FINAL REPORT

PANTANO JUNGLE RESTORATION
CIENEGA CREEK NATURAL PRESERVE

PARTNERS FOR WILDLIFE PROJECT
FWS Agreement No. 1448-00002-95-0901

Pima County, Arizona
Board of Supervisors

Ann Day, District 1
Ramon Valadez, District 2
Sharon Bronson, District 3
Raymond J. Carroll, District 4
Richard Elias, Chair, District 5

County Administrator
Chuck Huckelberry

Prepared by

David Scalero, Principal Hydrologist
Pima County Regional Flood Control District
Water Resources Division
97 E. Congress St., 3rd Floor
Tucson, Arizona 85701

for

Partners for Fish and Wildlife Program
U. S. Fish and Wildlife Service
2321 W. Royal Palm Rd., Ste. 103
Phoenix, Arizona 85021-4951

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Executive Summary

The Pantano Jungle Restoration Project was initiated by the Pima County Regional Flood Control District (formerly the Pima County Department of Transportation and Flood Control District) in response to a policy set forth within the Cienega Creek Natural Preserve Management Plan to revegetate with native vegetation all areas previously cleared for agricultural crop production within the Preserve. The project site was previously dominated by mesquite bosque and sacaton grassland prior to its conversion to Bermuda grass fields in 1974. Specific goals for the project were to reestablish mesquite bosque habitat in an area dominated by non-native vegetation and to increase the structure and diversity of native vegetation for the benefit of neotropical migratory birds. A secondary project was included to reduce erosion within an arroyo created by the grading of a dirt road along a hillside located just south of the abandoned field.

In cooperation with the U.S. Fish and Wildlife Service (USFWS) and the Arizona Game and Fish Department, the Pima County Regional Flood Control District (District) conducted site preparation and revegetation activities within 17 acres encompassing the project site. Perimeter fencing was installed to keep grazing livestock (6 horses owned by property caretakers in the vicinity) from entering the revegetated areas. Cultural resource surveys were conducted to obtain clearances through the Arizona State Historic Preservation Office (SHPO). A drip irrigation system was installed to provide water to planted trees and shrubs during the scheduled 2-year establishment phase. Native trees and shrubs were planted within a four-acre site that was clear of important cultural resource artifacts that would be affected by planting activities. Sacaton grasses were planted in areas not cleared by SHPO for the establishment of trees and shrubs, due to the lower impact of the grass root systems on soil disturbance. The District replaced the gravel stratum, constructed check dams and planted sacaton grass along the hillside arroyo to reduce flow velocities and promote the deposition of sediment.

Project monitoring was conducted to identify mid-course changes needed to correct problems such as rodent and insect damage, lack of water stress and other deleterious factors and to allow USFWS to evaluate the project for the purpose of guiding future endeavors. Plots were randomly established within the abandoned agricultural field to monitor the health and survival of planted native vegetation, to identify recruitment of volunteer plants, and to visually determine relative growth rates of native vegetation. Transects were marked and monitored along the hillside gully to determine vertical and lateral erosion, as well as progression of the head cut.

Surveys conducted from 1998 through 2008 indicated successful establishment of saltbush, mesquite and catclaw acacia species and poor establishment of hackberry, graythorn, elderberry and wolfberry species. Relative growth comparisons of the planted vegetation were insignificant over the ten-year period, except saltbush was more dominant. Native plant recruitment was limited to a few mesquite trees found within the non-grazed area. Factors affecting the health and growth of native plant species at the project site included lack of precipitation, competition from non-native invasive plants, and stress from small herbivores (rodents) and other pests. Surveys along the hillside gully indicated periods of deposition shortly after check dam construction followed by a period of channel down cutting and lateral erosion once the check dams deteriorated. The tributary stream has changed its configuration from a V-shaped gully to a U-shaped channel with terraces supported by sacaton grasses.

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1.0 INTRODUCTION

In 1996, the Pima County Regional Control District (District) entered into agreements with the U. S. Fish and Wildlife Service (USFWS) and the Arizona Game and Fish Department (AGFD) to restore lands that were significantly disturbed by human activities adjacent to Cienega Creek in Pima County, Arizona (**Figure 1**). This project intended to accelerate natural reclamation of approximately 17 acres of abandoned agricultural land within the District's Cienega Creek Natural Preserve (Preserve). Mesquite bosque and sacaton grassland species dominated the project area prior to its conversion to Bermuda grass fields in 1974 (**Figure 2**).

Specific project objectives include promoting the propagation and long-term reestablishment of mesquite bosque habitat in an area dominated by non-native species, and increasing the structure and species diversity of native vegetation for the benefit of neotropical migratory birds. Reestablishment of native riparian vegetation in the area will increase the overall length and width of the riparian corridor associated with Cienega Creek, and increase the area's potential to be used by species other than edge species (ecological generalists). Rehabilitation efforts were undertaken at the site because the rate of natural reestablishment of native plants was limited by the lack of seed transport into the field, competition with nonnative grasses, and inadequate soil moisture over the growing period.

A secondary project was developed to reduce gully erosion along a hillside located just south of the abandoned agricultural field (Figure 1-Tributary watershed project). A dirt road had been graded up the hill to gain access to a proposed well site by the previous land owner. The well was never constructed, but the road remained intact. Upon project implementation, a large V-shaped gully had formed within the roadway due to storm water runoff events. Project objectives included the replacement of coarse materials that were removed during road construction, sacaton grass planting to promote bank stabilization, and check dam construction to reduce storm water velocities, reduce erosion and trap sediment.

The purpose of this report is to summarize the construction, maintenance and monitoring activities associated with the project and to discuss the "lessons learned" for developing similar environmental restoration projects in the future.

2.0 REVEGETATION PROJECT

2.1 Site Preparation

Archeological surveys were conducted to determine if there were any important cultural artifacts that would be disturbed by revegetation activities. The subsurface of the field was analyzed through excavation of 16 trenches scattered throughout the 20 acre project site (**Figure 3**). Pit houses and historical artifact scatters were located along the southern half of the field, which limited the tree planting area to the northern half to avoid disturbance from irrigation line construction and tree rooting. The planting of grasses was permitted in the southern half because of their shorter root structure and no supplemental irrigation being provided for establishment. After analysis, the trenches were filled with the excavated earthen materials and native plant seeds were scattered over the disturbed area. Mesquite beans were collected from established trees within and around the area and scattered throughout the project site.

Fencing was installed around the perimeter of the project site to keep horses out of the planting area. A total of six horses were kept in the area by the on-site caretaker of the property. The fence was electrified to insure the horses would not try to break it down by constantly rubbing on it.

2.2 Irrigation System

A drip irrigation system was installed in the tree planting area to provide supplemental water during the establishment phase of the project (August 1997 through December 1999). The irrigation system consisted of multiple stations with drip lines running from each station to the plant clusters (**Figure 4**). Some of the lines to the mesquite trees were plugged in order to study the affects of not using supplemental irrigation for tree establishment. The project partners believed that the mesquite trees could still survive because of their propagation in tall pots (see Section 2.3). The irrigation system was connected to a nearby irrigation well and automated using a Rain Bird control unit.

2.3 Planting

The type and number of tree and shrub seedlings planted at the project site are provided in **Table 1**. The total number of trees was based on a typical density for a mature mesquite bosque (80 to 320 trees per acre), with mesquite trees composing approximately 75 percent (Stromberg 1993). Due to archeological and financial constraints, a density of 80 trees per acre were planted over 3.8 acres in the northern portion of the abandoned agricultural field. Shrub seedlings were also planted at a targeted density of 80 per acre to provide understory structure below the tree canopies.

Mesquite trees were propagated in tall pots as demonstrated in **Appendix A**. The tall pot method was used to establish a well-developed root system, including the taproot, which would presumably improve plant survival and aid in plant growth. Planting tall pot trees also reduced ground disturbance at the site, since holes could be drilled to fit the cylindrical pots instead of digging wide holes for normal nursery containers.

All of the trees and shrubs were planted by a group of contract workers and volunteers in November 1997. Each hole was pre-irrigated before plant placement to help keep the roots moist. Weed mats were laid around each plant to restrict competition from nonnative grasses. A browser cage, constructed of rebar and chicken wire, was placed around each seedling to protect it from herbivores (e.g., deer and rabbits).

Sacaton seedlings were planted by a group of volunteers in August 1996. The seedlings were planted within the southern portion of the project area since they were not restricted by the archeological clearance. Sacaton clusters were placed in natural depressions and along the hill slope to study the affects of drainage and soils on survival rates. A mix of tall pot containers and regular containers were used to propagate the seedlings to study the effects of propagation time on survival and growth rates of the plants. Supplemental irrigation was provided once to the grasses since they were not on the irrigation system and conditions at the site were initially dry.

2.4 Maintenance

The on-site caretakers were responsible for maintaining the fences and inspecting the field to insure the integrity of the irrigation system. Using contractors, the District maintained the irrigation well, repaired the irrigation system as needed, and removed weeds from the planted area by mechanical means. Some of the trees and shrubs were replaced due to mortality caused by the lack of irrigation from damaged irrigation lines. District staff inspected replanting to insure local, native stock was used. Browser cages were removed from mature plants when warranted and as time permitted.

2.5 Monitoring

Project monitoring was conducted to: 1) identify any mid-course changes needed to correct problems such as rodent damage, water stress, insect damage, and other deleterious factors; and 2) to allow USFWS to evaluate the successes and failures of the project for the purpose of guiding future endeavors. Project partners randomly identified and marked two 100 foot by 100 foot plots within the planted area to monitor plant survival and health, and four 50 foot by 50 foot plots to monitor the establishment of volunteer plants (recruitment) within the planted area, the non-grazed area and the grazed area of the abandoned agricultural field (**Figure 5**). Photo points were established in the center of each 100 foot by 100 foot plot within the irrigated section and in each of the two 50 foot by 50 foot plots in the non-irrigated section to determine relative growth rates of all the plants. A monitoring protocol was developed in January 1998 to guide the monitoring efforts (**Appendix B**).

Surveys conducted within the monitoring plots from 1998 through 2008 indicated successful establishment of mesquite, saltbush, and catclaw acacia species (0 – 25% mortality) and poor establishment of hackberry, graythorn, elderberry, and wolfberry species (60 – 100% mortality). The overall survival rate for the monitoring plots was 57% (35 out of 61 plants). A summary of plant mortality is provided in **Table 2**.

Measured tree growth was fairly limited during the monitoring period (**Table 3**). Average growth of the surviving trees was approximately 24 inches. This figure was cut in half (12 inches) if the number of dead trees was included (19 in total). The surviving mesquite trees had the greatest height increases, ranging from 7 inches to 64 inches, and the largest average growth (29 inches). One catclaw acacia showed 12 inches of die back (decreased height), while the other two had increased heights of 10 inches and 12 inches. Neither of the two elderberry trees survived after 2002, and only one hackberry survived after 2005 (22 inch height increase).

Appendix C displays a comparison of photographs taken in November 1999 and November 2007 within the four monitoring plots (NE Plot, SE Plot, Plot A and Plot B). Significant growth of the existing (pre-project) mesquite trees and the planted saltbush was the most notable change in the NE Plot. Growth of the existing and planted mesquite trees within and around the SE Plot was significant in the East and South facing photographs. Very little change can be seen in the photographs taken in Plots A and B, apart from some growth of the existing mesquite trees.

