FINAL REPORT

UPPER VERDE VALLEY RIPARIAN AREA HISTORICAL ANALYSIS

Submitted by
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Submitted to
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This report is submitted to fulfill
Task 7
Grant 98-057 WPF.

The Arizona Water Protection Fund Commission has funded a portion of this report. 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 nor Northern Arizona University.

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INTRODUCTION

Researchers at Northern Arizona University entered into a contract with the Arizona Water Protection Fund to conduct a study on historic changes of riparian vegetation in the Verde Valley. AWPF granted $44,019.00 for the study and NAU matched with $20,431.00. Work began in May 1999 and was completed in February 2001. This report is a task-by-task summary of the study's accomplishments. Management recommendations are included, based on the study's results. At the end of the report is an evaluation of project success.

Frequently throughout this report the reader is referred to the "Assessment of Human Influence on Riparian Change in the Verde Valley, Arizona" [Assessment report]. The Assessment report gives detailed information about the Upper Verde Valley Riparian Area Historical Analysis. It is the "companion" report to this final report.

Personnel

Abraham Springer, PhD, NAU Department of Geology, was the grantee and served as primary investigator. He supervised the work of research assistant Sharon Masek Lopez. Work done by Ms. Masek Lopez included the following:

- Arranged for the purchase of aerial photos (Task 1).
- Wrote the study plan (Task 2).
- Created a website, arranged for a press release, was interviewed by local news media, and responded to inquiries resulting from the public outreach (Task 3).
- Searched for background literature and data (Task 4).
- Mapped historic riparian vegetation and compiled results of GIS cover analyses (Task 5).
- Wrote an assessment of human influence on riparian change (Task 6).
- Wrote this final report (Task 7).
- Prepared a poster for the Information Transfer Meeting (Task 8).

Ms. Masek Lopez also arranged for geographers to assist with Task 5 and supervised their work. Kyle Bohnenstiehl created digital aerial photo imagery and analyzed ArcView covers to relate changes in distribution of riparian vegetation. Geographer Loretta Morgan mapped historic land use with the assistance of geographer Angela Marino and geologist Jeff Kennedy. Geographer Paul Lauck mapped historic Verde River morphology.

Others who should be acknowledged for their contributions to this project include Claudette Piper (NAU Grants and Contracts Office), Marlene Nibisti (NAU Sponsored Projects), Barbara Williamson (NAU Public Affairs), Susan Sabala-Foreman (NAU Dept. of Geology Office Manager), volunteer Daniel Borich, Nancy Burnett (Cottonwood resident) and the Cottonwood Nature Club.

TASK 1: OBTAIN AERIAL PHOTOGRAPHY

Task Description: NAU shall purchase and/or borrow stereo aerial photography of the Verde River study area depicting one year from each decade form the 1930s through the 1990s, as possible. Purchase will be from the U.S. Department of Agriculture, the U.S. Geological Survey, The National Archives, Arizona department of Transportation, the Fairchild Collection, Rupp Aerial Photos, and/or any other appropriate source. Acquisition of the aerial photography shall be initiated immediately upon execution of this contract, prior to Study Plan approval (see Task 2).

Deliverable: Progress report on aerial photos purchased and/or borrowed, including receipts and invoices.
Delivered: June 19, 2000
Budget: $ 2,550.00 (reimbursable cost)
Spent: $ 2,526.50

Aerial Photographs were purchased from three sources. Table 1. summarizes the photography obtained. For more description of the aerial photographs see page 8 of the report titled "Assessment of Human Influence on Riparian Change in the Verde Valley, Arizona" [Assessment report].

Table 1. Aerial photos purchased for Task 1 of the Upper Verde Riparian Area Historical Analysis.

YEAR	DATE FLOWN	AGENCY	PROJECT	SYMBOL	SCALE	COLOR	SOURCE	EXPENDITURE
1940	9/23/40	SCS	USDA 8920	COU	1:31,680	B/W	National Archives	$ 518.23
1954	12/19/54	SCS	SCS-16-54	DXI	1:20,000	B/W	National Archives	$ 460.72
1968	5/25/68	Forest Service		ETB	1:15,840	B/W	USDA	$ 185.00
1977	10/15/77	Forest Service	613090		1:24,000	color	USDA	$ 154.00
1989	5/20/89	Forest Service	613090		1:12,000	color	USDA	$ 436.00
	6/6/89	Forest Service	613090		1:12,000	color	USDA	---
	6/2/90	Forest Service	613040		1:40,000	color infrared	USDA	---
	8/2/90	Forest Service	623040		1:15,840	color	USDA	---
1995	6/20/95	Yavapai County	GIS		1:15,840	color	Rupp	$ 772.55
	6/1/97	Forest Service	613090		1:15,840	color	USDA	(included in '89 cost)

TASK 2: PREPARE AND SUBMIT STUDY PLAN

Task Description: The Grantee shall prepare and submit a study plan consistent with the ADWR study plan outline. Study plan shall identify and describe all methods to be used to conduct this project including factors to be evaluated and mapped; mapping; literature search; factors used to assess human impact; public outreach program; and identification of areas containing appropriate conditions for restoration, enhancement and maintenance of riparian vegetation. The plan shall also include a description of aerial photography to be acquired (type, date taken, scale, etc.) and a discussion of why that particular photography is chosen. After initial approval of the study plan, the study plan methodology may need to be changed as the project progresses. The Grantee shall submit in writing any changes or modifications of the method for approval to the ADWR Project Manager, prior to implementation.

