the mature forest was presumably due to a well-developed tree canopy and shrub understory which were completely lacking in the restoration area since it was plowed in 1998 before container saplings were planted.

In the non-breeding season, mature riparian forest and the restoration area had 4 common species in common **(Table 29)**. Three of these were more abundant in the mature forest whereas Lesser goldfinch, a seed-eating species, was more than twice as abundant in the restoration area (i.e., presumably foraging on sunflower which dominated the area). Ladder-backed woodpecker and a suite of warbler species were common in the mature forest but not in the restoration area whereas Bewick's wren and Mourning dove, a seed-eating ground-forager, were common in the restoration area but not in the control forest. Inspection of the count numbers in **Table 29** suggests that birds were more abundant in the mature forest than in the restoration area during the non-breeding season but as indicated above this was not the case **(Figure 21)**. The greater numbers of birds in the restoration area resulted primarily from one-time appearances of large flocks of meadowlark, Lincoln sparrow, and American robin.

Thus, in both the breeding and non-breeding season most of the consistently common species were similar in the mature forest and restoration area although their abundances differed. Ground-foraging species or those that feed mostly on seeds (Lesser goldfinch, Mourning dove, Redwinged blackbird) tended to predominate in the restoration area whereas species that forage on trees (Gila and Ladder-backed woodpeckers), in tree canopies (warblers) or in dense understory growth (warblers and Song sparrows) tended to be more abundant in mature forest. Furthermore, flocks of ground-foraging seed-eating species were recorded in the restoration area during single surveys but not in mature forest contributing to higher bird counts in the restoration area in every year.

Figure 20. The number of birds counted during breeding season (June) surveys conducted in mature, undisturbed riparian forest (controls) and in the riparian restoration area.

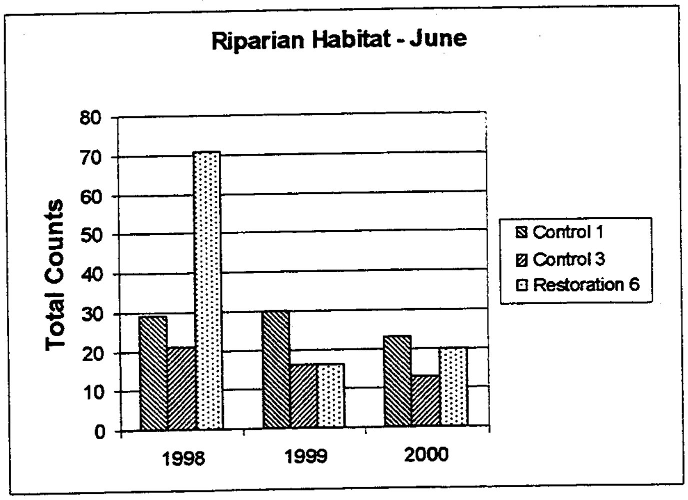


Figure 21. The number of birds counted during non-breeding season surveys (March, September, December) conducted in mature riparian forest (controls) and in the riparian restoration area.

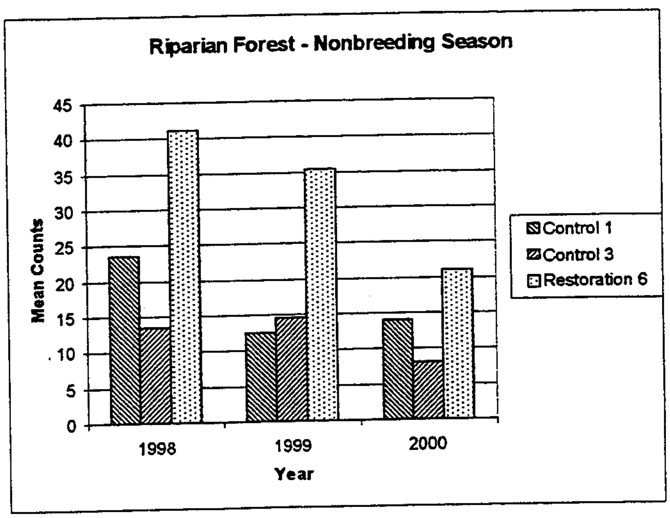


Table 28. Bird species recorded as common (n ≥ 2 individuals) for more than a single year during breeding season (June) surveys conducted at monitoring stations in mature riparian forest (controls) and in the riparian restoration area. Total counts for each species are given in parentheses; the number of years that the species was recorded as common is also given.

Control Stations (n = 2)		Restoration Station (n = 1)	
Number of Years	Species (Total No.'s)	Number of Years	Species (Total No.'s)
3	Mourning dove (10)	3	Mourning dove (14)
3	Redwinged blackbird (17)	2	Redwinged blackbird (23)
3	Song sparrow (8)	2	Song sparrow (5)
3	Yellow-breasted chat (34)	2	Yellow-breasted chat (10)
3	Warblers (Yellow, Yellow-rumped) (16)	2	House finch (4)
2	Bell's vireo (4)	2	Brown-headed cowbird (4)
2	Gila woodpecker (4)		

Table 29. Bird species recorded as common (n > 2 individuals) for more than a single year during non-breeding season surveys (March, September, December) conducted at monitoring stations in mature riparian forest (controls) and in the riparian restoration area. Total counts for each species are given in parentheses; the number of years that the species was recorded as common is also given.

Control (n = 2)		Restoration (n = 1)	
Number of Years	Species (Total No.'s)	Number of Years	Species (Total No.'s)
3	Gila woodpecker (21)	3	Gila woodpecker (12)
2	House finch (12)	2	House finch (10)
2	Goldfinch (Lesser, American) (12)	3	Lesser goldfinch (25)
3	Song sparrow (24)	3	Song sparrow (17)
2	Ladder-backed woodpecker (10)	2	Bewick's wren (4)
2	Flicker (5)	2	Mourning dove (4)
2	Warblers (Yellow-rumped, Wilson's, Townsend's) (11)		

Mature Mesquite Woodland and the Restoration Area

Similar to the pattern observed for riparian woodland, total counts of birds remained relatively stable during the breeding season (June) in undisturbed, mature woodland whereas counts in the restoration area varied between years in some years being greater (1998, 2000) and in 1999 being less than counts in mature mesquite woodland **(Figure 22)**. Similarly, in the non-breeding season, total counts in mature woodland remained relatively constant over time but they were always less than counts in the restoration area **(Figure 23)**. Variation in bird numbers between years was greater in the restoration area than in undisturbed woodland.

In June, mature woodland and mesquite restoration areas had 3 species in common including Bell's vireo **(Table 30)**. Bell's vireo was also common in mature riparian woodland but not in the riparian restoration area in keeping with its affinity for dense woodland vegetation. Its presence in the mesquite restoration area may be due to the fact that the mesquite were already densely-growing there and variable in size with many individuals exceeding 2.9 m in height. In addition, Lesser goldfinch, Mourning dove, and Vermilion flycatcher were consistently common in the restoration areas whereas Lucy's, Yellow and Yellow-rumped warblers were consistently common in undisturbed mesquite woodland. These differences in bird composition reflect existing differences in the size and structure of vegetation in the restoration area and in undisturbed habitat. Mourning dove, a ground-foraging bird, and Vermilion flycatcher, a species that catches insects on the wing from a fixed perch, are both characteristic of open habitats like the restoration areas whereas the warblers commonly feed by gleaning insects from the canopy of mesquite and other riparian trees or from tall understory shrubs associated with these woodlands.

In the non-breeding season, mature mesquite woodland and the restoration areas had 5 species in common **(Table 31)**, although Lesser goldfinch and blackbirds (both seed-eaters that forage in flocks in the non-breeding season) were much more common in the restoration area than in the mature woodland presumably because of the abundant weed and grass seed available in the former. Ruby-crowned kinglet and Bewick's wren were consistently common in the mature woodland but not in the restoration area whereas a number of sparrow species were consistently abundant in the restoration area but not in mature mesquite woodland. Again, these differences in bird composition are reflect differences in vegetation structure and composition in the two areas. Bewick's wrens are woodland species, whereas the suite of sparrow species are common in grassland and shrubland habitats. High sparrow numbers in the restoration area presumably reflect both the structural characteristics of the vegetation, that is, dense clusters of mesquite shrubs with large open patches of bare ground and herbaceous vegetation, as well as abundant food resources (i.e., seeds) there.

Thus, in both the breeding and non-breeding seasons, the restoration area shared a number of common species with mature mesquite woodland. That is, the composition of the restoration area is moving toward that of the mature woodland but certain species like Bewick's wren and several warbler species which are characteristic of the latter have not yet become consistently common in the restoration area. In addition, most of the "shared" species were more common in the restoration area than in the mature woodland (6 out of 8 species). In addition, among "unshared" species, large numbers of seed-eating, ground-foraging birds (finches, sparrows, doves) were recorded in the restoration area. Both of these factors contributed to the greater number of birds counted in the restoration area compared to mature woodland during single census periods and across years **(Table 32)**.

Figure 22. The number of birds counted during June surveys at monitoring stations in undisturbed mesquite woodland (controls) and in the mesquite restoration area.

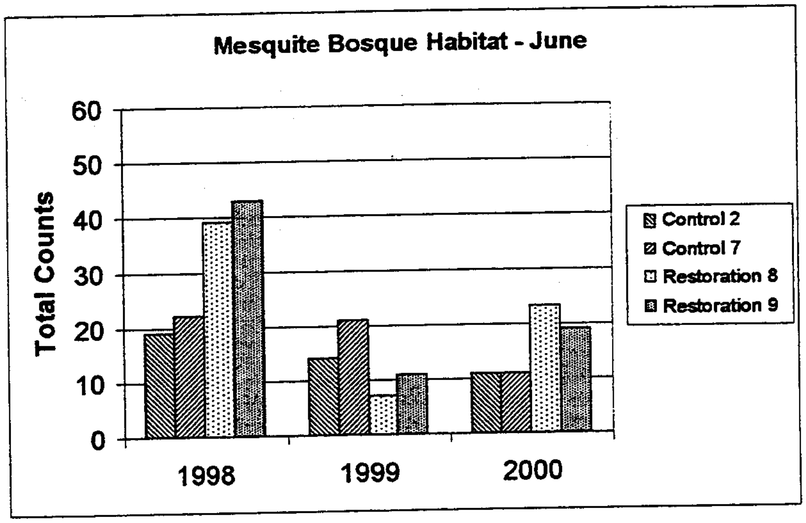


Figure 23. The number of birds counted during non-breeding season surveys (March, September, December) at monitoring stations located in mature mesquite woodland (controls) and in the mesquite restoration area.

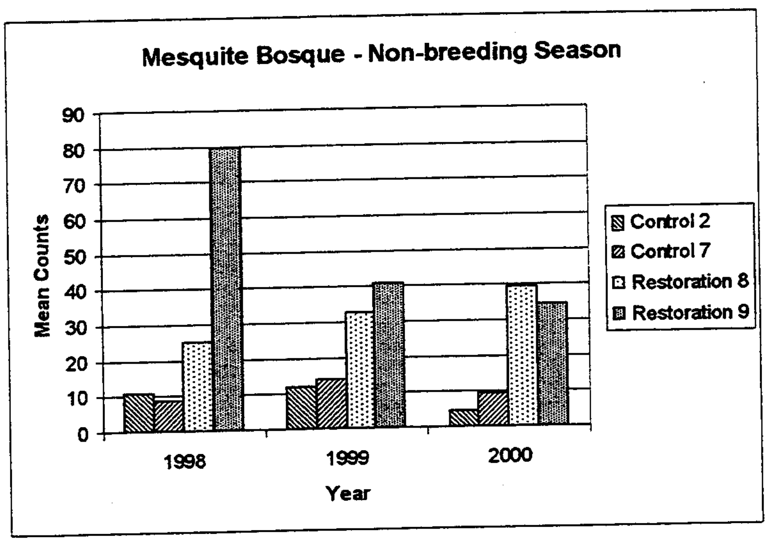


Table 30. Bird species that were recorded as common (n > 2 individuals) for more than a single year during June surveys at monitoring stations in mature mesquite woodland (controls) and in the mesquite restoration area. Total counts for the species are given in parentheses; the number of years that the species was recorded as common is also given.

