DETERMINING SUCCESS IN WATERSHED RESTORATION USING INTERDISCIPLINARY METRICS: RIO SALADO ENVIRONMENTAL RESTORATION PROJECT, PHOENIX, ARIZONA

Carly H. Schmidt[1]

ABSTRACT

Ecological restoration has yet to gain an in-depth understanding of the social dynamics that inform restoration design and enable improved watershed performance in urban environments. The Rio Salado Environmental Restoration Project is unique in that the scale of the project expands to new reaches of the Salt River with each successful venture. The 40-year project has been most successful in recent years due to innovative strategies that capitalize on public outreach and inclusion. Adoption of multi-purpose objectives that include partnerships, public stakeholders, and learning achievement have contributed to the project's success. The ability of the restored system to withstand flood events is one of the many examples demonstrating the project's qualifications as a model for future urban restoration efforts. Lessons about the social dynamics that inform urban restoration success have the potential to augment scientific learning in ecological restoration.

INTRODUCTION

Conservation, management, and restoration of watershed ecosystems have become top priorities in the wake of climate change and rapid urbanization. This is especially true for developed nations like the United States (Stromberg 2001). Numerous initiatives are now taking place which emphasize the reestablishment of riparian ecosystems that have been severely degraded in the last century (Goodwin et al. 1997). Riparian ecosystems serve essential functions in southwestern landscapes including maintenance of water quality, but most riparian environments are most threatened by climate change and human disturbance (Brinson 1981).

The Intergovernmental Panel on Climate Change (IPCC) predicts that the southwestern United States will be among the most severely affected environments by drought and extreme weather events. Climate models show that while rainstorm events will decrease in frequency throughout the American Southwest, these events will increase in intensity (IPCC 2013). While the relationship between drought and hydrophobicity are not yet completely understood, there is significant evidence to suggest that the combined effects of water repellency and extreme rainstorm events could result in catastrophic flood damage for aridland urban residents (Elbl 2014).

Phoenix, Arizona is currently facing the challenge of managing resources in the face of rapid urbanization and prolonged drought. Wetlands in this region typically run dry in periods between major rain storms (Megdal 2005). Mitigating the negative effects of a sustained drought on ecosystem fitness involves implementation of public sector river restoration projects that utilize feedback from local and federal agencies and the private sector. In the wake of massive urbanization and wetland degradation, restoration initiatives that address the deteriorating state of the Salt River have been prioritized by federal agencies and local government for nearly three decades (Water Resources Research Center 2012).

The Salt River is vital to many vegetation zones in its reach from eastern Arizona to the core of Phoenix (Autobee 2012). The movement to restore urban streams in the Southwest will challenge restoration ecologists to define clear parameters for measuring success, identify the extent of degradation, and decide the best management actions to reverse degradation and meet the realistic objectives of watershed restoration (Palmer et al. 2005).

River restoration initiatives seek to maintain or improve the quality of ecosystem services while protecting ecological integrity downstream (Palmer et al. 2005). There is growing need for interdisciplinary success metrics as ecological restoration efforts become essential in our changing climate. Subsequently, restoration assessment is essential to advancing the science of watershed restoration through adaptive management.

The attitudes and opinions of stakeholders can be used to define realistic and inclusive objectives in restoration. However, inclusion is known to cause internal conflict where interests and motivations may diverge (Conley 2003). Despite this challenge, the Rio Salado Environmental Restoration Project includes a myriad of stakeholders. Specifically, the project prioritizes non-governmental and public groups, which are often the most overlooked groups in restoration planning. Inclusion of these groups has the potential to increase the longevity of a project and produce

[1]Environmental Science and Management, Northern Arizona University.

more meaningful results. This paper will outline the dynamics that contribute to the ongoing success of the project, and how non-governmental stakeholders and public learning have been used for its benefit.

HISTORY OF RIO SALADO

The National Reclamation Act was signed on June 17, 1902. Thus began a collaborative effort for a Salt River reclamation project which combined "executive independence from Congress, nationalization and a scientific approach to natural resource management" (Autobee 2012). The Salt River Project was widely considered a success in terms of providing hydroelectric power to the Phoenix metropolitan area (Gooch 2007). The dams constructed in the early 20th century provide resources that still contribute to western urbanization (Waits 2000). While the dams provided freshwater support to the valley, they caused the river to run dry and barren, surrounded by landfills, sand pits, and industrial activity (Graf 2000). This urbanization has resulted in an inhospitable landscape and aesthetic deprivation for Phoenicians.

