Projects to Enhance Arizona's Environment: An Examination of their Functions, Water Requirements and Public Benefits*

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Sharon B. Megdal, Ph.D.
Kelly Mott Lacroix and Andrew Schwarz
Water Resources Research Center
University of Arizona, Tucson AZ

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Source: Arizona Water Protection Fund

Introduction[1]

In Arizona, many once lush riparian areas have been lost. This decline has not gone unnoticed, and in the past decade a growing number of efforts have been undertaken to restore, maintain or create new riparian and wetland areas. The number of riparian restoration projects nationwide has also increased, growing exponentially in the last decade.[2] Along side this explosion of restoration projects, the interest of the scientific community and the public at large has also grown significantly.[3] Scientists have conducted many studies examining various aspects of environmental enhancement projects. Considerable research and debate have surrounded defining and measuring restoration areas[4,5] and the value of "created" habitat. Other research has focused on identifying the common elements of restoration projects, such as the work by Bernhart, et al. who are compiling a comprehensive database of restoration efforts throughout the United States.

In this report, we provide complementary information to these studies in the form of a descriptive look at 30 environmental enhancement projects throughout the State of Arizona. The report examines the more subjective aspects of environmental enhancement projects. At the outset of the project we sought to answer a series of questions: Who are the key players in the implementation of environmental enhancement projects and what factors drive the project's undertaking? What are the benefits of these projects? How are these projects using scarce water resources? Do they have legal claim to these water sources? And how long will supplementary water be required? Along with answers to these questions, we sought lessons learned both through the specific projects and from the wider lens of the 30 projects taken as a whole.

Though the study can not be considered exhaustive, important observations are drawn from the projects we surveyed. The projects highlighted in this study are only a sample of the many environmental enhancement efforts underway in Arizona. In this study we wanted a diverse selection of projects; therefore, project selection was based, in part, on choosing projects with varied sponsors, locations, and intentions.

A unique aspect of this study is that it combines a descriptive project summaries with objective surveys to describe the project. The surveys created categories for each area we were interested in examining. For example, project drivers were summarized into categories such as

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[1] The authors of this study would like to thank Jennifer Jones, former research assistant at the WRRC and Magdalena Escobeda, WRRC NASA intern. We would also like to extend a special thanks to all of the project contacts and to the staff at the Water Protection Fund for their time spent responding to our surveys, answering our questions and attending stakeholder meetings. This report would not have been possible with out the funding and project support provided by the Phoenix office of the Bureau of Reclamation.

[2] Berhardt, E.S., et al. (2005). Synthesizing U.S. River Restoration Efforts. Science. Vol 308, 636

[3] Ibid. p. 6 (supporting online material).

[4] Westman, WE. (1991) Ecological restoration projects: Measuring their performance. Environmental Protection [ENVIRON. PROT.]. Vol. 13, no. 3, 207-215.

[5] David J. Schaeffer, Edwin E. Herricks and Harold W. Kerster. (1988). Ecosystem health: Measuring ecosystem health. Environmental Management, Volume 12, Number 4, 445 – 455.

flood control and public use and enjoyment. We filled in each survey based on information gathered for the project summaries and sent the survey to the project sponsors to accept or change our characterizations of their project. In the end, the project summaries provide detailed descriptions of the projects, while the surveys provide more objective information. Taken together, these two sources of information provide a more complete picture of the diverse ways in which environmental enhancement projects are pursuing their goals.

Background

The thirty projects examined here come from four of the seven ecoregions in Arizona as defined by the United States Environmental Protection Agency. An ecoregion denotes an area within which ecosystems (and the type, quality, and quantity of environmental resources) are generally similar.[6] Figure 1 shows the ecoregions throughout Arizona. The ecoregions represented in this study are Sonoran Basin and Range (81), Madrean Archipelago (79), Arizona/New Mexico Mountains (23) and Arizona/ New Mexico Plateau (22).

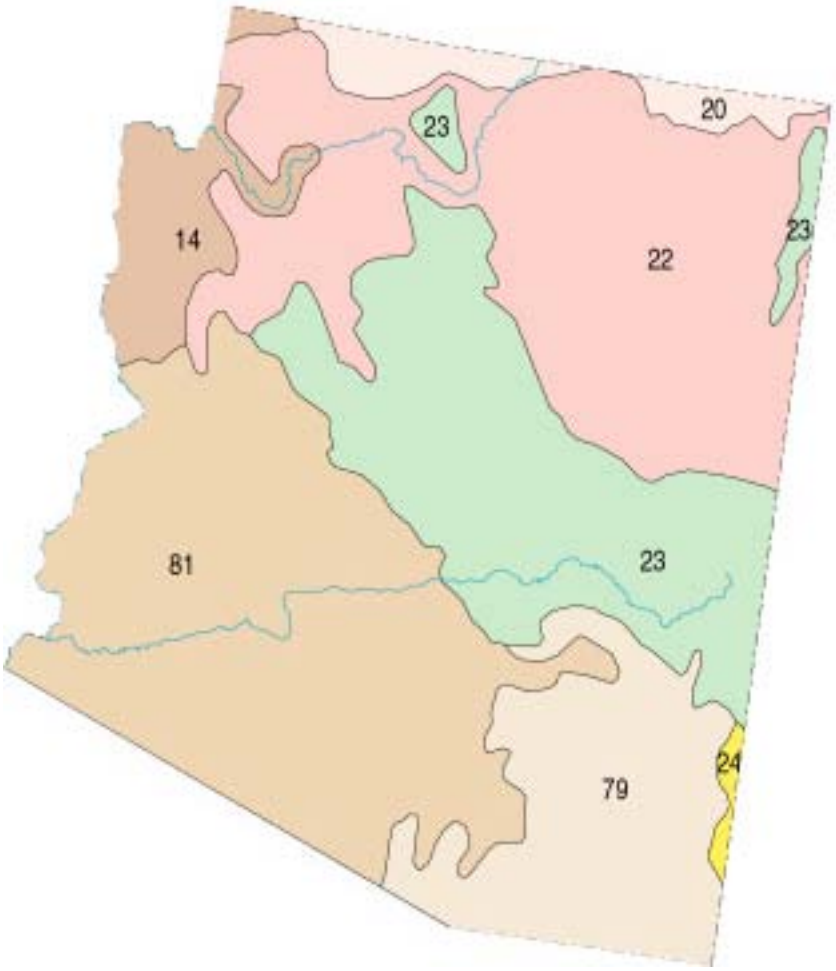

Figure 1. Type III ecoregions in Arizona. Source USEPA

The Sonoran Basin and Range ecoregion contains scattered low mountains and desert lowlands. Water is generally scarce in this area and palo verde-cactus shrub and giant saguaro cactus dominate. Average rainfall in the Sonoran ecoregion is 4-12 inches per year. Principal rivers through this area are the Salt River, Gila River, Verde River and the Colorado River.

The Madrean Archipelago, also known as the Sky Islands, is a region of basins and ranges with medium to high elevation, typically 3,300 to 5,000 feet. Native vegetation in the region is mostly grama-tobosa shrubsteppe in the basins and oak-juniper woodlands on the ranges, except at higher elevations where ponderosa pine dominates. The region has significance as both a barrier and bridge between two major mountain ranges of North America,

[6] U.S. Environmental Protection Agency, National Health and Environmental Effects Laboratory. Level Three Ecoregions of the Conterminous United States. Retrieved August 17th, 2005, EPA Website http://www.epa.gov/wed/pages/ ecoregions/level_iii.htm#Ecoregions.

the Rocky Mountains and the Sierra Madre Occidental. The principal rivers through this area are the San Pedro River and parts of the Santa Cruz River.

The Arizona/New Mexico Mountains are characterized by their lower elevations and vegetation typical of drier, warmer environments. Forests of spruce and Douglas fir are only found in a few high elevation parts of this region. Chaparral is common on the lower elevations, piñon-juniper and oak woodlands are found on lower and middle elevations, and the higher elevations are mostly covered with open to dense ponderosa pine forests. The principal river systems in this area are the Little Colorado River and the Gila River.

The final eco-region represented, the Arizona/New Mexico Plateau, represents a large transitional region between the semiarid grasslands and low elevation plateaus in the east, the drier scrublands and woodland covered high elevation plateaus in the north, and the lower, hotter, less vegetated Mojave Basin and Range in the west and Chihuahuan Deserts in the south. Elevation in the region varies from a few meters on plains and mesa tops to well over 900 feet along plateau side slopes. The principal rivers through this area are the Colorado River and the Little Colorado River.[7]

None of the projects studied would have happened without funding. There are many funding mechanisms used in the projects surveyed, however, only programs that have funded more than one of the projects will be discussed here. The sources of funding are the Arizona Water Protection Fund, Arizona Department of Environmental Quality-Water Quality Grant Program, Arizona Game and Fish Department-Heritage Fund Grant, Army Corps of Engineers, and the Bureau of Reclamation.