Plant recruitment within the designated monitoring plots was very limited during the 10-year monitoring period. A total of five mesquite trees were observed in the designated monitoring plots within the planted area (NE and SE Plots), with heights ranging from 36 inches to 71 inches. One mesquite (40 inches) and one graythorn (21 inches) were found within the non-planted, non-grazed area (Plot A). No recruitment was observed in the grazed area (Plot B). Other observations identified recruitment outside of the 50 foot by 50 foot plots within the NE and SE Plots as shown in the canopy cover analysis below.

Although not part of monitoring protocol, canopy cover from the woody perennial plants was evaluated for the NE and SE Plots to estimate the success of mesquite bosque reestablishment. Crown cover for each plant, including all existing and recruited plants, was calculated using the protocol described in **Appendix D**. The results from this analysis, which are also in **Appendix D**, indicate that woody perennials cover approximately 66 percent of the total area in the NE Plot and only six (6) percent of the total area in the SE Plot. Existing mesquite trees provided the majority of canopy cover. Planted trees and shrubs accounted for 10 percent and 2 percent of the total canopy covers, respectively.

3.0 TRIBUTARY WATERSHED PROJECT

3.1 Activities

Restoration activities were initiated in August 1997 to provide soil stabilization and reduce downcutting along an arroyo formed within an abandoned hillside roadway, south of the revegetation project (**Figure 1-Tributary Watershed Project outlined in red**). Half-inch to one-inch diameter gravel was dumped and spread over the gully area to cover the highly erodible, fine soils that were exposed during roadway construction. Using sandbags, four check dams were constructed along the arroyo to reduce runoff velocities and trap sediment (**Figure 6**). Sacaton seedlings were planted along the arroyo in 1998 to help stabilize the soils, and rock was used to fill the side gullies to reduce downcutting.

3.2 Monitoring

A monitoring program was developed in June 1997 prior to restoration activities (**Appendix E**). The goal of the monitoring program was to establish reference points for evaluating the migration of the headcut and changes in the gully dimensions (width and depth) over time. A baseline survey was conducted as part of the monitoring program, which included photo points selected to visually monitor changing conditions.

Figure 7 abstractly displays the current configuration of the gully based on monitoring conducted in May 2008. As indicated in the figure, the headcut of the gully has migrated 132 inches (11 feet) upstream over the last 11 years. A secondary headcut,approximately 38 inches to the west of the other headcut, was created between June 2007 and June 2008. A drop pool is located between the two headcuts and the first rock and brush dam, built between Markers 1 and 2.

The gully has widened over the last 11 years, with some fluctuations year to year, due to check dam construction and maintenance (**Table 4**). Most of the lateral erosion has been on the western bank of the gully, where the hill slope is eroding downward to reach equilibrium with the channel bottom. The eastern bank has mostly remained intact, with a couple of exceptions where flows have cut the bank as they have meandered back and forth across the channel.

Maximum gully depths quickly decreased with the construction of the check dams in August 1997, but have deepened over time since the dams deteriorated in 2001 (**Table 5**). Average depths have decreased over time with the formation of terraces within the middle and lower portions of the gully. The sacaton grasses have been successfully established along the terraces, which have helped to stabilize the soils and reduce bank erosion.

Appendix F displays a comparison of photographs taken during the following project milestone events: pre-restoration (May 1996), post-construction of check dams (June 1998), deterioration of check dams (June 2002), and construction of rock and brush dams (May 2008). The pictures help depict the transformation of the channel from a highly entrenched, V-shaped gully to a meandering channel with terraces and established vegetation.

4.0 FINDINGS AND CONCLUSIONS

This project faced a number of physical challenges that were directly linked to the stress and mortality of the planted vegetation and the lack of recruitment observed at the site. Efforts were made to fix problems that arose over the first two years, which was the establishment period set for the planted vegetation. However, continual maintenance over the life of the project was beyond the scope and some of the

problems could not be fixed without detriment to the surrounding environment. Below is a discussion of what were believed to be the major deterrents to the success of this project:

Drought

A display of monthly rainfall is provided in **Figure 8**. Average rainfall at the project site during the 12-year period was 13.28 inches. However, the largest annual rainfall totals occurred during the first five years (16-inch average). Except for July 2003 through June 2004, annual averages over the last seven years have been one to over four inches below the average for the project duration. The decrease in precipitation is reflected in water levels measured at a monitoring well located at the northeastern corner of the project site (**Figure 9**). Water levels significantly rose from June 1999 to March 2002 in response to greater than average rainfall over the first five years of the project, but then fell sharply from April 2002 through August 2005 due to significant decreases in rainfall. Water levels have steadily increased over the last couple of years (July 2006 through June 2008). Mortality of the vegetation reflected the rainfall and water level patterns, with 20 out of the 26 total dead plants (77 percent) perishing during the dry period.

Invasive Weeds

As depicted in a number of the photographs located in **Appendix C**, invasive weeds provided a great amount of competition for space and soil moisture at the project site. Two nonnative species, Russian thistle (*Salsola tragus*) and Bermudagrass (*Cynodon dactylon*), covered most of the abandoned agricultural field. Both species were mechanically cleared from the vegetated area, but there was no concerted effort to control the weeds with herbicide. Weed mats were not effective in controlling weeds around the planted trees and shrubs.

Animal Pests

Animal pests also provided a good deal of stress to the plants and, in some cases, directly caused their death. Psyllid damage to the mesquite trees was noted in a number of years, with the loss of leaves being the primary stress indicator. Gophers caused plant stress by chewing irrigation lines and plant roots. In a number of cases, dead plants were discovered with no root system or plants were missing completely. Although browser cages were placed around the planted trees and shrubs, they were not effective to keep some small herbivores from reaching the plants.

Constant Change

The sandbag check dams were initially effective in slowing flow velocities and allowing the accumulation of sediment behind them. Over time, however, flows were cutting around the dams and deteriorating the sandbags, thus making them ineffective to reduce lateral erosion and downcutting of the channel. Small rock and brush dams were recently constructed in 2007 to replace the check dams. Future maintenance of these dams will be required to maintain their integrity and help keep the channel from reverting back to a V-shaped gully.

5.0 RECOMMENDATIONS

Project activities were designed to increase habitat for a variety of neotropical bird species, reduce gully erosion along a tributary watershed, and reestablish mesquite bosque and sacaton grassland communities that were historically widespread throughout southeastern Arizona. To some degree, the project has met its goals by increasing the diversity of plant species occurring in the abandoned field, changing the channel characteristics of the tributary watershed coming off the hill slope, and successfully establishing

sacaton in the southern portion of the field. However, the overall success of the project to reestablish a mesquite bosque was limited by the challenges that were constant through its lifespan. The following are some of the lessons that were learned during construction, maintenance and monitoring of the project for the purpose of guiding future restoration efforts:

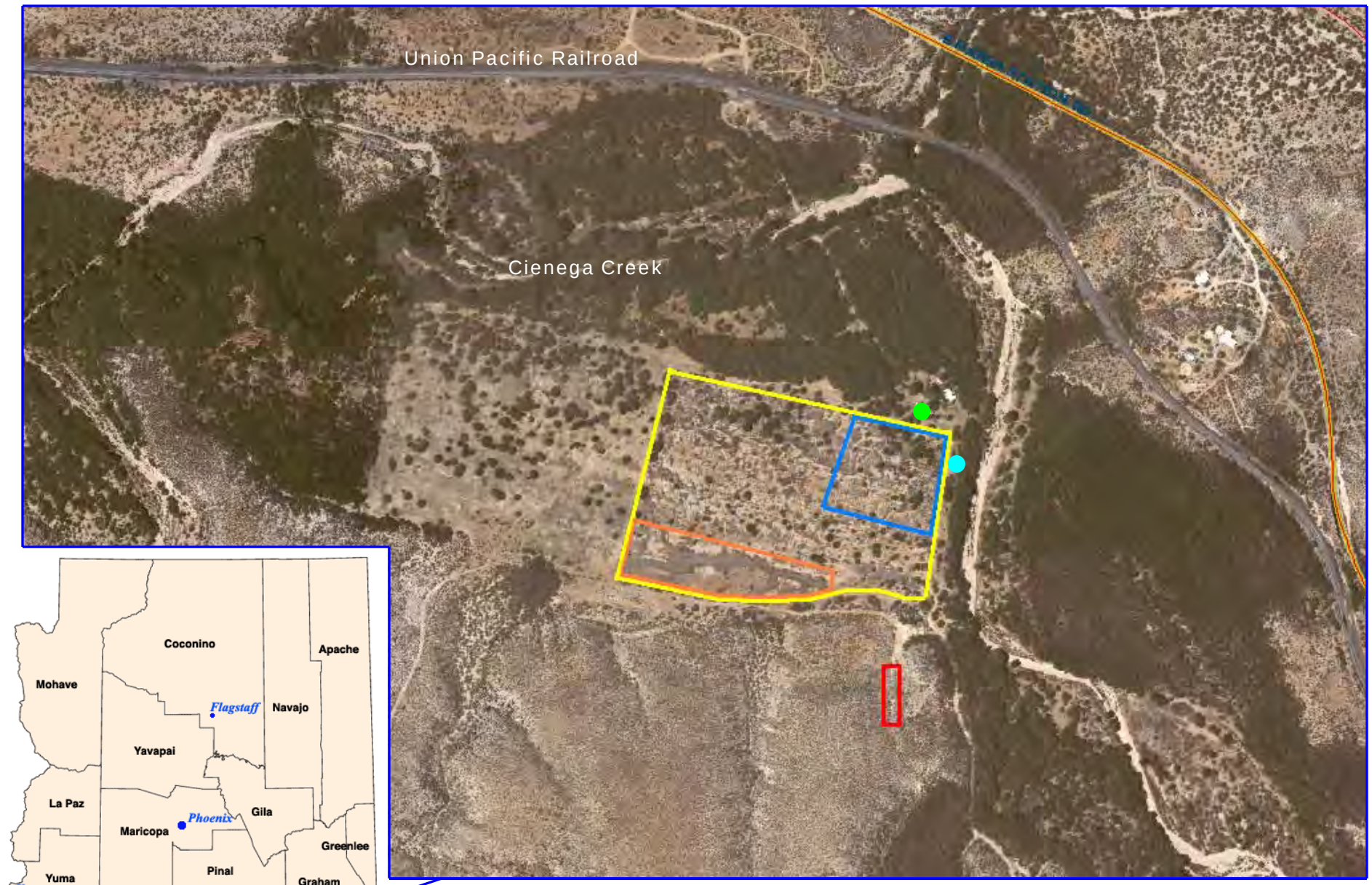
- **Active response to monitoring program:** The irrigation system needed to be utilized during periods of drought after the vegetation establishment period ended in December 1999. Rainfall was monitored and reported on an annual basis, but no effort was made to use monthly rainfall records to determine if supplemental irrigation was needed. Additional water may have greatly reduced the mortality and stress rates observed over the last seven drought years of the project duration.
- **Water harvesting:** Activities should be incorporated into the project to take advantage of flows coming off of the hills to the south of the project site. Interconnecting swales and shallow basins constructed within the abandoned field could have been used to provide water to the planted areas. Although adding to the overall cost of the project, water harvesting techniques would improve the success rate of plant establishment by directing water to the root zones.
- **Weed maintenance:** Aggressive weed maintenance is essential for revegetation efforts in areas that have been disturbed for a long period of time. The vast extent of weeds at the project site was the most visible challenge to the establishment of planted trees and shrubs and the recruitment of native vegetation. Weed mats may have been more effective if the area was recently disturbed and the invasive species were not already established. A concerted effort to remove the weeds before planting and constant maintenance of the planted areas would most likely have increased the success of this project.
- **Elimination of browser cages:** Browser cages were costly and very time consuming to build and they were not very effective in keeping the most destructive pests (gophers) from reaching the plants. Removing the cages has proven to be even more time consuming, especially where the branches of trees and shrubs have grown through the meshed wire. Grazing from deer and rabbits in the field appeared to be minimal, thus reducing the primary benefit for their installation.
- **Ongoing monitoring and maintenance:** In addition to monitoring, maintenance is essential to restore a degraded watershed to a more natural condition. Many of the efforts to restore the tributary watershed on the hill slope south of the revegetation project were conducted on a trial and error basis. The sandbag check dams needed to be modified with a spillway in the middle to allow stormwater to flow over the top so that flows would not try to force their way around the dams. Sacaton grasses were planted along terraces that formed in the channel to help strengthen banks and reduce flow velocities. Small rock dams were constructed and modified as flows changed their course over time. Rock and brush dams were constructed after the sandbags deteriorated to take advantage of available natural materials.