James Elmore, the founder of the School of Architecture at Arizona State University, first recognized the need for large-scale restoration. Elmore sought to design an experimental scheme that would emphasize flood control and restore the Salt River as a dynamic urban wetland and place of value to Phoenicians. His plan involved engineering of whitewater rapids, islands, and campgrounds (Gober 2006). The $2.5 billion project was easily defeated in municipal vote in 1987.

The Rio Salado Environmental Restoration Project was developed three years later in 1990 (Fig. 1). This small-scale project focused on a 5-mile stretch of the Salt River, and was designed in cohesion with Phoenix residents. Downsizing in scale gave the project the advantage of using public participation as a resource for outreach and community cleanup projects (DeSemple 2006).

In 1993, the City of Phoenix was granted an environmental impact study (EIS) for the Salt River. After review of the area and collaboration with the U.S. Army Corps of Engineers (USACE), the Rio Salado Habitat Restoration Project was allocated $85 million in 1999. The restored Rio Salado Habitat Restoration Area was opened in November 2005. Efforts to expand restoration efforts are still underway, using the original restoration area as a model for future initiatives and building on the project's successes. The Rio Salado Habitat Restoration Area has been successful in restoring riparian vegetation, constructing hiking trails, widening stream channel for flood control, removing accumulated waste, and returning native wildlife to the area (DeSemple 2006).

RIO SALADO DESIGN AND SUCCESS

The literature cites many models for measuring restoration success, many of which are only relevant in the context of the restoration project in question. Defining parameters for measuring the success of a restoration initiative is among the most challenging elements of learning and advancing the science. Zedler (2007) attributes this challenge to unclear definitions, stating that "the language of restoration ecology still needs clarification, particularly in the use of the term success. Confusion arising from the use of other terms has been reduced by redefinition." Consequently, it is crucial to identify and communicate objective parameters when measuring the success of any restoration initiative.

According to Palmer et al. (2005), the most efficient projects that aim to restore rivers or streams are designed at the interface of three axes of success: ecological success, stakeholder success, and learning success, shown in Figure 2. Palmer et

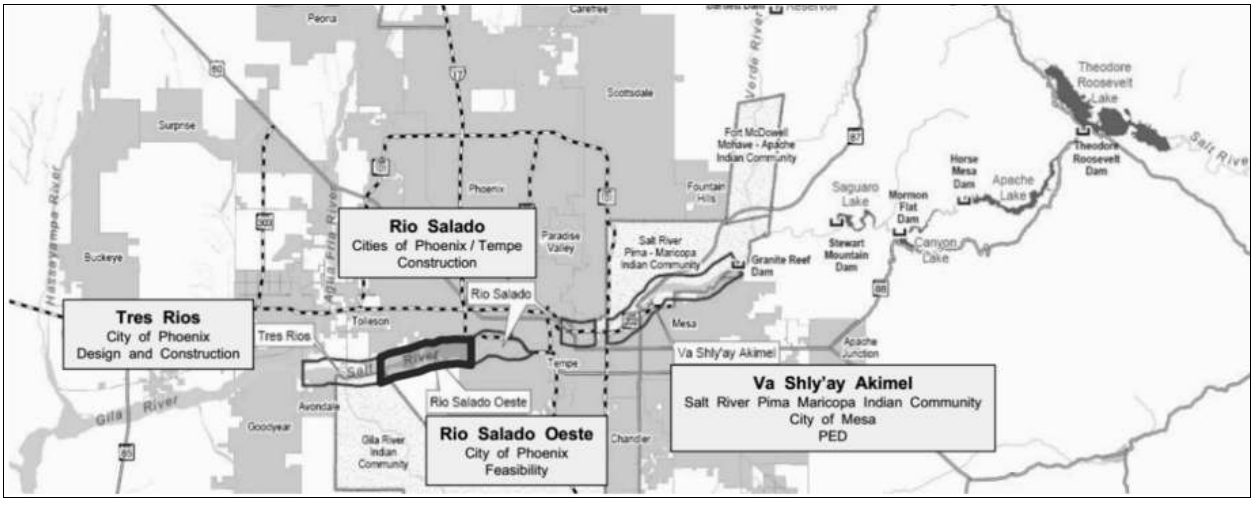

Figure 1. Rio Salado Project system in the Phoenix metropolitan area (USACE 2006).

Figure 2. Criteria for most effective river restoration (Palmer et al. 2005).

al. (2005) identified five criteria for measuring the success of river restoration, with special emphasis on ecological improvements. These include (1) providing a guiding image of the dynamic state, including structure and natural range of variability; (2) defining measurable indicators of ecological integrity and ecosystem health based on the types of stressors causing degradation; (3) measuring the self-sustainability of an ecosystem; (4) ensuring no lasting harm to an ecosystem as a result of restoration; and (5) assessing project completion through pre- and post-restoration monitoring. The Rio Salado Environmental Restoration Project has adhered to these objectives for each leg of the restoration process.