Control Stations (n = 2)		Restoration Stations (n = 2)	
Number of Years	Species (Total No.'s)	Number of Years	Species (Total No.'s)
2	Bell's vireo (7)	3	Bell's vireo (15)
3	Yellow-breasted chat (20)	3	Yellow-breasted chat (22)
2	Song sparrow (6)	2	Song Sparrow (5)
2	Lucy's warbler (8)	2	Lesser goldfinch (10)
2	Warblers (Yellow, Yellow-rumped) (10)	2	Mourning dove (20)
		2	Vermilion flycatcher (8)

Table 31. Bird species recorded as common (n > 2 individuals) for more than a single year during non-breeding season surveys conducted (March, Sepember, December) at monitoring stations in mature mesquite woodland (controls) and in the mesquite restoration area. Total counts for each species are given in parentheses; the number of years that the species was recorded as common is also given.

Control Stations (n = 2)		Restoration Stations (n = 2)	
Number of Years	Species (Total No.'s)	Number of Years	Species (Total No.'s)
2	Song sparrow (6)	2	Song sparrow (13)
3	Gila woodpecker (15)	2	Gila woodpecker (14)
2	Lesser goldfinch (7)	2	Lesser goldfinch (61)
2	Mourning dove (6)	2	Mourning dove (12)
2	Yellow-headed, redwinged blackbird (13)	3	Yellow-headed, redwinged blackbird (42)
2	Ruby-crowned kinglet (10)	3	Sparrows (Lincoln, White-crowned, Grasshopper, others) (64)
2	Bewick's wren (12)	2	House finch (30)

Table 32. Number of birds counted during quarterly surveys by station from 1998 to 2001.

Total Birds by Station													
		March			June			September		December			Total
Station Description	Station #	1999	2000	2001	1998	1999	2000	1998	2000	1998	1999	2000	
Riparian control	1	7	9	14	29	30	23	22	7	25	18	19	141
Riparian control	3	18	6	17	21	16	13	19	12	8	11	10	122
Riparian restoration	6	57	0	24	71	16	20	48	31	34	14	42	267
Ag. Field control	10	52	10	19	25	12	15	45	10	35	70	12	188
Sacaton grassland restoration	4	45	37	7	45	70	16	0	19	28	20	21	239
Sacaton grassland restoration	5	47	7	34	59	8	101	28	5	50	0	39	289
Mesquite bosque control	2	14	2	16	19	14	11	12	16	10	10	7	104
Mesquite bosque control	7	19	12	22	22	21	11	10	1	7	9	7	118
Mesquite bosque restoration	8	41	13	7	39	7	23	32	15	18	24	66	177
Mesquite bosque restoration	9	33	51	20	43	11	19	54	6	105	49	18	237
	TOTAL	333	147	180	373	205	252	270	122	320	225	241	1882

OUTREACH AND EDUCATION (TASKS 13 THROUGH 15)

Disseminating information took a variety of forms over the project's three-year duration. A brief summation of the more detailed accounts related earlier in the semi-annual reports follows. In general, we promote our habitat restoration goals, the species helped by the work, our funding sources, and the partners that are working together.

We conducted numerous field trips, averaging six each year. The participants ranged from high school students and urban youths, university and college students, TNC board members and members, other conservation club members, and local residents.

Staff met on site at various times with staff from Pima County Flood Control District, Arizona Game and Fish Department, Natural Resource Conservation Service, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, Redington Natural Resource Conservation District, Sonoran Institute, Arizona Department of Water Resources, The Nature Conservancy, and others.

The local newsletter, Redington Resource Review, carried informational articles about the project. The Nature Conservancy's local chapter newsletter was used to promote tours. Volunteer briefings afforded us the chance to reach interested folks from across the state.

Several conference presentations were made, including the Gila Basin Riparian Restoration Workshop, Pima Association of Governments Water Quality Committee, ADWR's Information Transfer Forum on Riparian Restoration, and the Arizona Hydrological Society Annual Symposium.

Two highlights of the outreach were conducting a picnic lunch and presentation of the project to almost fifty community members and participating in a lobbying effort in Phoenix to explain to state legislators how the Water Protection Fund monies are being used.

Photo by Harold Malde

SUMMARY

The Bingham Cienega Natural Preserve is a 285 acre site on the San Pedro River just north of the confluences of Redfield Canyon from the Galliuro Mountains to the east and Edgar and Buehman Canyons which drain from the Santa Catalina mountains to the west. It is owned by Pima County Flood Control District and managed by The Nature Conservancy under a long term management contract.

The planning and implementation of the Bingham Cienega Riparian Restoration Project has been an involved and complicated process that began to take focus in the early 1990's with Owen Davis's pollen analysis in 1994; Julia Fonseca's vegetation changes work; and the Conservancy's drafting of the initial management plan that outlined the requirements for habitat restoration. These works gave the initial insights into the vegetation types and plant species the Bingham Cienega harbored prior to the agricultural disturbances of the past century.

Following the management plan, TNC instituted studies of groundwater conditions and developed an ecological model of the site, which provided the necessary information to draft a restoration plan and outline the distribution of reintroduced plant communities. Thus were decisions made about the location of wooded deciduous forest, riparian grasslands, and mesquite bosque. When the implementation phase began the prior establishment and recovery of mesquite in much of the agricultural field area amended these theoretical determinations to some extent. In essence, the condition and extent of mesquite forest was viewed as prima facie evidence that certain portions of the site were well suited as mesquite recovery areas. This judgment was further supported with the pragmatic recognition of the value of mesquite bosque as migratory and nesting bird habitat.

In 1997, TNC wrote and submitted the grant to Arizona Water Protection Fund that funded a substantial portion of the restoration work. TNC also prepared grant and foundation requests to the U.S. Fish and Wildlife Service and Wallace Research Foundation for additional funding. Pima County Flood Control District also supported the restoration project through its a long term management agreement with TNC.

The Arizona Water Protection Fund (WPF) granted $84,679.00 towards the total project costs of $221,024.07. The project was initiated in April of 1998 and ended in September of 2001. We were able to complete all tasks with one contract revision that reallocated budgeted funds within the various tasks.

CONCLUSIONS

Since securing the funding, we have spent three years implementing the restoration plan. This work has been challenging and has required a great deal of flexibility in order to successfully carry out the project. The experience has also provided an opportunity to learn from our mistakes and recognize the pitfalls inherent in a restoration endeavor. Below we have articulated some general lessons we learned through the process in the hope that others might benefit from our experience. These general lessons are followed by a number of task specific recommendations that result from analysis of monitoring data and end of project assessments by project staff.

- Ideally, the project planning team should be composed of a multitude of disciplines ranging from plant ecologists, soil scientists, hydrologists, administrators, and most importantly the project implementation staff. To the extent possible these folks need to understand all aspects of the project design and their part in that design. Continuity of personnel is extremely important to ensure that lessons learned are applied throughout the project.

- A significant component of the project planning should be a very rigorous cost analysis designed to ferret out creeping cost escalations and false economies. For example, we estimate that had we installed a new well adjacent to our restoration fields the irrigation start-up cost could have been reduced by 50%. This project used volunteers in many activities. We discovered it was more cost effective to use a small paid crew with a tractor drawn plug planter to plant sacaton seedlings. Likewise, seedlings grown in a commercial greenhouse cost 24 cents per plant while seedlings grown in an on-site greenhouse with automated systems cost 10 cents per plant.

- Establish and enumerate a clear set of precursor conditions that must exist for a successful project and be absolutely sure that these have been accomplished before moving forward with other aspects of the project. Resist jumping forward because the project has fallen behind a pre-determined schedule. For example, there were unexpected delays in bringing the irrigation on-line. A decision was made to go ahead with the planting schedule without the availability of irrigation. This placed an enormous amount of stress on project personnel. The planting was made into very hard, dry soils which was difficult for workers and less than optimal for the plants.

- Exotic species (weeds) are the number one issue involved in active restoration projects in disturbed sites. Without question, weed infestations have driven the decision-making processes in this project and in others nearby. The lesson learned here is that weed control cannot be relegated to a treatment that is secondary to the "real goal" of introducing native species. **Weed management should be the number one objective of the project** with actual introduction of natives following as conditions are established. This means rethinking the concept of active restoration. It is probably reasonable to allocate two or more years solely to weed management activities prior to introducing natives into the restoration site.

In addition to the overarching points discussed above we have learned a variety of specific lessons from the experience that may be useful to share with others planning to embark on a restoration project of similar nature. They relate to specifics of field preparation for different purposes, irrigation treatments, and planting regimens for grasses, trees and seed mixes.

Field Preparation

Field preparation is extremely important to the success of any endeavor that would attempt to change the vegetation type from a fallow situation dominated by exotic species and woody encroachment species. At Bingham Cienega the fields had lain fallow for ten years and were heavily invaded with Bermuda grass, sunflowers, other exotic species, and mesquite scrub.

If the goal is to reestablish a grassland type, our experience is that the best preparation technique under the high density mesquite recruitment conditions we found at Bingham is to deep rip the fields to completely remove mesquite saplings and their root crowns. This allows full access in all project stages for mechanized planting, weed control and irrigation maintenance. The removal of the mesquite also sets the stage for long-term maintenance of the grassland through controlled burning and establishes a field condition that will allow a tilling or herbicide application regimen to be followed for weed management purposes.

In areas of low density mesquite invasion, it may be possible to carry out weed control protocols followed by planting of seedlings or seeding grasses directly into the areas between saplings. We planted a 14 species grass seed mix at 14 pounds per acre into a seven acre area using a no till Truax range drill in June of 2001, but it is too soon to have any results from this exercise.

Weed Management

As discussed above, weed management and control is of paramount importance to the success of a restoration project of this nature. We used several mechanisms to control weeds: mulching, mowing, tilling, herbicides and furrow maintenance (replowing). In our experience, none of these methods or combinations of methods were carried out to the extent needed to adequately manage the weed infestation. For example, in the fields that were ripped we had initial success (first year) in the control of sunflowers with tilling; however, sunflower and other weed infestation was severe in the second year after planting. Johnson grass and Bermuda grass were spot treated with ROUNDUP but these species still persist in the fields and there is no real belief that we will eliminate them through the treatments we are able to apply.

Treatments that we can recommend include continued mowing of annuals such as sunflowers to prevent them from going to seed and thus substantially reducing their density over time. This would involve mowing for several years. Mowing has the added benefit of reducing competition by annual weeds for nutrients, water, and sunlight for the reintroduced grasses and trees.

Forced germination using irrigation followed by repetitive tilling also has promise as a way to reduce the weed seed bank in the soils of the restoration fields and, under the right circumstances, is also reported to kill Johnson grass and Bermuda Grass. This technique would best be applied over a course of at least two years. We are examining the possibility of establishing a demonstration area at another site to track the success of this technique when applied over a multi-year period.

In our first year we attempted to use mulching to suppress weeds and support conditions conducive to sacaton survival. We found that this technique is not cost effective on larger sites and our observation is that while it may improve immediate conditions for sacaton seedling growth it also improves conditions for propagation of Bermuda grass.

Herbicide application needs to be carefully weighed; in the conditions found in our site it is not clear that we ever found the best combination of surfactants and herbicide concentration and application to be effective. Based on experience here and in other sites, we recommend that if herbicides are to be a significant component of weed management that considerable attention be paid to the use of surfactants, concentration, and other site environmental conditions before a treatment protocol is adopted.

Grass Propagation

When planting sacaton seedlings we found that pot size had little bearing on survival rates and thus, when factors such as handling ease and production cost are considered, the three inch by one and a half inch paper pots are the superior choice. Production cost for these seedlings was approximately 10 cents per plant and they lend themselves to planting with a mechanized plug planter.

Irrigation

Based on the monitoring data for this project, irrigation in the first year does improve survival of seedlings, however, irrigation in succeeding years does not appear to improve survival rates to any great extent. Our recommendation is to plant into a newly irrigated field and then to irrigate again immediately after planting. After the initial planting, additional irrigation should be carefully considered and weighed against the beneficial effects that increased soil moisture has for weed seed germination and growth. In other words, we find that supplemental watering favors growth of exotic species over native species. Native species are adapted to the site conditions that exist without supplemental watering.

