Restoration and river management in the arid southwestern USA: exploring project design trends and features

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Abstract

River restoration activities are becoming increasingly common in many communities today. Such efforts in Arizona are illustrative of a larger ecosystem and river restoration trend underway nationally and internationally. This paper examines river restoration efforts in Arizona in the context of changing federal and state agency missions and local priorities. Restoration projects on four significant rivers are analyzed with a keen look at the design features they share. Multiple purpose goals, collaborative funding and support, community involvement, and monitoring and maintenance emerged as important project design features. We found that the extent to which these features were planned and implemented in any given project varied with several factors such as size, accessibility to urban populations and the mission of the principal sponsoring entity.

Keywords: Project design features; Restoration; Rivers; Salt River; San Pedro River; Santa Cruz River; US Army Corps of Engineers; US Bureau of Reclamation; Verde River

1. Introduction

Since the National Research Council recommended the restoration of ecologically altered rivers and streams in the USA in 1992, significant river restoration projects have been undertaken (National Research Council (NRC), 1992). Research published in the journal Science reported that more than US$1 billion is spent on river and stream restoration projects annually nationwide (Bernhardt et al., 2005: 636–637). Under the broad umbrella of river restoration, there are a range of restoration efforts underway, including reclamation efforts, dam removals, restoration of habitat and simulation of natural flows (Riley, 1998; Lowry, 2003: 61–62; Clark, 2004).

Today many are familiar with endangered species restoration efforts along the Colorado River, or efforts to restore habitat along the Upper Mississippi (Vigmostad et al., 2005; Cohn, 2001). Restoration
activities in the Chesapeake Bay or along the Pacific Northwest’s Columbia River serve as models for large-scale collaborative ecosystem restoration and management (Heikkila & Gerlak, 2005). In recent years efforts have been undertaken to restore the Florida Everglades, which is considered to be the largest ecosystem restoration project in human history (Clarke & Dalrymple, 2003: 541).

This paper examines river restoration efforts in Arizona in the context of changing federal and state agency missions and the rise of environmental quality among local priorities. Restoration projects on four significant rivers are analyzed with a keen look at the design characteristics they share. It is an attempt to move beyond the single case study approach and reveal a broader set of features shared by existing restoration projects.

2. Restoration trends and changing agency missions

In response to growing political pressure, federal natural resource agencies have expanded their missions to incorporate environmental restoration values. The expanded missions of federal natural resource agencies, now encompassing environmental restoration, have created opportunities for collaboration with restoration interests at the local and state levels. Since the 1990s, the US Bureau of Reclamation and US Army Corps of Engineers, the two major US water project constructions agencies, both have implemented grant programs for environmental restoration.

The US Bureau of Reclamation (US BOR) announced no new water projects, shifting their mission to one of management and maintenance (US US Bureau of Reclamation (BOR), 1987). Recently, John Keys III, Commissioner of the Bureau announced that the bureau’s new role is one of “cooperating partner” (Keys, 2006: 27). The Challenge Grant Program of Water 2025, the agency’s latest program, is a 50–50 cost share program where the Bureau of Reclamation forms partnerships with local water districts (US Bureau of Reclamation (BOR) (2005)). Today, the Bureau of Reclamation is engaged in a number of restoration activities, including preserving wetlands and enhancing fish and wildlife habitat. Most notable, is the adaptive management and controlled flood policies of the Glen Canyon Dam on the Colorado River (Baish et al., 2002).

Following the 1993 midwest floods and the subsequent Galloway Report on Flood Control in 1994, the US Army Corps of Engineers (US ACE) began to move away from structural solutions signaling a shift in flood control policy. Under the Clinton Administration, it began its transition as “environmental protector”, moving from a water development mission to a water management one (Clarke & McCool, 1996: 45). In more recent years, it has also shifted its focus toward ecosystem restoration designed to re-establish the attributes of a natural, functioning and self-regulating system (US ACE, 2002). Other federal agencies, like the US National Park Service, US Forest Service and US Department of Agriculture National Resource Conservation Service, have also adopted environmental restoration goals in recent years. Today, some 40 federal agencies fund stream and river restoration projects (Palmer & Allan, 2006: 47). Changes in agency missions represent a broader policy shift occurring in water management in the United States today (Lowry, 2003; Miller, 2000).

This shift can be linked to parallel changes among the constituencies of these agencies at the local level, where sustainability and environmental health have joined development and economic health as community goals. Across the country a growing number of local jurisdictions are focusing attention on restoring natural amenities as part of their development and redevelopment strategies. Communities as diverse as Chicago, Boston, Houston and Los Angeles are burnishing their
environmental images with various environmental initiatives (Johnston et al., 2005; Platt, 2006; Millions, 2005; Hyman, 2005).

Today, dozens of non-governmental organizations focus on river restoration efforts in the USA. The Nature Conservancy and the Audubon Society are two that are actively advocating river ecosystem and habitat restoration activities. Every year, there are countless forums, symposiums and conferences dedicated to exploring river restoration efforts in various regions of the country. There are even postgraduate certificate programs offered in river restoration and management. A single recent internet “Google” search of “river restoration projects” yielded some 2.4 million hits.

3. A shift to restoration in the arid southwestern USA

Controlling property damage caused by flooding and meeting current and future water demands have long meant the construction of major public works projects involving federal and local agencies in the southwestern United States (Gerlak, 2006; Sabatier et al., 2005a; McCool, 1994: 14–35; Rogers, 1996: 45–73). For example, the Phoenix metropolitan area benefited from the construction of a series of dams and reservoirs that make up the Salt River Project, one of the first projects built by the US Bureau of Reclamation (Smith, 1986). For decades, cities and farms in Maricopa County have relied on water from the Salt and Verde Rivers. Historically, the Santa Cruz River fueled agriculture and development in the Tucson area, but since the middle of the 20th century, Tucson residents and farmers have relied almost entirely on groundwater. In more recent years, southern Arizona has benefited from the Central Arizona Project, a series of canals and aqueducts which delivers Colorado River water to the area (Jenkins, 2006).