Arizona Water Protection Fund is a state grant program that provides money to groups interested in maintaining, enhancing, and restoring river and riparian resources in Arizona. Applications for the grant program must be for capital projects, contain administrative costs less than 5% of funding requested, demonstrate legal and physical access and authority to manage restored area, provide documentation that water for project is legally and physically available, and demonstrate that vital partnerships (funding etc.) have been committed at the time of the application. The funds are awarded according to authorization in Arizona Revised Statutes and administered through the Arizona Department of Water Resources by the Arizona Water Protection Fund Commission.

The Water Quality Improvement Grant Program, administered by the Arizona Department of Environmental Quality, provides funding to improve water quality by controlling non-point source pollution. Applicants must improve or protect water quality by controlling non-point source pollution, have an on-the-ground implementation component, and provide for at least 40 percent of the project costs as non-federal match.

The Heritage Fund Program through Arizona Game and Fish sets aside $20 million each year for parks, trails, natural areas, historic preservation, and a full range of wildlife conservation activities. Eligible applicants include the federal government or any federal department or agency, Indian tribe, all departments, agencies, boards and commissions of this state, counties, school districts, cities, towns, all municipal corporations, and any other political subdivisions of Arizona.

Projects funded by the United States Army Corps of Engineers in this study are funded

[7] Ibid.

through their General Investigations (GI) efforts and Section 1135 or 206 of the Water Resources Development Act of 1986.[8] Under General Investigation, the Corps is authorized to participate in individually authorized programs, with the federal investment depending on the nature of the program and the amount appropriated by Congress. Projects funded under Section 1135 do so pursuant to 1135(b) of the Water Resources Development Act of 1986, which provides authority for the Corps to "investigate, study, modify, and construct projects for the restoration of fish and wildlife habitats where degradation is attributable to water resource projects previously constructed by the Corps."[9]

Projects funded by the United States Bureau of Reclamation in this study are funded through the Wetlands Development Program, Title III of the Colorado River Basin Project Act and the Title 28 program. The Wetlands Development Program provides funding for design and implementation of wetland enhancement projects aimed at improving water quality, wildlife habitat, recreation and aesthetic benefits. The Title 28 program permits the BOR to participate in cost sharing agreements to fund development, rehabilitation, and expansion of recreation and fish and wildlife areas and facilities on Reclamation project lands. Federal contributions must be matched at a minimum of 50/50 with non-Federal partner funds. For fish and wildlife projects the program allows for 75/25 cost sharing agreements. Multi-year funding agreements are possible under this program. [10]

Projects included in this study are shown in Table 1 and located in Figure 2.

Table 1. Projects included in the study

Little Colorado River Basin Projects			
1	EC Bar Ranch	2	Little Colorado River Enhancement Demonstration Project
Lower Colorado River Basin Projects			
3	Ahakhav Tribal Preserve	4	Yuma West Wetlands
5	Yuma East Wetlands		
Salt River Basin Projects			
6	Rio Salado Oeste	7	Tres Rios
8	Rio Salado Phoenix	9	Va Shly 'ay Akimel
10	Rio Salado Tempe		
San Pedro River Basin Projects			
11	Bingham Cienega	12	San Pedro Three Links Farm
13	Las Cienegas National Conservation Area	14	San Pedro Preserve
Santa Cruz River Basin Projects			
15	Agua Caliente Spring	16	San Xavier Indian Reservation Riparian Restoration
17	Ed Pastor Kino Environmental Restoration	18	Santa Fe Ranch Riparian Restoration

[8] Only one project in this study was funded under Section 206, Agua Caliente Spring. Agua Caliente Spring did not move beyond the planning stage.

[9] U.S. Army Corps of Engineers. 2004. Project Modifications for the Improvement of the Environment. Washington: U.S. Army Corps of Engineers. Available at: http://www.nab.usace.army.mil/whatwedo/civwks/CAP/1135.pdf.

[10] Tuel, Darlene (Bureau of Reclamation, Water Resources Planner).2005, November. Study correspondence with author (Andrew Schwarz).

19	El Rio Antiguo	20	North Simpson Riparian Recovery
21	Esperanza Ranch	22	Sweetwater Wetlands
23	Marana High Plains Effluent Recharge Project	24	Tres Rios del Norte
25	Paseo de las Iglesias	26	Accidental Restoration in Pima County
27	Rillito River Restoration (Swan Wetlands)		
Upper Colorado River Basin Project			
28	Grand Canyon Tamarisk Management		
Verde River Watershed Projects			
29	Fossil Creek Restoration	30	Verde River Headwaters Restoration

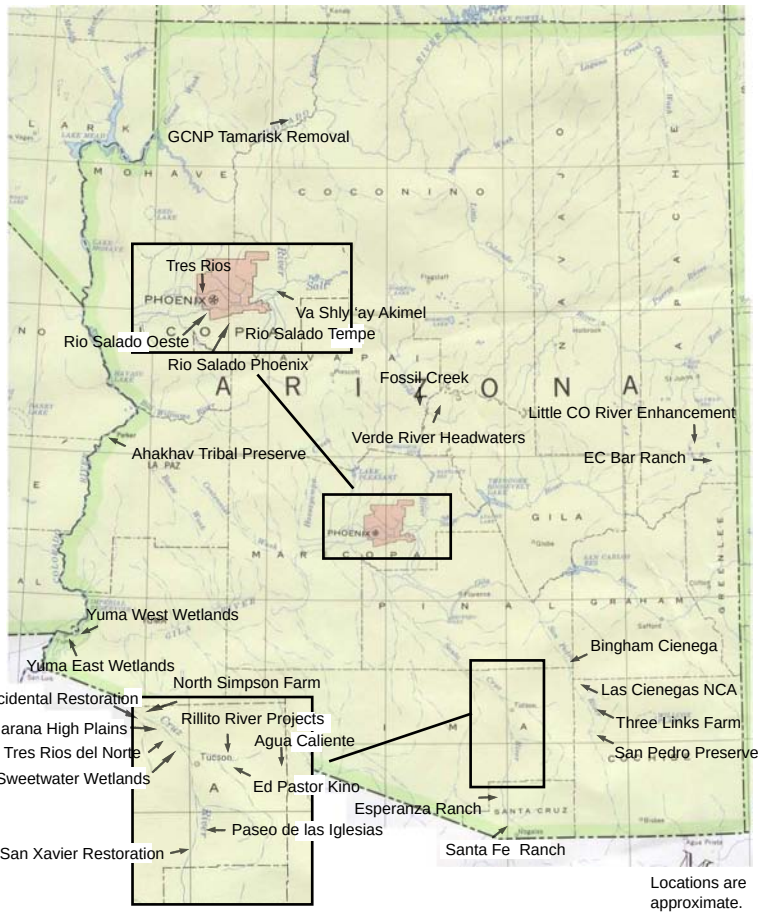

Figure 2. Project locations

Methodology

To select the projects for this study, we identified and invited over 100 people from various interest groups and backgrounds to come to two stakeholder meetings. At these meetings, a short

introduction to the study and an overview of the types of projects targeted for inclusions were provided. The meetings were held in October 2004 in Phoenix and Tucson. About 35 people attended the meetings. Project suggestions were also solicited from the Arizona Water Projection Fund. Over fifty projects were recommended from the various stakeholders. The thirty projects included in this study were evaluated and selected in order to provide a diverse study based on the following criteria:

- Geographic location
- Type of sponsors: private, state, federal (e.g., U.S. Army Corps of Engineers, City of Phoenix)
- Intent of project: wetlands, water quality, wildlife habitat etc.
- Unique element(s) in project
- Ease and availability of information on the project
- Current project phase (a preference was given to completed or nearly completed projects so that lessons learned were likely to be available).

This study builds upon a previous study focused on the environmental enhancement efforts of the U.S. Army Corps of Engineers.[11] Information gathered from the Corps of Engineers study was modified to fit the format of this study and all projects included in the Corps of Engineers study are also included in this study. Once the additional projects were selected, we compiled and analyzed written information such as environmental assessments, grant applications, management procedures, newspaper articles and websites. When possible, we also conducted an interview with the project sponsor and/or site visit. The information from these sources was then synthesized into a standardized project summary, which included information on the project's location, sponsors, history, phases, planning objectives, recommended or implemented plan, monitoring and maintenance, funding and cost, water requirements, land ownership, public outreach, drivers, and challenges/lessons learned.

Preliminary findings were drawn from these summaries and a draft report was circulated to all of the project contacts and other interested parties. Two stakeholder meetings were held in November 2005 to present the initial findings and receive feedback.