Trees

In the deciduous woodland restoration area we tested caging tree seedlings to protect them against herbivory by gophers. We found that there was an increased survival rate in young trees that were caged with chicken wire cages. However, uncaged trees that survived appeared to be more vigorous than caged trees. Caged trees had to have cages cut away by the second year after planting and this added additional cost and increased damage of seedlings due to manipulation of plants during cage removal. We concluded that caging isn't appropriate under the circumstances we encountered and that producing and planting replacement trees was more cost effective.

In a barren area of gypsiferous soils we attempted to increase the density of mesquite saplings by two methods. First, we attempted to hold cattle on the area which would "naturally" seed in mesquite through defecation and trampling of seeds into the soil. This was an approach which, although observed to be effective in many other locations, was unsuccessful here due to the overall lack of food and our inability to hold the cattle in the seeding area. Second, we obtained a stock of mesquites that were grown in 4 inch diameter PVC tubes by Arizona Game and Fish Department. These were planted after initial flood irrigation and were irrigated again following the planting. After two growing seasons there was essentially no gain in the density of mesquites in the barren area. Clearly, soil conditions are controlling restorability for mesquite.

In the mesquite fields that had good natural recruitment of saplings we tried two management techniques to increase growth rate and vigor of trees. We thinned trees in one area and found a good response in growth rates and that data is reported in the monitoring section. Likewise pruning also had a beneficial effect on growth rates. These techniques may be useful under circumstances related to imposed requirements to reach a certain height or percent canopy closure within a specified period. These requirements may be imposed as part of a mitigation requirement for example.

We also documented that where Bermuda grass cover exceeded 40% around mesquite saplings that growth rates were suppressed. These results are more fully documented and reported in the monitoring section.

Pole Plantings

We planted poles into the edge of the cienega in several clusters of willows in an attempt to expand the forested area and perhaps improve the area for riparian obligate bird species. As reported earlier, our results were limited as the entire planting area burned just days after that project was completed, thus torching the planted poles. With the ground barren we then had a heaving frost that expelled the surviving trees from the groundwater level in the cienega these events occurred leading into one of the worst droughts of the century. Subsequent to planting, we recorded steadily falling groundwater levels. After completing the torture of several hundred poles, we now conclude that planting should be delayed to somewhat later in the year (perhaps one month depending on conditions) and that careful attention should be paid to the groundwater conditions that could possibly occur to ensure that poles are planted at a time and to a depth that is most likely to lead to success.

Costs

Costs incurred for the period of the active restoration phase of the project are summarized in **Table 33**. The information provided does not address monitoring or reporting costs. As noted above, we believe that the costs allocated in this project could be substantially reduced and we believe that this could be by as much as 50%. However, this reduction in costs would not incorporate a more substantive weed control and elimination strategy.

TABLE 33 RESTORATION COST SUMMARY BY HABITAT TYPE (A=acres)

TASK DESCRIPTION	SACATON-13 A	WOODLAND-10 A	MESQUITE-2 A
IRRIGATION SYSTEM	$13,000 (1,000/A)	$10,000 (1,000/A)	$2,000 (1,000/A)
IRRIGATION	$8061 (620/A)	$4,447 (447/A)	$894 (447/A)
SITE PREPARATION/ MAINTENANCE	$19,451 (1,496/A)	$13,270 (1,327/A)	$2,454 (1,227/A)
PLANT GROWOUT	$6,320 (1,264/A-'98) $4,640 (580/A-'99/'00)	$4,000 (400/A)	DONATED
PLANTING	$20,235 (4,047/A-98) $14,976 (1,872/A-'99/'00)	$2,524(1,262/A-'98) $2,800 (350/A-'99-'01)	$300 (150/A)
TOTAL WITHOUT IRRIGATION SYSTEM	73,683 (5,668/A)	$27,041 (2,704/A)	3,648 (1,824/A)
TOTALS WITH IRRIGATION SYSTEM	$86,683 ($6,667/A)	$37,041(3,704/A)	$5,648(2,824/A)

REFERENCES

Agenbroad, L.D., 1967. Cenozoic stratigraphy and paleohydrology of the Redington-San Manuel area. University of Arizona Ph.D. Dissertation.

Aldon, E.F., 1975. Establishing alkali sacaton on a harsh site in the southwest. Journal of Range Management, pp. 129-132.

Baird, Ronayne, and Maddock, 1997. Preliminary vegation and hydrologic analyses for Bingham Cienega. University of Arizona Department of Hydrology and Water Resources. Prepared for The Nature Conservancy.

Bock, J.H. and Bock, C.E., 1986. Habitat relationships of some native perennial grasses in southeastern Arizona. Desert Plants, pp. 3-14.

Davis, O.K., 1994. Pollen analysis of borderland cienegas. Unpublished report to The Nature Conservancy of Arizona.

Fonseca, J., 1994. Vegetation changes at Bingham Cienega. Pima County Flood Control District.

Gori, D., J. Cooper, and E. Wilk. 1997. What is the most effective technique for restoring sacaton (*Sporobolus wrightii*) at Patagonia-Sonoita Creek Preserve? The Nature Conservancy, Tucson, AZ.

Hendrickson, D.A. and Minkley, W.L., 1984. Cienegas – vanishing climax communities of the American southwest. Desert Plants, pp. 131-175.

Humphrey, R.R., 1960. Forage production on Arizona ranges. University of Arizona Agricultural Experiment Station Bulletin 302.

Kenny, R., no date. Site and background report, Bingham Cienega. Prepared for The Nature Conservancy of Arizona.

Naiman, R.J., Decamps, H., and Pollock, M., 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications, pp. 209-212.

Ohmart, R.D. and Anderson, B.W., 1986. Riparian Habitat. *In* Inventory and Monitoring of Wildlife Habitat, Cooperrider, A.Y., Boyd, R.J., and Stuart, H.R. editors. Denver USDI Bureau of Land Management Service Center.

Pima Association of Governments, 2001. Bingham Cienega Sourcewater Study, Final Project Report

Roberston, F.N., 1992. Radiocarbon dating of groundwater in a confined aquifer in southeast Arizona. Radiocarbon, Vol. 34, No. 3, pp. 664-676.

Rohlf, F.J. and R.R. Sokal, 1969. Statistical Tables. W.H. Freeman and Company, San Francisco.

Sokal, R.R. and Rohlf, F.J., 1969. Biometry. W.H. Freeman and Company, San Francisco.

Stromberg, J.C., 1993a. Southern Arizona warm-temperature riverine marshes. Stewardship Abstract Responsibility. Prepared for The Nature Conservancy.

Stromberg. J.C. 1993b. Riparian mesquite forests: a review of their ecology, threats, and recovery potential. J. of Arizona-Nevada Acad. Sci. 27:11-124.

Appendix A

Water Levels for Monitor Wells 1997-July 2001

1997 MONTHLY WATER LEVELS, BINGHAM CIENEGA NATURAL AREA

WELL NAME	1/15/97	2/5/97	3/5/97	4/4/97	5/19/97	6/20/97	8/11/97	9/29/97	10/14/97	11/15/97	12/13/97
N1	-0.79	-0.83	-0.81	-0.9	-1.26	-3.89	-3.88	-3.87			-3.3
N2	0.37	0.37	0.4	0.39	0.34	-4.7	-4.7	-4.7	-3.6	-3.66	-3.63
N3	0.365	0.375	0.395	0.395	0.335	-4.7	-4.7	-4.7	-4.7	-3.115	-3.145
N4	0.765	0.775	0.785	0.785	0.685	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6
N5	0.66	0.55	0.69	0.68	0.63	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8
N6	0.655	0.785	0.715	0.735	0.625	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7
N7	0.76	0.48	-0.65	0.01	0.325	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8
N8	0.275	0.275	0.285	0.285	0.205	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4
N9	0.035	0.035	0.065	0.055	-0.035	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2
N10	-0.525	-0.545	-0.375	-0.445	-3.585	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4
N10a	-0.72	-0.72	-0.34	-0.57	-4.34	-4.68	-5.4	-5.4	-5.4	-5.4	-5.4
N10b	-2.6	-2.64	-1.82	-2.16	-4.32	-4.9	-5.25	-5.55	-5.19	-4.9	-4.9
N11	-4.63	-4.71	-4.12	-4.27	-6.02	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7
N12	-6.77	-7.04	-6.8	-6.98	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3
N13	-7.28	-7.32	-7.28	-7.48	-7.95	-8.75	-8.77	-9.17	-9.17	-8.99	-8.64
C1	-0.66	-0.72	-0.68	-0.71	-0.8	-2.14	-4.3	-4.3	-4.3	-3.55	-2.54
C2	0.215	0.295	0.135	-0.615	-0.66	-0.925	-2.665	-3.185	-3.6	-3.6	-1.095
C3	0.505	0.515	0.465	0.38	0.405	-0.425	-2.125	-2.695	-3.245	-1.2	-0.495
C4	0.79	0.8	0.81	0.81	0.79	0.11	0.89	-2.71	-4	-1.33	-0.37
C5	1.9	0.64	0.4	-1.07	-1.04	0.2	-2.9	-2.9	-2.9	-1.8	-0.58
C6	2.96	0.53	0.1	-2.1	-1.92	0.27	-3.3	-3.3	-3.3	-2.23	-0.69
C7	1.025	0.455	0.315	-0.165	0.145	0.335	-2.915	-4	-4	-2.505	-1.035
C8	0.365	0.345	0.385	0.365	0.305	0.095	-4.3	-4.3	-4.3	-3.335	-2.165
C8a	-0.175	-0.155	-0.085	-0.185	-0.995	-2.605	-3.7	-3.7	-3.7	-3.7	-3.7
C8b	-0.825	-0.735	-0.065	-0.745	-1.865	-3.085	-3.5	-3.5	-3.5	-3.5	-3.5
C9	-2.38	-2.3	-1.49	-0.34	-3.47	-4.79	-6.2	-6.2	-6.2	-6.2	-6.2
C9a	-5.07	-5.14	-4.71	-2.42	-5.96	-7.1		-7.89		-7.58	-7.15
C10	-6.615	-6.705	-6.355	-6.775	-7.455	-8.5	-7.315	-8.5	-8.5	-8.5	-8.5
C11	-7.15	-7.28	-7.09	-7.34	-7.77	-9	-9.03	-9	-9	-9	-8.43
C12		-9	-9	-9	-8.14	-9.27	-9	-9	-9	-9	-9
S1	-2.3	-2.3	-2.02	-2.29	-2.53	-2.99	-4.5	-4.5	-4.5	-2.73	-2.05
S2	0.63	0.59	0.61	0.59	0.58	0.51	0.49	0.47	0.49	0.51	0.49
S3	0.905	0.875	0.885	0.875	0.845	0.785	0.765	0.735	0.775	0.765	0.805
S4	0.475	0.495	0.255	-0.99	-0.99	0.185	0.355	0	0.285		0.375
S5	0.085	0.085	0.105	0.105	0.065	-1.885	-0.095	-0.065	-0.125	-0.045	-0.035
S5a	-1.385	-1.435	-0.585	-1.005	-1.795	-2.415	-2.205	-2.705	-2.835	-2.155	-1.765
S5b	-2.15	-1.91	-1.52	-2.03	-2.65	-3.7	-3.7	-3.7	-3.7	-3.7	-2.66
S6	-2.475	-2.525	-1.935	-2.485	-1.915	-3.665	-6	-6	-4.045	-3.425	-3.015
S7	-4.78	-4.85	-4.42	-4.87	-5.61	-7	-7	-7	-7	-7	-5.67
S8	-6.59	-6.64	-6.33	-6.69	-7.14	-7.68	-7.6	-7.6	-7.6	-7.6	-7.6
S9					-7.97	-8.77	-9.7	-9.7	-9.7	-9.7	-9.7
R1					-6.92	-7.61	-7.93	-5.9	-5.9	-5.9	-7.625
R2					-7.27	-7.85	-8.02	-8.61	-8.585	-8.215	-7.865
R3					-6.74	-6.67	-6.74	-7.1	-6.86	-6.96	-6.62
F1					-8.1	-11.89	-10.73	-12.06	-11.875	-11.695	-11.315
Kelly Well	-5.14	-5.24		-5.49	-5.21	-5.93	-6.25	-6.56	-6.76		-6.78
Rhodes Well	-24.67	-24.77		-24.92	-25.48	-26.53	-27.19	-27.28	-26.89	-27.24	-27.31

Notes:

Positive numbers are depth of standing water; negative numbers are depth to groundwater below land surface (feet).