Initially, there were limited concerns in Arizona about the impact of increasing water use and construction of control structures on riparian ecosystems. More recently, stories of declining groundwater tables and degraded riparian areas have become all too familiar. Today, there is a growing recognition that surface water diversions and groundwater pumping have greatly reduced or eliminated the flow of water in many of Arizona’s rivers and streams (Woodard, 2004: 133). As a result, significant efforts are underway to restore degraded habitat and improve and preserve the environment in communities and watersheds in Arizona. Other efforts are underway to replenish groundwater aquifers and store water for future use through novel water storage projects. In some instances, these goals have been combined along with others aimed at reversing losses. This paper focuses on restoration efforts along four significant rivers in Arizona: the Salt, Verde, San Pedro and Santa Cruz Rivers. Collectively, these projects reveal a rich picture of what characterizes existing restoration projects with regard to

2 Since 1980, when Arizona enacted the Groundwater Management Act, the focus of water management efforts in the two major urban areas of the state has been on substituting renewable water supplies for groundwater. The goal of the 1980 law was to slow the depletion of groundwater resources and, in some areas, to balance the amount of water pumped out of the ground with water returned to aquifers. About 20% of the state’s geographic area, and 80% of its population, is subject to the law. “Arizona’s Groundwater Management”, The Arizona Republic (27 July 27 2005) at http://www.azcentral.com/specials/special26/articles/0627rwatertwoways27.html. Recently, the state, led by Governor Janet Napolitano, initiated a drought planning strategy. See Governor’s Drought Task Force at http://www.azwater.gov/dwr/drought/ADPPlan.html. See also Megdal (2005b).
project sponsorship, goals, design and implementation on the ground in the watershed. It relies on project documents and reports as well as discussions and interviews with restoration project participants in over 22 restoration projects that are currently underway. See Table 1 for a review of the restoration projects studied here and Figure 1 for a look at the rivers.

3.1. Restoration along the Salt River

In the Phoenix metropolitan area, restoration efforts are underway to restore the riparian habitat in and around the Salt River. As diversions of water increased for urban and agricultural uses in this area, the river’s perennial flows ceased, causing the water table to drop. Today, only small isolated fragments of the natural riparian ecosystem remain. In his 1986 classic, Cadillac Desert, author Marc Reisner described this stretch of the Salt River this way.

“Phoenix owes its existence to [the Salt River], but even so it doesn’t seem to hold the Salt in high esteem. On both banks, the floodplain is encroached by industrial parks, trailer parks, RV parks, but no real parks. The flood channel itself has been developed to a degree, playing host to establishments which are, by nature, transient: topless bottomless joints, chop shops, cock-fighting emporia. Paris built its great cathedral by its river, Florence its palaces or art; Phoenix seems to have decided that its river is the proper place to relegate its sin” (Reisner, 1986).

The Rio Salado Project aims to change this urban landscape. Originally conceived as an urban renewal project in the late-1960s by the founding dean of Arizona State University’s School of Architecture, the plan evolved over two decades to include miles of lakes through the Phoenix metropolitan area. When the city took the plan to the voters in the late-1980s, it was overwhelmingly defeated. A significantly scaled down project, encompassing 8 km (5 miles) of river has been endorsed by Phoenix citizens (DeSemple, 2006). This revived project involves significant input from the US Army Corps of Engineers Ecosystem Restoration Program and is designed to affect positively the urban core of Phoenix. The projects’ concepts were developed by a class at Arizona State University. There are three components to this project, stretching along three significant reaches of the river— the Rio Salado-Phoenix Reach, the Rio Salado-Tempe Reach and the Rio-Salado Oeste Reach. All three projects are designed to restore native riparian wildlife and wetland habitat and provide recreational opportunities (US Army Corps of Engineers (ACE), 1998).

Tres Rios, a restoration effort at the confluence of the Gila, Salt and Agua Fria rivers, is a project designed to provide a sustainable and diverse native riparian habitat, reduce flood damage and increase environmental education and recreation in the area (US Army Corps of Engineers (ACE), 2000). It includes a demonstration wetland project, undertaken by the US Bureau of Reclamation. The Va Shly’ay Akimel Project, on Salt River Pima Maricopa Indian Community land, aims to restore the riparian ecosystem to the degree that it supports native vegetation and wildlife along a 23 km (14 mile) stretch of the Salt River. This project also seeks to provide passive recreation opportunities for visitors and create educational opportunities related to the Salt River ecosystem and its cultural resources (US Army Corps of Engineers (ACE), 2004).

3 Specifically, it builds from two key reports produced by the University of Arizona’s Water Resources Research Center (Megdal, 2005a; Megdal et al., 2006).
Table 1. Restoration projects studied in Arizona.

<table>
<thead>
<tr>
<th>Project name</th>
<th>Project costs*</th>
<th>Project size</th>
<th>Project status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rio Salado, Oeste</td>
<td>unknown</td>
<td>13 km (8 miles)</td>
<td>Plan</td>
</tr>
<tr>
<td>Rio Salado, Phoenix Reach</td>
<td>US$79.6 M (US$7.9 M annually)</td>
<td>8 km (5 miles) 241 hectares (595 acres)</td>
<td>Completed</td>
</tr>
<tr>
<td>Rio Salado, Tempe Reach</td>
<td>US$6.2 M (US$684 annually)</td>
<td>55 hectares (135 acres)</td>
<td>Plan</td>
</tr>
<tr>
<td>Tres Rios</td>
<td>US$99.3 M (US$97.4 M annually)</td>
<td>11 km (7 miles) 22,660 hectares (56,000 acres)</td>
<td>Construction</td>
</tr>
<tr>
<td>Va Shly’ay Akimel</td>
<td>US$138 M (US$14.4 M annually)</td>
<td>23 km (14 miles) 7,056 hectares (17,435 acres)</td>
<td>Plan</td>
</tr>
<tr>
<td>Verde River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fossil Creek</td>
<td>US$11.8 M for removing structures</td>
<td>23 km (14 miles)</td>
<td>Construction (structure removal), monitoring</td>
</tr>
<tr>
<td>Verde River Headwaters</td>
<td>US$318,000</td>
<td>945 m (3,100 ft) 1,133 hectares (2,800 acres) (site) 11 hectares (28 acres) (restoration)</td>
<td>Completed</td>
</tr>
<tr>
<td>San Pedro River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bingham Cienega Natural Preserve</td>
<td>US$221,000</td>
<td>115 hectares (285 acres)</td>
<td>Completed</td>
</tr>
<tr>
<td>Las Cienegas National Conservation Area</td>
<td></td>
<td>4 km (2.5 miles)</td>
<td>Management</td>
</tr>
<tr>
<td>San Pedro Preserve</td>
<td>US$4.4 M</td>
<td>344 hectares (850 acres)</td>
<td>Completed</td>
</tr>
<tr>
<td>Three Links Farm</td>
<td>US$4 M</td>
<td>876 hectares (2,165 acres)</td>
<td>Implement</td>
</tr>
<tr>
<td>Santa Cruz River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ed Pastor Kino Environmental Restoration Project</td>
<td>US$12 M (US$15,000 annually)</td>
<td>49 hectares (120 acres)</td>
<td>Completed</td>
</tr>
<tr>
<td>El Rio Antiguo</td>
<td>US$66.7 M (US$1.3 M annually)</td>
<td>7.7 km (4.8 miles) 431 hectares (1,066 acres)</td>
<td>Design</td>
</tr>
<tr>
<td>Esperanza Ranch Riparian</td>
<td>US$572,000</td>
<td>121 hectares (300 acres)</td>
<td>Construction</td>
</tr>
<tr>
<td>Marana High Plains</td>
<td>US$750,000 (US$28,000 annually)</td>
<td>1.9 km (1.2 miles) 7 hectares (18 acres)</td>
<td>Pilot completed</td>
</tr>
<tr>
<td>North Simpson site</td>
<td>US$550,000</td>
<td>688 hectares (1,700 acres) (site) 100 hectares (246 acres) (restoration)</td>
<td>Construction</td>
</tr>
<tr>
<td>Paseo de las Iglesias</td>
<td>US$92.1 M (US$1.1 M annually)</td>
<td>12 km (7.5 miles) 444 hectares (1,098 acres)</td>
<td>Design</td>
</tr>
<tr>
<td>Rillito/Swan Wetlands</td>
<td>US$2.7 M (US$205,000 annually)</td>
<td>24.6 hectares (60.7 acres)</td>
<td>Construction</td>
</tr>
<tr>
<td>San Xavier Indian Reservation</td>
<td>US$668,000</td>
<td>7.1 hectares (17.5 acres)</td>
<td>Completed</td>
</tr>
<tr>
<td>Santa Fe Ranch Riparian</td>
<td>US$68,000</td>
<td>366 m (1,200 feet) 4 hectares (10 acres)</td>
<td>Completed</td>
</tr>
<tr>
<td>Restoration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweetwater Wetlands</td>
<td>US$1.6 M (US$72,000 annually)</td>
<td>44 hectares (109 acres) (site) 7 hectares (17.3 acres) (restoration)</td>
<td>Completed</td>
</tr>
<tr>
<td>Tres Rios del Norte</td>
<td>US$287 M (US$3.1 M annually)</td>
<td>31 km (19 miles)</td>
<td>Plan</td>
</tr>
</tbody>
</table>