6.0 REFERENCES

Stromberg, J.C. 1993. Riparian mesquite forests: A review of their ecology, threats, and recovery potential. Journal of AZ-NV Academy of Science. Vol. 27. pp 111-124.

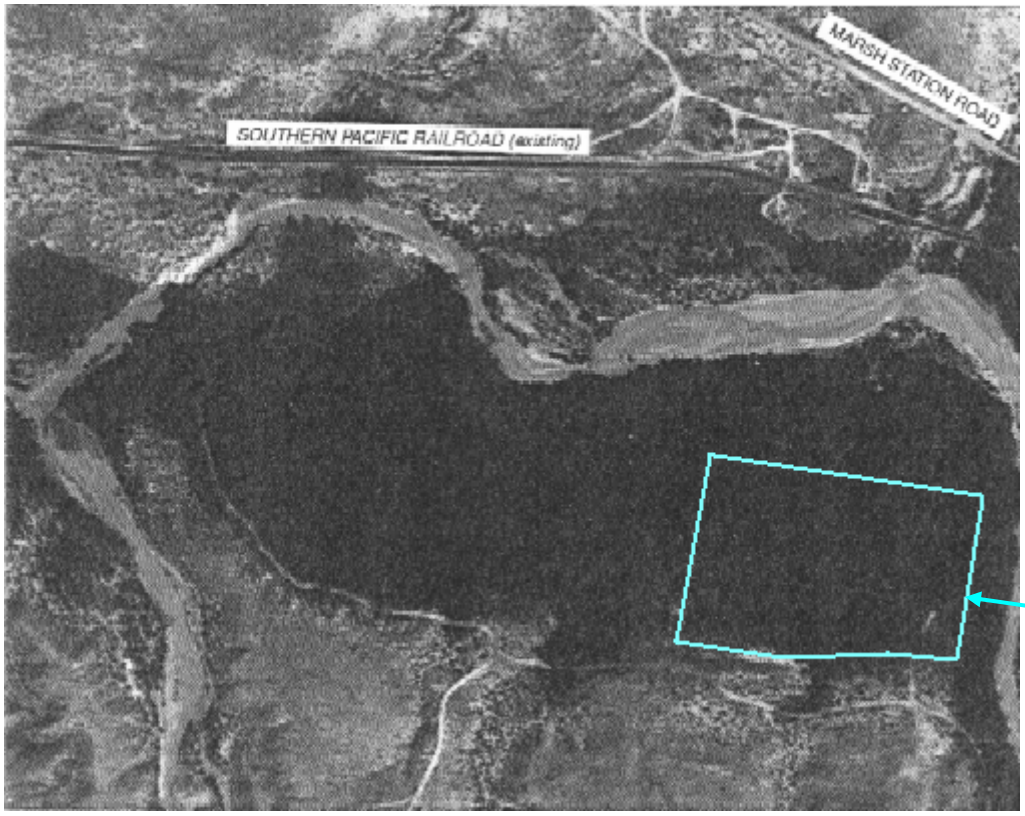
FIGURES

Figure 1. Partners for Wildlife Project Site Map



Source: Pima County MapGuide, 2005 Aerial

Figure 2. Historical versus Pre-project Conditions at Pantano Jungle



Historical aerial of project site (1964 Aerial) Scale ~ 1 : 12,000

Project Boundaries

Aerial of project site before commencement of restoration activities Scale ~ 1 : 11,000

Figure 3. Cultural Resources Survey Trenches

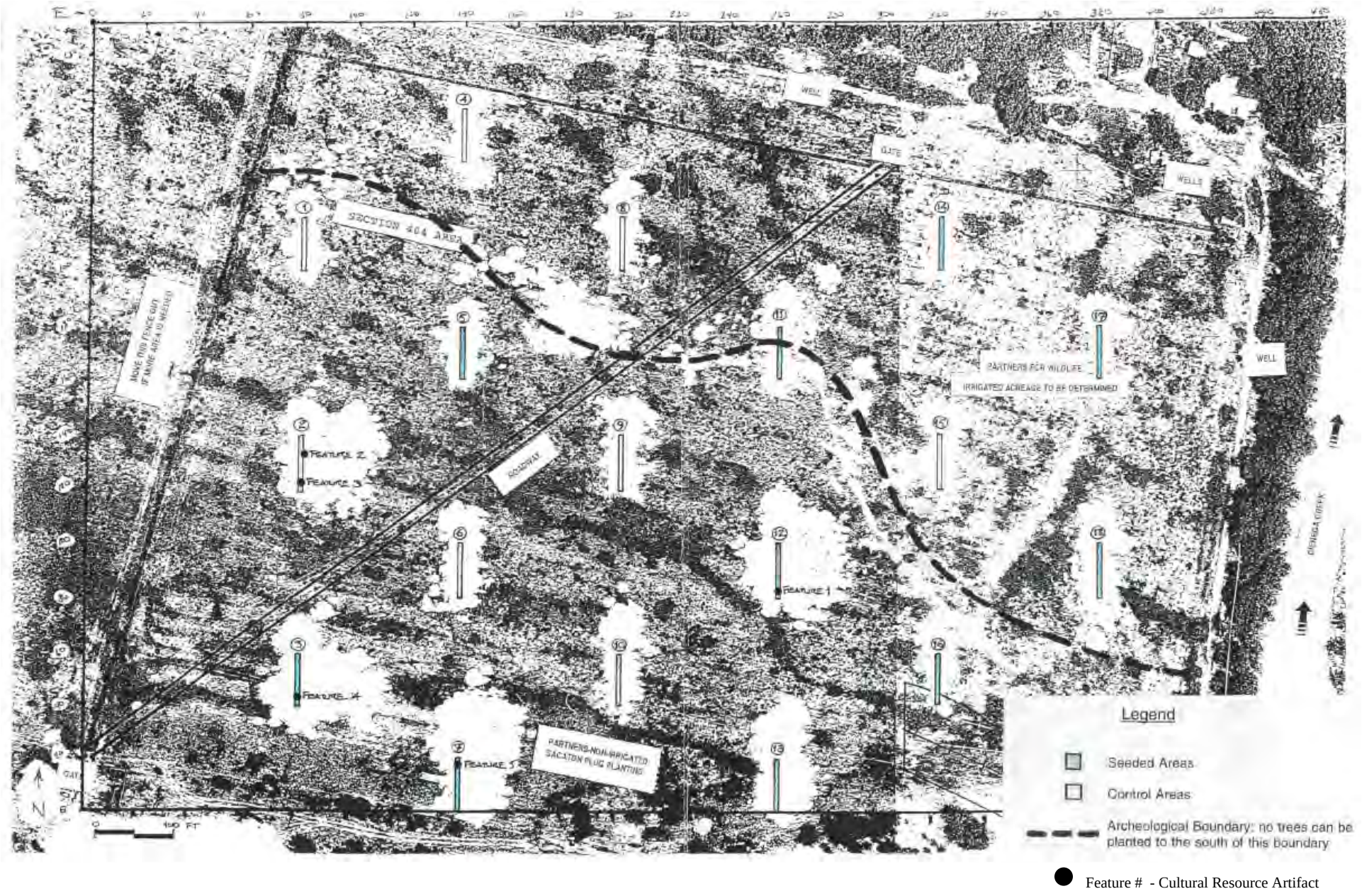


Figure 4. Irrigation System and Plant Cluster Map

Source: Partners for Wildlife Irrigation Plan, Design & Drawn by Karen Novak R.L.A., June 10, 1997, Revised August 12, 1997

Figure 5. Partners For Wildlife Vegetation Monitoring Plots

Source: Pima County MapGuide, 2005 Aerial

Recruitment Monitor Plot
(50 ft x 50 ft)

Plant Survival/Health Monitor Plot
(100 ft x 100 ft)

North

Scale 1 : 3,800 (approx.)

Figure 6. Gully Description with Check Dams (May 1998)