Deliverable: Study Plan
Delivered: May 20, 1999 (revised August 25, 2000 and February 28, 2001)
Budget: $ 1,103 (fixed cost)
Spent: $ 1,103

The study plan went through two iterations, because the methodology changed slightly. Originally, we planned to outline tree stands on mylar overlaid on the aerial photos and then digitize the overlays in either ArcInfo or ArcView. Instead, we created digital images of the aerial photos and digitized directly on the computer screen using ArcView software. This allowed for greater precision and accuracy in our mapping. Furthermore, the georeferenced digital images are a great resource that can be used in future investigations (Figure 1). See Appendix A for a complete copy of the final study plan.

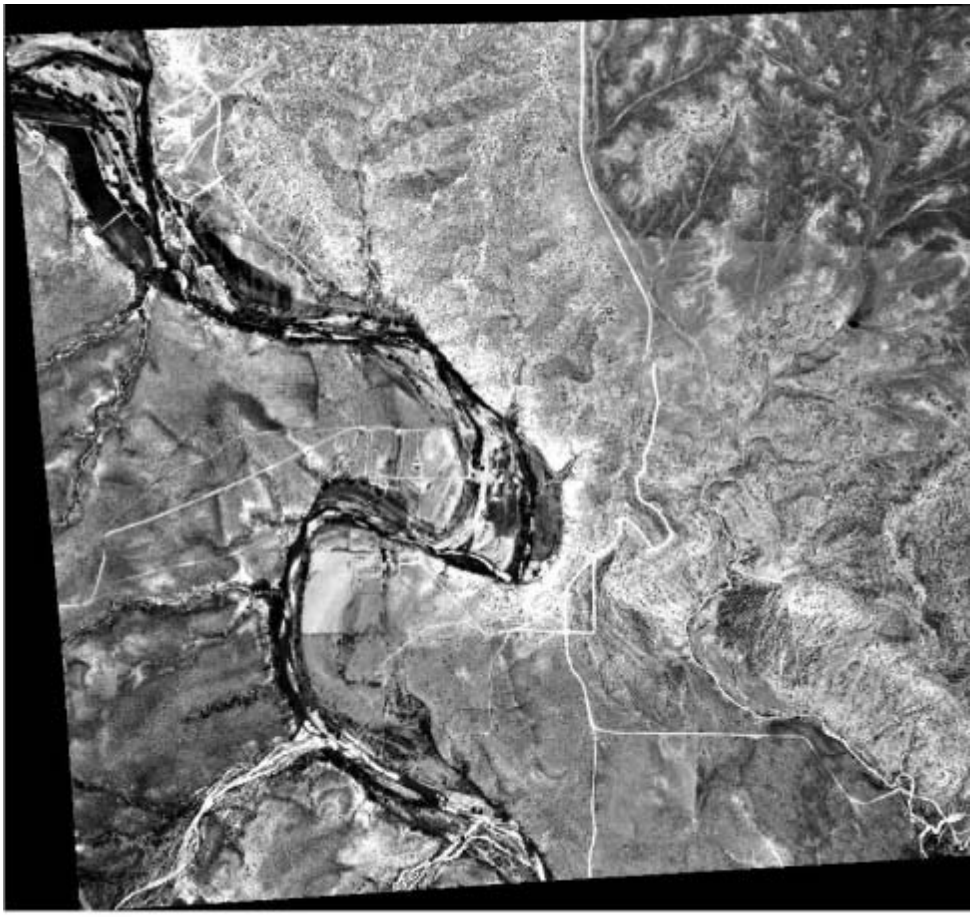

Figure 1. Example of a digital image used for digitizing.
Aerial photograph of Verde River near present-day Verde Village in 1968, prior to Verde Village development.

TASK 3: CONDUCT PUBLIC OUTREACH

Task Description: The Grantee shall conduct a public outreach component of this project. The methodology shall be described in the study Plan and shall be comprised mainly of a website to distribute study information and newspaper articles to notify the public of the study. The website shall be maintained until the end of the contract period.

Deliverable: Copy of website home page and press release(s).
Delivered: December 6, 1999
Budget: $ 2,300 (fixed cost)
Spent: $ 2,300

For this task, we created a website with the URL http://vishnu.glg.nau.edu/verde. The site contains four pages:

- Upper Verde Valley Riparian Area Historical Analysis Home Page
- Research Plan
- What's New
- Links

After the website was published on the internet, NAU Public Affairs Office distributed a news release about the study. Subsequent to the news release, Sharon Masek Lopez was interviewed by newspapers and radio stations. (See Appendix B for copies of articles). Newspaper and newsletter articles, radio news features, and a TV news spot appeared in the following places:

- Cottonwood Journal Extra
- Sedona Red Rock News
- Verde Independent
- "Confluence" newsletter of the Verde Watershed Association (VWA)
- "Arizona Water Resource" newsletter of University of Arizona, Water Resources Research Center
- KAZM radio
- KAFF radio
- KNAZ Channel 2 News

Several people contacted Ms. Masek Lopez after reading articles and/or website. Two people, Daniel Borich and Nancy Burnett, became volunteers on the project after reading about it in the newspaper. Mr. Borich helped research history of smelters. Mrs. Burnett conducted an inventory of dying cottonwood and willow trees. Also as a result of the outreach, hydrologist Winn Hjalmerson offered helpful comments and later reviewed the Assessment report. The study's website has now been linked to a website for the Verde Watershed Research and Education Program at NAU (http://verde.nau.edu).

Sharon Masek Lopez made several presentations regarding the study:

October 1999	Presented study design to an NAU geography class.
September 1999	Met with the Cottonwood Nature Club and gave them guidance on a cottonwood-willow mortality study that came about because of this study (see Assessment report, page 20).
February 2000	Gave an update to the VWA Natural Resources Committee.
August 2000	Presented geology, hydrology, and riparian history of the Verde Valley to The Nature Conservancy staff at their request.
November 2000	Gave a brief summary of study results at a Verde Riparian Corridor Workshop.
January 2001	Presented results to the VWA Natural Resources Committee and had the work peer-reviewed by the committee's members.