*Please note that project costs are not directly comparable but rather are reported here in their incomplete form to offer a broad picture of project expense. For projects still in the planning stage, these figures are estimated costs, but for completed projects, the figures represent total costs. Annual costs involve some combination of operation and maintenance as well as the costs for water and/or maintenance of project structures.
3.2. Restoration along the Verde River

The construction of water development projects to divert water from the Verde River in central Arizona also has resulted in negative environmental consequences. The Verde River takes form at Sullivan Lake in Yavapai County, then flows south about 275 km (170 miles) to its Salt River confluence just northeast of Scottsdale and Phoenix. Along the way, the Verde River passes through parts of three national forests, across Apache Nation lands as well as state and private lands. It is Arizona’s only federally designated “Wild and Scenic River” and is a rare perennial stream in a state full of “dry” rivers. However, this year, American Rivers listed the Verde as the nation’s 10th most endangered river because of plans by nearby cities to pump water from an aquifer feeding the river.

Already, groundwater pumping in the Prescott area is depleting the springs at the headwaters of the Verde River (Babbitt, 2004). Diversion of water through canals, pipes and tunnels to power plants from
Fossil Springs, a tributary of the Verde River, led to significantly reduced streamflows in Fossil Creek. Following a campaign of public pressure and behind-the-scenes negotiation, Fossil Creek Dam was decommissioned in 2005 and full flows were restored. Removal of the structures associated with the power plants there are underway (McCord, 2005). The effort that led to the decommissioning of Fossil Creek Dam was the subject of a recent documentary, *A River Reborn: The Restoration of Fossil Creek* and is considered emblematic of dam removal effort worldwide. In addition, it has been the focus of intensive research and monitoring by scientists from Northern Arizona University and several federal and state agencies before and after decommissioning (Northern, 2006). The project is thought to be a case study in ecosystem restoration after dam removal, providing research valuable for other regions of the USA (Gelt, 2005: 1). A little further north, a project is underway to reverse conditions of stream instability caused by human activities. Building from of an earlier US Forest Service erosion project at Clover Creek just outside Flagstaff, a restoration project in the Verde River headwaters is focused on revegetation and stabilization.

3.3. Restoration along the San Pedro River

Development and agriculture have greatly reduced the flow of the San Pedro River. This river, which flows from Mexico into the United States, has been called one of America’s last free-flowing rivers. The Nature Conservancy named it one of the “Last Great Places” (The Nature Conservancy, 2007). It is home to some 300 bird species with about 6 million birds nesting along the San Pedro each year while migrating back and forth from Latin America to Canada. It is described as a “ribbon of green, lined by huge colonies of cottonwood and willow trees”, a welcome site in a desert environment (Davis, 2005). In 2005, the San Pedro went dry (at the Charleston gauge) for the first time in at least 75 years (Davis, 2005) and was reduced to a trickle again in 2006 and 2007 (Davis, 2007). Some blame the persistent drought. Others see groundwater pumping as the culprit. It is estimated that the upper portion of the basin in the USA alone had an 8.7 million m³ (2.3 billion gallon) groundwater deficit in the year 2000 (The Natural Conservancy, 2007).

The Nature Conservancy has been a leader in riparian preservation and restoration in Arizona, acquiring a number of properties in the San Pedro watershed for the purpose of restoring flow to the San Pedro. In a northern (downstream) stretch of the river, the Nature Conservancy purchased the Three Links Farm, a 107 hectare (265-acre) alfalfa farm. Hydrological modeling shows that retiring the land will benefit some 32 km (20 miles) of river with increased base flows and healthier riparian vegetation. Another project, the San Pedro Preserve, is designed to protect and enhance the endangered willow flycatcher habitat. The restoration plan includes protecting riparian forest and native grassland communities and demonstrating agricultural techniques for use in large scale habitat restoration (The Nature Conservancy, 1997). Between these two projects, the Bingham Cienega Natural Preserve is employing a strategy of restoring habitat types based on depth to groundwater to achieve a diversity of riparian habitats in former agricultural fields.