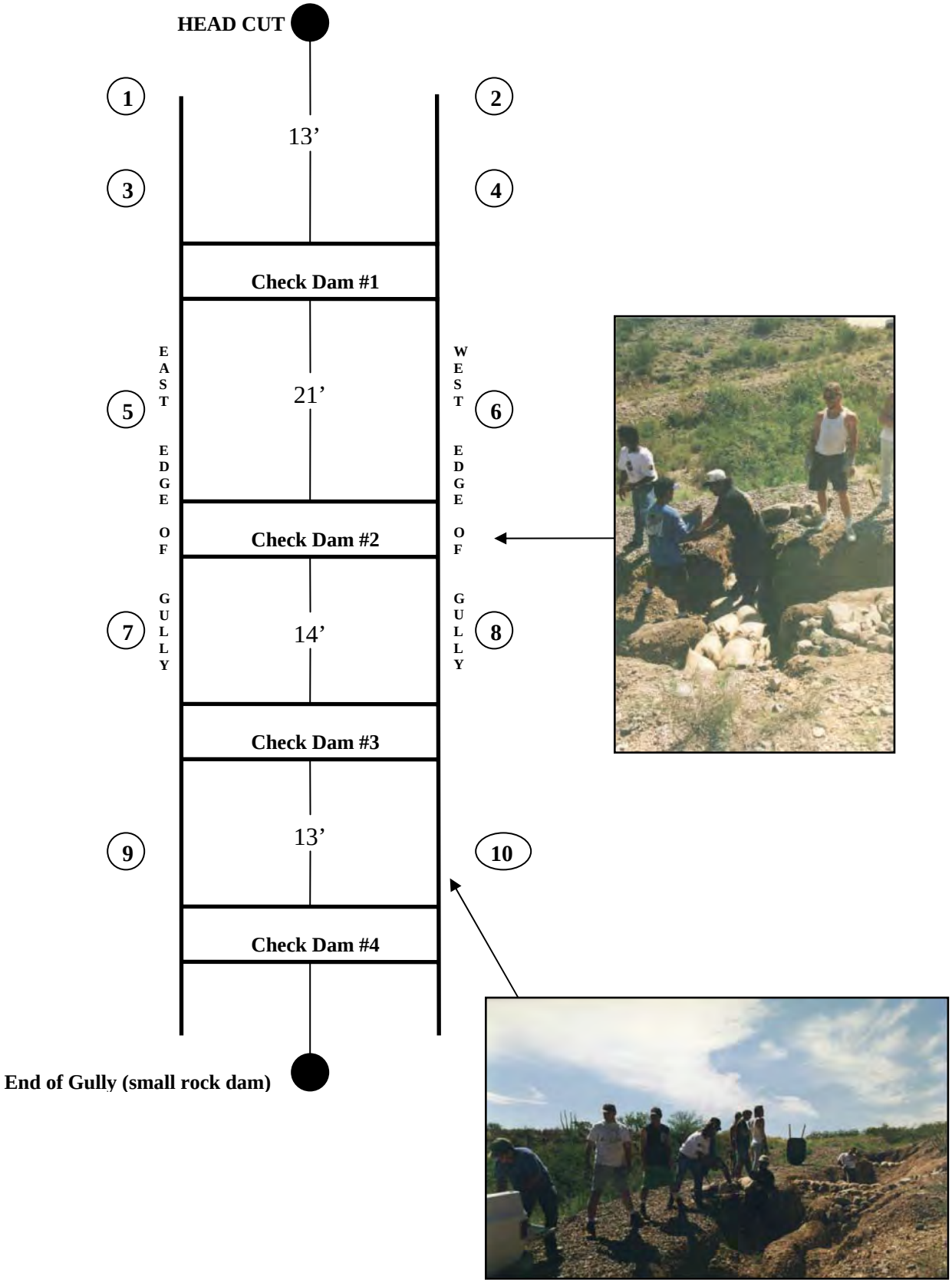


Figure 7. Gully Description (May 23, 2008)

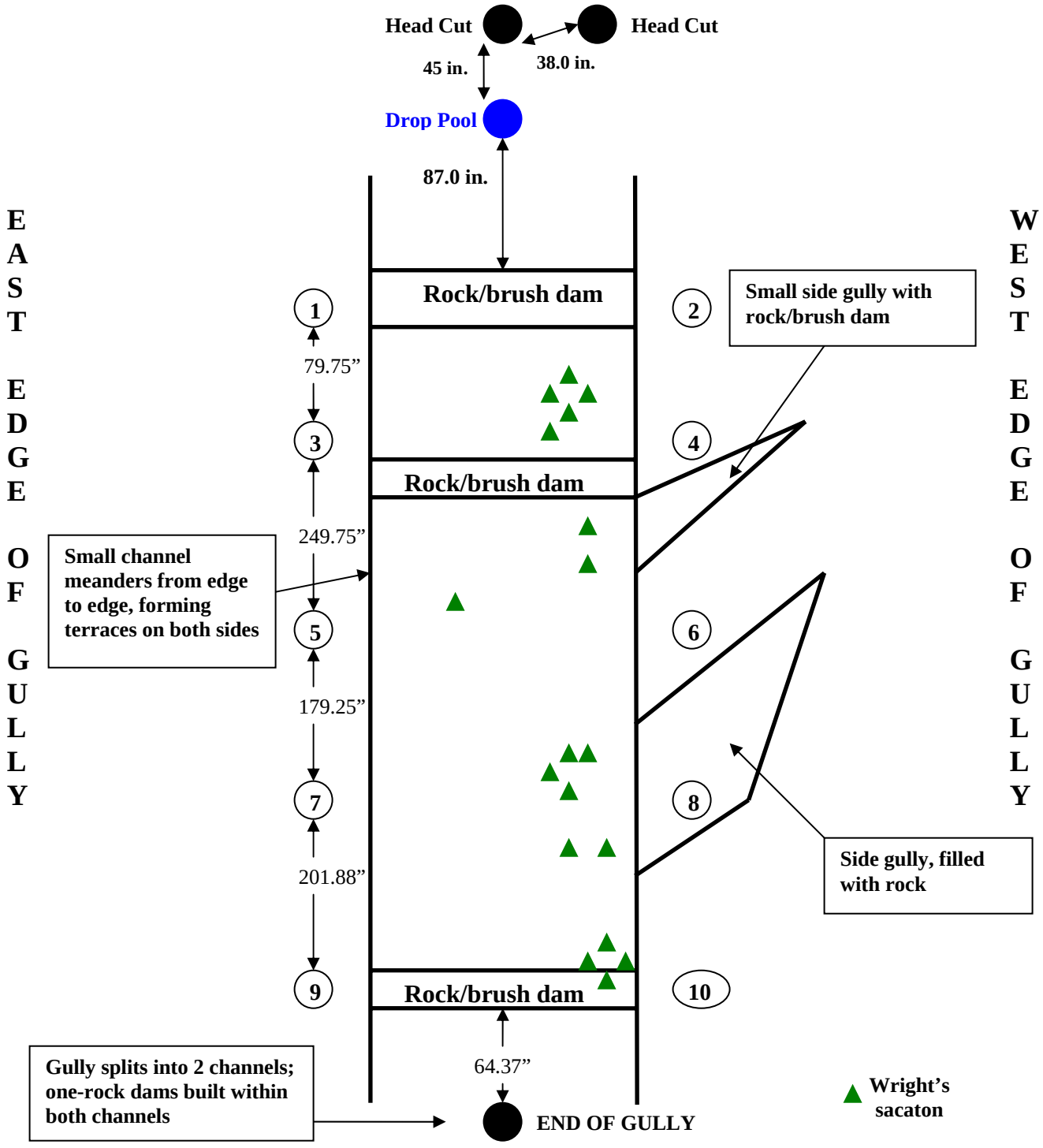


Figure 8. Rainfall measured at the Pantano Jungle site (data provided by caretakers and/or ALERT Flood Warning System)

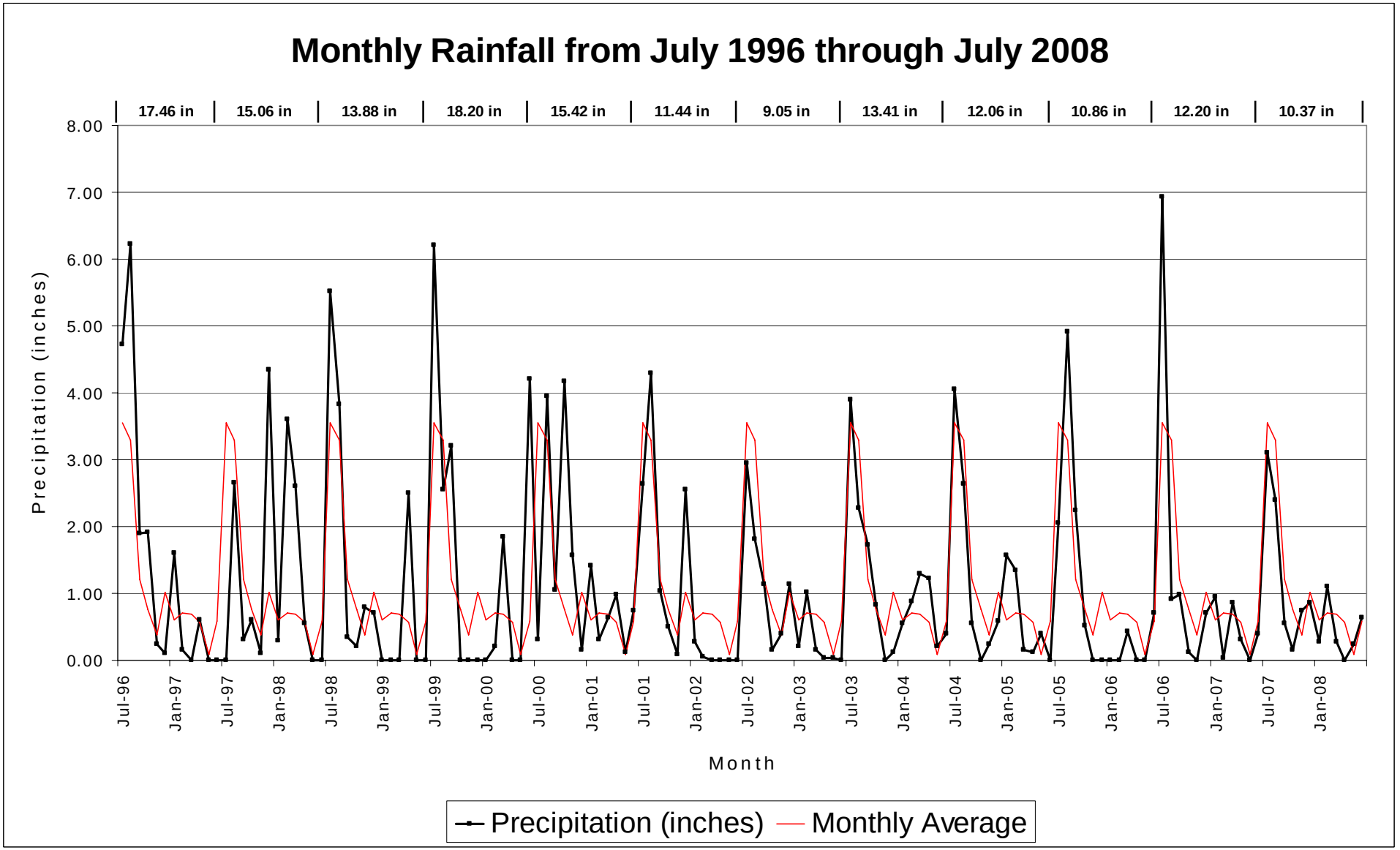
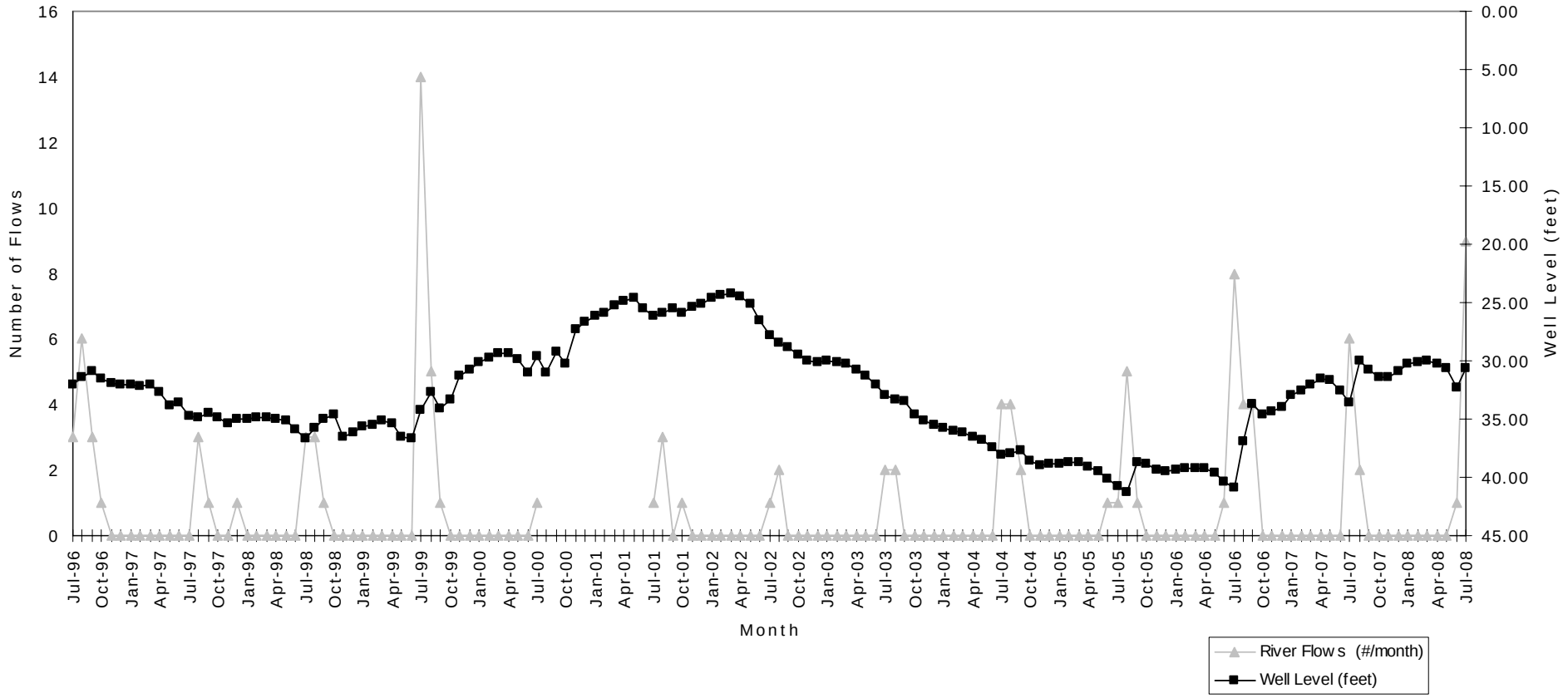