Following these meetings, in response to comments from stakeholders, a survey was developed to collect information regarding each of the subject areas of interest in the study. A copy of the survey can be found in Appendix A. A survey and the draft version of the project summary for each project were sent to each of the project contacts. The goal of this exercise was to double check the facts in the summary and give contacts an opportunity to comment on the draft summary. The surveys also provided a more standardized tool for analyzing the data. A database was compiled using the survey data and a list of summary findings was extracted from the database. The project summaries served as background and supporting information for the surveys and documented the details that make each project unique.

Summary Findings

Although every project has a unique story, there were aspects of the projects that can be

[11] Megdal, S.B. 2005. Environmental Restoration Projects in Arizona: The Army Corps Approach.

categorized and examined as a whole in order to create an overall picture of these 30 enhancement projects. The following section provides a summary of the projects' drivers, sponsorship, benefits, water requirements and lessons learned. Relationships among these categories are also discussed.

Drivers

The first question we wanted to answer in this study was what were the specific "drivers" that led the projects to be undertaken? Drivers are defined as the specific reason or force that initiated the project and/or moved the project forward. Drivers differ from other project benefits in an important way. Benefits may be realized from a specific, often ancillary element of a project whereas drivers are the reason the project exists in the first place. For example, public use benefits are derived from a trail constructed around a wetland created to maintain storm water detention and flood protection. The distinction is made between the elements that were integral to the project's conception and implementation and benefits that are complimentary but not integral to the project. The Ed Pastor Kino Environmental Restoration Project is a good example of this distinction. Conceived and funded by the Army Corps of Engineers under section 1135, the project involved redesigning the park area to provide additional storm water detention benefits and wildlife habitat. Trails were added to the project to capture additional benefits but were not a driver to the project's implementation; the project was actually driven by habitat restoration and storm water detention enhancement. Driving forces are an important aspect of the implementation of environmental enhancement projects; separating them from other benefits highlights the most important elements in how a project comes into existence. Benefits should not, however, be seen as after thoughts or superfluous additions to projects in order to make them more attractive. Many of the beneficial elements became part of the projects early in the design phase and were always considered important features.

Most of the projects cited multiple drivers, with an average of three drivers per project. Figure 3 shows a list of drives cited by the projects and the number of projects that cited them. Appendix A lists each project individually and shows the drivers cited by each project. One of the most interesting observations that can be made from a review of the projects is the diversity of the drivers. Nineteen different drivers were cited for the 30 different projects, highlighting a wide range of reasons these projects were undertaken.

Habitat value was the most common driver with 25 projects citing it. The remaining five projects listed habitat as a benefit but not one of the primary reasons the project was undertaken. Two projects listed habitat value as the only driver for the project (Rillito River Park/Swan Wetlands and El Rio Antiguo).

While habitat was by far the most common driver, there were several others that cut across multiple projects. Inclusion in a general or regional restoration plan was cited as a driver for nine projects. For the purpose of this study, general or regional restoration plans were defined as planning initiatives involving more than one project that attempt to meet common or related objectives. The Sonoran Desert Conservation Plan (SDCP) is one such regional planning initiative, integrating natural, historical, and cultural resource planning with urban planning. The Paseo de las Iglesias project is in part driven by its contribution and consistency with the SDCP. Paseo de las Igesias is also part of a three project proposal, including El Rio Medio and Tres Rios del Norte, along the Santa Cruz River that would improve environmental conditions along the river

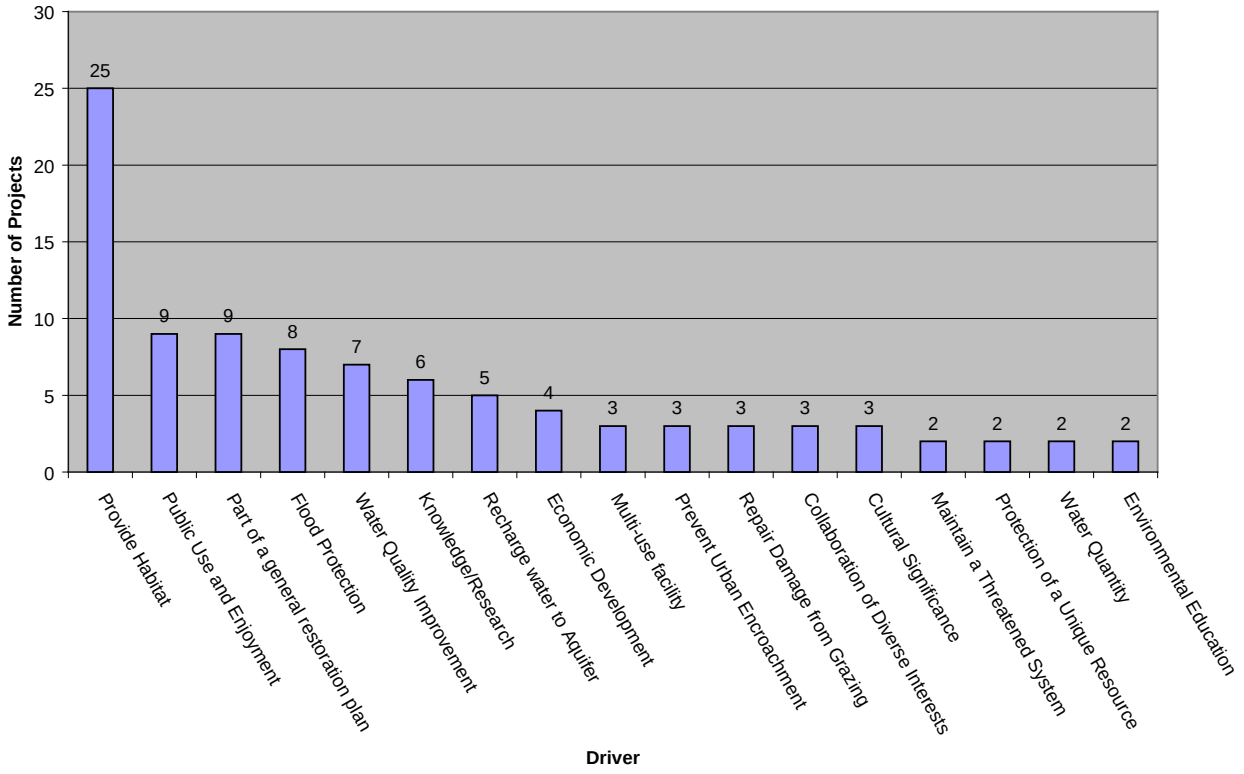

Figure 3. Project Drivers

continuously from the Tohono O'Odham Nation, San Xavier District to Marana. The San Pedro-Three Links Farm project is also part of a larger Nature Conservancy initiative to protect instream flows in the San Pedro River. The Nature Conservancy (TNC) has been systematically identifying properties that have groundwater pumping rights and a hydrological connection to the river, and acquiring the lands to retire the groundwater withdrawals.

Another driver for nine projects was public use and enjoyment. This driver typically involved providing recreational opportunities, including picnic facilities and hiking trails. Interestingly, only one of the projects that cited public use and enjoyment as a driver, the Fossil Creek Dam Removal and Riparian Restoration, was outside of a metropolitan area.

These two drivers, consistency with a general restoration plan and public use and enjoyment, seem to point to two important trends. Increased urbanization throughout Arizona has increased the demand for environmental recreation opportunities. This has become an important force behind many of the projects throughout the state of Arizona, but particularly in the largest urban areas (Metro Phoenix, Tucson, and Yuma). The high proportion of projects citing consistency with a larger general enhancement plan may indicate that project sponsors are taking a more systematic approach to project selection and design. Several of the projects that were part of general restoration plans involved protecting multiple reaches or long stretches of rivers. Dave Harris of The Nature Conservancy reinforced the importance of this approach saying "until the entire reach of the river is protected, all of the rehabilitated area is vulnerable, changes in upstream groundwater or surface

water use may undo the progress made down stream."[12]

Water quality and flood control were also important drivers, with seven and eight projects citing them, respectively. Interestingly, only one of the projects that cited water quality as a driver, EC Bar Ranch, had performed pre and post project Total Maximum Daily Load (TMDL) or Proper Functioning Condition (PFC) reports, two widely accepted methods of quantifying water quality and stream health. Not surprisingly, flood control benefits were distinctly associated with flood control districts (Pima County Regional Flood Control District and Maricopa County Flood Control District) and cities (Tucson, Phoenix, and Tempe). Four of those projects were partnerships between a flood control district and a city, indicating that agencies and organizations that have similar objectives are likely to team up on projects, perhaps to increase support and funding opportunities.