Many state and federal agencies, as well as non-governmental organizations, have actively participated in the management and restoration of segments of the river in recent years. Grassroots efforts led to establishment by the US Congress in 1988 of the San Pedro River Natural Conservation Area (SPRANCA) along a 64 km (40 mile) stretch of the river from the international border with Mexico to St. David, Arizona. The Bureau of Land Management (BLM) manages SPRNCA with the goal of protecting and enhancing this rare remnant desert riparian ecosystem. However, it became evident that
uncontrolled groundwater pumping would eventually dry the river. In 1999, the Upper San Pedro Partnership was formed, bringing together participants from 21 government agencies and private organizations, who work together to ensure a sustainable water supply for the area’s residents while protecting the San Pedro River (Upper San Pedro Partnership, 2008).

In 2000, Congress created the Las Cienegas National Conservation Area (NCA). This NCA encompasses an area of wetlands that actually straddles the San Pedro and Santa Cruz River watersheds. The largest section lies along Cienega Creek, which flows north and northwest toward Tucson, while the southeastern-most segment feeds creeks that flow east toward the SPNCA. Las Cienegas NCA is home to five of the rarest habitat types in the southwest, including cottonwood willow areas, cienegas, sacaton grasslands, semi-desert grasslands and mesquite bosques. It is managed also by the Bureau of Land Management to conserve, protect and enhance its unique and nationally important resources and values, while allowing livestock grazing and recreation to continue in appropriate areas. This project is considered vital to the city of Tucson in terms of both flood control and aquifer recharge.

3.4. Restoration along the Santa Cruz River

The Santa Cruz River, rising in the Santa Rita Mountains south of Tucson and curving briefly into Mexico, traces a 357 km (222 mile) long path north through Tucson before disappearing into the Sonoran desert on its way north to the Gila River. Today, the Santa Cruz River in the Tucson area is an ephemeral river with little riparian habitat, characterized by deeply incised banks and groundwater levels at 46 m (150 ft) below the surface. Approximately half of the groundwater pumped in Tucson comes from wells near Santa Cruz River (US Army Corps of Engineers (ACE), 2003). Some worry that the pumping is the cause of recent tree die-off along the river (Arizona Water Resources, 2005: 5). It “runs north through the 21st-century city like a desiccated scar, its eroded banks replaced with an ugly construction material called soil cement. Water runs in this glorified drainage ditch only when torrential rains fall and marring the former waterway is discarded trash, a shopping cart here, a dead cat there” (Regan, 2001).

Prior to degradation, the Santa Cruz River flowed all year round. It was a shallow stream with a wide flood plain, with cottonwood-willow forest and mesquite bosques. The first people who lived in Tucson got their water from the Santa Cruz River or from springs that bubbled to the surface (Gelt et al., 1999: 5). Indian and Anglo farmers diverted surface water, then later groundwater, for irrigating crops. In the 1950’s some one million tons of garbage was dumped in and around the Santa Cruz River, artificially narrowing the channel. By that time channelization, initiated possibly by digging of ditches, had entrenched the river bed and lowered the water table. Construction of freeways helped to further channelize the river, as did the addition of soil cement in portions of the Santa Cruz River to reduce bank erosion and flood damages.

The Santa Cruz River is central to Tucson’s downtown revitalization program, commonly called Rio Nuevo, or the “New River” project. The project, designed to spur development of the city’s fading downtown, features a river walk and a cienega along the banks of the Santa Cruz. Several additional activities are underway to restore segments of the Santa Cruz River. The Paseo de Las Iglesias project, commonly referred to as the “Walk of Churches” because it is adjacent to the San Xavier and San Agustin Missions in southern Arizona, is designed to increase the acreage of functional riparian and floodplain habitat and increase wildlife habitat diversity by providing a mix of riparian habitats within the river corridor, riparian fringe and historic floodplain. Creating diverse habitat is also an objective of
the Santa Fe Ranch Riparian Restoration project, along with reducing stream bank erosion. The Tucson Audubon Society is spearheading two projects along the river. The Esperanza Ranch Riparian Restoration project is designed to increase the diversity and density of riparian habitat for the benefit of birds and other wildlife. With the North Simpson Site Riparian Restoration project, the society, along with the City of Tucson, aims to restore some 688 hectares (1,700 acres) of former farmland.

Restoration of wetlands is the focus of two projects in the Tucson area. The Ed Pastor Kino Environmental Restoration Project, named for a popular former congressman, restored wetlands and riparian vegetative communities along the Tucson Diversion Channel of the Santa Cruz River. The Sweetwater Wetlands Project, which began as a water quality compliance project, involves the creation of urban wetlands designed to create wildlife habitat and provide public education opportunities. The Marana High Plains Effluent Recharge Project combines groundwater recharge with restoration of riparian habitat. It involves 7.3 hectares (18 acres) of created riparian habitat along 1.9 km (1.2 miles) of an oxbow of the Santa Cruz River in the town of Marana, just north of Tucson. In addition to its recharge objectives, the project will revegetate the area outside recharge basins, characterize wildlife and vegetative resources and provide trails and educational displays (Entranco, 1998). The San Xavier Indian Reservation Riparian Restoration Project involves two riparian sites of approximately 5.7 hectares (14 acres). A primary goal of the project is to enhance and restore riparian vegetation along two arroyos on the reservation. Invasive species, like tamarisk and tumbleweed, were removed and the areas were revegetated with native mesquites.

4. Elements of river restoration projects

Most restoration work in the USA, including both large-scale efforts and smaller stream and river projects, occur in a piecemeal manner. There are no national standards for measuring success, nor are there standard design and implementation rules. Some research attempts to fill this gap by offering a set of standards for ecologically successful river restoration (Palmer et al., 2005). Presently, the National River Restoration Science Synthesis project, a collaborative effort to synthesize knowledge on restoration projects in various geographic regions of the USA, is cataloging and summarizing policies and practices across thousands of projects (NRRSS, 2007).

Nonetheless, little attention has been paid to identifying the components of river restoration project design. A review of both the large-scale high profile restoration efforts and the thousands of small-scale case studies that have been published in recent years offer some insights into restoration project design features (Gerlak & Heikkila, 2006; Wyant et al., 2005; Van Cleve et al., 2006; Golet et al., 2006; Bernhardt et al., 2005). These include attention to design elements such as: (1) multiple-purpose goals; (2) collaborative funding and support; (3) community involvement; (4) monitoring and maintenance.

Restoration projects underway in Arizona are quite diverse. Some projects are small, while others are quite large. Some projects are public initiatives and others are public–private partnerships. Some projects are urban, but others are carried out far from cities. Some projects concern lowland river channels and others concern upland seeps and springs. Given this diversity, drawing generalizations is a challenge.

Leaving aside questions of ecological success, the existence of a project presupposes some success in conceiving, planning, funding, designing and implementing river restoration. This paper examines a sample of 22 such projects on four Arizona rivers. It does not attempt to explain why these projects were pursued and not others; rather it attempts to bridge the diversity of multiple restoration projects across
several river systems to draw generalizations about them in the context of the broader literature. Table 2 displays a comparison of restoration projects by the four project design features.