TASK 4: CONDUCT BACKGROUND LITERATURE AND DATA SEARCH

Task Description: The Grantee shall conduct an extensive literature and data search for information needed to complete the study, in accordance with methodology in the Study Plan. Information shall include Verde Valley history, water use values for riparian plant species along the Verde River, ecology of riparian vegetation regeneration, geology and hydrology of Verde Valley, historical climate data, and well data.

Deliverable: Summary of literature review
Delivered: December 6, 1999
Budget: $ 4,943 (fixed cost)
Spent: $ 4,943

A literature and data search was conducted using several media. Search venues included:

- NAU's Cline Library catalogue
- ASU online catalogue
- Silver Platter
- Yahoo internet search
- HotBot internet search

Approximately 700 references were found and submitted to AWPF on disc as a document file. We must recognize the Verde Watershed Association and especially Jim Byrkit for their excellent bibliography that contributed nearly half of the entries in our bibliography. We listed our references both alphabetically and by subject. Subjects included:

Ecology	Planning
Evaluation / Monitoring	Plant Identification
Floods / Flood Plain	Policy & Regulations
Geology	Recreation
Grazing	Remote Sensing & Riparian Mapping
History – regional	Restoration & Enhancement
History – Verde Valley	Sand & Gravel Mining
History – vegetation change	Smelter Damage
Hydrology – general & regional	Water Quality
Hydrology – Verde Valley	Wildlife
Management	Miscellaneous

Reference data found included the following:

- Climate data for Cottonwood, Tuzigoot, Jerome, and Prescott
- Well data from the Wells55 and GWSI databases
- Water use values for riparian plants
- Streamflow data from USGS gauges "Verde River near Clarkdale" and "Oak Creek near Cornville"
- History gleaned from local residents Nancy and Mike Burnett and museums, including Jerome State Historic Park, Jerome Historical Society, Clemenceau Historical Society Museum, and Fort Verde State Historic Park

TASK 5: INTERPRET AERIAL PHOTOS AND CREATE GIS DATABASE

Task Description: Consistent with approved changes in the Study Plan, the Grantee shall interpret aerial photography and transfer riparian vegetation information to ArcView themes in digital format using an upright digitizing method. In addition, and consistent with the Study Plan, build a GIS database for each year of aerial photos and produce maps of riparian vegetation. Analyze the changes in plant species composition, density and distribution.

Deliverable: Progress Report to discuss the aerial photo interpretation methods, copy of GIS maps and database and summary of vegetative analysis.
Delivered: February 28, 2001
Budget: $ 27,633.00 (reimbursable)
Spent: $ 27,633.00

Prolific maps and digital photo images were produced in the course of this study. Altogether, fifty-six (56) ArcView feature themes were generated (Table 2). These themes are included in an ArcView project on a CD inside the back cover of the Assessment report. Aerial photos were scanned and georeferenced, and photomosiacs were made from some of the digital images. (Table 3). The images were not included on CD in the Assessment report, because the file sizes were so large that many CDs would have been needed. For more detailed description of the mapping and image creation, see the Assessment report, pages 8-11.

Table 2. ArcView feature themes created for Task 5,
Upper Verde Valley Riparian Area Historical Analysis.

Cover Type	No. of Themes	Attributed
Study Area Boundary	1	Yes
Riparian Vegetation		
cottonwood/willow	6	Yes
mesquite	6	Yes
Land Use		
agriculture	6	No
commercial/industrial	6	No
high density residential	6	No
low density residential	6	
addon/adjust	3	No
River Morphology		Yes
channel & bare sediment	6	Yes
addon/adjust	5	No
Index Wells	2	No
Sand and Gravel Impacts	3	No

Table 3. Digital imagery produced to accomplish Task 5,
Upper Verde Valley Riparian Area Historical Analysis.

Year	Total File Size*	Number of Images	Mosaics
1940	187 MB	8 photos	
1954	115 MB	13 photos	
1968	273 MB	15 photos. 1 mosaic	Camp Verde boundary to Hwy 89 bridge
1977	329 MB	19 photos, 1 mosaic	Camp Verde boundary to Hwy 89 bridge
1989	695 MB	7 photos, 3 mosaics	Camp Verde boundary to Hwy 89 bridge, strips north and northwest of bridge
1995	505 MB	18 photos, 1 mosaic	Camp Verde boundary to Hwy 89 bridge
1997	136 MB	12 photos	
(* Individual photo images range from 10,000 KB to 12,000 KB)			

TASK 6: ASSESS HUMAN INFLUENCE ON RIPARIAN VEGETATION

Task Description: Consistent with the Study Plan methodology, the Grantee shall assess the extent to which riparian changes are human-caused. Grantee shall conduct an analysis of human-caused changes in riparian vegetation location, type, density, and water use in the Verde Valley.

Deliverable: Preliminary report on assessment of human influence.
Delivered: February 28, 2001
Budget: $ 2,100.00 (fixed cost)
Spent: $ 2,100.00

A 43-page report was written titled "Assessment of Human Influence on Riparian Change in the Verde Valley, Arizona" [Assessment report]. The Assessment report is the companion to this final report. In the Assessment report we described the geology, climate, and hydrology or the study area, gave a history of human inhabitation, described the study methods, gave the results, and discussed those results. The report contains 18 tables and 21 figures to make information easily available to readers.

Particular sections of the report convey the substance of the analysis of human influence. These sections are the Results, the Discussion, and the Appendices. Appendix D shows estimated changes in riparian water use as fulfillment of the contract.