ECOLOGICAL SUCCESS

Restoration success depends heavily on understanding the physical, biological, and structural elements that affect riparian ecosystems (Goodwin et al. 1997). Although the Rio Salado Project does not explicitly use the model set forth by Palmer et al. (2005), it has met many of its stated objectives. For example, in regard to criterion two, ecosystem health of the Salt River has improved in terms of water quality, increased riparian vegetation abundance, population viability of target species, and bio-assessment indices (Stromberg 2005). This information was presented at the Water Resources Research Center Conference in 2005. Furthermore, it has been determined that few interventions are needed to maintain the site, and the wetland ecosystem has demonstrated an ability to recover from disturbances such as fire, flood, and drought (Stromberg 2005).

Since the inception of the Rio Salado Project in the 1980s, restoration design has operated around the concept that ecosystems are dynamic and will change with time. In understanding the "open" nature of the Salt River watershed, restoration planners, namely the U.S. Army Corps of Engineers, were able to construct a plan in the delicate balance of defining measurable research indicators while avoiding determination of a "non-fixed, variable endpoint" (Palmer et al. 2005, Stromberg 2005).

The language of U.S. Army Corps of Engineers' restoration design adheres to the framework behind the second criterion, which is to improve ecosystems and ensure that ecological conditions of the river are measurably enhanced. Palmer et al. (2005) state that, "restoration success should not be viewed as an all or nothing single endpoint, but rather and an adaptive process where interactive accomplishments along a predefined trajectory provide mileposts toward reaching broader ecological and societal objectives."

STAKEHOLDER SUCCESS

Collaborative approaches to restoration and natural resource management are being hailed as essential ingredients to successful restoration. Across the board, collaborative groups are initiating monitoring and self-evaluation processes, often in order to integrate participation in an adaptive management approach (Conley 2003).

Collaborative efforts could mean a great number of things, from governmental partnerships to citizen-based action projects, however they all refer to integrating multiple stakeholder interests into project design. Partnership among multiple stakeholder and public groups is theorized to reduce internal conflict, build social capitol, facility a multidisciplinary approach, and result in a more holistic understanding of the natural environment (Innes 1996). In addition to the benefits collaboration offers to project performance, local citizens also expect to be informed about changes in their environment and decisions of their local government (Tunstall 2000). According to Palmer et al. (2005), the criteria to be addressed when measuring stakeholder success are (1) aesthetics, (2) economic benefits, (3) recreation, and (4) education. Recall that the Rio Salado Environmental Restoration Project has been an ongoing collaborative effort by the City of Phoenix and the U.S. Army Corps of Engineers since 1998. For each new stretch of restoration the USACE has provided a detailed feasibility study and environmental impact assessment to the public. In October of 2001, the Project broadened the scope of its stakeholder inclusion by tasking the engineering firm CH2M HILL with producing a project plan and contract documents. By including this firm, the Salt River prioritized establishing a public park that currently provides residents with access to miles of

trails and educational facilities (DeSemple 2006). Aesthetics and recreation opportunities are the most visible and discussed benefits that the project has provided to Phoenicians.

A prominent public interest group in the area is the Rio Salado Foundation, which was created in 2001 in response to the Rio Salado Environmental Restoration Project. This nonprofit has been active in performing public outreach regarding the importance of bringing water back to the Salt River and reinstating riparian habitats (Foundation 2013).

In regard to education, partnering organizations have been active in establishing youth and citizen groups which foster the acquisition of environmental knowledge while collecting useful monitoring and habitat data. As these education programs overlap with the method by which local scientists advance their understanding of the Salt River, these programs will be discussed in the section below.

LEARNING SUCCESS

In a study of the Hudson River Estuary Plan, the authors conclude that the overarching restoration goals of the project were more likely to be strongly supported than their implementation methods (Connelly 2002). Unwillingness to accept temporary and less desirable circumstances in order to produce a more sustainable and resilient ecosystem could be due to poor environmental or scientific literacy. Negative public perceptions have been combatted in the Rio Salado Project by involving the public in designing and implementing restoration methods in cohesion with local scientists and restoration practitioners.