4.1. Multiple-purpose goals

Prior research suggests that the most common goals of river and stream restoration are to “improve water quality, manage or replant riparian vegetation, enhance in-stream habitat, provide for fish passage and stabilize banks” (Palmer & Allan, 2006: 43). According to preliminary results from the NRSS, most restoration projects have multiple goals (Bernhardt et al., 2005). The closely related public policy goals associated with environmental values can make natural partnerships, as between riparian ecosystem restoration and threatened and endangered species habitat mitigation. Preservation of good watershed or rangeland conditions, rehabilitation of abandoned farmland, control of invasive species and noxious weeds are all specifically identified public policy environmental goals, with associated sponsors, programs and resources that are combined in Arizona’s environmental restoration projects.

We found multiple purpose goals across 19 of the 22 restoration projects studied here. In the Verde watershed, for example, the US Forest Service needed to arrest deterioration of the natural system and preserve forest quality. The existence of a road had led to serious erosion and stream down cutting problems, and structural efforts to stabilize the situation were failing. Soil condition, soil productivity and water quality all showed a negative impact, undermining the US Forest Service’s watershed protection policy goals. A more comprehensive ecosystem restoration project addressed the problems created by the road at the same time that it advanced other environmental goals, such as enhancing habitat for threatened and endangered species and increasing species diversity.

Typically, the restoration projects studied here aim to restore habitat. This may include vegetation and revegetation efforts, the control of invasive species, endangered and threatened species protection, and water quality improvements. At the same time, restoration planners aim to promote and often expand public access to the area. For example, the Verde River Headwaters Riparian Restoration project aims to restore approximately 900 m (3,000 feet) of perennial stream along the river. Perennial streams in this region are rare and when they do exist, they are typically supported by groundwater discharging through seeps or springs. These wetland meadows are a unique and valuable resource within the dry ponderosa pine forest above the Mogollon Rim in central Arizona (Megdal et al., 2006: 106). The project seeks to restore the proper functioning riparian condition by improving vegetation and increasing species diversity, and maintaining satisfactory soil conditions and productivity. It also aims to maintain access to nearby wilderness areas, maintain compliance with water quality standards and design and construct roads to serve the needs of the public.

In urban areas particularly, ecological restoration goals may be coupled with civic improvement goals. Measures of urban quality of life in Arizona include aesthetics, outdoor recreational opportunities and natural setting. Other river restoration success stories, such as San Antonio’s, appeal to economic development interests as well as nature lovers. The Rio Salado projects, through the urban cores of Phoenix and Tempe, were initiated as civic improvements and developed into restoration projects with habitat and native species components and also provide for increased recreational activities. In Tucson, the Rio Nuevo project is designed to anchor development for downtown revitalization with a river walk and restored streamside vegetation. Another project on the Santa Cruz River, El Rio Antiguo, seeks to address the sad state of the river through midtown Tucson. Key objectives include returning the river to its “pre-World War II beauty” (Megdal et al., 2006: 95).
Table 2. River restoration project design features.