Six of the projects cited the advancement of knowledge as a driving force in the implementation of their projects. This typically involved studying new types of invasive species eradication, revegetation methods, or overall restoration principles and procedures. For example, the Verde Headwaters restoration project emphasized the importance of learning about the ecosystem as well as using the restoration project as a research tool for Northern Arizona University students. In other cases, advancement of knowledge applied to other areas of interest, such as decision making amongst diverse interests. The fact that a fourth of the projects indicated advancement of knowledge as a driver demonstrates that many sponsors still feel that there is much to learn about restoration efforts and the best way to implement them. Improving the overall body of knowledge available to restoration professionals can improve the success rate of projects and possibly improve their cost effectiveness.

The next most common driver was aquifer recharge. The five projects in this category can be distinguished into two groups. The first group included projects that were constructed as recharge facilities (Sweetwater Wetlands and Marana High Plains Recharge Facility)[13] and the second group included projects seeking to increase or protect natural aquifer recharge through a variety of methods. In the case of the Tres Rios project an effluent stream will be diverted through the project area where a wetland will be constructed to help improve the quality of the water before it is allowed to recharge into the ground. The Las Cienegas Preserve, on the other hand, was in part driven forward because it serves as a crucial area of recharge for the aquifers that flow under the Tucson area. Urban encroachment would have significantly damaged the area's ability to function in this manner, therefore, protecting the area in its natural state was an important driver for the project.

Ten other drivers were cited by the project contacts as important reasons for their implementation. These other drivers, with the number of projects citing them in parentheses, are the following: economic redevelopment (4), cultural significance (3), collaboration of diverse interests (3), repair damage from grazing (3), prevent urban encroachment (3), multi-use facilities (3), environmental education (2), increase water quantity (2), protect unique water resources (2), and maintain threatened systems (2). The diversity of drivers is striking considering the limited geographical area (Arizona) and relatively compressed time frame (last 10 years) over which the

[12] Harris, David (TNC- Director of Land and Water Protection). (2006, January) Interview with author -Andrew Schwarz.

[13] Recharge facilities as applied to the two projects in this study refer to constructed spreading basins to take a renewable source of water and allow it to percolate into the aquifer below the surface.

projects were carried out.

Many of the projects in this study evolved between conception and implementation. For example, the Little Colorado River Enhancement Demonstration Project found it necessary to change many of their restoration techniques after high river flows in the winter and spring of 2004-2005 damaged or destroyed much of the restoration work that had previously been done. On the whole, however, the projects remained focused on the original purposes and intent for which they were conceived, maintaining the same drivers throughout the process.

There are several ways to group drivers into larger related groups. One of the most useful ways was to separate those drivers that are more human focused from those that are more non-human focused. Appendix C shows a spider diagram of the 17 drivers separated into these two categories. Two of the drivers, part of a general restoration plan and multi-use facility, embody elements of both. The two major categories were broken down further into major issues. Human focused drivers were divided into education, water issues, quality of life issues and collaboration of diverse interests. Quality of life issues included drivers that dealt with economic, cultural, and social aspects that pertain to the fulfillment and enjoyment derived by humans from their surroundings. Non-human focused drivers included water, land use, and habitat issues. It is important to note that all of these drivers have connections to both human and non-human benefits. The distinction is made as a way to look at the human versus non-human values that move environmental enhancement projects forward.[14]

Interestingly, a total of 44 non-human focused and 40 human focused drivers were cited, indicating that projects in the study were driven forward by a values balanced between human and non-human benefits. Another finding is that water issues appear on both sides of the diagram. Non-human focused water issues include quantity, quality and uniqueness of the resource, while the human focused water issues include flood control and recharge. Perhaps it isn't surprising that water crosses over between human and non-human focused drivers, as water is equally essential to humans and wildlife. As a group, water related drivers were indicated by 22 projects, second only to the 27 projects that cited habitat issues.

Sponsorship

Sponsorship was defined as the group or groups that primarily implemented or supervised the enhancement project. As with drivers and benefits, there is a subtle but important difference between sponsorship and funding. In many cases the projects were funded by grants from agencies that, other than approving the grant application, had little influence on the actual design of the project. The Arizona Water Protection Fund (AWPF), was a very important funding agency, endowing 12 of the projects with funds. The AWPF, however, was not listed as a primary sponsor on any of the projects. While AWPF has a broad mandate to provide a source of funds for

[14] Some of these classifications are certainly subject to debate. We believe, however, that the ways in which these elements are employed by the projects justify their classification in this way. For instance, recharge of water to aquifers was classified as human focused, and while there are undeniable benefits that accrue to non-human populations from recharge, in this context most recharge was done to accumulate groundwater recharge credits that could be recovered for later use by humans. Water quantity improvements were classified as non-human focused because most of the additional water was left instream to be used by plants and animals. Knowledge and research was classified as human focused because the improvements in understanding accrue to humans, even though the fruits of that increased understanding may accrue to non-human populations.

projects that maintain, enhance or restore rivers and streams and associated riparian habitats,[15] the AWPF is an administrative agency that does not implement projects. The United States Army Corps of Engineers have the rare combination of both funding mechanisms and the human resources for implementation making them an important sponsor for multiple projects in the study.

The projects highlighted in this study are sponsored wholly or in part by city and county agencies, Native American tribes, non-governmental organizations (NGO), private landowners, federal and state agencies, and universities. A range of projects that had been sponsored by various diverse entities was intentionally selected to elicit information about how the goals reflect the objectives of the sponsoring group. Figure 4 shows a pie chart depicting project sponsorship in the study. (The total number of projects in the graph exceeds 30 because several projects had multiple sponsors.)

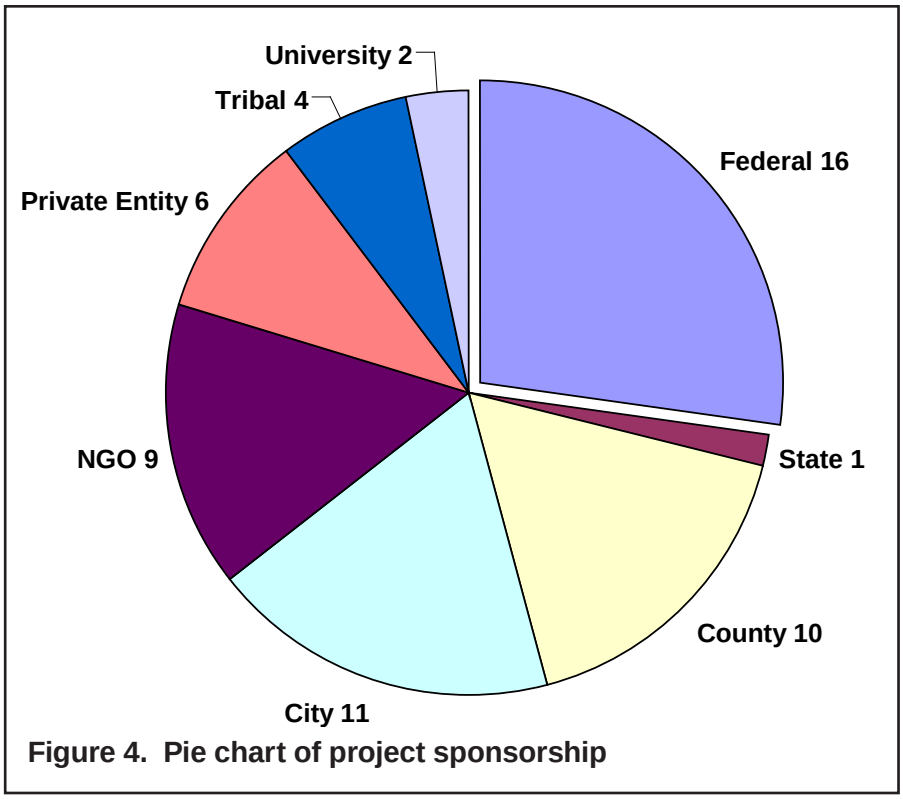

Figure 4. Pie chart of project sponsorship

Project sponsorship was found to be an important factor in the design and implementation of the projects. One factor that was influenced by project sponsorship was the project's size. Projects in this study varied from very large to quite small. Size could be measured in several different ways: acreage, river or stream miles enhanced and cost. Size in acreage of the projects studied varied from less than 20 acres to over 5,600 acres. The largest project studied was the Tres Rios project in the Phoenix area. About half of the projects fell within the range of 100 to 600 acres. It must be noted, that some of the projects that included very large tracts of land did not always involve revegetation or active enhancement on the entire parcel. Areas included in the project, even if they were not actively enhanced, provided open space protection, buffer zones and other benefits to the project. All of the projects had some connection to riparian habitat. Many, but not all, of the projects directly abutted a water course and a length of stream or river was enhanced as a result of the project. Other projects provided wetland or cienega habitat that was not measured in stream miles. Projects that did directly abut water courses ranged in size from less than a quarter of a mile to 19 miles of water course in the case of Tres Rios del Norte in Pima county. Finally, the projects can be

[15] ARS 45-2101.

measure by their costs of implementation. The projects in this study varied in cost from $210,000 to almost $300 million. The projects also had large variations in operating costs including costs for purchasing water. Operation and maintenance budgets were as large as $9.7 million per year. So many variables are involved in distinguishing one project from another that a direct side by side comparison of costs, size, and benefits would be nearly impossible.