Shaded cells represent DRY wells (depth to bottom of well is represented) or wells without data (blank cells)

1998 MONTHLY WATER LEVELS, BINGHAM CIENEGA NATURAL AREA

WELL NAME	1/19/98	2/22/98	3/24/98	4/24/98	5/20/98	6/28/98	7/26/98	8/29/98	10/16/98	11/30/98	12/28/98
N1		-0.74	-0.64	-0.61	-1.04	-1.56	-1.36	-1.59	-2.50	-1.04	-0.89
N2	-2.39	0.23	0.27	0.30	0.23	0.12	0.14	0.16	-0.26	0.14	0.22
N3	-2.34	0.01	0.01	0.05	0.01	-0.09	-0.095	-0.04	-0.36	0.05	0.10
N4	-2.01	0.57	0.55	0.60	0.55	0.47	0.455	0.51	-0.16	0.45	0.51
N5	-1.86	0.44	0.45	0.47	0.43	0.35	0.34	0.38	-0.29	0.36	0.38
N6	-2.7	0.58	0.53	0.55	0.51	-2.7	-2.7	0.44	-2.7	0.39	0.53
N7	-3.72	0.26	0.26	0.31	0.27	0.17	0.17	0.03	-2.43	0.10	0.16
N8	-4.4	0.09	0.11	0.14	0.10	-0.03	DRY	-0.44	-4.4	-0.08	-0.04
N9	-4.2	-0.07	-0.05	-0.01	-0.11	-1.30	-0.945	-2.79	-4.2	-1.06	-0.39
N10	-4.4	-1.35	-0.91	-0.77	-3.18	-4.27	-3.065	-4.4	-4.4	-4.4	-4.4
N10a	-5.4	-5.4	-2.06	-1.48	-4.07	-5.4	-4.93	-5.4	-5.4	-5.4	-4.53
N10b	-4.95	-4.83	-4.02	-3.43	-4.44	-4.9	-4.8	-4.9	-4.9	-4.9	-4.9
N11	-7.7	-5.79	-5.21	-4.56	-6.14	-7.7	-6.71	-7.7	-7.7	-7.7	-6.34
N12	-8.3	-6.24	-8.3	-7.08	-8.3	-8.3	-7.24	-8.3	-8.3	-8.3	-8.3
N13	-9.09	-6.59	-7.37	-7.60	-8.62	-8.32	-8.03	-8.54	-8.93	-8.42	-7.99
C1	-1.42	-0.81	-0.83	-0.87	-0.86	-0.93	-0.87	-0.94	-0.98	-0.84	-0.81
C2	-0.36	0.14	0.24	0.19	0.13	0.05	0.095	0.09	0.12	0.16	0.16
C3	-0.10	0.39	0.40	0.40	0.43	0.35	0.395	0.39	0.41	0.43	0.44
C4	0.11	0.59	0.62	0.65	0.63	0.59	0.6	0.61	0.61	0.61	0.61
C5	-0.16	0.41	0.42	0.47	0.43	0.40	0.46	0.39	0.41	0.44	0.46
C6	-0.37	0.25	0.25	0.31	0.26	0.22	0.25	0.21	0.23	0.23	0.25
C7	-0.37	0.22	0.22	0.24	0.24	0.22	0.225	0.24	0.25	0.26	0.26
C8	-1.50	0.15	0.16	0.23	0.21	0.29	0.205	0.17	0.05	0.20	0.24
C8a	-2.68	-0.43	-0.37	-0.25	-0.46	-0.76	-0.705	-1.08	-1.38	-0.86	-0.67
C8b	-3.5	-0.92	-0.91		-1.16	-1.60	-1.615	-2.05	-2.41	-1.76	-1.58
C9	-4.82	-2.62	-2.39	-2.02	-2.73	-3.30	-3.17	-3.61	-3.93	-3.31	-3.13
C9a	-7.36	-4.97	-5.39	-5.07	-5.80	-6.30	-7.69	-7.25	-6.65	-6.10	-5.79
C10	-8.5	-6.27	-6.90	-6.59	-7.44	-8.5	-5.785	-8.5	-8.5	-8.5	-8.5
C11	-9	-6.41	-7.46	-7.36	-7.83	-8.03	-7.76	-8.38	-8.63	-8.17	-7.8
C12	-9	-7.09	-8.16	-8.10	-8.55	-9	-8.95	-9	-9	-9	-9
S1	-1.98	-1.41	-1.43	-1.40	-1.65	-1.81	-1.82	-2.07	-2.14	-1.90	-1.95
S2			0.69	0.69	0.64	0.59	0.47	0.56	0.56	0.46	0.29
S3	0.88	0.93	0.94	0.98	0.88	0.87	1.185	0.81	1.68	1.71	0.95
S4	0.39	0.26	0.57	0.60	0.39	0.22	-2.3	0.39			0.39
S5	-0.04	0.09	0.13	0.14	0.12	0.07	0.115	0.12	0.12	0.12	0.12
S5a	-1.84	-0.20	-0.16	-0.11	-0.24	-0.59	-2.7	-0.91	-0.98	-0.41	-0.96
S5b	-2.75	-1.11	-1.00	-0.92	-1.31	-1.83	-3.7	-2.10	-2.17	-1.88	-1.85
S6	-3.18	-1.48	-1.43	-1.34	-1.74	-2.26	-2.235	-2.44	-2.61	-2.30	-2.24
S7	-7	-4.02	-4.30	-4.21	-4.71	-4.86	-4.9	-5.20	-7	-7	-7
S8	-7.6	-5.76	-6.42	-6.28	-6.85	-7.27	-6.87	-7.6	-7.6	-7.6	-7.6
S9	-9.7			-7.33	-9.7	-7.83	-7.83	-8.21	-8.26	-8.28	-7.88
R1	-5.9	-5.54	-1.94	-0.41	-3.99	-5.9	-5.245	-5.9	-5.9	-5.9	-5.9
R2	-8.23	-5.96	-5.27	-2.52	-5.43	-7.18	-7.265	-7.94	-8.25	-7.45	-6.91
R3	-7.01	-4.54	-4.87	-4.64	-5.51	-6.19	-6.07	-6.71	-7.00	-6.39	-5.85
F1	-11.74	-9.72	-7.36	-7.24	-7.85	-8.22	-7.875	-6.96	-3.54	-8.48	-8.24
Kelly Well	-6.59	-2.94	-3.73		-3.87	-4.77	-6.2		-5.27	-5.67	-5.47
Rhodes Well	-27.35	-22.77	-22.62		-22.43	-23.13	-24.15		-25.56	-25.51	-25.47

Notes:

Positive numbers are depth of standing water; negative numbers are depth to groundwater below land surface (feet).

Shaded cells represent DRY wells (depth to bottom of well is represented) or wells without data (blank cells)

1999 MONTHLY WATER LEVELS, BINGHAM CIENEGA NATURAL AREA

WELL NAME	1/20/99	2/26/99	3/31/99	4/30/99	6/28/99	8/11/99	9/29/99	11/17/99	12/9/99
N1	-0.92	-0.96	-1.04	-1.34	-3.74	-2.74	-1.24	-1.24	
N2	0.15	0.14	0.09	0.04	-4.7	0.44	0.14	0.24	0.34
N3	0.13	0.12	0.1	0.03	-4.7		1.45		
N4	0.47	0.45	0.45	0.38	-4.6		1.75		
N5	0.36	0.36	0.36	0.26	-4.8		0.36		
N6	0.44	0.36	0.41	0.34	-2.7	1.56	0.46	0.96	1.46
N7	0.17	0.15	0.12	-0.15	-4.8	0.45	0.35	0.15	0.15
N8	-0.05	-0.1	-0.15	-0.7	-4.4	-0.1	-0.05	-0.45	-0.45
N9	-0.31	-0.76	-1.31	-2.67	-4.2	-0.31	-1.51	-2.81	-2.61
N10	-4.4	-4.4	-4.4	-4.4	-4.4		-4.4	-4.4	-4.4
N10a	-4.25	-4.53	-4.73	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4
N10b	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9
N11	-6.18	-6.41	-6.44	-7.7	-7.7	-6.61	-6.61	-6.51	-7.7
N12	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3
N13	-7.98	-8.05	-8.09	-8.17	-9.47	-7.77	-8.14	-8.67	-8.47
C1	-0.81	-0.86	-0.86	-0.91	-4.3	0.04	-0.96	-0.76	-0.86
C2	0.14	0.14	0.15	0.12	-3.6				
C3	0.43	0.43	0.41	0.41	-1.2				
C4	0.64	0.59	0.59	0.57	-4				
C5	0.44	0.44	0.43	0.43	-2.9				
C6	0.25	0.25	0.26	0.27	-3.3				
C7	0.26	0.26	0.26	0.23	-4				0.1
C8	0.24	0.23	0.21	0.05	-4.3	0.4	-0.11	0.39	-0.21
C8a	-0.57	-0.72	-0.98	-1.32	-3.7	-0.62	-1.22	0.43	-2.22
C8b	-1.44	-1.84	-1.79	-2.15	-3.5	0.52	-2.09	-0.49	-2.49
C9	-3.04	-4.24	-4.36	-3.66	-6.2	-2.64	-3.29	-2.14	-4.14
C9a	-5.76	-6.34	-5.99	-6.17	-8.24	-5.34	-4.73	-5.79	-6.74
C10	-7.24	-8.5	-8.5	-8.5	-8.5	-6.95	-5.73	-8.5	-8.5
C11	-7.85	-8.23	-7.96	-8.01	-9	-7.33	-7.43	-8.33	-8.23
C12	-9	-9	-9	-9	-9	-8.25	-9	-9	-9
S1	-2.05	-2.05	-2.15	-2.29	-4.5	-1.65	-1.75	-1.85	-1.85
S2	0.29	0.19	0.14	0.56	-3.2	0.89	0.49	0.59	0.54
S3	0.93	0.93	0.33	0.83					
S4	0.14	0.15	0.17	0.19					0.39
S5	0.07	0.06	0.06	0.08	-2.7	-1.09	0.12	0.12	0.12
S5a	-0.71	-0.66	-0.61	-2.34	-2.7		-0.86	-0.96	-0.96
S5b	-1.84	-1.94	-1.94	-2.22	-3.7		-1.84	-1.74	-2.34
S6	-2.29	-2.29	-2.29	-2.61	-6		-2.19	-2.09	-2.69
S7	-7	-7	-7	-5.15	-7	-4.65	-4.35	-3.75	-5.45
S8	-7.6	-7.6	-7.6	-7.6	-7.6	-7.07	-7.42	-6.12	-7.6
S9	-7.97	-8.01	-8.11	-8.12	-9.7	-6.81	-6.89	-8.01	-8.31
R1	-5.9	-5.9	-5.9	-5.9	-5.9		-5.9	-5.9	-5.9
R2	-6.67	-6.82	-6.79	-7.21	-9.3		-6.92	-7.77	-7.57
R3	-5.78	-5.85	-5.91	-6.07	-7.18				
F1	-8.25	-9.17	-8.34	-8.48	-9.66	-7.82	-7.87	-8.27	-8.37
Kelly Well	-5.95	-6.05	-6.05	-6.45	-7.53	-5.05	-5.45	-6.1	-6.15
Rhodes Well	-25.17	-25.47	-25.67	-26.04	-27.32	-24.27	-24.62	-25.78	-26.07

Notes:

Positive numbers are depth of standing water; negative numbers are depth to groundwater below land surface (feet).