Figure 9. Water levels measured at the Jungle Well (located near NE corner of project site)



TABLES

Table 1. Plant list for the Partners for Wildlife Project

Species Name	Common Name	Type	Origin*	Number
Acacia greggi	Catclaw Acacia	Tree	Southern Arizona	15
Atriplex canescens	Fourwing Saltbush	Shrub	Site collection by others or by MSWN in Cochise County	76
Celtis reticulata	Netleaf Hackberry	Tree	Tucson	15
Chilopsis linearis	Desert Willow	Tree	site collection by others or by MSWN in Cuatro Cienegas, Mexico	15
Lycium pallidum	Pale Wolfberry	Shrub	Tucson	76
Prosopis velutina	Velvet Mesquite	Tree	Site collection by AGFD	228
Rhus microphylla	Littleleaf Sumac	Shrub	Dragoon foothills, Whetstone foothills	76
Sambucus cerulean var. Mexicana	Mexican Elderberry	Tree	Sonoita Creek, west of Sonoita	15
Sporobolus wrightii	Wright's Sacaton	Grass	Site collection by others	670
Zizyphus obtusifolia	Graythorn	Shrub	Mesa, Apache Junction	76

* Origin of seeds used for propagation of plants by Mountain States Wholesale Nursery (MSWN); mesquite plants propagated by Arizona Game and Fish Department (AGFD)

TABLE 2
PLANT MORTALITY FOR THE NORTHEAST AND SOUTHEAST MONITORING PLOTS

Plants	Total Planted	Total Dead											Yearly Mortality[c] (%)									
		1998	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
Catclaw Acacia[a]	3	0	0	0	0	0	0	0	1	0[e]	0	0	0	0	0	0	0	0	0	33	0	0	0
Elderberry	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0
Graythorn[a]	5	2	0	0	1	0	0	0	0[f]	0	0	0	40	0	0	33.3	0	0	0	0	0	0	0
Hackberry	14	0	0	0	3	1	0	7	2	0	0	0	0	0	0	21.4	9.1	0	70	66	0	0	0
Mesquite[b]	20	1	1	0	0	0	1	1	0	0	0	1[g]	5	5.2	0	0	0	5.6	5.9	0	0	0	6.7
Saltbush	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wolfberry[b]	1	NA	0	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	100	NA	NA	NA	NA	NA	NA	NA	NA
All	61	3	1	1	4	3	1	8	4	0	0	1	5	1.7	1.7	6.9	5.8	2	16.7	10	0	0	2.7

[a] Based on observations made in 1999 to the present, it appears that 3 catclaw acacias were mislabeled as graythorns in 1998. The three graythorns were not found during the 1998 monitoring session, so they were listed as dead. Later monitoring sessions have indicated three healthy catclaws in these locations.

[b] The one mesquite that died in 1998 was replaced by a wolfberry plant, which died by July 2000.

[c] Yearly mortality is determined by dividing the number of plants that died within the year by the total number of plants that were alive the previous year.

[d] Cumulative mortality is determined by dividing the total number of plants that died by the total number of plants planted.

[e] The one catclaw acacia that was recorded as being dead in 2005 had some new growth (green leaves) in 2006.

[f] The graythorn not found in 2005 was located in 2008, with a height of 6 inches

[g] Mesquite #24 in the Southeast Plot could not be located and is presumed to be dead

TABLE 2
PLANT MORTALITY FOR THE NORTHEAST AND SOUTHEAST MONITORING PLOTS

Cumulative Mortality[d] (%)
0
100
60
93
25
0
100
42.6

TABLE 3. Comparison of Plant Heights from July 1998 through July 2008

Plot	Plant #	Plant Type	Plant Height (inches)		
			1998	2008	Difference
NE	1	Mesquite	39	77	38
NE	2	Mesquite	34	NA	NA
NE	3	Mesquite	36	69	33
NE	11	Mesquite	28	50	22
NE	21	Mesquite	21	40	19
NE	22	Mesquite	22	59	37
NE	23	Mesquite	23	31	8
NE	24	Mesquite	24	61	37
NE	25	Mesquite	25	32	7
NE	26	Mesquite	26	55	29
NE	27	Mesquite	27	45	18
NE	28	Mesquite	28	35	7
SE	1	Hackberry*	76	98	22
SE	2	Hackberry	60	NA	NA
SE	3	Hackberry	86	NA	NA
SE	4	Hackberry	72	NA	NA
SE	5	Hackberry	63	NA	NA
SE	6	Hackberry	63	NA	NA
SE	7	Hackberry	74	NA	NA
SE	8	Catclaw Acacia*	22	32	10
SE	9	Catclaw Acacia*	15	22	7
SE	10	Hackberry	60	NA	NA
SE	12	Catclaw Acacia*	19	7	-12
SE	16	Hackberry	60	NA	NA
SE	17	Hackberry	63	NA	NA
SE	18	Mesquite	54	97	43
SE	19	Mesquite	20	84	64
SE	20	Mesquite	29	NA	NA
SE	21	Mesquite	48	83	35
SE	22	Mesquite	52	87	35
SE	23	Mesquite	24	NA	NA
SE	24	Mesquite	34	NA	NA
SE	26	Hackberry	62	NA	NA
SE	27	Hackberry	63	NA	NA
SE	28	Hackberry	42	NA	NA
SE	29	Hackberry	38	NA	NA
SE	30	Elderberry	35	NA	NA
SE	31	Elderberry	48	NA	NA

NA = Not Applicable (Plant perished during the course of the project)

* These plants were planted after the July 1998 survey, so heights were taken in July 1999

Table 4. Comparison of gully widths from 1997 to 2008

Marker #'s	Gully Widths (inches)											
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007[c]	2008
1-2	0	30	33	54.5	66	71	75	80.6	96	105	120.7	100.32
3-4 [a]	53	71	71	102.6	108	107	117.75	114.4	124	131	77	119.38
5-6	70	78	102.5	93	127	101	138.75	82.9	141	141	87	108
7-8	32	37.5	47	43.4	53	59.5	132	114.3	119	130	107.75	120.12
9-10 [b]	58	85	85	84.4	110	105	113	93.15	107	108	120	106.81

Table 5. Comparison of gully depths from 1997 to 2008

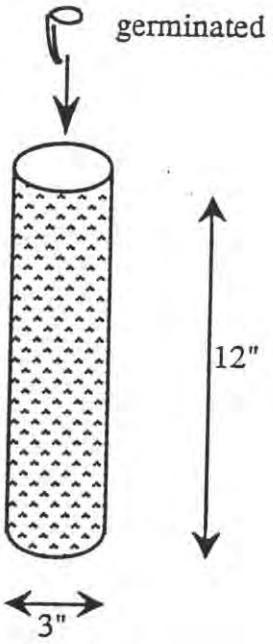
Marker #'s	Gully Depths (inches)											
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007[c]	2008
1-2	0	19.5	20	29.5	33	47	49	39	43	52.5	48.1	54
3-4 [a]	49.5	30	26.5	30	32	45	45	52.9	57	55.5	47.8	52.75
5-6	50	13.5	16	33	34	27	34	32.5	34.5	34.5	28.9	30.25
7-8	40.5	19	20	22	27	25	28.75	30.4	42	42	33.5	38
9-10 [b]	23	14	8	6.5	16	20.5	21.5	27.4	25.25	26	25	26.75

[a] Since Check Dam 1 was location at the original cross-section of these markers, they were moved 60 inches upstream in November 1997 to better monitor erosion at the upstream end of the gully.

[b] Since Check Dam 4 was located at the original cross-section of these markers, they were moved 56 inches upstream in May 1998 to better monitor erosion of the gully.

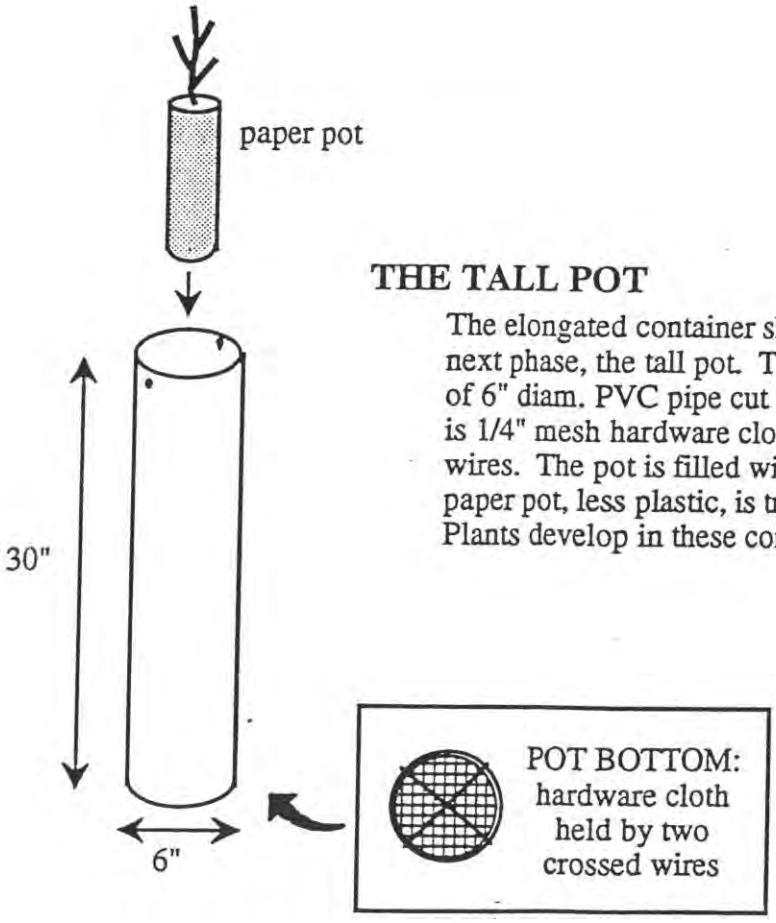
[c] The cross-sections were delineated in order to provide more accurate measurements of gully width and depth in June 2007.