The project design is also influenced by project sponsors because most of the project sponsors have a constituency or mandate that directs their activities. City governments provide services to their citizens which often include providing amenities to improve the quality of life in the city. The county flood control districts in this study are charged with minimizing flood damage and some times also take on other related issues.[16,17] Federal agencies, such as the Army Corps of Engineers, have a broad mission to provide engineering services and capabilities to the public.[18] As part of the 1986 Water Resources Development Act, the Army Corps of Engineers was authorized to participate in environmental restoration and remediation projects as authorized by congress or in an effort to repair damage done by previous Corps projects.[19]

Federal agencies sponsored the largest number of projects (16). The U.S. Army Corps of Engineers sponsored 11 of the projects.[20] The National Park Service, National Forest Service, Bureau of Reclamation, and Bureau of Land Management also sponsored projects.

County and city agencies were the next largest sponsors, leading 11 and 10 projects, respectively. In all 11 projects sponsored by county agencies, the agency was the county flood control district (Pima County Regional or Maricopa County). All of these projects took place in the major metropolitan areas of Tucson and Phoenix.

Non-governmental organizations and/or non-profit groups sponsored nine of the projects. An interesting aspect of these projects was that they usually listed several drivers. The San Pedro Preserve and San Pedro Three Links Farm projects, both sponsored by The Nature Conservancy, had four and three different drivers respectively. The Little Colorado River Enhancement Project, sponsored by Apache Natural Resources Conservation District (NRCD) and Upper Little Colorado Watershed Partnership had four different drivers. The Grand Canyon Tamarisk removal project, sponsored by The Grand Canyon National Park Foundation, Wildlands Council and the National Park Service, had four different drivers. This may reflect the need for non-governmental organizations to incorporate multiple objectives into their projects in order to pursue diverse funding sources and broad support from their constituencies. Appendix B shows a complete list of the projects and drivers for the study sample.

The Yuma East project was very interesting in this respect. It was sponsored by the City of Yuma, the Yuma Crossing National Heritage Area (a federally funded commission), and the Quechen Indian Nation. This diverse group of sponsors, as well as a diverse set of

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[16] http://www.fcd.maricopa.gov/District/Default.asp. Retrieved March 3, 2006.

[17] http://rfcd.pima.gov/. Retrieved March 3, 2006.

[18] http://www.usace.army.mil/missions/index.html#Water%20Resources. Retrieved March 3, 2006.

[19] U.S. Army Corps of Engineers. 2004. Project Modifications for the Improvement of the Environment. Washington: U.S. Army Corps of Engineers. Available at: http://www.nab.usace.army.mil/whatwedo/civwks/CAP/1135.pdf.

[20] This number may be artificially skewed due to the inclusion of 11 projects in the study from the previous environmental enhancement study focused on the efforts of the Army Corps of Engineers.

concerns from neighboring property owners and stakeholders, resulted in this project having nine different drivers, almost twice the number of any other project. According to Kevin Eatherly, project manager for the Yuma Department of Public Works, "The East Wetlands is a highly unusual project; because it would have never gotten off the ground had we not listened and responded to all the landowners and stakeholders. Thus, the consensus has created a wide variety of key factors."[21] Each of the stakeholder groups felt strongly about a particular issue and was able to advocate for specific elements to be included in the project. The process resulted in a diverse project that met the needs of the community.

Certain drivers were only associated with specific sponsoring agencies, indicating objectives that are unique to that agency. For example, The Nature Conservancy cited "protection of a threatened system" as a main driver to both their San Pedro River projects, a driver that was not cited by any other project. The driver is a direct reflection of their mission to preserve and protect land and waters for the life that depends upon them. City governments function to provide service and support local economies. The study results show that the driver of economic development was associated predominately with city government sponsored projects in metropolitan areas. Not surprisingly, the driver of flood control was almost exclusively associated with city governments and flood control districts. All four of the projects sponsored by tribal governments had cultural benefits associated with them, and three of the four stated that the cultural elements were primary drivers to the project. In the case of the San Xavier Restoration, the project was initiated to restore a stretch of the Santa Cruz River so that members of the tribe would have a place to walk, mediate and reflect. During the design of the project, tribal elders were consulted in an effort to acquire information about what the area looked like decades ago during their youth. NGOs, such as the Tucson Audubon Society and The Nature Conservancy, appear to shape their restoration efforts more around creating habitat for the intrinsic value of habitat and often restrict public access or prohibit public access all together.

Six of the projects were sponsored by private entities. These projects can be broken down into two groups. The first group includes four projects that involved private consultants who helped public groups undertake the restoration work. In these cases, the consultants were usually intimately involved with the planning and implementation of the work. Mark Briggs of Briggs Restoration, Inc. who helped the San Xavier District implement the San Xavier project states: "We (Briggs Inc.) were hired to help the district select the most appropriate site (we did an analysis that prioritized five potential sites based on a variety of ecological and sociopolitical considerations). Once the site was selected, we did the project design jointly with the District, and then the implementation, monitoring, and evaluation. It was and still continues to be a solid partnership that is a true team effort."[22] The other group includes projects where the private entity actually funded and spearheaded the restoration. The EC Bar Ranch, the private property of Jim Crosswhite, is perhaps one of the most unique projects in the study group. Mr. Crosswhite has pursued funding from nearly every state and federal agency that provides funding for environmental restoration and has followed the guidance of the NRCS, ADEQ, US FWS and others. Mr. Crosswhite has spent tens of thousands of his own dollars in his restoration efforts, and asserts that although no universally accepted definition of a restored riparian area

[21] Eatherly, Keven (City of Yuma, Department of Public Works). 2006, February. E-mail correspondence with author (Andrew Schwarz).

[22] Briggs, Mark (Briggs Restoration, Inc.). 2006, January. Study correspondence with author (Andrew Schwarz).

exists, his property meets more of the acceptable criteria then any other area in the State.

The final category of sponsors in the study was universities. Only two of the projects in the study were sponsored by universities, both by Northern Arizona University. Not surprisingly, both projects were driven by knowledge and research advancement.

Benefits

Although the drivers were the key elements behind each project's undertaking, all of the enhancement efforts incorporated other elements that provided additional benefits. For this study, benefits are defined broadly and do not necessarily have to accrue to human populations. A total of sixteen different benefits were attributed to the projects. These benefits accrue to different human and non-human populations. Appendix C contains a complete list of the projects and the benefits cited by each project.

Figure 5 shows all of the diffent benefits cited by the projects and the number of projects that cited them. All 30 projects cited more than one benefit, with most having between four and six benefits. Not surprisingly, all 30 cited habitat value as a benefit of the project. The problem arises, however, in the definition of "habitat value." There are several measures of habitat value but no universally accepted metric, making the definition of habitat value a contentious issue.[23] Further, although many of the projects continued to monitor wildlife characteristics, the projects rarely conduct a comprehensive review of the project's success. In this study we