Shaded cells represent DRY wells (depth to bottom of well is represented) or wells without data (blank cells)

2000 MONTHLY WATER LEVELS, BINGHAM CIENEGA NATURAL AREA

WELL NAME	1/12/00	2/9/00	3/8/00	4/7/00	5/10/00	6/8/00	7/13/00	8/17/00	9/14/00	10/4/00	11/13/00	12/11/00
N1	-1.14	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N2	0.24	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N3		Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N4		Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N5		Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N6	0.855	0.455	0.555	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	0.885	0.555
N7	0.45	0.25	0.15	-2.25	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	0.28	-0.63
N8	-0.045	-0.445	-0.345	-3.545	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-0.005	0.035
N9	-2.305	-2.605	-2.705	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-0.005	-0.085
N10	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-0.865	-0.835
N10a	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-1.63	-1.95
N10b	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-3.1	-3.7
N11	-6.71	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-4.01	-4.67
N12	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3	-2.94	-6.19
N13	-8.07	-8.27	-8.17	-8.77	-10.6	-10.6	-10.6	-10.6	-10.6	-10.6	-4.97	-6.55
C1	-0.86	Burned	Burned	Burned	Burned	Burned	Burned	Burned	-4.3	-4.3	-0.96	-0.81
C2		0.215	-0.085	-0.135	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	0.045	0.215
C3		0.505	0.505	0.255	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	0.335	0.505
C4		0.69	0.59	0.54	-4	-4	-4	-4	-4	-4	1.19	1.19
C5		0.52	0.52	0.22	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	0.44	0.52
C6		0.33	0.33	-0.02	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	0.25	0.33
C7	0.095	0.195	0.095	-0.105	-4	-4	-4	-4	-4	-4	0.225	0.315
C8	-0.105	0.045	-0.005	-0.905	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	0.065	0.145
C8a	-1.515	-1.415	-1.415	-1.915	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-0.615	0.315
C8b	-2.285	-2.485	-2.385	-2.985	-3.5	-3.5	-3.5	-3.5	-3.5	-3.5	-1.285	-1.485
C9	-4.14	Burned	Burned	Burned	Burned	Burned	-6.2	-6.2	-6.2	-6.2	-1.74	-2.11
C9a	-6.44	-6.54	-6.54	-6.94	-8.14	-9.14	-9.34		-8.94	-9.34	-4.34	-5
C10	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	-5.345	-6.315
C11	-7.98	-8.18	-7.98	-8.18	-9	-9	-9	-9	-9	-9	-5.08	-6.34
C12	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-5.65	-6.75
S1	-1.95	-1.85	-1.85	-2.05	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-1.65	-1.67
S2	0.49	0.89	0.89	0.49	-3.2	-3.2	-3.2	-3.2	-3.2	-3.2	0.56	0.72
S3		0.825	0.925	0.625					-3	-3	0.625	0.925
S4		0.385	0.385	0.385	-2.3	-2.3	-2.3	-2.3	-2.3	-2.3	0.385	0.385
S5	0.115	0.115	0.115	0.015	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	0.115	0.115
S5a	-0.755	-0.255	-0.755	-1.155	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	0.295	0.085
S5b	-2.14	-2.04	-2.14	-2.34	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-0.99	-1.27
S6	-2.685	-2.185	-2.485	-2.785	-4.685	-6	-6	-6	-6	-6	-0.785	-1.605
S7	-5.35	-5.45	-5.45	-5.75	-7	-7	-7	-7	-7	-7	-3.15	-4.03
S8	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6	-4.52	-5.69
S9	-8.21	-8.31	-8.31	-8.71	-9.7	-9.7	-9.7	-9.7	-9.7	-9.7	-5.21	-6.39
R1	-5.9	Burned	-5.9	-5.9	-5.9	-5.9	-5.9	-5.9	-5.9	-5.9	0.075	-0.095
R2	-7.065	-7.265	-7.165	-7.765	-8.965	-9.3	-9.3	-9.3	-9.3	-9.3	-2.265	-3.015
R3									-7.65	-7.65	-2.75	-3.9
F1	-8.265	-8.365	-8.265	-8.665	-9.365	-9.365	-10.765	-10.465	-9.765	-10.565	-5.465	-6.515
Kelly Well	-6.05	-6.25	-6.35	-6.65	-7.35	-7.35	-7.95	-8.65	-7.45	-7.95	-1.45	-4.7
Rhodes Well	-26.22	-26.47	-26.27	-27.07	-28.06	-28.06	-29.07	-29.17	-28.27	-28.97	-18.07	-20.65

Notes:

Positive numbers are depth of standing water; negative numbers are depth to groundwater below land surface (feet).

Shaded cells represent DRY wells (depth to bottom of well is represented) or wells without data (blank cells)

2001 MONTHLY WATER LEVELS, BINGHAM CIENEGA NATURAL AREA

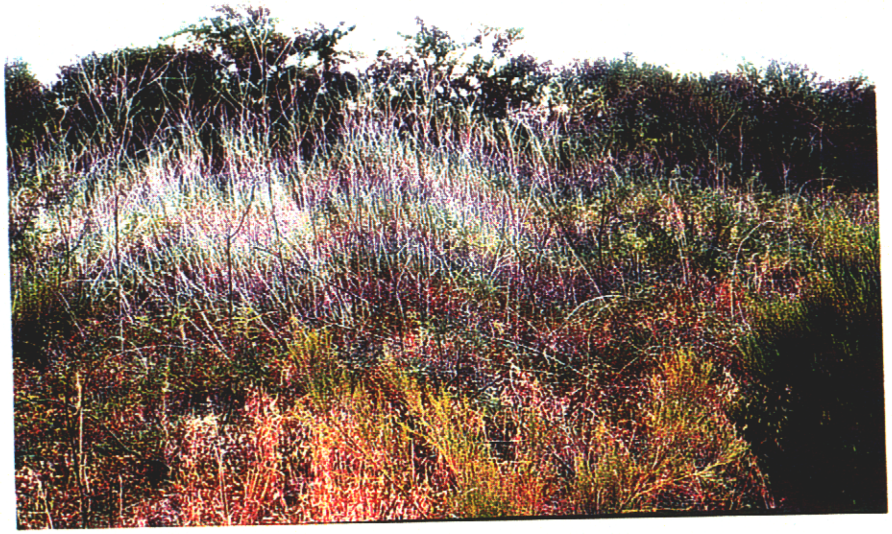
WELL NAME	1/9/01	2/26/01	3/30/01	4/30/01	5/24/01	6/15/01	7/26/01
N1	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N2	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N3	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N4	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N5	Burned	Burned	Burned	Burned	Burned	Burned	Burned
N6	0.555	0.605	0.505	0.505	0.605	0.555	0.605
N7	0.35	0.3	0.25	0.35	0.35	0.25	0.3
N8	0.055	0.055	0.005	-0.015	0.055	0.005	-0.045
N9	-0.005	-0.005	-0.205	-0.005	-0.005	-0.205	-0.105
N10	-0.665	-0.615	-0.865	-1.065	-1.415	-1.865	-2.065
N10a	-1.23	-1.23	-2.93	-3.13	-2.83	-3.63	-2.83
N10b	-3.4	-3.05	-3.55	-3.55	-3.9	-4.9	-4.9
N11	-4.51	-4.41	-4.91	-1.58	-5.11	-5.73	-5.18
N12	-6.14	-5.94	-6.4	-6.56	-6.44	-8.3	-6.89
N13	-6.57	-6.32	-6.77	-7.17	-6.82	-7.47	-7.05
C1	-0.76	-0.86	-0.91	-1.91	-0.86	0.3	0.26
C2	0.215	0.115	0.015	0.085	0.115	0.115	0.085
C3	0.505	0.365	0.305	0.385	0.385	0.355	0.355
C4	1.19	0.59	Burned	Burned	Burned	Burned	Burned
C5	0.52	0.33	0.27	0.22	0.32	0.32	0.32
C6	0.33	0.23	0.11	0.18	0.13	0.18	0.18
C7	0.295	0.145	0.045	0.075	0.095	0.145	0.165
C8	0.095	0.045	-0.105	-0.025	-0.055	-0.205	-0.155
C8a	-0.515	-0.665	-0.915	-2.115	-2.215	-3.215	-1.115
C8b	-1.385	-1.525	-1.785	-2.115	-2.285	-2.545	-2.085
C9	-2.14	-2.02	-2.34	-2.64	-2.74	-3.2	-3.14
C9a	-4.84	-4.85	-4.84				
C10	-6.445	-6.135	-6.505	-6.775	-6.795	-8.5	-6.945
C11	-6.38	-6.19	-6.55	-6.72	-6.68	-7.32	-6.92
C12	-7.05	-6.8	-7.17	-7.33	-7.35	-7.95	-7.55
S1	-1.65	-1.5	-1.55	-2.6	-1.65	-1.74	-1.7
S2	0.49	0.59	0.49	0.52	0.59	0.54	0.44
S3	0.925	0.875	0.775	-0.275	0.825	0.775	0.775
S4	0.385	0.235	0.355	0.335	0.885	0.435	0.435
S5	0.115	0.065	0.115	0.115	0.115	0.115	0.065
S5a	0.045	0.395	0.045	-0.025	0.045	-0.155	-0.255
S5b	-1.34	-1.04	-1.34	-1.44	-0.54	-1.69	-1.64
S6	-1.585	-1.285	-1.685	-1.785	-1.885	-2.045	-1.985
S7	-4.05	-3.81	-4.2	-4.33	-4.45	-4.82	-4.58
S8	-5.82	-5.51	-5.87	-6.04	-6.52	-7.6	-7.6
S9	-6.51	-6.31	-6.63	-6.89	-6.91	-7.4	-7.11
R1	-0.145	-0.395	-0.495	-0.695	-1.395	-3.625	-2.245
R2	-2.465	-2.265	-2.285	-2.565	-3.115	-5.045	-3.995
R3	-3.95	-3.77	-4.07	-4.16	-4.2	-5	-4.5
F1	-6.665	-6.365	-6.715	NA	-7.115	-7.545	-7.165
Kelly Well	-3.05	-4.05	-2.85	-3.45	-3.75	-4.25	-4.25
Rhodes Well	-20.97	-22.07	-20.23	-20.47	-21.27	-26.82	-22.6

Notes:

Positive numbers are depth of standing water; negative numbers are depth to groundwater below land surface (feet).
Shaded cells represent DRY wells (depth to bottom of well is represented) or wells without data (blank cells)

Appendix B
Photo Point Monitoring

Bingham Cienega Preserve
Year 1 Field Deciduous Riparian Woodland, Monitor Pt. 1
Bearing-125°



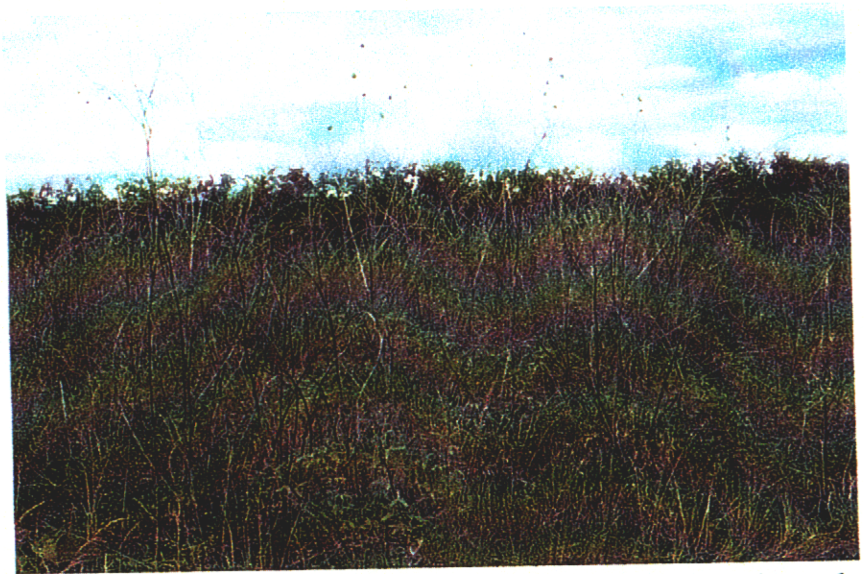
Pre-restoration, July, 1998

Planted December, 1998

7 Months After Restoration, July, 1999

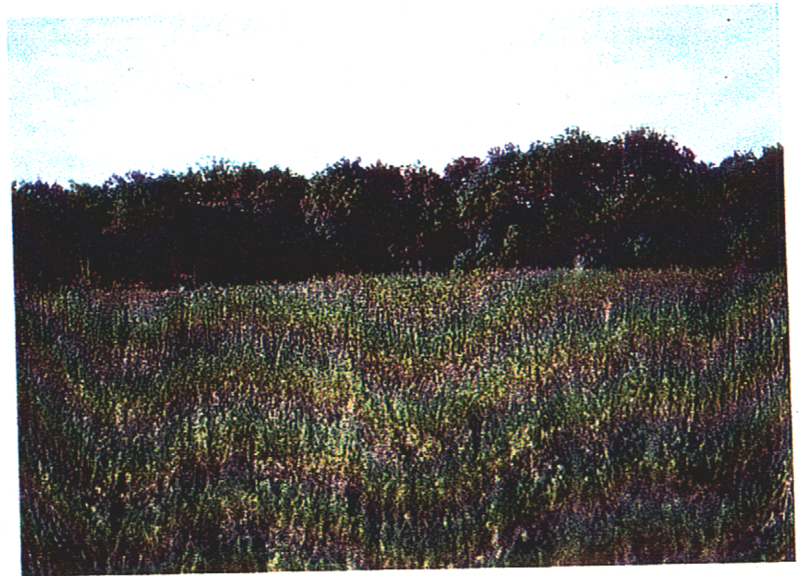
1.5 Years After Restoration, June, 2000

Bingham Cienega Preserve
Year 1 Field, Sacaton Grassland, Monitor Pt. 2
Bearing 150^0