APPENDIX A



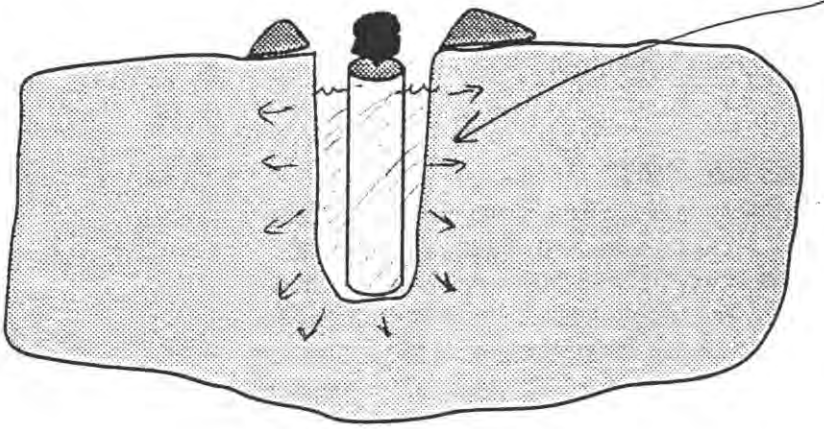
THE PAPER POT

The paper pot is the first stage of the container system. It is constructed of a single sheet of newspaper rolled into a tube and stapled, then wrapped in a single sheet of plastic wrap. This "pot" is used for both germinated seed or rooted cuttings, and measures 12" tall by 3" in diameter. This shape is critical for the early development of the plants' deep tap root systems, which can outstrip top growth by 10 to 1. Seedlings stay at this stage for 2-3 months.



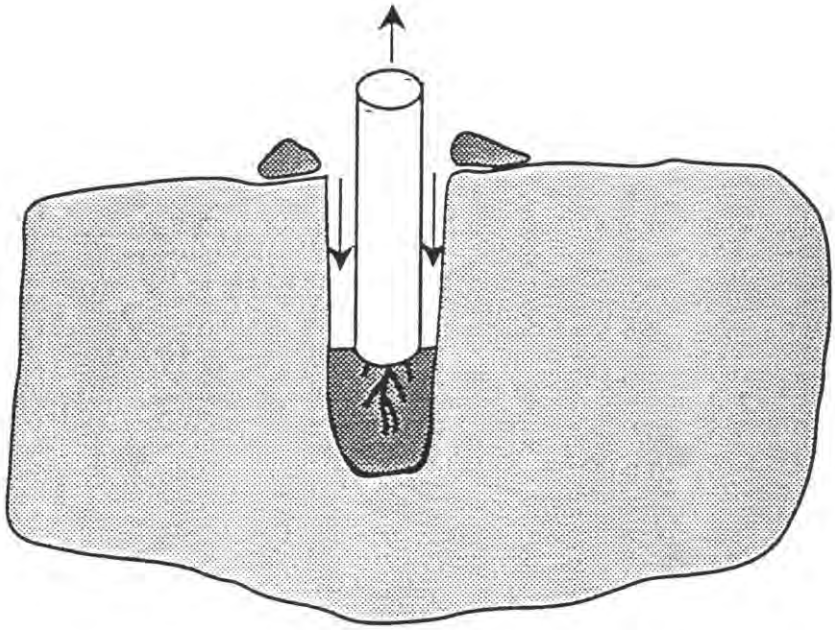
THE TALL POT

The elongated container shape continues into the next phase, the tall pot. This container is constructed of 6" diam. PVC pipe cut into 30" sections. The bottom is 1/4" mesh hardware cloth held in place by two crossed wires. The pot is filled with potting soil, and the entire paper pot, less plastic, is transplanted into the top of the pipe. Plants develop in these containers for up to two years.



1.

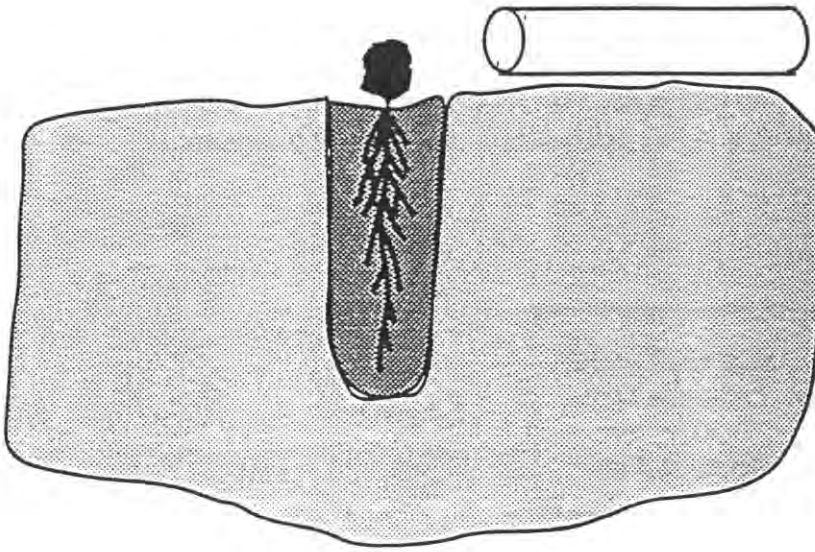
A hole is augered to fit the PVC pot. The crossed wires and hardware cloth are removed, and the potted plant is lowered into the hole.



2.

Using hay hooks, the pot is slowly raised up and around the plant as the hole is filled.

If plant sticks, push down from top with a 2x4.



3.

When finished, a mature plant with a well-developed root system has been placed in the ground. Plants excavated 3 years after planting showed the roots had lost the cylindrical pot shape, and had grown into the surrounding soil.

Return tubes to owner.

APPENDIX B

Monitoring Protocol for the Pantano Jungle PWP Project

January 30, 1998

Introduction

The specific project objectives include: (1) promoting the propagation and long term re-establishment of mesquite bosque habitat in an area that is currently dominated by non-native species, particularly grasses; and (2) increasing the structure and species diversity of native vegetation for the benefit of neotropical migratory birds. In order to accomplish these goals, a revegetation program has been designed and is being implemented. This monitoring plan, which outlines the methods and measurements which will be taken, has been developed to ensure that the revegetation project is progressing toward the ultimate goal of providing high quality habitat.

Based on these goals, the monitoring should provide information to: 1) identify mid-course changes in the project needed to correct problems such as those caused by rodent damage, water stress, insect damage, and other deleterious factors; and 2) to allow the Fish and Wildlife Service to evaluate the long-term success of the project and identify any possible changes needed for future projects. The monitoring methods will reflect the goals of the project. The monitoring methodology will need to be easily understood and well documented, work well over a relative long period, and be able to be completed in one day.

Guiding Principles

Principles guiding the monitoring program include:

1. Identify potential problems early enough in the project so that corrective action may be taken.
2. A major emphasis is placed on long-term monitoring and repeatability of the measurements.
3. The monitoring should be able to be done by a person(s) unfamiliar with the project with minimum of sampling expertise.
4. Monitoring can be accomplished in one day.

Sample plots

Two areas will be monitored under this plan: 1) a 3.8 acre section which will be planted with trees and shrubs and irrigated (irrigated section) and 2) a (13 acre section) area which has been fenced but not planted (non-irrigated section). Two 100 ft x 100 ft plots have been selected in the irrigated section which are representative, to the maximum extent possible, of the project site and different treatment types. These plots have been labeled according to their relative location within the planting site, "NE" (northeast) and "SE" (southeast).

Four 50 ft x 50 ft plots have been established to collect data on the recruitment (establishment) of trees and shrubs. One of these plots is located directly to the south of the planting area, labeled as "A". The other plot, labeled "B", is located in a representative area of the non-irrigated section. The other two plots are located in the northeast quadrants of plots "NE" and "SE". A map displaying the two monitored quadrants and the four recruitment quadrants is attached for reference.

Because the sampling is not necessarily statistically valid, the same individual trees and shrubs which are planted will be sampled throughout the monitoring life of the project. These trees and shrubs must be permanently marked so that the same individuals (or the locations were they were planted) can be found throughout the life of the project.

Trees and shrubs were marked by a 2 ft aluminum stake obtained from the Pima County Sign Department and driven into the ground a fixed distance and direction (azimuth from magnetic north) from the selected plant[1]. The stakes were engraved with information which identified each individual tree or shrub and their location surveyed in so that they can be easily located or it can be determined if they have been removed. Plant identifiers for each plot are exhibited in Tables 1 and 2.

Parameters

Parameters to measure include:

1. Plant survival/health (Objective definitions for each category need to be developed).
   a. Alive
   b. Stressed
   c. Dead
   d. Seed set

2. Growth rate. Annual growth rate will be determined by using data obtained from the photo points using the "MacArthur" board.

3. Recruitment (establishment of volunteer plants) of trees and shrubs will be sampled for each of the two treatment (irrigated and non-irrigated) areas. Recruitment will be determined by recording the number of trees and shrubs by species which were not planted (unmarked) in each of the four 50 ft x 50 ft plots[2]. The trees and shrubs must be at least 1 ½ foot tall at the time of the monitoring to be counted as being

[1] In the NE quadrant, stakes 4, 6, and 9 are located south of the plant to avoid irrigation lines.

[2] Some plants existed within the four plots prior to the installation of the monitoring program: 1) NE quadrant has two mature, non-planted mesquites and one graythorn; 2) SE quadrant has one >6 ft mesquite; 3) Plot A has two, >6 ft mesquites, one 4 ft lycium/condalia and one 18 in lycium/condalia; 4) Plot B has no trees or shrubs greater than 18 in tall.

recruited into the population from volunteer origin. Besides data on volunteer trees and shrubs, estimated percent cover by the 1st and 2nd dominate species will be collected for the herbaceous layer in each plot, if known, and recorded in the comments section of the data sheet.

4. Photo Points. Photo points will be established in the center of each 100 ft x 100 ft plot in the irrigated section and the center of each 50 ft x 50 ft plots in the non-irrigated section. A photograph will be taken at each of the cardinal directions based on magnetic north (N,S,E& W) from this known point on an annual basis. The photographs will be 35mm slides taken level (parallel with the ground surface). The focal length of the lens used for photographs will be the standard 50mm lens. In the center of each photo will be a modified MacArthur board consisting of a white board 18 inches wide and the height of the board will be equal to or greater than the tallest tree in the plot. The distance from the marker to the board will be 50 feet. On the board, in letters large enough to be legible in the slide will be the plot number, the direction the photograph is taken towards, and date, in that order. For example, a photo taken in plot no. 2, looking east on July 11, 1998 would be 2E 7/11/98.

Sampling Frequency and Season

Survival data and photo points will be taken annually (photo monitoring will be conducted annually for the monitoring life of the project) for the first three years after the project is completed or substantially completed. Recruitment and plant survival will be monitored in July and photo monitoring will be conducted in October. Baseline data on plant recruitment will be obtained prior to initiation of planting in November 1997. Survival will be monitored for the first three years of the project, then every 3 years thereafter. Table 2 outlines the monitoring schedule.