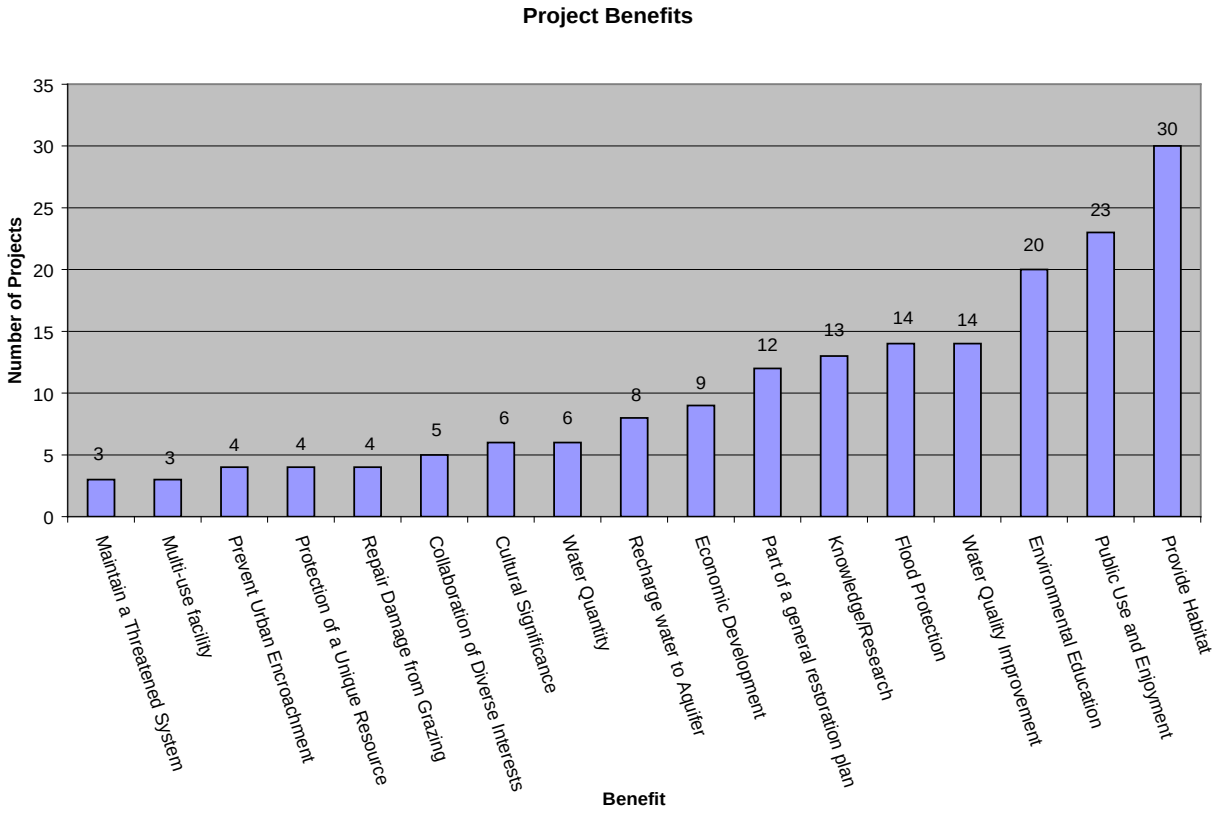

Figure 5. Project Benefits

[23] Hall, L., Krausman, P., and Morrison, M. (1997). The habitat concept and a plea for standard terminology. Wildlife Society Bulletin 25:173-182.

have not attempted to apply any metric to the value of habitat and no requirements were set in order for a project to achieve this benefit.

While all 30 projects captured a habitat value benefit, the next three most often cited benefits were directed predominantly at human populations [public use (23), environmental education (20), and flood protection (14)]. Taken as a whole, project drivers tended to be very balanced between human focused (40) and non-human focused drivers (44), whereas for benefits the totals were skewed toward human focused benefits (98-65). Appendix C shows a spider diagram of how the benefits and drivers were divided between those that were human focused and those that were non-human focused.

The benefit of public use and enjoyment was most commonly expressed through parks and trails that were open to the public with few restrictions on access. Two of the 23 projects, the Audubon Society projects at the North Simpson site and Esperanza Ranch, allow public access but with strict restrictions, including the need for visitors to make advanced reservations to visit and be supervised while on the property.

Projects with public use benefits were frequently coupled with environmental education benefits. Eighteen of the 23 projects included an education component. For example, the Ahakhav Tribal Preserve in its first year took over 300 youths canoeing on the river and backwaters and hosted environmental education programs at the Colorado River Indian Tribes Head Start Program and a local junior high school. Of the projects that indicated environment education as a benefit, however, most realized it through interpretive signs on the property. Two additional projects, EC Bar Ranch and Santa Fe Ranch, achieved education benefits without allowing public access to their sites. The Santa Fe Ranch project used a unique method for environmental education. They partnered with local elementary and high schools to develop a riparian ecosystem teacher's guide and tree nursery management activities with students.

Interestingly, of the 20 projects that listed environmental education as a benefit only two of them cited it as a driver for the project. This was by far the largest discrepancy between a characteristic that could be a driver and/or a benefit. This suggests that the project sponsors included environmental education elements in the projects as a way to increase the value of the project to the community and perhaps garner increased support. But few projects were actually conceived as a way to provide environmental education. Figure 6 shows the relationship between project benefits and project drivers.

Knowledge and research benefits were cited by 13 of the projects. Knowledge and research benefits improve the overall understanding of environmental enhancement processes and procedures, but are directed toward the academic community and restoration professionals as opposed to environmental education which is directed at the general public. Knowledge and research benefits were captured by projects that improved the body of knowledge of enhancement techniques, processes and strategies and made their findings available to the wider public.

Knowledge and research values were most frequently cited as benefits in the projects sponsored by NGOs; seven of the nine projects sponsored by them cited this benefit. This is understandable since many of the NGOs implement several projects every year and could improve their ability to carry out their mission by improving their methods and overall knowledge.

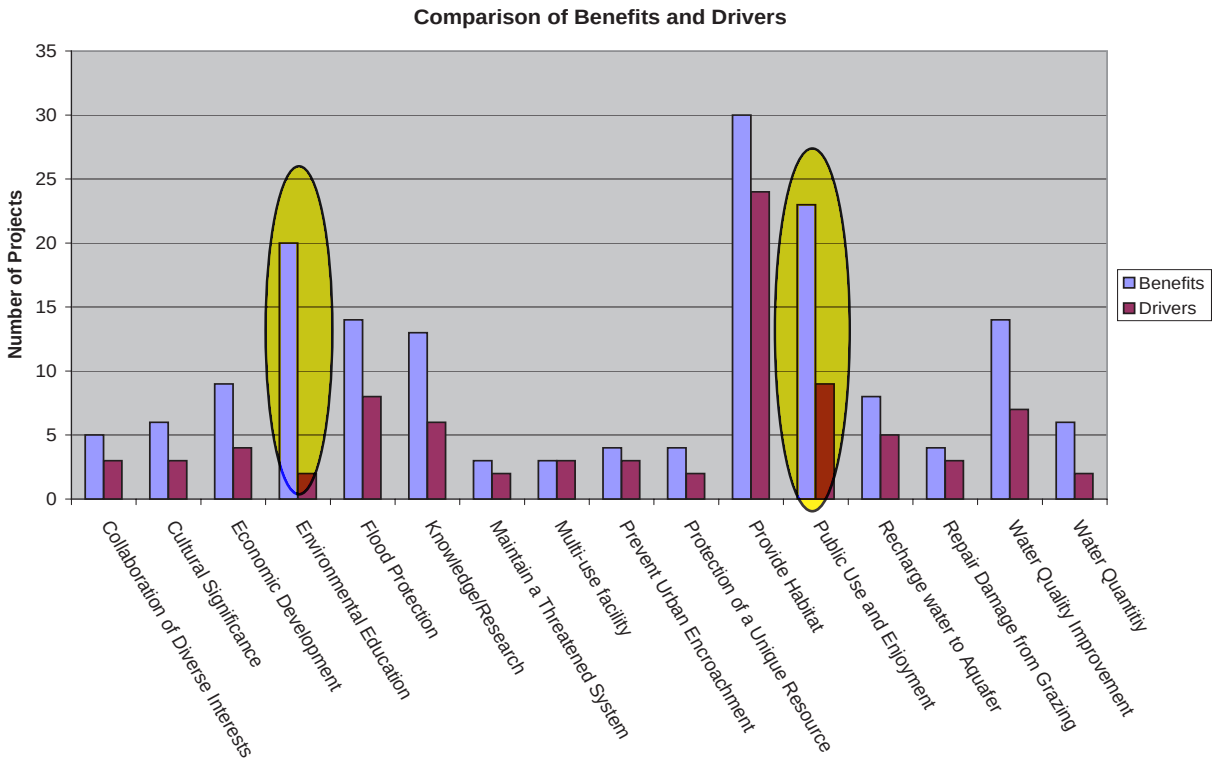

Figure 6. Comparison of benefits and drivers

Improved flood protection also proved to be an important benefit of projects in the study, with 14 projects indicating it as a benefit. Again, we saw an affinity toward a specific benefit by a certain sponsor. Eight of the 10 projects sponsored by cities cited flood control as a benefit. Not surprisingly, 10 of the 11 projects sponsored by county and regional flood control districts also included this benefit. The only county flood control project that did not was the Rillito River Riparian Area (Swan Wetlands), which receives storm water and puts it to beneficial use by creating a wetland, but, does not provide additional flood protection for the area. The U.S. Army Corps of Engineers co-sponsored a great many of these projects, again showing the connection between the mandate of a sponsoring agency and the benefits that are derived from their projects.

Water quality is one of the most significant issues with impaired riparian systems, and 14 projects cited water quality improvements as a benefit, and seven projects listed it as a driver. Unlike habitat value, water quality can be quantitatively measured through techniques such as Total Maximum Daily Load (TMDL). The TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards.[24] Water quality standards are set by federal, state and tribal agencies and may depend on the intended use of the water body i.e., drinking, swimming or aquatic life. Even with this quantitative and accepted measurement for water quality, only one of the projects reviewed in our study, EC Bar Ranch, referenced an TMDL report. This is quite striking and perhaps shows something about the rigor of applications and criteria for funding environmental enhancement projects.

Seven other benefits were noted in our project survey including: cultural significance (6), water quantity (6), collaboration of diverse interests (5), protection of a unique water resource

[24] www.epa.gov/owow/TMDL/intro.html. Retrieved March 3, 2006.