<table>
<thead>
<tr>
<th>Restoration project</th>
<th>Multiple-purpose goals</th>
<th>Collaborative funding and support</th>
<th>Community involvement</th>
<th>Monitoring &amp; maintenance</th>
</tr>
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<tbody>
<tr>
<td>Salt River</td>
<td></td>
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</tr>
<tr>
<td>Rio Salado, Oeste</td>
<td>Yes</td>
<td>US Army Corps of Engineers; City of Phoenix</td>
<td>Advisory committee, plans for elaborated US ACE</td>
<td>To be determined</td>
</tr>
<tr>
<td>Rio Salado, Phoenix Reach</td>
<td>Yes</td>
<td>US Army Corps of Engineers, City of Phoenix, Maricopa County</td>
<td>Advisory committee, public steering committee, elaborated US ACE</td>
<td>Habitat/with assessment criteria, by Phoenix</td>
</tr>
<tr>
<td>Rio Salado, Tempe Reach</td>
<td>Yes</td>
<td>US Army Corps of Engineers, Maricopa County, City of Tempe</td>
<td>Typical US ACE, limited public access</td>
<td>Habitat/with assessment criteria</td>
</tr>
<tr>
<td>Tres Rios</td>
<td>Yes</td>
<td>US Army Corps of Engineers, City of Phoenix</td>
<td>Advisory committee, typical US ACE</td>
<td>Habitat/with assessment criteria</td>
</tr>
<tr>
<td>Va Shly’ay Akimel</td>
<td>Yes</td>
<td>US Army Corps of Engineers, City of Mesa, Salt River Pima-Maricopa Indian Community</td>
<td>Plans for elaborated US ACE</td>
<td>Multi-level, model-based plan</td>
</tr>
<tr>
<td>Verde River</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Verde River headwaters</td>
<td>Yes</td>
<td>US Forest Service, Northern Arizona University, Arizona Water Protection Fund, Arizona Department of Environmental Quality</td>
<td>Public information, education, scoping, public comment</td>
<td>Water quantity, water quality, channel stability, vegetation</td>
</tr>
<tr>
<td>San Pedro River</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Bingham Cienega</td>
<td>No</td>
<td>The Nature Conservancy, Pima County Flood Control, Arizona Water Protection Fund</td>
<td>Organized visits, presentations, newsletter articles</td>
<td>Hydrologic, vegetation and birds, by TNC</td>
</tr>
<tr>
<td>Las Cienegas National Conservation Area</td>
<td>Yes</td>
<td>Bureau of Land Management, Arizona Water Protection Fund</td>
<td>Public steering committee with consensus as goal</td>
<td>Every 2–5 years</td>
</tr>
<tr>
<td>San Pedro Preserve</td>
<td>Yes</td>
<td>The Nature Conservancy, Arizona Water Protection Fund, Bureau of Reclamation, Salt River Project</td>
<td>Volunteers</td>
<td>Annually for at least 3 years, vegetation, habitat</td>
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<td>Three Links Farm</td>
<td>No</td>
<td>The Nature Conservancy, Bureau of Land Management, Arizona Department of Environmental Quality</td>
<td>Neighbor meeting, news articles</td>
<td>Water quality, steam flow, habitat, wildlife, geomorphology</td>
</tr>
<tr>
<td>Santa Cruz River</td>
<td>Yes</td>
<td>US Army Corps of Engineers, Pima County Flood Control</td>
<td>Public education, limited access</td>
<td>Birds, wildlife, post-completion assessment</td>
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<table>
<thead>
<tr>
<th>Restoration project</th>
<th>Multiple-purpose goals</th>
<th>Collaborative funding and support</th>
<th>Community involvement</th>
<th>Monitoring &amp; maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Rio Antiguo</td>
<td>Yes</td>
<td>US Army Corps of Engineers and Pima County Flood Control</td>
<td>Work group, public meetings</td>
<td>To be determined</td>
</tr>
<tr>
<td>Esperanza Ranch</td>
<td>Yes</td>
<td>Tucson Audubon Society, Arizona Water Protection Fund, Pima Energy Corporation (landowner), private individual and Sky Island Alliance</td>
<td>Public involvement a primary goal, public education, volunteers</td>
<td>Observation</td>
</tr>
<tr>
<td>Marana High Plains</td>
<td>Yes</td>
<td>Pima County Flood Control, Bureau of Reclamation, Town of Marana, Cortaro-Marana Irrigation District, private individual, Arizona Water Protection Fund</td>
<td>Limited access, public education</td>
<td>Detailed biological, water quality, water level, vegetation</td>
</tr>
<tr>
<td>North Simpson site</td>
<td>Yes</td>
<td>Tucson Audubon Society, City of Tucson, Arizona Water Protection Fund, US Fish &amp; Wildlife Service, US Army Corps of Engineers</td>
<td>Audubon outreach, volunteers, limited access</td>
<td>Vegetation, bird, erosion, hydrologic, 20 years</td>
</tr>
<tr>
<td>Paseo de las Iglesias</td>
<td>Yes</td>
<td>US Army Corps of Engineers, Pima County Department of Transportation, Pima County Flood Control</td>
<td>Public meetings, workshops, public comment</td>
<td>To be determined</td>
</tr>
<tr>
<td>Rillito/Swan Wetlands</td>
<td>Yes</td>
<td>US Army Corps of Engineers and Pima County Flood Control</td>
<td>Typical US ACE, public meetings, public comment</td>
<td>Vegetation, mosquito, photo and qualitative, annually</td>
</tr>
<tr>
<td>San Xavier Indian Reserve</td>
<td>Yes</td>
<td>San Xavier Reservation, Arizona Water Protection Fund, US Department of Agriculture Natural Resources Conservation Service, Bureau of Reclamation, Sonoran Joint Venture, US Fish &amp; Wildlife Service</td>
<td>Steering committee, public information</td>
<td>“Plant performance”, every 5 years</td>
</tr>
<tr>
<td>Santa Fe Ranch</td>
<td>No</td>
<td>Coronado RCDA, Inc., Arizona Water Protection Fund, Arizona Department of Environmental Quality, US Department of Agricultural Natural Resources Conservation Service</td>
<td>Neighbor meetings, public information and education</td>
<td>Survival of plantings, 20 years</td>
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<tr>
<td>Sweetwater Wetlands</td>
<td>Yes</td>
<td>City of Tucson</td>
<td>Steering committee, public input on design, public information and education</td>
<td>Mosquito, water quality</td>
</tr>
<tr>
<td>Tres Rios del Norte</td>
<td>Yes</td>
<td>US Army Corps of Engineers, Pima County Flood Control, Town of Marana, City of Tucson</td>
<td>Typical US ACE, public meetings</td>
<td>Restoration performance, invasive species</td>
</tr>
</tbody>
</table>
Some of the most popular projects have come about because environmental restoration supplied an essential component to a project intended to solve an entirely different problem. The planning for such a project may provide restoration proponents and others with an opportunity that results in a multi-purpose project. The Sweetwater wetlands were developed in settlement of a lawsuit brought by the Arizona Department of Environmental Quality over violations of state water quality laws and rules and its primary objective was to address the issue of backwash water used to clean treatment plant filters. The wetlands were constructed on the same site as groundwater recharge basins that recharge reclaimed water, and backwash water filtered by the wetlands ultimately flows into recharge basins. The legal settlement also required creation of wildlife habitat and a public education component. Settlement of another legal issue, involving the Endangered Species Act, provided the necessary funding for restoration activities on the San Pedro Preserve. Through agreements with the Salt River Project and the Bureau of Reclamation, restoration and maintenance of habitat for the endangered willow flycatcher on the preserve is funded in perpetuity to mitigate loss of habitat caused by raising the height of Roosevelt Dam on the Salt River.

4.2. Collaborative funding and support

Increasingly, natural resource management is characterized by collaborative funding and support (Wondolleck & Yaffee, 2000; Sabatier et al., 2005b; Gerlak, 2006). In river and stream restoration projects there are typically several parties, including governmental agencies, non-profit organizations and university researchers, involved in the design and implementation of a project. Often it is their combined resources that make a project feasible. Environmental restoration projects may be initiated by an organization working to further its primary missions, but frequently they are developed through partnerships between such agencies and others. These agency programs may provide the extra resources that enable a group or individual to pursue a project that might otherwise have stalled for lack of resources. The cost sharing requirements of federal and state programs mean projects that rely on these funds must be collaborative. All but one of the restoration projects studied here depend on a collaborative framework.

The evolution of the Rio Salado projects came about, in part, through involvement with the US ACE Ecosystem Restoration Program. These projects are the largest and most costly of the projects examined in this paper. The local jurisdictions, recognizing the value of an attractive riverfront, approached large-scale river revitalization in the same way they approached large-scale water development—through partnerships with the federal government. Funding for the Rio Salado projects is shared between local sponsors and the US ACE Ecosystem Restoration Program and the projects are designed for native species habitat restoration in accord with the ecosystem restoration mission of the Corps.

The large US ACE sponsored projects on the Santa Cruz, such as the Tres Rios del Norte, are newer than the Phoenix area projects. Collaborators, including the Corps, the City of Tucson and Pima County Flood Control District (PCFCD), have yet to agree on important elements of project design—especially issues relating to water supply. Irrigation water will be needed to maintain plantings and Tucson’s water managers are unwilling to dedicate the substantial amount of water that would be required. In addition, the federal budget situation has reduced expectations for project funding. Consequently the future of these projects is uncertain and scaling back plans may be necessary (Davis, 2007).