Pre-Restoration, July, 1998

Planted August, 1998



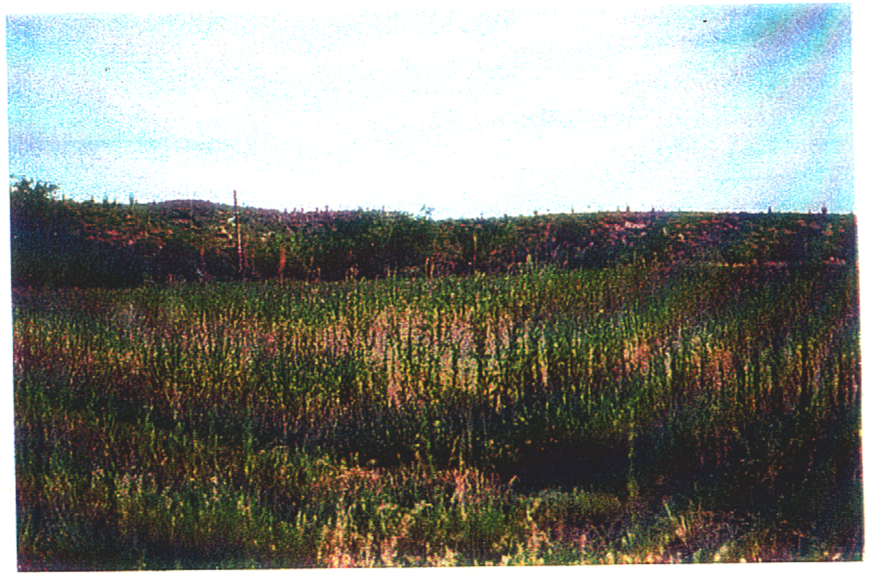
1 Year After Restoration, July, 1999

2 Years After Restoration, June, 2000

Bingham Cienega Preserve
Year 1 Field, Sacaton Grassland, Monitor Pt. 2
Bearing 315^0

Pre-Restoration, July, 1998

Planted August, 1998



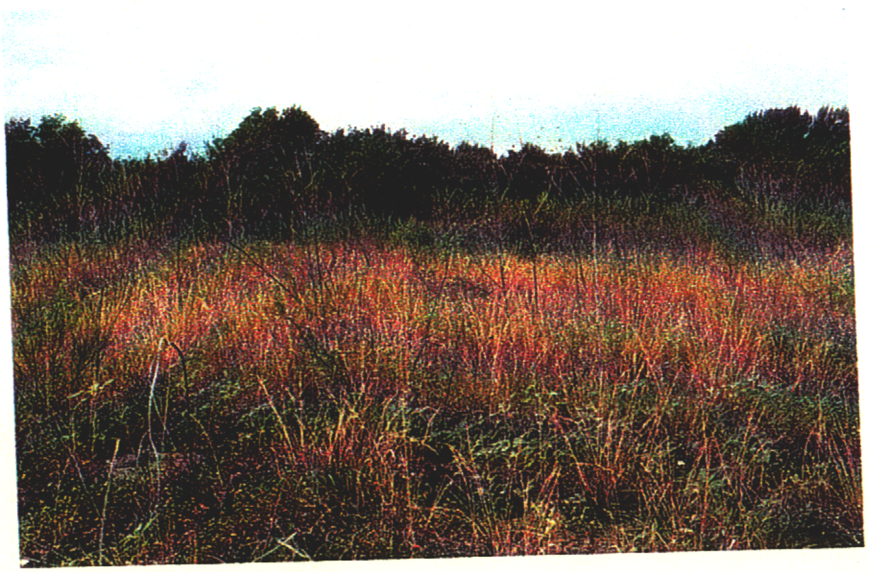
1 Year After Restoration, July, 1999

2 Years After Restoration, June, 2000

Bingham Cienega Preserve
Year 1 Field, Decidious Riparian Woodland, Monitor Pt. 1
Bearing 352^0

Pre-Restoration (Field Plowed), July, 1998   Planted December, 1998   1.5 Years After Restoration, June, 2000

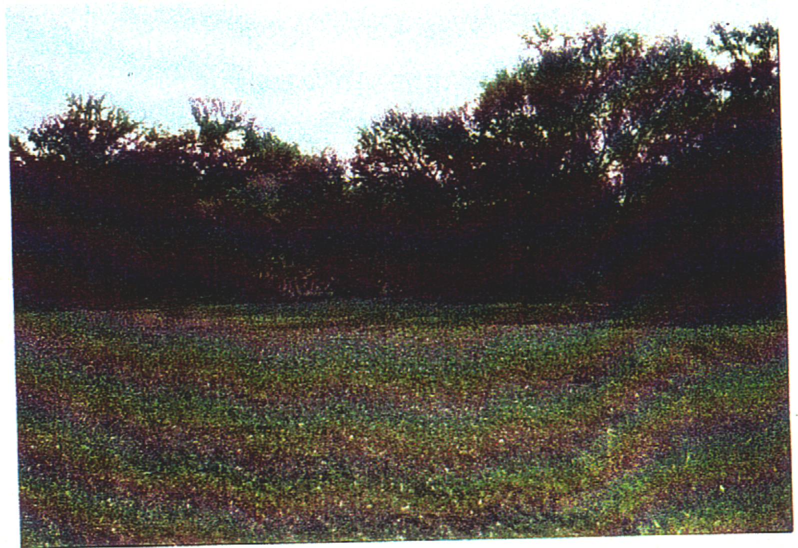
Bingham Cienega Presereve
Year 1 Field, Sacaton Grassland, Monitor Pt. 2
Bearing 60^0



Pre-Restoration, July, 1998 | Planted August, 1998 | 2 Years After Restoration, June, 2000

Bingham Cienega Preserve
Year 2 Field, Sacaton Grassland, Monitor Pt. 6
Bearing 60^0

Pre-Clearing, August, 1998



Pre-restoration (Cleared, Not Yet Planted), July, 1999
Planted July Through September, 1999

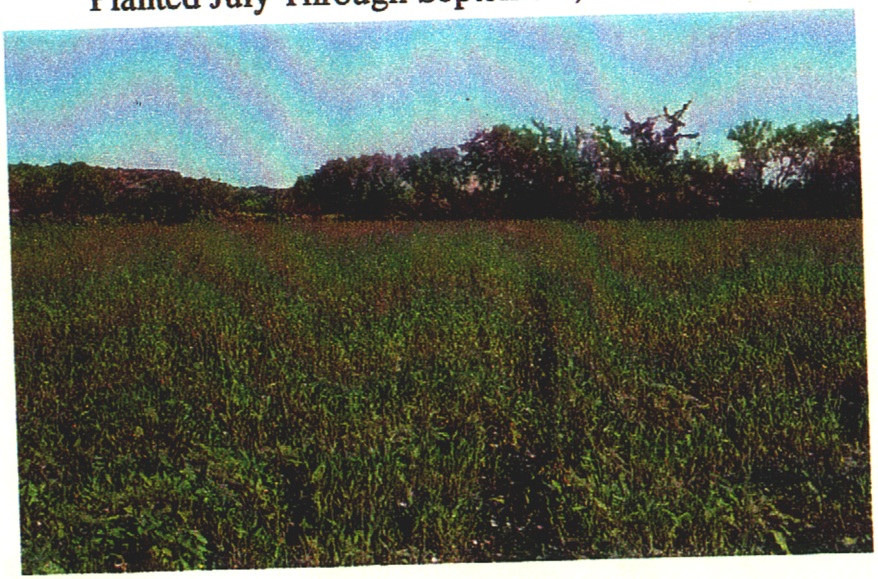
1 Year After Restoration, June, 2000

Bingham Cienega Preserve
Year 2 Field, Sacaton Grassland, Monitor Pt. 6
Bearing 330°

Pre-Clearing, August, 1998

Pre-restoration (Cleared, Not Yet Planted), July, 1999

Planted July Through September, 1999



1 Year After Restoration, June, 2000

Appendix C
Bird List

BIRD LIST FOR BINGHAM CIENEGA

Abert's Towhee
American Coot
American Goldfinch
American Kestral
American Pipit
American Redstart
American Robin
American Widgeon
Annals Hummingbird
Ash-throated Flycatcher
Audubon's Warbler
Barn Owl
Bell's Vireo
Black Phoebe
Black Throated Gray Warbler
Black-bellied Whistling Duck
Black-chinned Hummingbird
Black-crowned Night Heron
Black-headed Grosbeak
Black-tailed Gnatcatcher
Black-throated Sparrow
Blue Grosbeak
Brewer's Sparrow
Bridled Titmouse
Brown Creeper
Brown-crested Flycatcher
Brown-headed Cowbird
Cactus wren
Canyon Towhee
Cassin's Kingbird
Cedar Waxwings
Chihuahuan Raven
Chipping Sparrow
Cinnamon Teal
Cliff Swallow
Common Ground-Dove
Common Moorhen
Common Snipe
Common Yellow-throat
Comon Raven
Cooper's Hawk
Curve-billed Thrasher
Dark-eyed Junco, Oregon race
Dowick's Wren
Dusty capped Flycatcher
Eastern Meadowlark
European Starlings
Ferruginous Hawk
Fox Sparrow
Gadwall
Gambel's Quail
Gila Woodpecker
Golden Eagle
Gray Flycatcher
Great Blue Heron
Great Horned Owl
Greater Roadrunner
Great-tailed Grackle
Green Heron
Green-tailed Towhee
Green-winged Teal
Harris' Hawk
Hermit Thrush
Hooded Oriole
House Finch
House Sparrow
House Wren
Hutton's Vireo
Inca Dove
Killdeer
Ladder-backed Woodpecker
Lark Sparrow
Lazuli Bunting
Lesser Gold-finch
Lincoln's Sparrow
Loggerhead Shrike
Lucy's Warbler
MacGillivray's Warble
Mallard
Marsh Wren
Mourning Dove
N. Rough-winged Swallow
Nashville Warbler
Northern Beardless-Tyrannulat
Northern Cardinal
Northern Flicker - Red-shafted
Northern Flicker - Yellow-shafted
Northern Harrier
Northern Mockingbird
Northern Oriole
Northern Pintail
Olive-sided Flycatcher
Orange-crowned Warbler
Pacific-slope Flycatcher
Phainopepla
Pied-billed Grebe
Pine Siskin
Purple Martin
Red-naped Sapsucker
Red-winged Blackbird
Ruby-crowned Kinglet
Rurous-sided Towhee
Sage Thrasher
Savannah Sparrow
Say's Phoebe
Scott's Oriole
Scrub Jay
Solitary Vireo
Song Sparrow
Sora Rail
Southwestern Willow Flycatcher
Spotted Towhee
Steller's Jay
Summer Tanager
Townsend's Warbler
Tree Swallow
Turkey vulture
Verdin
Vermilion Flycatcher
Violet-green Swallow
Virginia Rail
Warbling Vireo
Western Kingbird
Western Meadowlark
Western Tanager
Western Wood-Powee
White-crowned Sparrow
White-faced Ibis
White-throated Swift
White-winged Dove
Willow Flycatcher
Wilson's Warbler
Yellow Warbler
Yellow-headed Blackbird
Yellow-billed Cuckoo (nesting 8/19/90)
Yellow-breasted Chat
Zone-tailed Hawk