Monitoring Reports

The District shall submit monitoring reports by October 31 annually to the following addresses:

Director
Arizona Game and Fish Department
2221 West Greenway Road
Phoenix, Arizona 85023-4312
(602) 789-3249

State Supervisor, or
Partners for Wildlife Coordinator
U.S. Fish and Wildlife Service
2321 W. Royal Palm Rd, Suite 103
Phoenix, AZ 85021-4951
602/640-2720

The report shall include rainfall data through September 30, groundwater monitoring data through June 30, and vegetation and gully monitoring data. Copies of data sheets will be included, along with labeled slides.

Materials

Materials needed for monitoring include:

1. metal engraver
2. extra stakes
3. data sheets
4. pen
5. compass
6. 100 foot tape
7. Modified MacArthur board
8. black marker
9. white sheet paper
10. masking tape (to affix paper to Board)
11. 50 mm lens, slide film, and camera

Monitoring Maintenance

During each monitor session a check will be made to ensure that all of the aluminum stakes marking individual trees and shrubs, those marking the stratified and recruitment plots, and the photo point markers are in place. Stakes will be replaced as needed during the monitoring.

Table 1. Plant Identifiers Within the Northeast Monitoring Plot

Plant Number	Plot ID	Plant Type	Irrigation ID
1	NE	M	B
2	NE	M	B
3	NE	M	B
4	NE	SB	
5	NE	SB	
6	NE	SB	
7	NE	SB	
8	NE	SB	
9	NE	SB	
10	NE	SB	
11	NE	M	B
12	NE	SB	
13	NE	SB	
14	NE	SB	
15	NE	SB	
16	NE	SB	
17	NE	SB	
18	NE	SB	

Plant Number	Plot ID	Plant Type	Irrigation ID
19	NE	SB	
20	NE	SB	
21	NE	M	B
22	NE	M	B
23	NE	M	B
24	NE	M,E	B
25	NE	M	B
26	NE	M	B
27	NE	M	B
28	NE	M	B

Legend

Plant Type
M - Mesquite
W - Wolfberry
SU - Sumac
SB - Saltbush
A - Acacia
G - Graythorn
E - Elderberry
D - Desert Willow

Irrigation ID
B - Blocked
I - Irrigated
NI - Non-Irrigated

Note: Markers for shrubs were not labeled with an Irrigation ID because all shrubs are irrigated.

Table 2. Plant Identifiers Within the Southeast Monitoring Plot

Plant Number	Plot ID	Plant Type	Irrigation ID
1	SE	H	
2	SE	H	
3	SE	H	
4	SE	H	
5	SE	H	
6	SE	H	
7	SE	H	
8	SE	G	
9	SE	G	
10	SE	H	
11	SE	G	
12	SE	G	
13	SE	G	
14	SE	G	
15	SE	G	
16	SE	H	
17	SE	H	
18	SE	M	I

Plant Number	Plot ID	Plant Type	Irrigation ID
19	SE	M	I
20	SE	M	I
21	SE	M	I
22	SE	M	I
23	SE	M	I
24	SE	M	I
25	SE	M	I
26	SE	H	
27	SE	H	
28	SE	H	
29	SE	H	
30	SE	E	
31	SE	E	
32	SE	G	

Legend

Plant Type
M - Mesquite
W - Wolfberry
SU - Sumac
SB - Saltbush
A - Acacia
G - Graythorn
E - Elderberry
D - Desert Willow

Irrigation ID
B - Blocked
I - Irrigated
NI - Non-Irrigated

Note: Markers for shrubs were not labeled with an Irrigation ID because all shrubs are irrigated.

Table 3. Monitoring Schedule

Recruitment	Survival	Photo Monitoring
November 1997	X	X
July 1998	X	
October 1998		X
July 1999	X	
October 1999		X
July 2000	X	X
October 2000		X
October 2001		X
July 2002	X	X
October 2002		X
October 2003		X
July 2004	X	X
October 2004		
October 2005		X

APPENDIX C

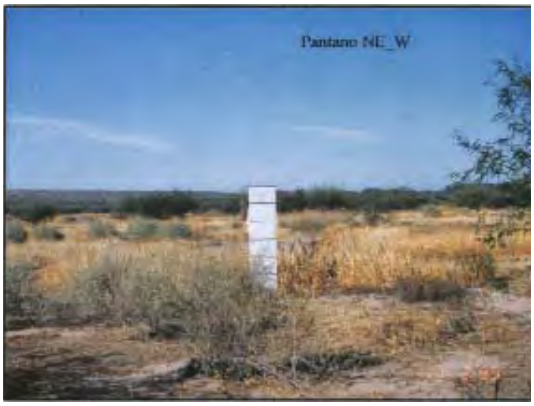
November 2, 1999

November 20, 2007

NE Plot
Looking North

NE Plot
Looking East

NE Plot
Looking South



NE Plot
Looking West

November 2, 1999

November 20, 2007

SE Plot
Looking North

SE Plot
Looking East

SE Plot
Looking South

SE Plot
Looking West

November 2, 1999		November 20, 2007
	**Plot A Looking North**	
	**Plot A Looking East**	
	**Plot A Looking South**	
	**Plot A Looking West**	

November 2, 1999

November 20, 2007

Plot B
Looking North

Plot B
Looking East

Plot B
Looking South

Plot B
Looking West

APPENDIX D

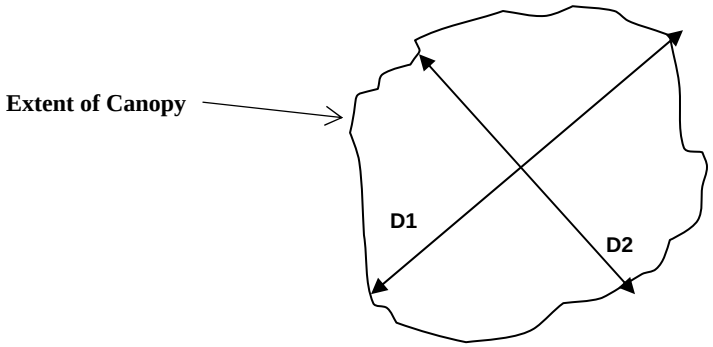
Canopy Cover

The extent of canopy cover from all of the woody perennial plants (existing, planted and recruited) was determined for the NE Plot and SE Plot. Crown cover for each plant was calculated using the following formula:

$$\left(\frac{D1+D2}{4}\right)^2 \pi$$

where D1 is the first canopy diameter measurement and D2 is the second canopy diameter measurement (Diagram 1). Only portions of the canopies occurring within the plot boundaries were used for this analysis. Percent cover of the woody perennials was determined for each plot by summing the crown covers, subtracting any overlapped canopy areas, dividing this value by the total plot area (10,000 ft^2) and multiplying the product by 100.

Diagram 1. Graphic of field measurements needed to calculate canopy diameter.



CANOPY COVER
Northeast Plot

Plant Type	Origin	Canopy Diameter (inches)		Canopy Diameter (feet)		Crown Cover	Overlap*	Canopy Cover@
		D1	D2	D1	D2	(ft^2)	(ft^2)	(% of Total Area)
mesquite	planted	86	74	7.17	6.17	34.89	0.00	0.35
mesquite	planted	0	0	0.00	0.00	0.00	0.00	0.00
mesquite	planted	27	44	2.25	3.67	6.87	0.00	0.07
mesquite	existing	412	428	34.33	35.67	961.63	0.00	9.62
saltbush	planted	90	102	7.50	8.50	50.24	0.00	0.50
saltbush	recruited	65	71	5.42	5.92	25.21	0.00	0.25
mesquite	existing	360	363	30.00	30.25	712.40	60.00	6.52
saltbush	planted	94	97	7.83	8.08	49.72	49.72	0.00
saltbush	planted	104	117	8.67	9.75	66.56	0.00	0.67
mesquite	existing	309	318	25.75	26.50	535.77	193.00	3.43
saltbush	planted	100	114	8.33	9.50	62.41	0.00	0.62
saltbush	planted	92	92	7.67	7.67	46.14	0.00	0.46
saltbush	planted	104	143	8.67	11.92	83.15	0.00	0.83
saltbush	planted	92	95	7.67	7.92	47.66	0.00	0.48
mesquite	recruited	19	21	1.58	1.75	2.18	0.00	0.02
saltbush	planted	42	49	3.50	4.08	11.29	0.00	0.11
saltbush	planted	107	111	8.92	9.25	64.77	0.00	0.65
saltbush	planted	110	117	9.17	9.75	70.23	0.00	0.70
saltbush	planted	120	144	10.00	12.00	94.99	0.00	0.95
saltbush	planted	60	66	5.00	5.50	21.64	0.00	0.22
saltbush	planted	95	95	7.92	7.92	49.20	0.00	0.49
saltbush	planted	85	88	7.08	7.33	40.79	0.00	0.41
saltbush	planted	112	130	9.33	10.83	79.81	0.00	0.80
saltbush	planted	100	100	8.33	8.33	54.51	0.00	0.55
saltbush	planted	96	108	8.00	9.00	56.72	0.00	0.57
mesquite	recruited	18	12	1.50	1.00	1.23	0.00	0.01
mesquite	recruited	15	17	1.25	1.42	1.40	0.00	0.01
mesquite	planted	34	37	2.83	3.08	6.87	0.00	0.07
mesquite	recruited	81	107	6.75	8.92	48.17	0.00	0.48
mesquite	recruited	49	46	4.08	3.83	12.30	12.30	0.00
mesquite	existing	293	406	24.42	33.83	665.89	0.00	6.66
mesquite	existing	216	184	18.00	15.33	218.06	20.00	1.98
mesquite	existing	265	230	22.08	19.17	333.93	12.00	3.22

* Amount of crown cover that is overlapped by another plant's crown cover

@ Crown cover minus overlap

CANOPY COVER
Northeast Plot

Plant Type	Origin	Canopy Diameter (inches)		Canopy Diameter (feet)		Crown Cover	Overlap*	Canopy Cover@
		D1	D2	D1	D2	(ft^2)	(ft^2)	(% of Total Area)
mesquite	recruited	21	29	1.75	2.42	3.41	0.00	0.03
mesquite	recruited	16	15	1.33	1.25	1.31	0.00	0.01
mesquite	existing	293	215	24.42	17.92	351.70	49.00	3.03
mesquite	existing	220	412	18.33	34.33	544.35	17.00	5.27
mesquite	existing	552	297	46.00	24.75	982.34	0.00	9.82
mesquite	existing	419	370	34.92	30.83	848.40	262.00	5.86
mesquite	planted	41	81	3.42	6.75	20.28	0.00	0.20
mesquite	planted	34	43	2.83	3.58	8.08	8.08	0.00
mesquite	planted	34	37	2.83	3.08	6.87	0.00	0.07
mesquite	planted	8	10	0.67	0.83	0.44	0.44	0.00
mesquite	planted	36	54	3.00	4.50	11.04	11.04	0.00
mesquite	planted	30	38	2.50	3.17	6.30	0.00	0.06
mesquite	planted	35	46	2.92	3.83	8.94	0.00	0.09

	Crown Cover (ft^2)	**Canopy Cover (% of Total Area)**
Existing	6154	55
Planted	1060	10
Recruited	95	1
Total	**7310**	**66**