Cause and effect relationships are difficult to determine in complex and continually changing systems such as riparian systems are. We found that we could identify trends in both natural influences and human influences on riparian vegetation, but not all trends proved to be statistically significant using simple linear regression. We could not infer causation from the trends with any certainty. Perhaps future studies will be able to establish the cause and effect relationships in a more definite way. Even so, the analyses and information provided in the Assessment report should be valuable to agencies and the public as they plan their approaches to managing riparian vegetation in this region. Inside the back cover of the Assessment report, there is a CD ROM containing maps as ArcView shapefiles depicting historic riparian vegetation, which should be helpful in designing restoration projects.

TASK 7: FINAL REPORT

Task Description: Grantee shall prepare a final report. The final report shall provide information on all technical as well as public outreach components of this project. It shall include a description of background, methods, results, conclusions and identification of riparian areas containing appropriate condition for restoration, enhancement and maintenance of riparian vegetation. It will also evaluate project success measured against the objectives.

Deliverable: Final report and electronic copy of final report
Delivered: February 28, 2001
Budget: $ 2,940.00 (fixed cost)
Spent: $ 2,940.00

This final report is intended to be a concise summary of all aspects of conducting this study. For in depth description of the "background, methods, results, and conclusions" as required by the contract, see the Assessment report. The "Recommendations" section below fulfills the contract terms for "identification of riparian areas containing appropriate conditions for restoration, enhancement and maintenance of riparian vegetation". The final section of this report evaluates "project success measured against the objective."

TASK 8: ATTEND INFORMATION TRANSFER MEETING

Task Description: The Grantee may attend an AWPF Information Transfer Meeting and participation in either an oral presentation or a poster presentation about this project. The value of this task is a $500.00 fixed cost to compensate the Grantee for their expertise and participation in the meeting.

Deliverable: Photograph of poster to be used at AWPF Information Transfer Meeting with an abstract, or copy of paper to be presented.
Delivered: March 23, 2000
Budget: $ 500.00
Spent: $ 500.00

A poster was presented at the AWPF Information Transfer Meeting on March 23, 2000 (Figure 2). Due to advanced pregnancy, Ms. Masek Lopez did not attend the meeting. Instead, she sent her poster with senior geology student Jeff Kennedy who was familiar with the project since he has assisted with the land use mapping.

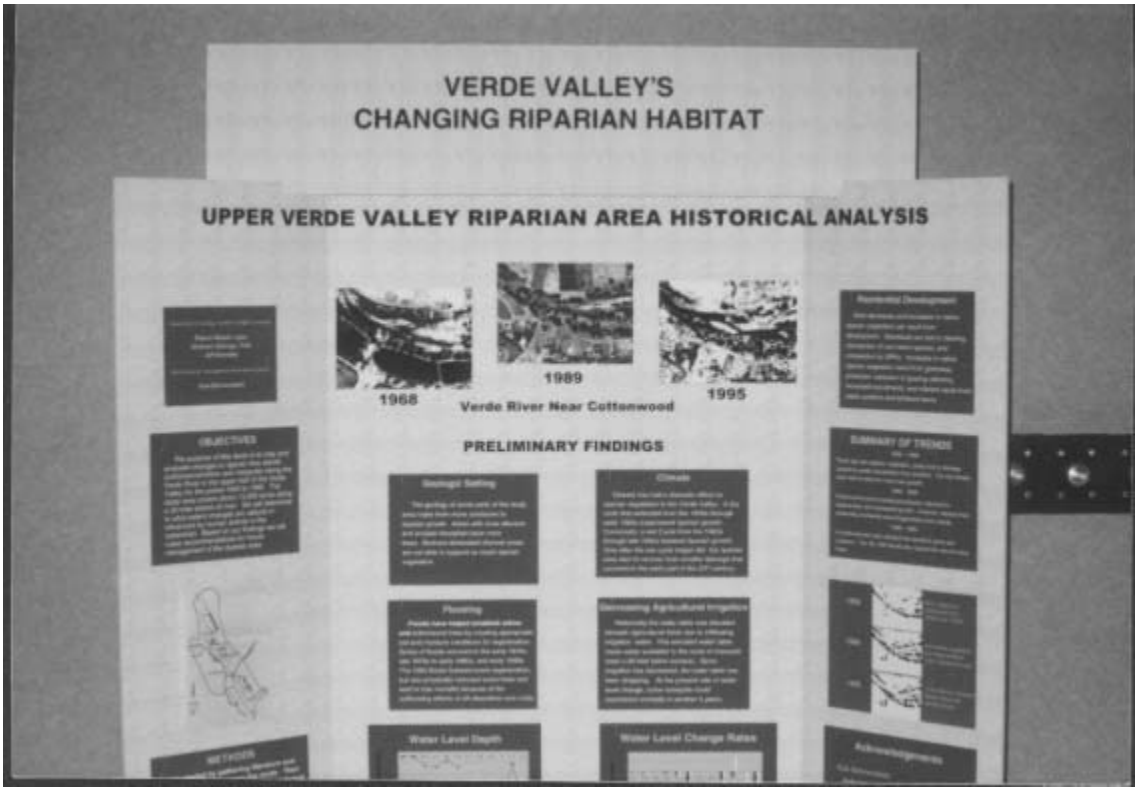

Figure 2. Photograph of poster presented at AWPF Information Transfer Meeting, Upper Verde Valley Riparian Area Historical Analysis.

RECOMMENDATIONS

The following recommendations are based on results of the Upper Verde Valley Riparian Area Historical Analysis as reported in the "Assessment of Human Influence on Riparian Change in the Verde Valley, Arizona". These views are the Grantee's and do not necessarily represent those of the Arizona Water Protection Fund Commission, nor the Arizona Department of Water Resources, nor Northern Arizona University. The recommendations propose possible management actions. However, this is by no means an exhaustive list of all places that riparian habitat can be preserved or enhanced in this area.