Arizona Water Protection Fund
GRANT PAYMENT REQUEST

1. Participant	2. Grant Number	3. Type of Payment	4. Payment Request
Pima County Flood Control District	*WPF 97-040*	☐ 100% ☐ Partial ☑ Final ☑ Reimbursement ☐ Advance	Number: 8
5. Federal Employer I.D. # *86-6000543*			
6. Participant Mailing Address and Telephone #: *520-740-6350* *201 N. Stone Avenue, 4th Floor* *Tucson, AZ 85705*	7. Project Period: *April 1998- September 2001*		8. Grant Award: *$84,679.00*
9. Project Title: *Bingham Cienega Riparian Restoration Project*	10. Period Covered (Month, Day, Year) by this Request: From: 7/1/01 To: 9/14/01		

11. Approved Project Scope Items	Prior Payments	This Request	Total to Date
2. Revegetation & Monitor Plans	$1,208.95	$0.00	$1,208.95
3. Install irrigation system	24,476.76	-	24,476.76
4. Planting site preparation	11,716.21		11,716.21
5. Grow-out grasses, shrubs & trees	7,076.70		7,076.70
6. Plant native grasses	16,989.94	318.39	17,308.33
7. Plant native trees & shrubs	678.19		678.19
8. Install electrical fencing	781.60		781.60
9. Irrigation management & mainten	6,036.46		6,036.46
10. Groundwater depth & precip mon	263.26	154.41	417.67
11. Monitoring reveg success	8,956.20		8,956.20
13. Dissemination of Project Information	34.13		34.13
14. Progress Reports	1,872.62		1,872.62
15. Final Report	58.97	4,056.22	4,115.19
Totals	$80,149.98	$4,529.02	$84,679.00

* If payment request is reimbursement, Expenditure Record must be attached.

CERTIFICATION

I certify that this request is correct and just and is based upon actual commitments/obligations of the Grantee; that payment from the State has not yet been made or received; that the work and services are in accordance with the project as aproved, including amendments thereto; and that progress of the work and services under the project is acceptable and is consistent with the amount requested.

Signature: Elizabeth Hill Date: 10/9/01

LEAVE BLANK-TO BE COMPLETED BY ARIZONA WATER PROTECTION FUND

I have examined this claim and certify that the expenditure is for valid public purpose and that the funds have been appropriated or are otherwise available for payment of this claim and payment of the amount claimed is hereby approved.

Program Manager Approval__________ Date:________ Contract Officer Approval__________ Date:________

Submitted with 8th Billing (7/1/2001-9/14/2001) for Water Protection Fund Grant No. 97-040, "Bingham Cienega Restoration Project"
(TNC Grant Center AWPF Bingham 1030527806)

BUDGET SUMMARY REPORT
(submit at least quarterly)

Grant Funds Expended by the Participant:
$84,679.00 (as of 9/14/01)*

APPROVED SCOPE ITEMS**

		% BUDGET EXPENDED	% COMPLETE
Task 1	Obtain permits	100%	100%
Task 2	Revegetation & monitoring plans	100%	100%
Task 3	Install irrigation system	100%	100%
Task 4	Planting site preparation	103%	100%
Task 5	Grow-out grasses, shrubs & trees	86%	100%
Task 6	Plant native grasses	90%	100%
Task 7	Plant native trees & shrubs	131%	110%
Task 8	Install electrical fencing	100%	100%
Task 9	Irrigation management & maintenance	114%	100%
Task 10	Groundwater depth & precip monitoring	199%	100%
Task 11	Monitoring revegetation success	114%	100%
*Task 12	Monitoring bird use of the restoration area	0%	100%
*Task 13	Dissemination of Project Information	0%	100%
Task 14	Progress Reports	182%	100%
Task 15	Final Report	1%	100%

OVERALL % EXPENDED	% COMPLETE
100%	101%

*These tasks are not funded by AWPF; numbers given represent % completion of task.

PROBLEMS ENCOUNTERED AND SOLUTIONS TO PROBLEMS

*Report the amount of grant funds received from AWPF which have been expended for approved scope items.

** See Section G, Scope of Services to the Grant Agreement for a listing of approved scope items.

prepared 9/21/2001

Arizona Water Protection Fund
DETAILED EXPENDITURE RECORD

Grant Number: 97-040 WPF
Project Name: 86-6000543
Grantee Name: Pima County Flood Control District
Attached to Pay Request #: 8

Record Preparation
Date: September 24, 2001
By: Elizabeth Hill
Tele #: 520-740-6350

Date	Invoice Number	Vendor	Item Description/How Used	Amount paid or Donated	Check Number
9/21/01	1030527806-8	The Nature Conservancy	See attached worksheets for tasks	$ 4,529.02	

Bingham Cienega (AWPF/Pima County)
Invoice #8 (see Attachment 1 for reimbursable expenses breakdown & Attachment 2 for matching expenses breakdown)

Please note not all matching from 4/01-9/01 is included

TASK #	DESCRIPTION	7/01-9/14/01 BILLING REIMBURSABLE COSTS	7/01-9/14/01 BILLING REIMBURSABLE COSTS +5% OVERHEAD	PREVIOUS BILLINGS TOTAL TO DATE (5/98-6/01) REIMBURSABLE COSTS	PROJECT TOTAL TO DATE (5/98-9/14/01) REIMBURSABLE COSTS	TOTAL BUDGET REVISED PER AMENDMENT 1	MATCHING COSTS (5/98-6/01)	MATCHING UNRECOVERED INDIRECT COSTS (5/98-6/01)
Task 1	Obtain required permits							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	0.00	0.00		71.07	14.21
	Personnel	0.00	0.00	0.00	0.00		306.07	61.21
		0.00	**0.00**	**0.00**	**0.00**	**0.00**	**377.14**	**75.43**
Task 2	Prepare revegetation and monitoring plans							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	56.36	56.36		0.00	8.45
	Personnel	0.00	0.00	1,152.59	1,152.59		1,127.79	398.45
		0.00	**0.00**	**1,208.95**	**1,208.95**	**1,208.95**	**1,127.79**	**406.90**
Task 3	Install irrigation system							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	24,476.76	24,476.76		0.00	3,671.51
	Personnel	0.00	0.00	0.00	0.00		2,099.25	419.85
		0.00	**0.00**	**24,476.76**	**24,476.76**	**24,476.76**	**2,099.25**	**419.85**
Task 4	Planting site preparation & maintenance							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	6,001.69	6,001.69		5,471.92	1,994.64
	Personnel	0.00	0.00	5,714.51	5,714.51		19,219.87	4,701.15
		0.00	**0.00**	**11,716.20**	**11,716.20**	**11,353.64**	**24,691.79**	**6,695.79**
Task 5	Grow-out grasses, shrubs, and trees							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	5,086.35	5,086.35		7,310.00	2,224.95
	Personnel	0.00	0.00	1,990.34	1,990.34		5,113.95	1,321.34
		0.00	**0.00**	**7,076.69**	**7,076.69**	**8,224.67**	**12,423.95**	**3,546.29**
Task 6	Plant native grasses							
	Supplies and Materials, Professional Services, Travel	(376.41)	(395.23)	11,963.46	11,568.23		5,254.79	2,786.19
	Personnel	679.64	713.63	5,026.48	5,740.11		31,562.72	7,173.56
		303.23	**318.39**	**16,989.94**	**17,308.33**	**19,169.00**	**36,817.51**	**9,959.75**
Task 7	Plant native trees and shrubs							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	538.50	538.50		2,007.51	482.28
	Personnel	0.00	0.00	139.70	139.70		6,502.66	1,321.49
		0.00	**0.00**	**678.20**	**678.20**	**516.19**	**8,510.17**	**1,803.76**

CONTINUED ON NEXT PAGE

AWPF Bingham Cienega Restoration Grant No. 97-040WPF
Pima County Flood Control District / TNC Grant Center (1030527806)
Invoice for expenses incurred from 7/1/01-9/14/01

TASK #	DESCRIPTION	7/01-9/14/01 BILLING REIMBURSABLE COSTS	7/01-9/14/01 BILLING REIMBURSABLE COSTS +5% OVERHEAD	PREVIOUS BILLINGS TOTAL TO DATE (5/98-6/01) REIMBURSABLE COSTS	PROJECT TOTAL TO DATE (5/98-9/14/01) REIMBURSABLE COSTS	TOTAL BUDGET	MATCHING COSTS (5/98-6/01)	MATCHING UNRECOVERED INDIRECT COSTS (5/98-6/01)
Task 8	Install electrical fencing							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	781.60	781.60		47.73	126.79
	Personnel	0.00	0.00	0.00	0.00		737.65	147.53
		0.00	**0.00**	**781.60**	**781.60**	**781.60**	**785.38**	**274.32**
Task 9	Irrigation management and maintenance							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	1,341.73	1,341.73		893.25	379.91
	Personnel	0.00	0.00	2,056.78	2,056.78		4,681.84	1,244.89
		0.00	**0.00**	**3,398.51**	**3,398.51**	**5,272.17**	**5,575.09**	**1,624.79**
Task 10	Groundwater depth and precipitation monitoring							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	93.69	93.69		0.00	14.05
	Personnel	147.06	154.41	169.58	323.99		2,203.58	489.31
		147.06	**154.41**	**263.27**	**417.69**	**210.00**	**2,203.58**	**503.37**
Task 11	Monitoring revegetation success in the three planting areas							
	Supplies and Materials, Professional Services, Travel		0.00	1,638.50	1,638.50		432.72	332.32
	Personnel	0.00	0.00	6,511.29	6,511.29		4,094.57	1,795.61
		0.00	**0.00**	**8,149.80**	**8,149.80**	**7,870.91**	**4,527.29**	**2,127.93**
Task 12	Monitoring bird use of the restoration areas							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	0.00	0.00		557.21	111.44
	Personnel	0.00	0.00	0.00	0.00		1,105.21	221.04
		0.00	**0.00**	**0.00**	**0.00**	**0.00**	**1,662.42**	**332.48**
Task 13	Dissemination of Project Information							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	34.13	34.13		245.00	54.12
	Personnel	0.00	0.00	0.00	0.00		1,739.28	347.86
		0.00	**0.00**	**34.13**	**34.13**	**0.00**	**1,984.28**	**401.98**
Task 14	Progress Reports							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	315.38	315.38		0.00	47.31
	Personnel	0.00	0.00	1,693.43	1,693.43		3,639.71	981.96
		0.00	**0.00**	**2,008.81**	**2,008.81**	**1,027.11**	**3,639.71**	**1,029.26**
Task 15	Final Report							
	Supplies and Materials, Professional Services, Travel	0.00	0.00	0.00	0.00		0.00	0.00
	Personnel	3,863.06	4,056.22	729.19	4,785.41		0.00	717.81
		3,863.06	**4,056.22**	**729.19**	**4,785.41**	**4,568.00**	**0.00**	**717.81**
	TOTAL VALUE	**$ 4,313.35**	**$ 4,529.02**	**$ 77,512.05**	**$ 82,041.08**	**$ 84,679.00**	**$ 106,425.35**	**$ 29,919.72**

