A STUDY OF THE ROLES OF GEOMORPHOLOGY AND PERCEPTION IN THE IMPLEMENTATION OF STREAM RESTORATION PROJECTS

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The undersigned, appointed by the Dean of the Graduate School, have examined the thesis entitled

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Presented by Claire Ruffing

A candidate for the of Master of Arts

And hereby certify that in their opinion it is worthy of acceptance.

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ABSTRACT

Stream restoration is a popular management technique for addressing degraded freshwater resources in the United States despite the uncertainty surrounding its effectiveness. The implementation of restoration projects has created the need for administrative structures at the local and regional scale which influence public and scientific contributions in the planning process. This study uses a dual approach to investigate the dynamics between scientific contributions and public participation within the framework of stream restoration projects. The first component addresses the motivations behind restoration projects and the ways in which restoration projects are carried out. The history of restoration and the legislative structures define a role for geomorphic contributions in restoration science however; actual disciplinary contributions have been limited to channel specific investigations. Geomorphology has the potential to make greater contributions by incorporating a coupled human-environment system approach in restoration studies. The second component is a case study which relies on a questionnaire to investigate the perceptions of the public members of a local watershed partnership in southwest Missouri to better understand their awareness and support for restoration projects. The findings indicate that specific perceptions are heavily influenced by group characteristics such as residence area, length of residence in the watershed and level of stream-centered interaction. Group differences are an essential aspect of studying the relationship between streams and environmental perception because they strongly influence common ground between the public and scientists and environmental managers.

Chapter 1

Introduction

Stream Restoration

Stream restoration has become an increasingly widespread method for addressing impaired stream systems since the mid-1990s (Bernhardt et al 2005). Despite the prevalence of restoration practices and the considerable investment necessary for project implementation, the effectiveness of such efforts are inconsistent and poorly understood (Bernhardt et al. 2007). To date, restoration has often proven insufficient at improving stream systems. This presents a challenge for science explicitly focused on the physical and ecological processes fundamental to watershed systems (Palmer 2009).

Like other areas of water resource management, stream restoration is an inherently social enterprise; therefore, successful water resource management policies rely on the integration of both scientific and local knowledge (Rhoads et al.1999). Local knowledge directly influences the choice and implementation of specific management techniques, regardless of the associated paradigmatic conflicts between parties (Gregory 2006). Formalized community participation in watershed management initiatives is increasing because of the improved understanding of social influences in program success as well as support from agencies such as the US Environmental Protection Agency (USEPA) (Junker and Buchecker 2008; Rhoads et al. 1999). At the same time, restoration projects are functions of institutional structures operating at both the regional and local level. These institutional structures have evolved into two main forms: large-scale, agency driven collaborations and local, collaborative partnerships involving multiple stakeholders (Gerlak 2008). The unique characteristics of these structures ultimately determine the types of contributions from both scientists and the public.

The scientific community can learn to better navigate this position by situating their research in a socially relevant context and welcoming stakeholders into the decision making process (Rhoads et al.1999). However, the dynamics involved between community stakeholders and the decision process are complicated at best and make this task more difficult. Scientists need to recognize the unique political structures behind restoration scenarios as well as the differing roles of community participation in order to make the most effective contributions.

Thesis Content and Format: Meta-analysis and Case Study

This thesis has a dual purpose. The first is to identify how different institutional structures generate different demands for information, data and scientific experts so that scientists, specifically geomorphologists can strengthen their contribution to current stream restoration policy. The second purpose is to take a deeper look at restoration in the context of a local watershed partnership and examine community perceptions in order to identify specific areas of dissonance or overlap between science and public perception in order to improve collaboration between scientists, the community, and managers in the watershed.

In keeping with this duality, the thesis is divided in into two related but distinct components. As such, there is some overlap between the two sections. Part one is an examination of the political movement driving restoration, an exploration of the institutional characteristics of large and small scale restoration projects and how the science of geomorphology contributes to restoration strategies. The intent of this section is to provide a guide for understanding the motivations behind the restoration movement and the typical players and strategies employed in initiatives. The way in which restoration projects come to fruition is often taken for granted or assumed, yet it is this process which fundamentally determines how the most cutting edge research is incorporated in management.