(4), repair damage from grazing (4), prevention of urban encroachment (4), maintenance of a threatened system (3), and multi-use facility(3)[25]. As with drivers, the diversity of benefits derived from the projects is remarkable.

Water use

Riparian areas throughout the state depend on water to maintain their habitat characteristics. There are, however, many competing demands for water in Arizona. Examining how these 30 projects use this limited resource was an important aspect of the project. Our examination of water use in environmental restoration focused on a few pertinent questions. Are environmental projects in the state dependent on un-protected instream flows? Are they surviving without the artificial importation of water? Have they purchased water rights or water supplies such as effluent from those willing to sell them? And what is the range of prices that projects have paid to secure water for the projects.

In order to analyze the information on water use, the projects were classified in one of three ways: 1) project does not require supplemental irrigation; 2) project requires only temporary supplemental irrigation (1-3 years); and 3) project requires long-term supplemental irrigation. The projects that did require some type of supplemental irrigation were then defined by the water supplies they were using to meet their requirements and whether contracts were in place to guarantee the supply of that water. Appendix D contains a flow chart showing each of the classifications, the water sources and the projects that used those water sources.

Six of the projects surveyed did not require any supplemental irrigation water. It is worthwhile to note that most of these projects are located along a natural river channel or ephemeral river supplemented with effluent flow. So, while these projects do not remove any water from the stream channel for irrigation, much of the character and value of the projects is dependent on instream flows. In the case of the Esperanza Ranch project, for example, this is especially critical since the project is oriented around an ephemeral effluent flow that is not guaranteed by contract. In the Grand Canyon at the Grand Canyon Tamarisk removal project, the situation is quite different. This project focused on removing tamarisk and other invasive species along the river corridor. The invasive species consume more water than native species and have a deleterious effect on the character of the river channel. Removing the invasive species was estimated to conserve almost nine acre feet of water per acre of tamarisk removed, thus leaving more water in the stream channel after completion of the project.

Nine of the 30 projects required only temporary supplemental irrigation. In these projects, irrigation is employed to support revegetation efforts through the critical first three years. After the initial establishment of the vegetation, the vegetation is expected to survive without any supplemental water. Like the first category, there are projects that rely on water sources that are not firm for some of the character and value of the project, but do not rely on these sources for irrigation.

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[25] A multi-use facility was classified as a facility that provided a number of functions for the community including (public use, education, recharge, water quality improvement, etc.). These facilities were counted for each of the individual benefits that they provided and additionally counted as a multi-use benefit because of the synergy benefit that is provided by providing multiple benefits in one space.

At the North Simpson site for example, the Tucson Audubon Society will eventually turn off ground water irrigation systems and leave the meso-riparian revegetation to adapt and compete on its own. Hypo-riparian vegetation will continue to be dependant on effluent flows from wastewater treatment plants in Tucson. If the flows were diverted to another use, the character of the riparian corridor would change significantly but the upland meso-riparian habitat would most likely continue to persist. While this may sound like a tenuous guarantee that the habitat will survive, project sponsors point to the natural ephemerality of riparian corridors in the desert and the value of putting a waste stream to productive use. Ann Phillips, project manager for the site notes that "the North Simpson Site may change character over time due to changes in the volume of effluent releases, impacts of large floods, prolonged drought, or other major impacts. With the exception of changes in effluent flows, these changes are to be expected in all riparian areas. Regardless of how changes might alter habitat in the future, the site right now is serving as habitat for numerous birds and other wildlife. Regardless of how the effluent flows might change over time, the site is now and will continue to be important meso/xeroriparian habitat because of the periodical flood flows that pass through the site".[26] Her point is that in some cases the here and now value of the habitat is sufficient to justify the expense of the project, even if some of the benefits of the project may be lost in the future due to changes in effluent flows. In addition, taking advantage of a waste stream to create hydroriparian habitat that otherwise would not have been present has an significant value.

Another project that will use supplemental irrigation is the Yuma East project. This project will use earthwork to reconfigure open water areas and the eradication of invasive species. Initially, the sponsors will remove water from the river to support revegetation efforts, but the design estimates show that once irrigation ceases, the project will actually leave more water in the Colorado River.

Half of the projects studied required only short-term or no irrigation, the other 15 projects required long-term inputs of water. In the arid climate of Arizona, where populations are expanding all over the state, competition for water supplies gets tighter every day. So how have these projects managed to secure long term water supplies? Many of the projects take advantage of multiple sources of water and can supplement their supplies with storm water or rainwater when available. Other projects provide benefits that augment water supplies by recharging large quantities of water. And others use unique supplies that are not of sufficient quality to be used for other purposes.

Seven of the 15 projects rely on effluent flows. Effluent is a waste product produced after municipal sewage has been treated to a level that is acceptable for re-release to the environment. For years this water was discharged into streambeds and allowed to mix with other surface water or percolate into the ground. Today, the demand for effluent has grown because it is increasingly used for irrigation of turf facilities and municipal landscaping. The seven projects in the study that use effluent employ it in several different ways.

One example is a restoration that was unintentional. A discharge of wastewater in Pima County has created a rich pocket of riparian habitat where volunteer species have colonized the area. The discharge is a result of the waste water treatment plant having no other use for the water and thus discharging it to the stream channel. A number of incidental benefits have emanated from the addition of water to an otherwise dry area. Much of the water eventually seeps in to the

[26] Phillips, Ann (Tucson Audubon Society). 2005, December. Site visit to North Simpson Project (Andrew Schwarz).

aquifer as the water percolates into the ground. The pocket area also provides habitat for birds and other wildlife and has started to attract bird watchers. The project doesn't have a sponsor or any drivers; it isn't really even a "project" per se. It does, however, show that restoration projects need not necessarily be complex pre-planned exercises in order to provide both human and habitat benefits.

In contrast, three of the seven projects that use effluent were intentionally designed to take advantage of effluent flows. The Marana High Plains Recharge Project, Sweetwater Wetlands and Tres Rios on the Salt River near Phoenix were designed to improve the quality of effluent flows and/or recharge them to underground aquifers. All three facilities use the effluent flows to support vegetated areas, a wetland that improves the quality of the water while providing habitat in the case of Sweetwater and Tres Rios and a riparian corridor in the case of the Marana High Plain Recharge project. The effluent streams flow through the riparian habitat and then into large spreading basins to be recharged into the ground. In these projects the water supply is an available waste stream and one of the key benefits: recharge, actually augments water supplies instead of competing with other consumers. The Sweetwater Wetlands project is different from the other two projects in that the water that is recharged into the ground is recovered a short time later to be delivered through the Tucson reclaimed water system. The process of recharge and recovery further improves the quality of the water producing a valuable water supply that can be used for irrigation purposes. The other four projects use effluent to varying degrees as it flows through the project site as an instream flow or piped in tertiary treated reclaimed water for irrigation purposes.

The second most common source of water for the projects studied was storm water. Five of the projects employed storm water as a source of irrigation water. Only three of these projects actually had agreements or contracts in place guaranteeing the delivery of the water during storm events. All five of these projects had at least one other source of water whose delivery was more dependable and predictable.

Four of the projects used groundwater, all of which had contracts for its use. One of these projects, Rio Salado Phoenix, used a groundwater supply under the site that had been contaminated by urban runoff from Phoenix. The water had very little alternative economic value because the cost of treatment that would have been required for municipal use. The project was able to take advantage of the water by treating it to acceptable standards for irrigation and putting it to use.

Of the projects that require long-term irrigation, two use surface water, San Xavier and Yuma West, and a third project Va Shly ay Akimel is planning on using surface water. The San Xavier project was the first project to employ their Central Arizona Project (CAP) water allotment for environmental restoration and laid the groundwork for nearly 50,000 acre-ft of CAP water to be used on the reservation for restoration projects over the next several years. Va Shly ay Akimel project planners also intend to use CAP water to provide irrigation for the project. The Yuma West project uses main-stem Colorado River water from the City of Yuma's entitlement. The Yuma West experience is unique and the long-term water requirements are actually disconnected from the major habitat values of the project. In this project the long-term irrigation requirements are for the upper parkland area which is turf grass. The lower terrace, which contains the revegetated riparian species and most of the habitat value of the project, did not require irrigation beyond the initial establishment period.

An interesting characteristic of the 15 projects that required long-term supplemental inputs

of water was that they were focused exclusively in the main population centers of Arizona, Phoenix Metro, Tucson and Yuma. The 15 projects that do not require long-term inputs of water are scattered through out the state in every eco-region studied.