prepared by Lynn Richards, TNC, Submitted 9/21/01

t:\grants\awpf\bingham\binv0109.xls

WORKSHEET for Personnel expenses through 9/14/01

TASK #	TASK DESCRIPTION	7/1/01-9/14/01 REIMBURSABLE HOURS	7/1/01-9/14/01 REIMBURSABLE COST	5/98-6/01 REIMBURSABLE HOURS	5/98-6/01 REIMBURSABLE COST	CUMULATIVE MATCHING HOURS	CUMULATIVE MATCHING VALUE
Task 1	Obtain required permits	0	$ -	0	$ -	18	306.07
Task 2	Prepare revegetation and monitoring plans	0	$ -	63	$ 1,097.70	51	1,127.79
Task 3	Install irrigation system	0	$ -	0	$ -	140	$ 2,099.25
Task 4	Planting site preparation & maintenance	0	$ -	372.6	$ 5,442.40	1347.6	$ 19,219.87
Task 5	Grow-out grasses, shrubs, and trees	0	$ -	147	$ 2,078.88	540	$ 5,113.95
Task 6	Plant native grasses	45	$ 679.64	418.6	$ 4,423.96	2359.16	$ 31,562.72
Task 7	Plant native trees and shrubs	0	$ -	10	$ 133.05	627.5	$ 6,502.66
Task 8	Install electrical fencing	0	$ -	0	$ -	55	$ 737.65
Task 9	Irrigation management and maintenance	0	$ -	145.2	$ 1,958.84	300.5	$ 4,681.84
Task 10	Groundwater depth and precipitation monitoring	6	$ 147.06	12.1	$ 161.50	115	$ 2,203.58
Task 11	Monitoring revegetation success in the three planting areas	0	$ -	469	$ 7,463.53	428	$ 4,094.57
Task 12	Monitoring bird use of the restoration areas	0	$ -	0	$ -	121.5	$ 1,105.21
Task 13	Dissemination of Information	0	$ -	0	$ -	99.5	$ 1,739.28
Task 14	Progress Reports	0	$ -	79	$ 1,612.79	191.5	$ 3,639.71
Task 15	Report	155.5	$ 3,863.06	37.5	$ 694.45	0	$ -
	TOTAL $ VALUE		$ 4,689.76		$ 25,067.10		$ 84,134.15

prepared by Lynn Richards, TNC, Submitted 9/21/01

Attachment 1:
TNC REIMBURSABLE COSTS (BY TASK NUMBER AND CATEGORY) 7/1/01-9/14/01

TASK#	ACCT#	CHECK REQUEST#	DATE		VENDOR NAME	CHECK #	AMOUNT	TOTAL
PLEASE NOTE: THE FOLLOWING FIVE CHARGES WERE IN BOTH BILL #3 AND BILL #4 BY MISTAKE								
6	5507	T540683	4/23/99	DUPLICATE	Jason Ekstein -- moving tractor from San Rafael	732860	(39.30)	
6	5303	CR1936-AZFO1	7/28/99	DUPLICATE	Home Depot	769430	(179.63)	
6	5508	CR1806-AZFO1	7/9/99	DUPLICATE	Barbara Clark -- gas receipts	756042	(32.74)	
6	5508	CR1938-AZFO1	8/3/99	DUPLICATE	Barbara Clark -- gas receipts	766954	(44.98)	
6	5503	CR2030-AZFO1	9/21/99	DUPLICATE	Barbara Clark -- furrow replacement parts	774008	(79.76)	
TOTAL								$ (376.41)

TOTAL $ (376.41)

Attachment 2:
TNC MATCHING COSTS (BY TASK NUMBER AND CATEGORY) 5/98-9/14/01

AWPF Bingham Cienega Grant No. 97-040WPF
Pima County Flood Control District / TNC Grant Center 1030527806

TASK#	ACCT# (s)	MATCH?	CHECK REQUEST#	DATE	VENDOR NAME	CHECK #	AMOUNT	TOTAL
1	5601	YES	CR1664-AZFO1	6/8/99	Barbara Clark -- vehicle registration	746558	71.07	
TOTAL								71.07
4	5825	YES	CR1042-AZFO1	12/18/98	American Fence Company	702731	105.93	
4	5077	YES	CR1119-AZFO1	1/15/99	Faron Bingham	707306	3,000.00	
4	5075	YES	CR1227-AZFO1	2/1/99	John Evans	716468	130.00	
4	5225	YES	CR1664-AZFO1	6/8/99	Barbara Clark -- office supplies	746558	11.06	
4	5508	YES	CR1664-AZFO1	6/8/99	Barbara Clark -- gas receipts	746558	13.90	
4	5303	YES	CR1825-AZFO1	7/1/99	Shannon's Auto Parts	759188	103.83	
4	5507	YES	CR1825-AZFO1	7/1/99	Shannon's Auto Parts	759188	34.99	
4	5508	YES	CR1765-AZFO1	6/1/99	Barbara Clark -- gas receipts	754380	42.55	
4	5077	YES	CR2234-AZFO1	11/1/99	Faron Bingham	792540	2,000.00	
4	5825	YES	Petty Cash (3/20/01)	3/20/01	Petty Cash (fencing supplies)	951292	9.66	
4	5825	YES	Petty Cash (4/20/01)	4/20/01	Petty Cash (fencing supplies)	947257	20.00	
4	5503	YES	Petty Cash 6/01	6/8/01	Barbara Clark (petty cash for tractor maintenance)	991331	44.12	
4	5508	YES	CR4251-AZFO1	8/1/01	Texaco	981165	17.15	
TOTAL								5,471.92
5	5077	YES	CR0601-AZFO1	8/3/98	CORONADO HEIGHTS NURSERY		4,815.00	
5	5077	YES	CR2235-AZFO1	11/1/99	Bernadette Jilka (Coronado Nurseries)	792394	2,445.00	
5	5027	YES	Petty Cash (3/20/01)	3/20/01	Petty Cash	951292	50.00	
TOTAL								7,310.00
6	5107	YES	T532984	7/24/98	Kimberly Fox		30.62	
6	5107	YES	T532984	7/24/98	Kimberly Fox		31.55	
6	5107	YES	T532989	8/1/98	Kimberly Fox		41.05	
6	5107	YES	T540303	8/14/98	Kimberly Fox		30.53	
6	5107	YES	T532843	9/1/98	Kimberly Fox		10.67	
6	5107	YES	T532955	9/1/98	Kimberly Fox		89.21	
6	5108	YES	T532986	7/24/98	Kimberly Fox		34.92	
6	5108	YES	T532989	8/1/98	Kimberly Fox		32.47	
6	5108	YES	T540303	8/14/98	Kimberly Fox		9.40	
6	5508	YES	T540303	8/14/98	Kimberly Fox		14.55	
6	5508	YES	T540303	8/14/98	Kimberly Fox		21.15	
6	5507	YES	CRO595-AZFO1	8/6/98	Kimberly Fox		99.80	
6	5107	YES	TER T532847	9/14/98	Kimberly Fox	667452	10.00	
6	5310	YES			LELAND STEVENS TRUCKING		1,456.00	
6	5310	YES	CR0698-AZFO1	9/12/98	H&H SMALL EQUIPMENT		917.03	
6	5075	YES	CR0822-AZFO1	10/16/98	Jack Kelly	678157	376.00	
6	5075	YES	CR1015-AZFO1	12/10/98	Jack Kelly	699289	723.00	
6	5075	YES	CR0964-AZFO1	11/25/98	Jack Kelly	694993	322.00	
6	5107	YES	Petty Cash	10/13/98	Nancy Schenk (Petty Cash)	708477	10.17	
6	5107	YES	TER T532890	10/28/98	Kimberly Fox	686851	49.32	
6	5108	YES	TER T532890	10/28/98	Kimberly Fox	686851	19.73	
6		YES	CR1543-AZFO1	5/4/99	Dorothy Gaske Center	738365	330.00	
6		YES	CR1626-AZFO1	5/4/99	Dorothy Gaske Center	738365	200.00	
6	5508	YES	CR1806-AZFO1	7/9/99	Barbara Clark -- gas receipts	756042	30.86	
6		YES	CR2019-AZFO1	9/3/99	Dorothy Gaske Center	774103	202.90	
6	5102	YES	TER T532896	9/17/98	David F. Gori	670118	42.88	
6	5508	YES	CR2021-AZFO1	9/13/99	Texaco	771739	46.28	
6	5503	YES	CR2030-AZFO1	9/21/99	Barbara Clark -- volunteer planting day toilet	774008	72.70	
TOTAL								5,254.79

CONTINUED ON NEXT PAGE

Attachment 2:
TNC MATCHING COSTS (BY TASK NUMBER AND CATEGORY) 5/98-9/14/01

AWPF Bingham Cienega Grant No. 97-040WPF
Pima County Flood Control District / TNC Grant Center 1030527806

TASK#	ACCT# (s)	MATCH?	CHECK REQUEST#	DATE	VENDOR NAME	CHECK #	AMOUNT	TOTAL
7	5310	YES		6/1/98	PAYLESS		47.73	
7	5310	YES	CR0451-AZFO1	6/1/98	HOME DEPOT		66.36	
7	5310	YES	CR0451-AZFO1	6/1/98	HOME DEPOT		92.98	
7	5303	YES	Petty Cash	12/5/98	Nancy Schenk (Petty Cash)	708415	12.84	
7	5508	YES	Petty Cash	12/7/98	Nancy Schenk (Petty Cash)	708415	72.54	
7	5303	YES	CR1039-AZFO1	11/24/98	Home Depot	703050	47.06	
7	5075	YES	CR1015-AZFO1	12/10/98	Jack Kelly	699289	723.00	
7	5508	YES		12/14/98	Kimberly Fox		25.00	
7	5075	YES	CR0964-AZFO1	11/25/98	Jack Kelly	694993	322.00	
7	5075	YES	CR1107-AZFO1	12/28/98	Jack Kelly	706637	520.00	
7					Dorothy Garske Center (12 volunteers)		78.00	
TOTAL								2,007.51
8	5310	YES	JER100227	1/15/99	reclassified to Partners grant (MATCH)	667392	47.73	
TOTAL								47.73
9	5075	YES	CR0822-AZFO1	10/16/98	Jack Kelly	678157	376.00	
9	5075	YES	CR1320-AZFO1	3/1/99	Jack Kelly	720622	496.00	
9	5508	YES	CR1664-AZFO1	6/8/99	Barbara Clark -- gas receipts	746558	21.25	
TOTAL								893.25
11	5107	YES	T532978	8/6/98	Dana Backer		29.85	
11	5508	YES	T532978	8/6/98	Dana Backer		13.80	
11	5102	YES	TER T542819	6/15/99	Dana Backer		60.70	
11	5102	YES	TER T598962	5/1/00	Dana Backer	842400	42.16	
11	5107	YES	TER T598943	4/1/00	Dana Backer	833301	11.53	
11	5075	YES	CR2890-AZFO1	6/1/00	Roy Stewart	853015	225.00	
11	5102	YES	TER T615979	4/1/00	Dana Backer	944833	49.68	
TOTAL								432.72
12	5102	YES	TER T542819	6/11/99	Dana Backer		44.20	
12	5075 & 5508	YES	CR2836-AZFO1	5/11/00	Quinto Sol	848130	245.49	
12	5075	YES	CR2844-AZFO1	6/1/00	Julie Conley	851675	225.00	
12	5508	YES	T615953	10/13/00	Dave Gori (reimbursement for fuel)	890989	11.25	
12	5508	YES	T615990	12/13/00	Dave Gori (reimbursement for fuel)	908645	31.27	
TOTAL								557.21
13	5151	YES	Petty Cash (4/20/01)	4/17/01	Petty Cash (for luncheon provided by Sun Station @ Cascabel)	947257	225.00	
13	5508		Petty Cash 6/01	6/8/01	Barbara Clark (petty cash for vehicle fuel)	991331	20.00	
TOTAL								245.00
15	5102		TER# T532913	8/1/01	Barbara Clark (mileage to come to Tucson one day to work on report)		51.75	
15	5507		Petty Cash 8/01	8/30/01	vehicle fuel & maintenance (coming to Tucson to finish report)	991331	54.42	
15	5205		Petty Cash 8/01	8/30/01	postage	991331	34.00	
15	5303		Petty Cash 8/01	8/30/01	photo developing / non-office supplies	991331	9.60	
15	5201		Petty Cash 8/01	8/30/01	phone bills	991331	14.23	
15	5102		TER# T532921	9/1/01	Barbara Clark (mileage to come to Tucson every day for a week to work on report)		258.75	
TOTAL								422.75

TOTAL CUMULATIVE MATCHING EXPENSES FROM 7/98-9/01: 22,713.95

-prepared by Lynn Richards, TNC, Submitted 9/21/01

t:\grants\awpf\bingham\binv0109.xls