If there are landowners interested in understanding the riparian community on their property and preserving or enhancing it, we recommend that they read the Assessment report, view the attached ArcView shapefiles, and consider ways of enhancing, restoring, or maintaining riparian vegetation on their property. In many cases, the distribution of vegetation in 1977 can serve as a guide, because 1977 was the year we observed peak distribution of riparian vegetation. However, some places may have peaked earlier or later, so inspection of all the riparian shapefiles is recommended to evaluate the desired condition. It is important to understand that only certain places seem capable of supporting vigorous riparian growth. Restoration efforts should be focused on those areas.

General Recommendations

Non-native plant species

Two non-native plant species appear to successfully compete with native riparian vegetation in the study area. In the past decade, tree-of-heaven (genus *Ailanthus*) and tamarisk (genus *Tamarix*) have increased noticeably.

Ailanthus prefer moist sites and compete vigorously for water and nutrients with native riparian trees. Some residents have observed a marked increase of *Ailanthus* in the riparian area over the past 30 years. Eradication programs in the riparian area would probably benefit native riparian vegetation.

Tamarisk or "salt cedar" has been in the active channel area of this study area at least since 1940. There is a large decadent stand of tamarisk at the base of the slag heap in Clarkdale and some other old stands in the mile upstream of the slag heap. Residents have noticed an increase in young tamarisk since the 1993 flood. Some young tamarisk appears to out-compete young cottonwood and willow, as observed at Dead Horse Ranch State Park by the Cottonwood Nature Club. Eradication programs could benefit native riparian vegetation, but it is important to first weigh the environmental cost of trying to remove tamarisk from the system.

Although a slope analysis was not performed, it appears as if the old tamarisk stand at the base of the slag heap at Clarkdale may actually be working to stabilize the base of the slag heap. Removal of the vegetation is not recommended without somehow providing structural or alternative vegetative stability to the sand bar at the base of the slag heap. Perhaps a program of gradually restoring native vegetation would be preferred to any sudden change.

Grazing

Grazing in the riparian area appears to negatively affect riparian vegetation, particularly cottonwood and willow (see page 25 of the Assessment report). Exclusion of grazing from the active channel area is recommended. If landowners must water cattle at the river, structures could be built to allow minimal access to the channel. Cost-sharing programs could facilitate the building of such structures.

Tree pathogens

Numerous pathogens are attacking riparian trees in the Verde Valley, including septoria fungus, pleurotus fungus, wet wood bacteria, and mistletoe. Surveys should be conducted to locate areas of concentrated disease. Such areas should be further investigated for potential mitigation.

Water conservation

Depth to groundwater appears to be increasing in Cottonwood west of the river. Whereas the water table was above the level of the river at one time, it now lies below the level of the river in places. Whether this has any effect on the flow of the Verde River and water available to riparian vegetation is unknown. Research is needed to thoroughly describe any groundwater-surface water interaction at Cottonwood. In the meantime, it is prudent to recommend conservation of groundwater in order to avoid the potential of diminishing flow in the Verde River. Public awareness programs are recommended. If in the future it is shown that the dropping water table does affect flow of the river, then more stringent water conservation programs are advised.

Recommendations by Municipality or Home Owner Association

Town of Clarkdale

The Town of Clarkdale could help protect riparian vegetation through planning, zoning, and city ordinances. Planning and zoning to establish greenway protection for tributary washes could preserve mesquite habitat that supports wildlife. Ordinances governing treatment of the Verde River corridor could protect cottonwood and willow. Of particular concern would be young cottonwood and willow growth established subsequent to the 1993 and 1995 floods, because there are some healthy new stands at Clarkdale that, if sustained, could become important mature stands in the future. Also, holistic water management programs could help alleviate stress to groundwater or increase recharge to aquifers.

Town of Cottonwood

Like the Town of Clarkdale, the Town of Cottonwood could use planning, zoning, and city ordinances to protect mesquite habitat in tributary washes and cottonwood-willow in the Verde River corridor. In addition, we recommend that the city inventory invasive non-native trees (tamarisk, tree-of-heaven) and diseased cottonwood and willow trees at Riverside Park. Diseased trees should be treated if possible. Invasive trees should be eradicated, unless eradication compromises Southwestern Willow Flycatcher habitat or has other undesirable environmental consequences. Also, holistic water management programs could help alleviate stress to groundwater or increase recharge to aquifers.

An opportunity exists at Riverside Park to do some restoration work. The area of cottonwood-willow decreased between 1977 and 1995. By examining the tree distribution in 1977, park managers might visualize possible placement of trees if they choose to implement revegetation programs. See the Dead Horse Ranch State Park recommendation below for a map showing 1977 vegetation distribution (Figure 5).

Verde Village Homeowners Association

The Verde Village Homeowners Association established a protected corridor along the river adjacent to Verde Village properties. Excluding off-road vehicles has apparently improved the condition of the riparian area, since fragmented tree stands have coalesced.

Some large old cottonwoods have been dying in the corridor at Verde Village in the last few years. Perhaps they were stricken with some of the diseases previously mentioned, or maybe there is another cause. If there are citizens interested in taking the initiative, they could inventory dead and dying trees in the corridor, try to determine what is causing the mortality, and treat the trees if possible.

Another problem in the corridor at Verde Village is invasion of tree-of-heaven and tamarisk. Work parties could be organized to try to eradicate invasive non-native trees, with the understanding that only certain methods are usually successful. We recommend the homeowners association consult with The Nature Conservancy on this matter.

