APPENDIX A - STUDY PLAN

UPPER VERDE VALLEY RIPARIAN AREA
HISTORICAL ANALYSIS

INTRODUCTION

The goal of the Upper Verde Valley Riparian Area Historical Analysis is to compare the historical riparian system with the modern system to determine what changes have occurred in riparian vegetation, from the 1940s through the present. This will be accomplished though interpretation of historical aerial photos and analysis using GIS. Human impact on the riparian area will be evaluated by assessing the relationships between vegetation changes and human land use activities, groundwater level variation, and climate variation. The results of the analysis will be used to make recommendations for the preservation, enhancement, and restoration of riparian habitat.

Project Location

The study area, referred to as the Upper Verde Valley Riparian Area, is approximately a 13,000-acre area which extends along the Verde River corridor from three miles below the Oak Creek confluence to seven miles above Clarkdale and includes the lower reaches of Oak Creek. This corridor ranges in width from approximately 300 to 5,000 feet. See attached map.

Personnel

Northern Arizona University personnel on this project includes three people and additional staff as needed.

- Abe Springer, PhD is a geology professor specializing in hydrogeology. He will act as Primary Investigator and review all work including reports. He is the official contact at NAU.

- Sharon Masek Lopez is a hydrologist and a student at NAU. She will act as the Research Assistant. In this capacity she will perform the following duties: write the research plan, obtain the aerial photographs, design and maintain the website, conduct a literature and data background search, interpret the aerial photos, digitize some or all of the photo overlays, work with the GIS Analyst in analyzing the data, write an assessment of human influence on the riparian vegetation, write a final report, and present methods and findings at the information transfer meeting. Although Dr. Springer is the official contact at NAU, technical questions regarding the project are best directed to Ms. Masek Lopez.

- Kyle Bohnenstiehl is a geography graduate student specializing in Geographical Information Systems. He will act as the GIS analyst. Mr. Bohnenstiehl will scan and register historic aerial photographs to create image themes in ArcView which will then be used by Sharon Masek Lopez and additional staff to digitize vegetation, land use and channel area. After the digitizing and attributing are completed, Kyle will analyze the database to help draw conclusions relevant to the study.

- Additional staff includes the following:

worker	status	duties
Jeff Kennedy	Geology Undergraduate Senior	Digitize land use
Loretta Morgan	Geography Graduate Student	Digitize land use
Angela Marino	Geography Graduate Student	Digitize land use
Paul Lauck	Geography Graduate Student	Digitize and attribute river channel and bare sediment

APPENDIX A (continued)

Time Line Overview

There are eight tasks with deliverable dates extending over the 22-month life of the project. The first deliverable, this research plan (Task #2), is due May 31, 1999. Other tasks having early deliverables are Public Outreach (Task #3) due July 15,1999, Obtaining Aerial Photos (Task #1) due September15, 1999, and the Literature and Data Background Search (Task #4) due September 15, 1999. After these tasks are completed, there will be a several-months-long phase of conducting the aerial photo interpretation. The deliverable for Task 5 (Interpret Aerial Photos and Create GIS Database for Verde Valley Riparian Vegetation) deliverable is due December 20, 2000. Two reports at the end of the project. The Assessment of Human Influence (Task #7) and the Final Report (Task #8) are due February 20, 2001. By the end of the project, Dr. Springer and Ms. Masek Lopez will attend an Information Transfer Meeting (Task # 8), whenever one is scheduled, to present the results of the work.

METHODS

Obtaining Aerial Photography - Task #1

Aerial photography will be purchased which depicts the study area over a period of seven decades, from the 1940s to the present. Most likely we will use the following photo sets:

year	source
1940	National Archives - Cartographic Branch, College Park, MD
1954	National Archives - Cartographic Branch, College Park, MD
1968	USDA - Aerial Photography Field Office, Salt Lake City
1977	USDA - Aerial Photography Field Office, Salt Lake City
1989	USDA - Aerial Photography Field Office, Salt Lake City
1995	Rupp Aerial Photography, Phoenix

However, other sources may be utilized. Photos may be purchased from the USGS EROS Data Center, Arizona State Cartographers Office, Arizona Department of Transportation, Army Corps of Engineers, Salt River Project, or other sources. Some photos may be borrowed form Natural Resources Conservation Service, Prescott and Coconino National Forests, university libraries, or other sources.