Part two investigates the perceptions of public members of the James River Basin Partnership in relationship to stream aesthetics, restoration goals and planning, and stream system function. While the first component has a wider scope, focusing on the scales of restoration practice in general, this second component focuses in to a current example of restoration practice under the framework of a local watershed partnership. This is a more illustrative example meant to highlight ways in which other geomorphologists can identify ways to collaborate with their local watershed partnerships.

PART I

Chapter 2

The Policy and Practice of Stream Restoration

Abstract

Stream restoration has become one of the most prominent fresh water resource management techniques over the past two decades. However, geomorphologic considerations are often overlooked in the administration of projects. This paper traces the history of restoration in the United States and outlines trends in current restoration practices. Successful restoration techniques require a rigorous scientific foundation. However, restoration strategies and initiatives are fundamentally political and require improved dialogue between scientists and policy makers. Geomorphologists must address the political and social considerations when situating their research findings in order to improve their contributions to restoration science.

Introduction

Surface water systems continue to be degraded by human activities despite the growing social demand for freshwater resources (Gleick 2003). In the United States alone, approximately 45% of the nation's rivers are classified as endangered or impaired (EPA 2000). Efforts to improve water quality and aquatic habitat are essential in order to protect high-quality freshwater systems and ameliorate those that are degraded (Bernhardt et al. 2007).

The significance of descriptors such as *degraded, impaired, and endangered* is an important qualifier for the justification of restoration efforts. Labeling streams in this way signals that some aspect of system function, be it chemical, biological, or morphological is not acceptable given predetermined social expectations. For example, acceptable chemical function is defined by the limits set on allowable concentrations of compounds and streams exceeding those limits would be described as impaired or degraded. Acceptable conditions of biological functions are more vague but refer to ecosystem characteristics such as the presence of certain species and habitat conditions. The morphological, or physical characteristics of stream systems are not usually explicitly addressed in water resource policies but they nevertheless provide the context for the other system components. Evidence of unacceptable physical function include erosion, deposition, and flooding which are caused by an imbalance in the sediment and hydrologic systems at play (Graf 2001).

An increasingly widespread method for mitigating impaired stream systems are a set of practices loosely referred to as *restoration*. The practice has become one of the most relied upon water resource management strategies since the mid-1990s and has evolved into a billion dollar industry (Bernhardt et al. 2005). Despite the prevalence of restoration and the considerable investment necessary for project implementation, the effectiveness of such efforts are inconsistent and poorly understood (Bernhardt et al. 2007). To date, restoration is often insufficient at improving desired aspects of stream system which presents a challenge for science explicitly focused on the physical and ecological processes fundamental to watershed systems (Palmer 2009).

The practice of restoration has grown faster than any such systematic examination of the techniques employed, extent of projects, and variety of goals. The literature base exploring restoration techniques continues to grow and there has been a recent effort to understand and document the nature of stream restoration projects around the country

(Bernhardt et al. 2005). The literature addressing the social aspects of restoration is also growing but because of the decentralized nature of water resource policies, much of it is place specific. A great deal of attention has been focused on defining and exploring the theoretical underpinnings of restoration but that theme will not be addressed here (Bradshaw 1997). Despite this foundation, a greater understanding of the ways in which restoration is initiated and used as a management technique is needed in order to identify opportunities for increased scientific contribution in this area of resource decision making.

Research in fluvial geomorphology can make unique contributions to restoration science. Geomorphic forms and processes provide the foundation for engineering approaches as well as hydrology-centered approaches. The success of popular restoration techniques such as channel reconfiguration, bank stabilization and floodplain reconnection rely on sound geomorphic considerations like flow regime, sediment transport dynamics, and the effects of modifying channel shape and planform (Shields et al. 2003). Similarly, geomorphology is complementary to ecological restoration goals in that geomorphic characteristics can increase habitat availability and condition species diversity (Frothingham et al. 2002).