In Arizona, the Arizona Water Protection Fund (AWPF) plays a considerable role in the funding of restoration projects. Established in 1994 by the Arizona Legislature, the Fund is earmarked for supporting projects that will enhance riparian areas. The AWPF encourages cost sharing, but does not require matching funds. The Verde River Headwaters Riparian Restoration, a collaborative effort involving the
US Forest Service, the Coconino National Forest, Northern Arizona University and the Arizona Department of Environmental Quality, received some significant funding from the Arizona Water Protection Fund for the initial project costs. Forest Service personnel led on-site vegetation and revegetation efforts. On the Santa Cruz, the AWPF contributed significantly to restoration efforts on the Santa Fe Ranch, a project site just north of the Arizona–Mexico border, as well as projects by the San Xavier Indian Reservation and the Tucson Audubon Society. The AWPF also contributed approximately half of the necessary funding for restoration activities at the San Pedro Preserve, a project led by the Nature Conservancy, in collaboration with the Bureau of Reclamation (Megdal et al., 2006: 52).

The state’s Water Protection Fund often supports the efforts of non-governmental organization such as the Nature Conservancy and the Tucson Audubon Society. The Nature Conservancy established the long-term goal, in keeping with its conservation mission, of preserving and restoring the San Pedro River watershed in southeastern Arizona. At the San Pedro Preserve this has meant returning a cattle ranch and aquaculture ponds to stable, naturally functioning riparian forest and native grassland. Along the Santa Cruz River in the Tucson area, the Tucson Audubon Society led several restoration efforts designed to restore riparian habitat for bird and other wildlife species. In one project, this has included the construction of fencing to exclude cattle and to allow better for increased native plant diversity and the stabilization of erosion-prone areas.

Research interest in a project can lead to additional collaboration and add research funding to the pool of resources supporting restoration activities. National Science Foundation funding is contributing to restoration efforts at Fossil Creek in the Verde watershed through activities of Northern Arizona University researchers. Monitoring and assessment, which frequently are not provided for in project funds, are project design features that may be strengthened through research collaborations, as both of the Verde River projects studied here demonstrate.

4.3. Community involvement

When the federal government is the primary sponsor of a restoration project, the lead agency is mandated by the National Environmental Policy Agency to conduct an Environmental Impact Statement or Environmental Assessment. Federal agencies then conduct public scoping and solicit comments on the draft document. In addition to this type of public outreach, there is commonly some form of educational component to the restoration project. Typically, this involves some transmission of information following the project’s completion to educate the public about the project itself or restoration more broadly. We found some level of public outreach in all of the projects studied.

It is hardly surprising that large projects near large urban populations have more elaborate public outreach programs than small and/or remote projects. However, this rule of thumb is not universal. Project goals and project sponsorship also have impacts on the nature of public outreach. The US ACE has a public consultation process that has been extended and elaborated with help from their co-sponsors for projects with public use goals, such as the Rio Salado Phoenix project. Environmental education and passive recreation opportunities are central to the Rio Salado project. For the Phoenix reach of the project, three parking areas allow for public access and an educational staging area and restrooms have been constructed. In addition to the investment of the public sector, the National Audubon Society and Audubon Arizona are building a nature center at the site where it will develop an urban nature education and interpretive center telling the story of the Salt River and the importance of water in the desert (Arizona Audubon, 2006). The Rio Salado Update Newsletter published by the City
of Phoenix provides periodic updates for local citizens on the status of restoration efforts. The Rio Salado Citizens Advisory Committee established by the City of Phoenix is another mechanism for community involvement.

At the opposite extreme, the San Pedro Preserve is relatively distant from urban populations and its goal of protecting and enhancing willow flycatcher habitat precludes most public use of the site. For this project, The Nature Conservancy has limited its outreach efforts to public information materials and use of volunteers. The Verde River Headwaters Riparian Restoration also involved public outreach limited to providing information. This included a 20-minute video of the entire process, two information kiosks at the restoration site and signs along the nearby highway to direct the public to the restoration site. The information kiosks are designed to demonstrate stream restoration techniques.

Many restoration projects also seek to increase awareness and understanding of natural ecosystems and their value to human communities. Construction of riparian restoration projects, like museums, zoos and botanical gardens, may reflect public education goals. Beyond the simple goals of a more informed citizenry, public involvement and education components may be expected to increase support for environmental restoration projects and reflect positively on project sponsors. In addition, the projects provide an opportunity to demonstrate and reinforce important cultural values, a feature that may be especially important for environmental restoration projects sponsored by Arizona Tribes or located on tribal land. Planning objectives for the Va Shly’ay Akimel reach of the Rio Salado restoration projects, for example, specify the intention to create awareness of the significance of cultural resources relating to the Salt River and its ecosystem. The restoration project on the San Xavier Indian Reservation in southern Arizona is considered to be of paramount “importance to many elders and other community members who would like to see a semblance of how the Santa Cruz River used to be before it was affected by human impacts” (Briggs et al., 2003: 7).

Many of the restoration projects along the Santa Cruz River are designed to provide public outreach, such as Saturday morning bird walks, community lectures and volunteer work days. Most are within the Tucson metropolitan area. The projects with Tucson Audubon Society participation in particular emphasize these kinds of community outreach. The Santa Fe Ranch restoration project, although privately owned, includes an outreach component involving teachers and students in the Nogales area, fact sheets, presentations and site tours.

4.4. Monitoring and maintenance

The science of restoration is young and water resource experts have highlighted the need for research on water’s environmental roles, including the impact of modifications on aquatic ecosystems and scientific knowledge necessary for riverine restoration (Vaux, 2002). The National Research Council has called for a scientifically based strategy of aquatic and riparian ecosystem restoration (National Research Council (NRC), 1992). There is a lot to be learned through restoration projects by trying out new methods, monitoring results and evaluating outcomes.

While monitoring is frequently discussed as a mandatory component of restoration projects, research suggests that all too often, monitoring does not occur (Bash & Ryan, 2002; Hill & Blair, 2005; Bernhardt et al., 2005). The projects in Arizona may be unusual in that, of the restoration projects studied here, all planned some form of monitoring and half had developed monitoring programs. Most of the projects in some way addressed what will be monitored and how, but three of the projects merely reported that monitoring will be determined at a later date. The three projects are marked “to be determined” because
they are in an early phase and the monitoring plans have not yet been fully developed. Given other projects studied, we expect the US ACE will develop monitoring plans as these projects move forward. Projects with US ACE involvement that have progressed beyond the initial feasibility and planning stages generally include monitoring plans, which the local sponsor is expected to implement. Some of these, such as plans for Va shy ay Akimel project monitoring and assessment, can be detailed and technically sophisticated. Others, the Ed Pastor Kino project is a good example, provide for observations and/or monitor only for specific concerns such as birds or invasive species.