Because aerial photos were taken by different entities at different times for different purposes, it may not be possible to get complete coverage of the study area for every decade or to match the time of year that photos were taken. However, we will try to get the best and most complete coverage we can. Furthermore, we will try to get coverage of the growing season in order to minimize apparent differences in vegetation density due to canopy closure varying between seasons. In the September 15, 1999 deliverable we will include the month, year, and scale for each set of photographs.

Public Outreach - Task #3

Prior to beginning substantial research work, the research assistant will conduct public outreach. First she will design a website which informs the public about the study. The website will be updated as the work progresses. As far as possible, links will be established to other websites, such as the Verde Watershed Association and the Arizona Water Protection Fund websites, to increase access. Other potential links include Arizona Department of Water Resources, NAU Geology and Geography Departments, U of A Water Resources Research Center, Prescott and Coconino National Forests, Arizona Riparian Council, Town of Cottonwood, Dead Horse Ranch State Park, and the various aerial photo suppliers. In the July 15, 1999 deliverable we will describe all of the website's network links.

Once the site is established, the research assistant will have local newspaper reporters interview her about the study and publish the website address. The newspaper articles will emphasize how citizens can access the website at local libraries if they do not otherwise have internet access. Hard copies of the website will be filed with local libraries for review. The website will invite people to e-mail their comments and concerns, and we will encourage constructive dialogue between the researchers and residents of the study area. Website readers can respond with comments either by clicking on a "hot link" to the research assistant's e-mail or by letter to the research assistant at the NAU geology department. Any residents of the study area who make a request will be provided, at cost, copies of the Assessment of Human Influence and the final report at the conclusion of the study.

Literature and Data Background Search - Task #4

An extensive search will be conducted to find literature and data needed to support the study. First, we will review the history of Verde Valley to see which land use practices may have affected the riparian area. Secondly, we will review comparable riparian studies which used remote sensing to insure that our methods are consistent with accepted practices. Next we will review pertinent riparian ecology literature to understand how riparian vegetation of this study area regenerates, how it is affected by varying groundwater levels, how its distribution is affected by the processes of fluvial geomorphology, and other relevant questions. Fourth, we will calculate specific water use values for riparian species in the Verde Valley using an appropriate method as selected from the literature review. Last, we will examine existing hydrologic information for the Verde Valley including reports, water level data for wells, climate data, and stream gauging data in order to describe the interaction between the hydrologic system and the riparian system. Information sources may include ALRIS, GWSI, USGS, BOR, COE and/or other databases and reports.

Interpretation of Aerial Photos and Creation of GIS Database - Task #5

Photo interpretation

Using the photos (scale range 1:12,000 to 1:30,000) and a stereoscope, we will interpret riparian tree stands. The interpretation will be entered directly into GIS using "upright digitizing" (see Task 6). Two types of vegetation will be mapped: cottonwood/willow and mesquite. Most of the cottonwood in the study area is Fremont cottonwood (*Populus fremontii*), but there may be some narrowleaf cottonwood (*Populus angustifolia*). Gooddings willow (*Salix gooddingii*) is the most common willow in the study area, but coyote willow (*Salix exugia*) and other willows are likely to occur as well. Most of the mesquite is velvet mesquite (*Prosopis velutina*), but there may be other species. Because of the limitations in the scale of photography, we will not attempt to separate out different species. The various species of each genus will be lumped together. No attempt will be made to map willow stands separate from the cottonwood stands, because the two species are intermingled and indistinguishable in dense stands. This will not pose too much of a problem, since the two species have similar water use values. Sycamore trees are scarce in the study area and will not be mapped.

Tree stands will be classed as high, medium, or low density. Numerical values for tree stand density will be based on information derived from the literature search. The values will be percentages judged by comparison to a standard crown density scale such as in the Forester's Guide to Aerial Photo Interpretation (T.E. Avery, 1978). The density classes we choose will probably reflect the following: low density = 10-40% canopy cover, medium density = 40-70%, high density =70-100%.

In addition to vegetation coverage, we will interpret land use. Land use types will include forest, agriculture, residential, industrial/commercial and others as necessary. Also, the river channel and adjacent bare sediment will be mapped.

Work will begin with the most recent set of photos (e.g. 1995). After a few photos have been interpreted we will ground-truth a sample. Ground-truthing will involve taking into the field and checking for accuracy in interpretation of tree species and extent of tree stands. When interpretation of all the most recent photos is complete, we will conduct a more extensive ground-truthing. Our ground-truthing methods will be consistent with accepted standard methods as discovered during the literature search.