Recommendations by land ownership

National Forests

In the North Fringe of our study area, which is Prescott National Forest west of the river and Coconino National Forest east of the river, riparian vegetation has changed very little in the past 60 years. This may be because the river is generally incised into the Verde Formation and there is little room for the channel morphology to shift causing gain or loss of vegetation on the bars. On the other hand, it might be because cattle grazing suppressed regeneration of riparian trees during this period. Recently, the national forests have moved to exclude grazing from the river corridor. The next few years will be very informative as to whether the apparent stability of the riparian area from 1940 to 1995 was natural or influenced by grazing pressure.

In the South Fringe of the study area, just upstream of the Oak Creek confluence and east of the river, there is a patchwork of land ownership including some Coconino National Forest land. In the SW 1/4, NW 1/4 Section 20, T15 N, R4E, there is a stand of mesquite that has persisted since 1954 and increased in density (Figure 3). Even though the balance of mesquite in the NW 1/4 is mostly low density, it does appear to support much bird life and there is potential for tree stand density to increase. We recommend that the Forest Service protect the mesquite stands by excluding cattle grazing (or continuing to do so as the case may be). Because other mesquite stands on nearby private properties seem to form a habitat mosaic together with tree stands on public land, we recommend the Forest Service work together with neighboring land owners to provide a comprehensive approach to protecting this riparian habitat that benefits bird life.

West of the river in the South Fringe on Prescott National Forest land, there are several tributary washes with persistent mesquite stands which have increased in density over time (Figure 3). We recommend that the Forest Serve protect at least the first quarter mile of these tributary washes, because they form habitat embayments along the Verde River.

Although it may not be necessary to state this, retaining public land in the South Fringe is a keystone to protecting the riparian area from residential development. We recommend that the Forest Service retain all lands in this area and add lands as possible. The riparian maps included on CD in the Assessment report could serve as a guideline in identifying lands to potentially acquire, as they become available for purchase, transfer, or exchange.

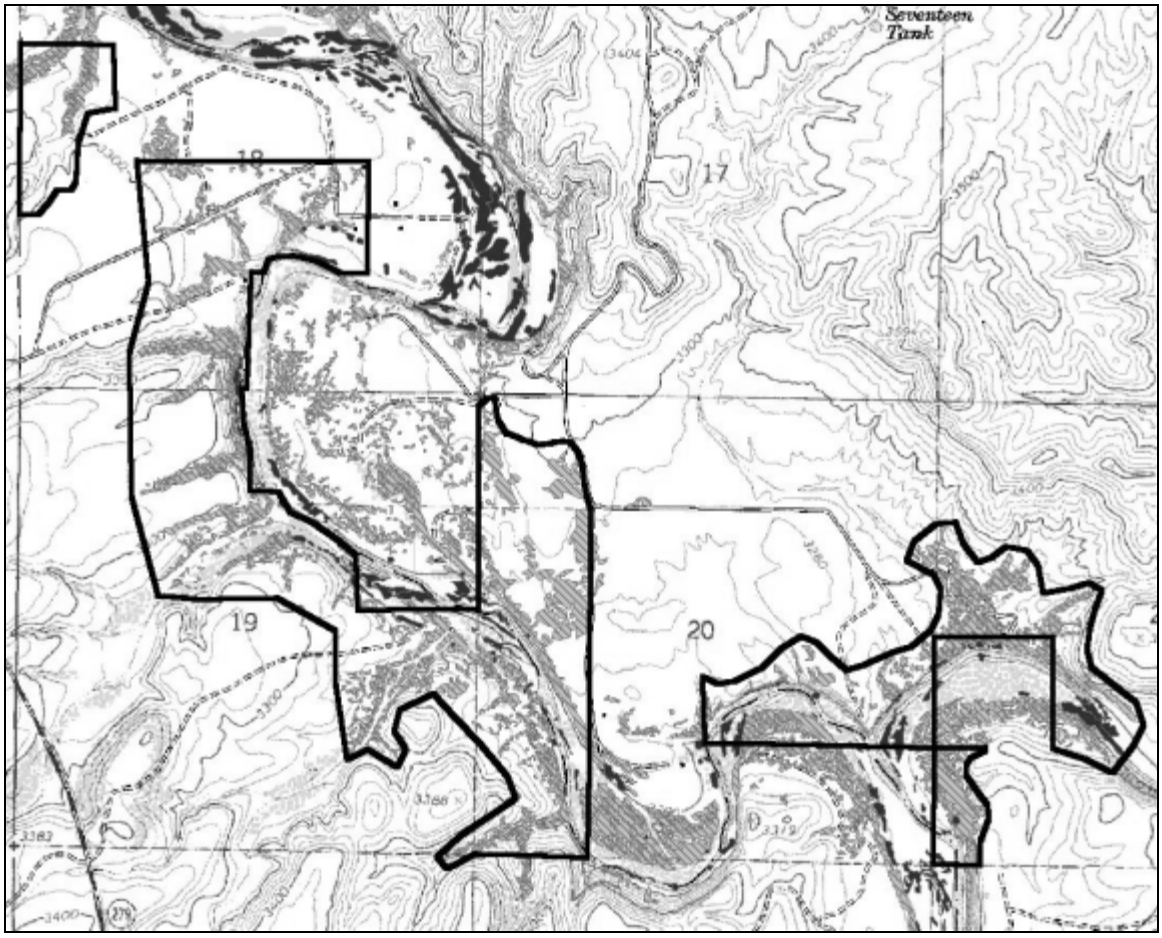

Figure 3. This map outlines national forest lands (in the vicinity of the Oak Creek confluence) having riparian vegetation that merits preservation. Cottonwood-willow is shown as dark polygons along river. Mesquite stands are shown as lighter polygons with diagonal hashing.

Yavapai-Apache Nation

We recommend the Yavapai-Apache Tribe work together with the City of Clarkdale to establish greenway protection for tributary washes that contain mesquite habitat. In particular, there is an uncommon mesquite-hackberry stand in the SE 1/4 of Section 20, T16N, R3E that merits preservation (Figure 4).