Commonly, projects are monitored most intensively during implementation, and monitoring will end or taper off after project completion. Currently, monitoring of Las Cienegas for management purposes is scheduled for every 2 to 5 years. Projects involving the AWPF frequently include agreements requiring the grantee to monitor and maintain defined aspects of the project. Implementation monitoring for the Esperanza Ranch project consisted of observations and photo monitoring for site condition, seedling survivorship, bird and wildlife use. In addition, the agreement with AWFP requires long-term monitoring and maintenance for 15 years after installation of the fence used to exclude cattle; the revegetation site must be operated and maintained for 20 years. By a similar agreement, the San Xavier project sponsors must monitor the operation of the irrigation system for as long as it is in use and must monitor the plantings for at least 5 years.

Projects with explicit research and/or demonstration objectives are most likely to contain strong monitoring components, frequently provided through the involvement of university or other science and education institutions. Northern Arizona University, along with scientists from several federal and state agencies, are advancing the understanding of factors affecting aquatic species diversity, the spread of exotic species and re-establishment of native fish species through their work on Fossil Creek restoration. For the Verde River Headwaters project, researchers at Northern Arizona University studied the site to determine the factors causing the degradation of the stream banks and they monitored baseline groundwater and spring flow, as well as vegetation. They also are responsible for monitoring project results. Involvement of Northern Arizona University researchers in that project shaped the project design and monitoring activities so that it contributed directly to research on natural processes of riparian systems in a high elevation meadow and on best restoration practices.

Among the project’s objectives, sponsors of the San Pedro Preserve included developing and demonstrating techniques for habitat restoration that could be used on a much larger scale, and their efforts advanced understanding of revegetation in a desert environment as the restoration team struggled to recruit Giant Sacaton, a native grass, to the area. The Marana High Plains Effluent Recharge Project on the Santa Cruz River seeks, among its multiple objectives, to evaluate infiltration rates in basins and characterize wildlife and vegetative resources. Research was an explicit goal of the project from its inception. Both of these projects are implementing developed monitoring and assessment plans that are integral to their efforts.

5. Interactions of common design features

Collaboration requires harmonization of the goals of different entities. It follows that a collaborative framework and multiple-purpose goals will often go hand-in-hand. Nineteen of the 22 projects, or 86%, studied here share these two design features. Exceptions to this rule include the Sweetwater Wetlands, which was developed with multiple goals by a single sponsor and the Santa Fe Ranch with
multiple collaborators and a single goal—to re-establish a corridor of historic vegetation on a segment of the Santa Cruz River to increase habitat and reduce stream bank erosion.

The multiple-purpose design of the projects often combines goals related to the missions of the sponsoring agency (e.g. ecological restoration or flood control) with public enjoyment and education goals. This was the case with 15, or about 68%, of the projects studied. As one would expect, in urban areas public use goals are often emphasized and even urban projects with other primary aims come to include public use benefits. In addition to cases described above, the Ed Pastor Kino project in Tucson added recreational amenities to a project primarily intended to repair deteriorated conditions in the area around a flood control detention basin, including restoration of a wetland and riparian area. Plans for the Paseo de las Iglesias project included the objective of incorporating public input into the design. Public input called for the addition of “civic amenities” such as self-guided walks and ramadas.

Public outreach provides tools for achieving public use goals and projects with public use objectives included some of the most extensive public outreach elements. Of the 17 projects, or 77%, with public enjoyment and education as objectives, nine have multifaceted community outreach components and the other eight have employed at least one of the following: mechanisms, such as steer committees, for obtaining community input; public presentations or workshops; informative and educational materials; and activities involving local schools. For example, a public workshop and two open houses were held to involve the public in planning for the Rillito River-Swan Wetlands project (Santa Cruz River), in addition to providing an environmental impact assessment for public comment.

Multiple purpose projects with research and education goals tend to support projects with stronger monitoring and assessment components. The influence of NAU research on the Verde River projects already has been noted. Collaborations also produce enhanced monitoring components when sponsors encourage and fund post construction monitoring and maintenance activities. Agreements with AWPF provide for monitoring of vegetation, birds, stream cross-section and hydrologic data at the North Simpson site on the Santa Cruz River and similar activities at the Bingham Cienega on the San Pedro River. Of the 22 projects studied here, 18, or 82%, report some form of monitoring that is planned or presently underway.

6. Discussion and conclusions

River restoration efforts are on the rise nationally and internationally. In response to trends in public attitudes and effective political pressures, federal water development agency missions have changed to encompass environmental restoration. These same trends are reflected in state and local programs and in plans that place environmental quality high among their concerns. Changes in federal agency missions, state level initiatives and local priorities are fostering river restoration activities across a broad spectrum of conditions. Federal programs put large-scale projects within the reach of local entities and state programs provide essential funding for smaller projects. Cost share requirements make collaboration necessary and we see many cases in which collaboration goes beyond the federal-state or local partnership to include NGOs and others.

Restoration projects in Arizona reflect the same trends and pressures that are driving environmental efforts in other areas. Addressing urban quality of life concerns, repairing damage from prior development decisions, providing passive recreation and learning opportunities, protecting native species and advancing scientific understanding, among others, are goals Arizona’s projects share with projects across the country and the globe.
With a wide brushstroke, we examined 22 restoration projects along four important rivers in Arizona. Despite the great variation in projects underway along these rivers, we find common trends with regard to project design features. We found that the projects tend to have multiple-purposes and involve multiple collaborators. They include a community involvement component, which is basic or elaborate depending on project characteristics such as location and primary sponsor. In more urban settings, we found more elaborate community involvement and educational opportunities. In addition, the projects examined here include some form of monitoring, although it is often limited. Funding for project monitoring, especially the level of monitoring needed to assess the long-term viability of the project is problematic. Inclusion of a research and/or learning component leads to stronger monitoring programs.

The influences between and among these components are strong. Collaborations lead to multiple goals and the needs and opportunities associated with multi-purpose projects require and attract collaborators. Certain collaborators and certain goals are associated with more intensive public outreach components and stronger monitoring and assessment components. For instance, public outreach that includes public involvement frequently influences project design and may add to project objectives. Monitoring and assessment may also indicate the need for changes to the project design—including changes to any or all of the four design components discussed here.

This research does not attempt to determine to what extent these design features contribute to the success of restoration projects, nor does it attempt to explain why these projects were pursued and not others. Rather it seeks to examine what multiple restoration projects across several river systems look like—their diversity serves to offer better insights into what restoration has really come to mean on the ground. Because many of these projects are still underway, it is beyond our scope to examine their effectiveness or matters of implementation in any serious detail. Instead, we have attempted to provide a snapshot across a wide numbers of projects in time. Research on restoration projects in other regions can serve to test these conclusions. So too can the post-project appraisals that are underway as part of the National River Restoration Science synthesis project.

Acknowledgements

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