The Central Arizona-Phoenix Long-Term Ecological Research project (CAP LTER) and the City of Phoenix have been active in creating and encouraging participation in community-based restoration projects. Education outreach partner programs capitalize on local knowledge and public participation to collect data for monitoring and future restoration planning purposes. By invoking interest and a sense of responsibility in schoolchildren, the project is creating a new generation of experienced and scientifically literate citizens who understand the need for watershed restoration in an environment under extreme stress (McCarthy 2012). Three leading community programs are summarized below.

In 2006, CAP LTER began the Service at Salado program, which joins scientists and local students in restoring an urban riparian environments. Service at Salado is an after-school club which involves young students in the scientific process. With the guidance of graduate students and CAP LTER researchers, the students work to propose and implement restoration tactics that aim to maintain a restored habitat. In 2006, nearly 350 middle-school and 50 undergraduate-level students had participated in the program. In recent years, middle-school students have been included through a lottery-style selection process due to the high level of interest (Saltz 2006).

The Ecology Explorers is an education outreach program designed and instituted by CAP LTER and Arizona State University. Through this program, K-12 school teachers and students can participate in ecological research being conducted by LTER scientists. Professional scientists guide students in collecting data for experiments, which is then used to inform future restoration planning for the Salt River. Student research emphasizes wildlife and arthropod data collection (ASU 2014).

The Southwest Center for Education and the Natural Environment (SCENE) is a program designed to provide scientific experience to high school students since the initiation of the Rio Salado Environmental Restoration Program in 1998. This program involves a partnership between the Julie Ann Wrigley Global Institute of Sustainability, the Leroy Eyring Center for Solid State Science Research, and private sector supporters. Research projects completed by high school students in conjunction with professional scientists have addressed effluent from wastewater treatment plants, water purification and chlorine tolerance, and electrical properties of metal/pyrite junctions (ASU 2015).

Not only have these programs contributed to improving scientific literacy among youth and Phoenicians, but they have contributed to monitoring and pre-implementation data that restoration scientists will use to inform future efforts. Through monitoring of what has already been achieved and ecosystem dynamics that have yet to be fully understood, restoration practitioners can learn about the best practices in their field and advancing the science of ecological restoration in the context of the arid Southwest.

CONCLUSION

The Rio Salado Environmental Restoration Project taskforce has demonstrated an ability to produce meaningful change in an urban watershed system. The Project has since become a model for future restoration initiatives in similar desert environments (DeSemple 2006).

According to Stromberg (2001), in order to improve success of restoration initiatives, information sharing must be prioritized regarding the quality of riparian ecosystems, causes of degradation, and strengths or limitations to various restoration approaches. Although the physical science elements of designing and implementing restoration are crucial to meet project goals and objectives, it is also essential that social science is recognized as a key ingredient of success (Weber and Stewart 2009). Restoration success is dependent on more dynamics

than are typically discussed in the scientific literature.

This analysis of the Rio Salado Environmental Restoration Project has determined the Project to be successful in more ways than restoring ecological integrity to a heavily degraded riparian and aquatic network. In addition to ensuring the improvement of ecosystem function and resilience, the Project has also made contributions that indicate stakeholder success and learning success. As evidenced by the vast scope of public environmental education programs, LTER's efforts to include public stakeholders in monitoring and analysis studies, and the increase in recreational opportunities.

The Rio Salado Environmental Restoration Project is a prime example that illustrates to environmental scientists, environmental engineers, and restoration ecologists that a pure scientist approach to restoration is not enough to ensure success. The model of Rio Salado supports the approach of embracing multi-purpose goals including partnerships, public stakeholders, and local policy representatives.

REFERENCES

ASU. 2014. Ecology Explorers education outreach. Retrieved from Julie Ann Wrigley Global Institute of Sustainability: <https://ecology explorers.asu.edu/>.

ASU. 2015. Retrieved from Southwest Center for Education and the Natural Environment: <https://scene.asu.edu/>.

AUTOBEE, R. 2012. Salt River Project. U.S. Bureau of Reclamation, 1-30. <http://www.usbr.gov/projects/ImageServer?imgName=Doc_1305577664538.pdf>

BRINSON, M. M. 1981. *Riparian Ecosystems: Their Ecology and Status*. U.S. Fish and Wildlife Service.

CONLEY, A., and M. A. MOOTE. 2003. Evaluating collaborative natural resource management. *Society of Natural Resources* 16:371-386.

CONNELLY, N. B. 2002. Public support for ecosystem restoration in the Hudson River Valley, USA. *Environmental Management* 29(4):467-476.

DESEMPLE, D. 2006. *Rio Salado Environmental Restoration Project*. Water Environment Foundation. <http://acwi.gov/swrr/Rpt_Pubs/wef06_session36/Rio-Salado-224.pdf>.