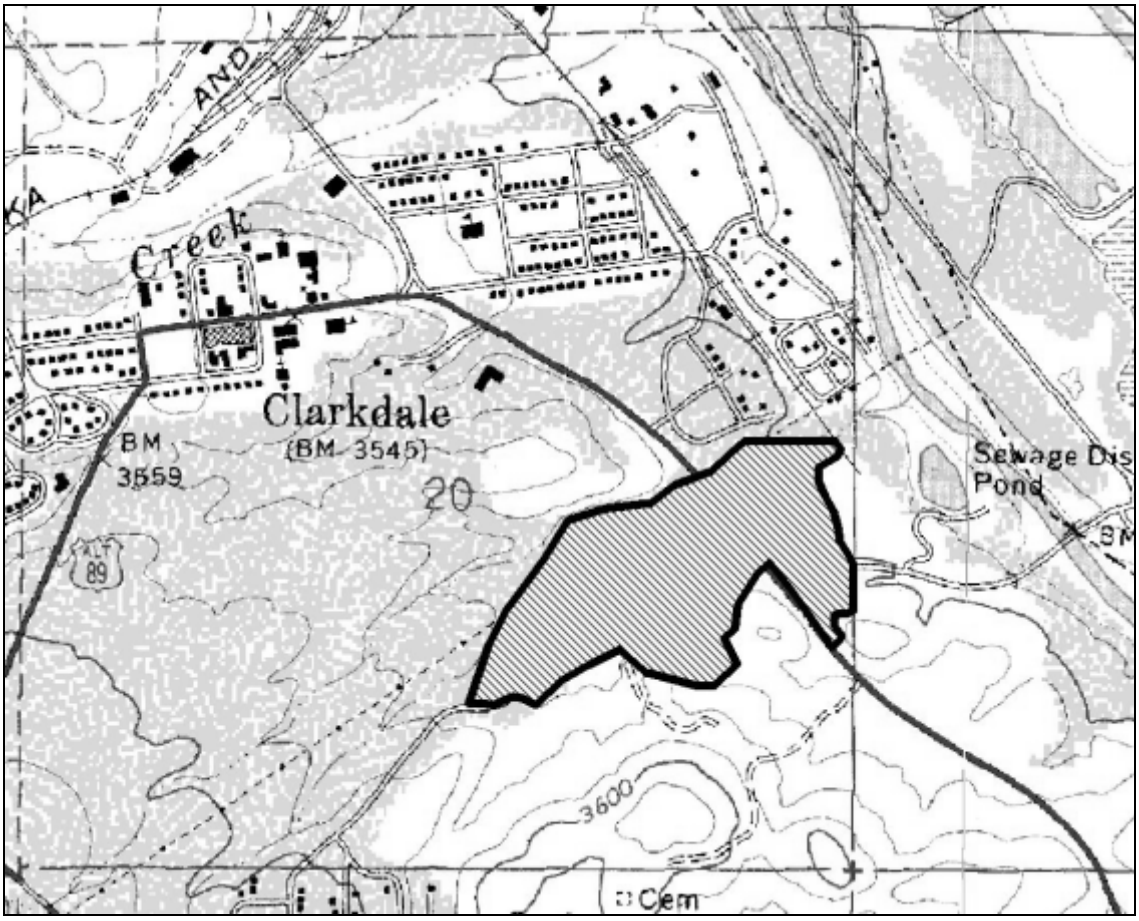

Figure 4. The polygon with diagonal hashing shows the location of some mesquite stands on Yavapai-Apache land, including an uncommon mesquite-hackberry stand, recommended for preservation. Upper Verde Valley Riparian Area Historical Analysis.

Dead Horse Ranch State Park and Verde River Greenway

The Arizona State Parks Department (ASP) has purchased 410 acres of land between Tuzigoot and Bridgeport bridges for the Verde River Greenway. Combined with Dead Horse Ranch State Park, ASP manages a total of 735 acres in the riparian corridor and has a unique opportunity to implement a comprehensive riparian management program. We recommend ASP take the following actions:

- Inventory diseased riparian trees and treat if possible.
- Attempt to eradicate tamarisk and tree-of-heaven if appropriate, after consideration of possible environmental consequences (such as change in available bird habitat).
- Design and implement restoration programs based on vegetation that existed in the area at the peak of cottonwood-willow distribution, c. 1977 (Figure 5).
- Attempt to vegetate former Valley Concrete sand & gravel mine site to stabilize sediment. Plant cottonwood, willow, and other native riparian plants near the river channel and mesquite farther from the channel in places where it existed historically.
- Promote cooperation with neighboring private landowners in the Verde River Greenway.