GIS Database

For the GIS analysis we will use a combination of ArcInfo and ArcView. We will create digital spatial data sets that can be made available in ArcView shapefile format or ArcInfo coverage format. We will digitize the vegetation, land use, and river channel and assign attributes to each polygon. An ArcView "theme" will be created for each cover type (cottonwood/willow, high density residential, river channel, etc.). After all the themes are complete, we will perform various analyses of the data.

We will map polygons using "upright digitizing" (as opposed to using a digitizing board). This involves looking at the photo image on the computer screen and digitizing around areas of interested by clicking the mouse. We can zoom in and out as needed to improve the accuracy and continuity of our polygons. Attributes will then be assigned to each polygon. These attributes include vegetation type, density, and water use. After each layer is completely entered, we will proof and edit the layers as necessary to achieve a highly accurate database.

The GIS analyst will conduct a distribution analysis for each layer (decade) of data. The analyses will be a useful way to compare vegetation from decade to decade and quantitatively show shifts or trends. Tables and graphs will be generated to display this information in a format that is easily understandable to the public. An analysis will be conducted, also, that relates land-use to riparian vegetation. This analysis will provide quantitative information to be used in the Assessment of Human Influence along with other qualitative historical information.

Assessment of Human Influence - Task #6

Much vegetation change is natural, associated with climate cycles which span decades. However, human activity in the watershed can also have a significant effect on the distribution and density of riparian tree species. For example, groundwater withdrawal can lower the groundwater surface below the depth to which tree roots can reach, thereby causing tree mortality. Sand and gravel mining operations sometimes remove whole stands of trees. Pollutants can damage vegetation. Overgrazing by cattle can discourage new growth. The Assessment of Human Influence report will discuss changes in riparian vegetation location, type, density, and water use in the Verde Valley from the 1940s through the 1990s as they relate to human activity in the watershed.

To assess the extent to which riparian changes are influenced by human activity, we will compare vegetation trends to climate variations, changing groundwater levels, and land use. Qualitative information from the literature (see task #2) will be used to complete this assessment, as well as quantitative information from the GIS analysis. Climate data will be evaluated to show correlation between annual precipitation and vegetation density. Flood history will be evaluated, because floods can cause dramatic changes in riparian vegetation. By separating out the natural causes of vegetation change, we should be able to ascertain where, when, and how human activity (groundwater pumping in particular) has affected the distribution, density, and species composition of riparian tree stands. Index wells will be identified within or near the riparian area and we will compare historic groundwater levels with riparian vigor for the same time frames.

APPENDIX A (continued)

Final Report - Task #7

A report will be written summarizing the study's methods, results, and conclusions. The report will describe past and present riparian conditions in the Verde Valley. A major emphasis will be recommendations for management of the riparian corridor. Specifically, we will describe human activities affecting the riparian area, and we will recommend sites for riparian tree stand maintenance, enhancement, or restoration.

Along with the written report, there will be numerous maps made available in digital format. A list of maps could include (but not be limited to):

riparian vegetation in 1940	land use in 1940
" " 1954	" 1954
" " 1968	" 1968
" " 1977	" 1977
" " 1989	" 1989
" " 1995	" 1989

index well locations
weather station, stream gauge, and historic flood locations
site recommendations for riparian preservation, restoration, and enhancement

The databases will include specifics about vegetation type and density, water use, historic groundwater levels, climate, land use, and the results of data analysis. As this report will be the property of the AWPF, we request permission to reprint the report in scientific journals.

Information Transfer - Task #8

The primary investigator and/or research assistant will attend an information transfer meeting whenever one is scheduled during the life of the project. We will present a paper or display an educational poster for this meeting

FINAL PRODUCTS

The final products of this research will be maps (in digital format), databases, a poster paper for use in public education, an assessment of human influence, and a final report. An extensive array of data about the Verde Valley riparian corridor will be made available to AWPF and the interested public. During the life of the project, preliminary results can be viewed on the website. After completion, we will entrust the results of the study to an ongoing website, such as the Verde Watershed Association or the Verde Watershed Research and Education Program, and we will give hard copies to local libraries.

The aerial photos are a resource that may prove useful to others interested in the history of the Verde Valley. We will find a qualified curator (perhaps at NAU special collections, but possibly at a public library or resource management office in the watershed) and entrust the photo collection to them so that other investigators and resource managers may use these photos in the future.