ELBL, J. J., and J. ZAHORA. 2014. The comparison of microbial activity in rhizosphere and non-rhizosphere soil stressed by drought. Pp. 234-247 *in* O. Polok, R. Cerkal, and P. Skarpa, eds., *Mendel Net 2014: Proceedings of the International PhD Students Conference*, 19-20 November 2013, Brno, Czech Republic..

GOBER, P. 2006. *Metropolitan Phoenix: Place Making and Community Building in the Desert*. University of Pennsylvania Press, Philadelphia.

GOOCH, R. C. 2007. Salt River Project experience in conversion from agriculture to urban water use. *Irrigation and Drainage Systems* 21(2):145-157.

GOODWIN, C. H., C. P. HAWKINS, and J. L. KERSHNER. 1997. Riparian restoration in the western United States: Overview and perspective. *Restoration Ecology* 5(4S):4-14.

GRAF, W. 2000. Locational probability for a dammed, urbanizing stream: Salt River, Arizona, USA. *Environmental Management* 25(3):321-335.

INNES, J. E. 1996. Planning through consensus building: A new view of the comprehensive planning ideal. *Journal of the American Planning Association* 62(4):460-472.

MCCARTHY, P. D. 2012. Climate change adaptation for people and nature: A case study from the U.S. Southwest. *Advances in Climate Change Research* 3(1):22-37.

MEGDAL, S. J. 2005. *Environmental Restoration Projects in Arizona: The U.S. Army Corps of Engineers' Approach, Final Report*. University of Arizona.

PALMER, M. A. , R. F. AMBROSE, and N. L. POFF. 1997. Ecological theory and community restoration ecology. *Restoration Ecology* 5(4):291-300.

PALMER, M. A., E. S. BERNHARDT, J. D. ALLAN, P. S. LAKE, G. ALEXANDER, S. BROOKS, J. CARR, S. CLAYTON, C. N. DAHM, J. FOLLSTAD SHAH, D. L. GALAT, S. G. LOSS, P. GOODWIN, D. D. HART, B. HASSETT, R. JENKINSON, G. M. KONDOLF, R. LAVE, J. L. MEYER, T. K. O'DONNELL, L. PAGANO, and E. SUDDUTH. 2005. Standards for ecologically successful river restoration. *Journal of Applied Ecology* 42(2):208-217.

RIO SALADO FOUNDATION. 2013. *2013 Impact Report*.

SALTZ, C. 2006. Service at Salado: CAP LTER's schoolyard program benefits students and teachers. *LTER Network News* May 4, 2006 <http://news.lternet.edu/article81.html>

STROMBERG, J. 2001. Restoration of riparian vegetation in the south-western United States: Importance of flow regimes and fluvial dynamism. *Journal of Arid Environments* 49(1):17-34.

STROMBERG, J. 2005. A few thoughts on riparian ecosystem restoration. Presentation at the *2005 Annual Conference - Water and the Environment: The Role of Ecosystem Restoration*. Water Resources Research Center. University of Arizona, Tucson. <https://wrrc.arizona.edu/conferences/2005>

TUNSTALL, S. M., E. C. PENNING-ROWSELL, S. M. TAPSELL, and S. E. EDEN. 2000. River restoration: Public attitudes and expectations. *Water and Environment Journal* 14(5):363-370.

USACE. 2005. *Environmental Operating Principles*.

USACE. 2006. *Rio Salado Oeste: Final Feasibility Report and Environmental Impact Statement*. <http://azmemory.azlibrary.gov/cdm/ref/collection/feddocs/id/1561>

USACE. 2011. *Review Plan: Tres Rios Environmental Restoration Project*. U.S. Army Corps of Engineers, Los Angeles District, Los Angeles. California. <http://www.spl.usace.army.mil/Portals/17/docs/review_plans/Tres_Rios_Environmental_Restoration.pdf>

WAITS, M. R. 2000. *Hits and Misses: Fast Growth in Metropolitan Phoenix*. Morrison Institute for Public Policy, College of Public Programs, Arizona State University. <http://www.asu.edu/copp/morrison/hitsandmisses.pdf>

WATER RESOURCES RESEARCH CENTER. 2012. *Celebrating Arizona's Rivers*. University of Arizona.

WEBER, M. S., and S. STEWART. 2009. Public values for river restoration options on the Middle Rio Grande. *Restoration Ecology* 17(6):762-771.

ZEDLER, J. B. 2007. Success: An unclear, subjective descriptor of restoration outcomes. *Ecological Restoration* 25(3):162-168.