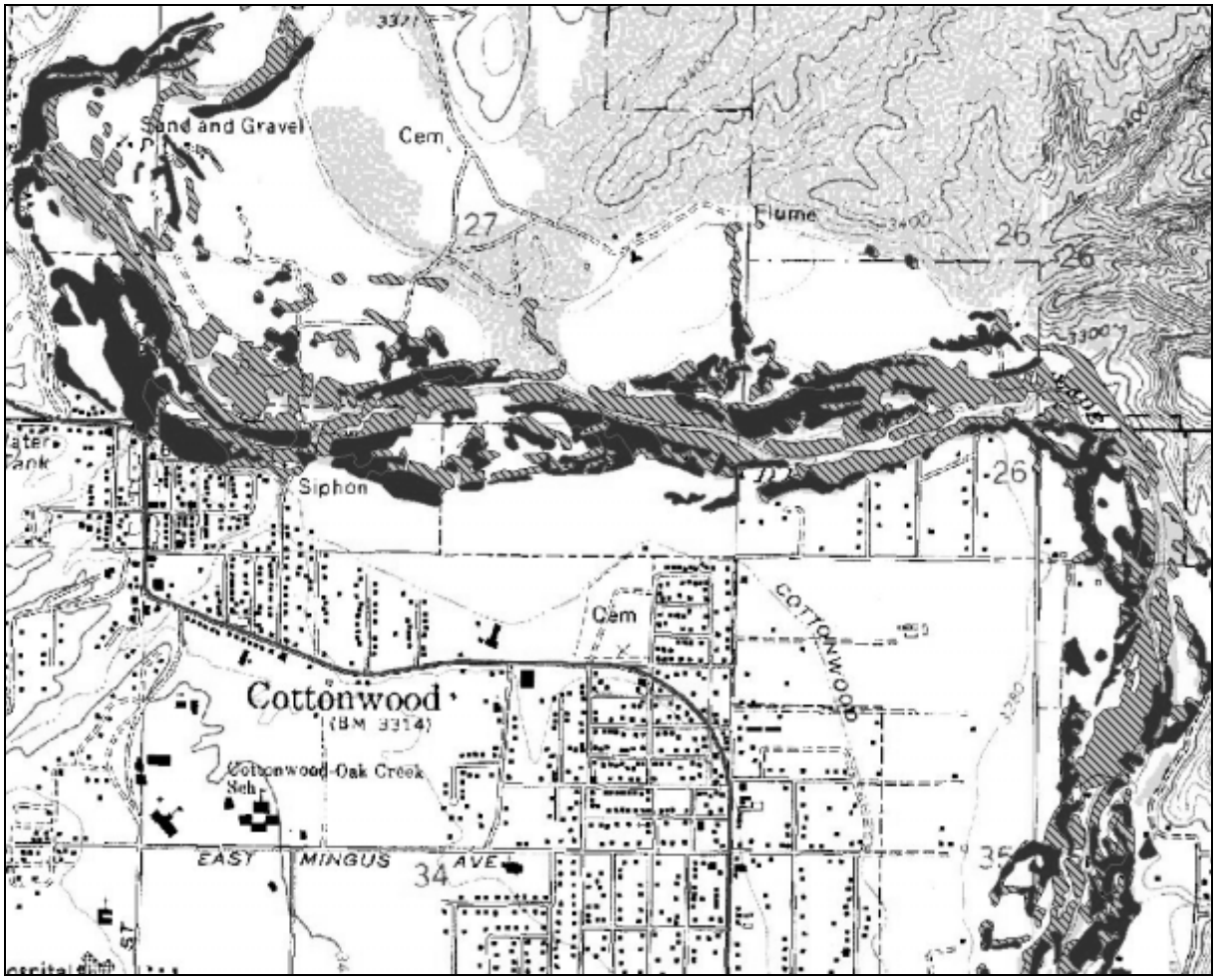

Figure 5. In the vicinity of Dead Horse Ranch State Park, we recommend that restoration efforts focus on sites where cottonwood-willow existed in 1977 (light polygons with diagonal hashing on this map). The distribution of cottonwood-willow in 1995 (dark polygons overlying 1977 polygons) clearly shows a pronounced decrease in vegetation in the active channel area between 1977 and 1995. Upper Verde Valley Riparian Area Historical Analysis.

EVALUATION OF PROJECT SUCCESS

The purpose of this final section is to evaluate project success as measured against objectives. Following are the Objectives, as stated in the grant proposal, and evaluation of the success of meeting these objectives:

> **Objective #1:** Determine riparian vegetation type, density, and area by interpreting historic aerial photographs of the Upper Verde Valley from each decade ranging from the 1930s to the present.

Aerial photography was not available for our study area for the 1930s (although it exists for the Camp Verde area for 1934), so we started with 1940 photography which was the earliest available. For each decade from the 1940s through the 1990s, we mapped riparian vegetation by type (mesquite or cottonwood-willow) and density (high - 100%, medium 70%, low - 30%) and calculated area for each type and density using ArcView software. We were fully successful in meeting this objective. Furthermore, we generated maps of land use and river morphology that were helpful in assessing the influences on riparian change.

> **Objective #2:** Compare the historical riparian system with the modern system to determine changes in vegetation and define reference reaches which display stability over time.

We compared the historical riparian system (1940 - 1989) with the modern system (1995) and determined changes in vegetation. These changes were related as text, tables and graphs in the Assessment report so that the information is easily accessed. Because of continual changes, we were not able to define specific reference reaches that showed stability over time. We did state that riparian vegetation on national forest land in the North Fringe changed very little, but because this vegetation does not necessarily represent the optimum condition, we are hesitant to call the area a reference reach. What we were able to state is that the riparian vegetation seemed to be at its peak around 1977 and that the conditions in 1977 might be used as a guide in designing restoration efforts. We were successful in this objective insofar as we were able to achieve it.

> **Objective #3:** Assess the relationships between vegetation changes and climatic factors, human land use activities, and varying groundwater levels to determine which vegetation changes were caused by human activities in the watershed.

Much effort went into achieving this objective. We inspected the climate record of three weather stations and two streamflow gauges. We carefully and completely mapped land use for six decades. We sorted through the well records of approximately 1600 wells in the study area to identify index wells. Then we used these index well records to generate three water table profiles showing changes in the water table, which might influence the riparian area. We discovered that cause and effect relationships are extremely difficult to substantiate. What we were able to do was display trends in climate, river morphology, water table levels, land use, and riparian vegetation coverage. These trends suggest relationships between natural phenomena or human activity and changes in riparian coverage. Based on the trends, we qualitatively evaluated the extent of natural and human influence on the riparian area. We were successful in this objective insofar as we were able to achieve it.