Projects in the study that required supplemental inputs of water varied widely as to the quantity of water that was required. Some projects required as little as a few hundred acre feet of supplemental water per year while other projects required tens of thousands of acre feet per year. For example, the Rio Salado-Phoenix project will use about 6 million gallons of groundwater per day. Many of the projects paid only costs for pumping groundwater while others projects such as the Rillito River (Swan Wetlands) paid in excess of two hundred dollars per acre foot of water. An in depth analysis of the quantities and costs of water for the projects is not provided here. The significant differences in water sources, availability, and use make it impossible to do an accurate side-by-side analysis. Information about the water use and costs for each project can be found in the project summaries in Part II of this report.

Three of the 15 projects that had long-term irrigation requirements were still in the planning stage and had not finalized the source of water that would be used. As this study was a snapshot of the projects in Arizona we were not able to make any observations about how water source issues affect the eventual implementation or cancellation of projects.

Lessons Learned Summary

Through the process of studying these 30 projects, much has been learned regarding the development of environmental enhancement projects. We categorize the most salient lessons learned as the six peas (P's) in the pond: preparation, persistence, partnerships, progress, pests, and post-construction. These six P's represent six broad categories of advice compiled from a combination of our observations, as well as comments from the project contacts.

Preparation: environmental enhancement projects are complex and dynamic. Many of the projects experienced difficulties due to foreseen and unforeseen obstacles. In some cases pre-construction planning or terrestrial information, such as surveying, was insufficient in some respect and led to large cost increases. Environmental enhancement projects change the character of the landscape in some cases creating undesirable situations such as increasing grass fire danger or attracting homeless people. Many of the projects faced significant regulatory permitting processes and some dealt with complications related to establishing conservation easements. The Rio Salado project, for example, had to obtain nearly 100 federal, state, county and city permits for various aspects of the project. These processes tended to be long and sometimes costly, draining resources and energy. Project teams that devoted significant consideration toward planning and presaging these issues were often able to implement their projects more smoothly and were able to more closely adhere to their project schedules. One example of where more pre-planning would have been helpful was the Bingham Cienega project. In this project, the restoration team, by their own admission, did not consider all of the costs associated with the irrigation lines, which resulted in unexpected expenditures. As a result they recommend that a rigorous cost analysis be conducted prior to project implementation. Had they done this analysis they would have seen, for example, that it was cheaper to drill a well adjacent to the fields rather than depending on the existing well at the house site and irrigation lines from that well. In some cases, especially where the project

Figure 7. The 6 P's in the pond

involved many unknowns, a smaller scale pilot project was conducted. These pilot projects elicited valuable information about the challenges and solutions that could be used in implementing a full scale project.

Persistence: adversity is common and flexibility is a key to success. Many of the projects surmounted huge obstacles or even failed completely on their way to implementation. For example, the Rio Salado Project was first conceived in the late 1960s by James Elmore, the founding dean of Arizona State University's School of Architecture. Elmore's plan evolved over two decades to include 28 miles of lakes throughout the Maricopa metropolitan area and carried a price tag of $2.5 billion. When the City of Phoenix took this plan to the voters in 1987, it was overwhelmingly defeated. Today's Rio Salado Habitat Restoration Project is considerably scaled down, encompassing 5 miles of river and has been endorsed by Phoenix residents. [27] Projects in this study also evolved from their original designs due to outside forces such as adjacent land owners, stakeholders or funding agencies. Projects needed to navigate this process without compromising the goals of the project. EC Bar sponsor, Jim Crosswhite, recommends identifying one focus from which all activities stem. A successful strategy for manipulating this process was assigning one specific person to spearhead fundraising or supervise critical aspects of the project.

Partnerships: different groups bring different strengths. Partnerships were not just about funding. In several instances project partnerships allowed one sponsor to focus on restoration efforts while another sponsor provided heavy equipment, water tanks and wells or police monitoring to keep unauthorized users off of the property. Projects that had multi-disciplinary teams were able to foresee and deal with a wider range of issues. Some projects brought together very diverse interests and agencies. When these partnerships were able to find common ground, they tended to be very successful. Partnerships also included joining together multiple enhancement efforts to pursue common goals. These types of partnerships can sometimes capture synergies between multiple projects. Environmental enhancement projects often become more valuable when their benefits are combined with other projects to provide a more comprehensive improvement. In many cases, partnerships involved cost sharing agreements. Funding from the Bureau of Reclamation and Arizona Department of Environmental Quality used by projects in this study required a percentage

[27] De Semple, Daniel. (2006) Phoenix Rises. Civil Engineering. Vol. 76 Issue 2, p 42-47

of matching funds to be provided by the sponsor. Funding from the Arizona Water Protection Fund requires that monitoring and maintenance of the projects be continued indefinitely into the future. The Fund does not allow their grant money to be put to this use, thus sponsors had to identify other funding sources to cover these costs.

Progress: measuring success of an environmental enhancement project is difficult and sometimes contentious. Quantitative measurement techniques are not widely used by these projects despite the common use of them by state and federal agencies. Most funding agencies do not require reporting of pre-project or post-project reports for water quality (Total Maximum Daily Load measurements) or overall riparian health (Proper Functioning Condition). Our research did not indicate that any widely used quantitative standards or requirements exist for measuring the success of projects. Retrospective evaluations of any kind were also rare.

Pests: many projects faced problems from invasive species, mosquitoes and unwanted wildlife. In many cases the presence of water in areas where there had previously not been water attracted mosquitoes and unwanted wildlife such as beavers and elk. The Verde Headwaters project, for example, found it necessary to construct elk fences around large portions of the site. In places where elk were allowed problems arose from not only the elk grazing but also the elk disturbing the nets placed on the ground to prevent erosion. In other cases invasive species that had been present on the land for years proved nearly impossible to remove. When invasive species on the property could be controlled problems often arose from adjacent properties which provided seed sources for re-colonization. Many projects stressed long time horizons for dealing with invasive species, allowing multiple seasons to continuously deplete seed banks in the soil.

Post-Construction: Monitoring and maintenance are extremely important factors in gauging and achieving success, but are difficult to fund. In many cases the post restoration or enhancement monitoring is arguably the most important aspect of the project. Monitoring post-dam removal in Fossil Creek restoration project, for example, will reveal how this unique travertine system restores itself. Funding for this monitoring has, however, been difficult to find. The Arizona Water Projection Fund requires that its grantees commit to monitoring of the project site after completion but do not allow their funds to be allocated to monitoring. Maintenance considerations are especially important in projects with continued irrigation needs. Several projects experienced irrigation system failures that in some cases caused large die offs of vegetation.

Conclusions

This report details the many benefits that environmental enhancement projects provide to humans and wildlife. Although some projects in this study were designed to use no or minimal surface water diversions, most projects require water to maintain their character. Allocation of scarce water resources is increasingly a concern across Arizona.

Recognizing the link between public awareness of the value of environmental enhancement projects and their future, we suggest two more P's, the Process and the Public. These two P's are not independent. In order to gather the support of the public for the required resource investments, the process should include public outreach and involvement during all phases of the project. Engaging the public early in the process, during project conceptualization, allows citizens to comment on possible design elements and management goals. Using volunteer labor during construction can increase public ownership of the project and foster a deeper understanding of the ecology and appreciation of the value of these projects. And continuing to involve the public after completion by using the site for educational and recreational events can increase the value of the project and

promote the site's use.

Environmental enhancement projects can be expensive, both in terms of water and funding. Through incorporating the public early and often, agencies can ensure public understanding. Public knowledge is important because of the many competing interests for limited financial and natural resources. Better public appreciation of the need for and value of such projects may result in increased support for environmental enhancement projects, especially those with long-term water resource requirements and significant other public investment.

The Process is important not only for its ability to incorporate the public and engender support but, also in how the projects are managed. Another overarching concept that can be taken from these 30 environmental enhancement projects is adaptive management. Most project sponsors described flexibility, experimentation, communication and evaluation as keys to project success. In the face of water and financial uncertainty, adaptive management strategies can give project teams the tools to adjust to changing conditions and limitations.

Finally, the Process and the Public come together for another important consideration in environmental enhancement projects. Given the rapid growth throughout Arizona, the focus on water resource utilization can overlook the water needs of the environment. Although the environment is recognized as a water using sector[28], this sector's "demand" for water is often not recognized in municipal water planning or provided equal footing in water rights allocations. The three largest urban areas in Arizona, Maricopa, Pima and Yuma counties, all have multiple, large-scale environmental enhancement projects underway. These projects currently use water that the municipalities do not want or can't use economically at this time, e.g., effluent and contaminated groundwater. In the future, however, scarcity of supply may lead municipalities to look to these sources of water to provide for their populations. Public outreach and education and a better understanding of environmental enhancement projects could assist the process of considering environmental water needs in our overall planning for growth in the future.

[28] Anderson, Mark T., and Woosley, Lloyd H., Jr., 2005, Water availability for the Western United States--Key scientific challenges: U.S. Geological Survey Circular 1261, 85 p.