* Amount of crown cover that is overlapped by another plant's crown cover

@ Crown cover minus overlap

CANOPY COVER
Southeast Plot

Plant Type	Origin	Canopy Cover (inches)		Canopy Diameter (feet)		Crown Cover (ft^2)	Canopy Cover (% of Total Area)
		D1	D2	D1	D2		
hackberry	planted	45	52	3.75	4.33	12.82	0.13
hackberry	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
mesquite	recruited	57	49	4.75	4.08	15.31	0.15
mesquite	recruited	84	92	7.00	7.67	42.22	0.42
mesquite	recruited	53	64	4.42	5.33	18.66	0.19
mesquite	recruited	84	87	7.00	7.25	39.85	0.40
catclaw acacia	planted	11	16	0.92	1.33	0.99	0.01
catclaw acacia	planted	19	31	1.58	2.58	3.41	0.03
hackberry	planted	0	0	0.00	0.00	0.00	0.00
catclaw acacia	planted	4	4	0.33	0.33	0.09	0.00
catclaw acacia	planted	4	4	0.33	0.33	0.09	0.00
graythorn	planted	0	0	0.00	0.00	0.00	0.00
graythorn	planted	0	0	0.00	0.00	0.00	0.00
graythorn	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
mesquite	planted	75	101	6.25	8.42	42.22	0.42
mesquite	planted	68	69	5.67	5.75	25.58	0.26
mesquite	planted	0	0	0.00	0.00	0.00	0.00
mesquite	planted	60	63	5.00	5.25	20.62	0.21
mesquite	planted	83	125	6.92	10.42	58.96	0.59
mesquite	planted	0	0	0.00	0.00	0.00	0.00
mesquite	planted	0	0	0.00	0.00	0.00	0.00
mesquite	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00
hackberry	planted	0	0	0.00	0.00	0.00	0.00

APPENDIX E

Pantano Jungle/Tributary Watershed Project

Field Notes - 6/17/97

By David Scalero, Hydrologist

Gully Monitoring Program

The goal of this project is to establish reference points along a gully which could be used to monitor changes in width and depth with time. The gully is located on a hillside, just south of a former farm field where revegetation efforts are currently ongoing. This gully has been created by extensive water erosion along an abandoned dirt road. Grading of the dirt road removed an underlying gravel mantle layer, thus exposing fine layered sediments which were easily eroded by hillslope runoff. Efforts are being made to arrest this erosion. The gravel layer was replaced last year by a youth group provided by the Pima County Operations Division. A group of volunteers is currently being solicited to help with the construction of check dams, which will be used to trap sediments contained within the hillslope runoff and restore the hillside to a more natural state.

Thin strips of cut-up, aluminum road signs were used to mark the reference points along the gully. A total of ten markers were staked into the ground. The first two were used to identify the location of the headcut. The midpoint of a line between the markers indicates where erosion of the gully begins. The remaining stakes were combined into four sets, each set containing two a piece. The two markers in each set were placed on opposite sides of the gully and measurements were taken of the distances from each marker to their respective gully edge, the total distance between the two markers, and the maximum depth of the gully between the two markers. Gully width was determined by subtracting the sum of the distances of each marker to the gully edges from the total distance between the markers. A thin cord was tied to each stake so that the measurements would be taken along a straight line. The cord was lowered down to the ground surface adjacent to the gully so that the depths of the gully could be accurately monitored.

Since the west side of the gully had extended into the hillside, determining an edge to measure from was difficult. To solve this problem, I determined to use a point with the same elevation as that of the east edge. Table 1 summarizes the initial measurements taken along the gully. In addition to the table, I have included an abstract diagram showing the top view of the gully monitoring system with the initial measurements taken (Figure 1). The total length of the gully is approximately 72 feet.

A small hillside gully is located between Marker 8 and the west edge of the main gully. This small gully is approximately 30 inches wide and has a depth of 15.5 inches. Along a straight line between Markers 7 and 8, the distance measured between the west edge of the main gully and the east edge of the small gully is 21 inches. The small gully eventually connects with the main gully about 5-6 feet downstream of this point.

Three photo points have been established to provide a photographic reference of the erosion, and the subsequent erosion control efforts, for the hillslope gully. The first photograph was taken

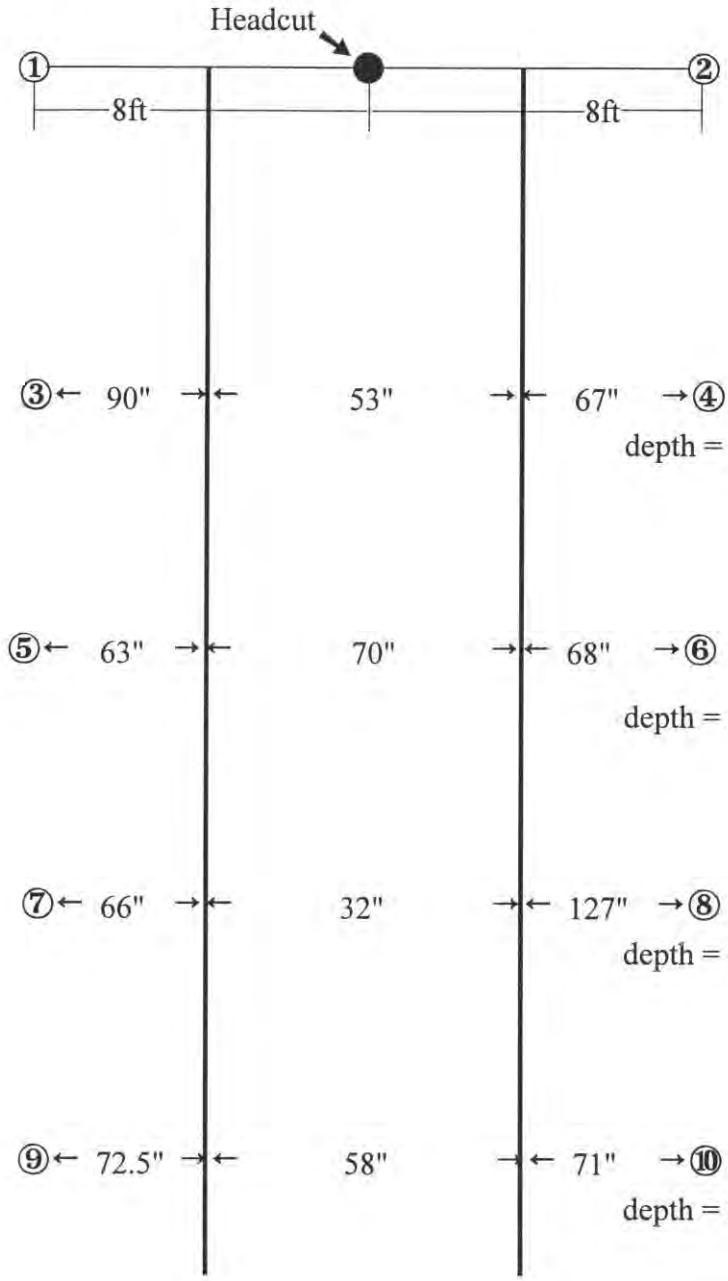
from the sacaton planting area at the base of the hill, looking south towards the gully. The main reference for this photograph is the small mesquite tree, located near the center of the photo. The second photograph shows a closeup view of the gully, looking uphill (upstream). This shot was taken approximately 5 feet from the downstream end of the gully. The last photo shows the gully from the upstream end looking downhill. The shot was taken approximately five feet from the headcut. All of the original photographs were taken in May of 1996. Due to difficulties with the camera and the quality of film, the photos for May 1997 did not turn out very well. A better set of photographs was taken during June of 1997, so this will be used as the reference set. For future monitoring purposes, photographs should be taken during the month of May.

TABLE 1. INITIAL GULLY EROSION MEASUREMENTS

Marker #'s	Distances Between Markers and Edges of the Gully (inches)	Total Distance Between Markers (inches)	Gully Width (inches)	Gully Depth (inches)	Comments
1-2	----	192	0[a]	0	Midpoint of the line between these two markers indicates headcut beginning.
3-4	90 + 67 = 157	210	53	49.5	
5-6	63 + 68 = 131	201	70	50	
7-8	66 + 127 = 193	225	32	40.5	A small gully is located between Marker 8 and the west edge of the main gully. It has a width of 30" and a depth of 15.5".
9-10	72.5 + 71 = 143.5	201.5	58	23	This point is approximately 4 feet from the end of the gully.

[a] The small stream from which the headcut occurs at this point is approximately 12 inches wide and 4 inches deep.

MONITORING SYSTEM FOR GULLY EROSION



CANOPY COVER
Southeast Plot

Plant Type	Origin	Canopy Cover (inches)		Canopy Diameter (feet)		Crown Cover (ft^2)	Canopy Cover (% of Total Area)
		D1	D2	D1	D2		
mesquite	existing	225	206	18.75	17.17	253.16	2.53
mesquite	recruited	61	68	5.08	5.67	22.68	0.23
elderberry	planted	0	0	0.00	0.00	0.00	0.00
elderberry	planted	0	0	0.00	0.00	0.00	0.00
graythorn	planted	35	46	2.92	3.83	8.94	0.09

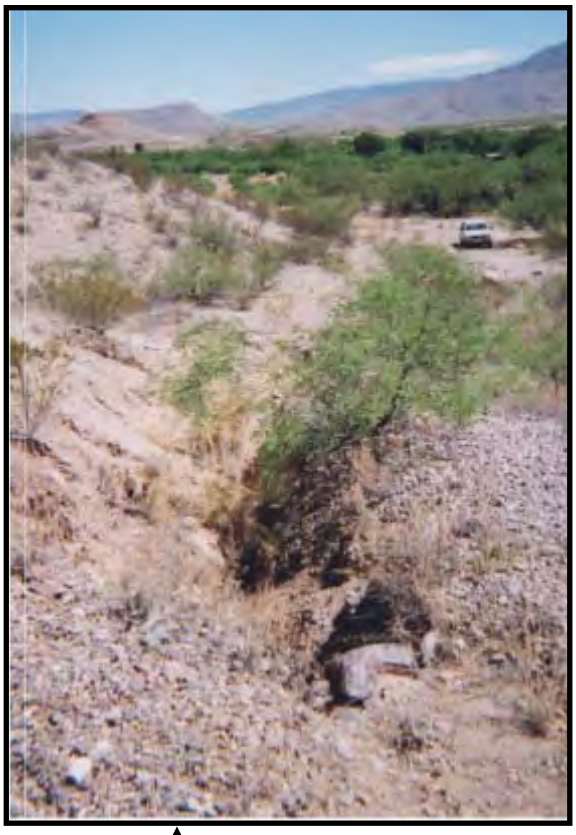
	Crown Cover (ft^2)	Canopy Cover (% of Total Area)
Existing	253	3
Planted	174	2
Recruited	139	1
Total	**566**	**6**

APPENDIX F

Appendix F. Photographs taken from gully headcut, looking downstream (towards North)

May 1996

June 1998



June 2002

January 2009

Appendix F. Photographs taken at base of gully, looking upstream (towards South)

← May 1996

← June 1998

June 2002 →

January 2009 →

Appendix F. Photographs taken from base of hillslope, looking upstream (towards South)

← May 1996

June 1998 ↓

↑ June 2002

January 2009 →