In addition to geomorphology, perspectives from other fields such as ecology, hydrology and engineering are integral to improving the quality of restoration science (Palmer and Bernhardt 2006). However, the geographic tradition underlying geomorphology gives it a disciplinary advantage in studying restoration science in the context of human-environment interactions (Newson and Large 2006). Successful restoration requires a holistic understanding of the stream system characteristics throughout the watershed as well as aspects of the social system such as land use policies, economic drivers, and historical development (James and Marcus 2006). As restoration, and water resource management in general, becomes more institutionalized the need for understanding the dynamic relationship between human and political action and environmental impacts will increase.

The purpose of this review is to provide a background on the policy decisions driving restoration, to explore the institutional characteristics of large and small scale restoration projects and outline the research direction of geomorphically related restoration strategies. The term restoration covers a wide range of activities and has a shifting definition depending on the agency, stakeholder groups, or environmental context in which the practice is being employed which will not be discussed here (James and Marcus 2006). Because of the political focus, this paper will focus on restoration related issues in the United States (see Newson and Large 2006 for a discussion of restoration and the European Union's Water Framework Directive). In the context of this paper it is understood that the term restoration is a practice which is derivative of the definition outlined by the NRC: "return of an ecosystem to a close approximation of its condition prior to disturbance" (NRC 1992, 523).

Origins of Stream Restoration

Legislative Mandate

Two important pieces of environmental legislation are influential for providing the context for restoration practices over the past twenty years and continue to play an important role in guiding funding and support for restoration projects. First, the Clean

Water Act is a major precursor to the movement towards stream restoration. The primary aim of the Clean Water Act, which was passed in 1972, is to protect the biological, chemical and physical integrity of surface water systems in the United States (Clean Water Act 1972). The inclusion of physical integrity, which is defined by fluvial forms and processes, provides the foundation for biological and chemical integrity (Graf 2001). The Environmental Protection Agency (EPA) and U.S. Army Corps of Engineers (USACE) are the primary federal agencies responsible for permitting and overseeing the regulations outlined in the Clean Water Act (Clean Water Act 1972).

The Endangered Species Act, which was passed in 1973, is the second most common piece of legislation motivating stream restoration projects. The Endangered Species Act was created to protect threatened and endangered species of plants and animals and their habitats. The federal agencies responsible for overseeing the regulations of the Endangered Species Act are the U.S. Fish and Wildlife Service (FWS) and the National Oceanic and Atmospheric Association (NOAA) (Endangered Species Act 1973). As mentioned before, geomorphic forms and processes are important components of ecosystems. As such, geomorphic variables have become important components of habitat restoration (Roni et al. 2008 and Roni et al. 2002)

The intentions behind the Clean Water Act and the Endangered Species Act and their role supporting stream restoration reinforce the significance of geomorphology and the importance of interdisciplinary collaboration in project planning and implementation. Whether the issue is nutrient and sediment loading or habitat recovery, geomorphologists have the toolset to inform project decisions and work collaboratively with members of other disciplines such as ecologists and civil engineers. Both of these regulations should be kept in mind when framing geomorphic research contributions.

NRC Report: Restoration of Aquatic Ecosystems

In 1992 the National Research Council (NRC) published a report detailing the state of restoration science as it applies to aquatic ecosystems. The report was written by the Committee on Restoration of Aquatic Ecosystems, a group of professionals spanning water resource related disciplines such as geomorphology, limnology, hydrology, ecology, and engineering. The committee was tasked with defining restoration, identifying and evaluating restoration project case studies, generating criteria indicative of successful restoration efforts, identifying federal policies and policy conflicts impacting water resources, and recommending data and political needs necessary for improving restoration efforts. Although stream environments are the focus of this paper, the report also details the scientific, technological, and political aspects of restoration in lake and wetland environments (NRC 1992).

The NRC report defines restoration as returning an ecosystem to its previous condition before it was influenced by human disturbance. This definition is meant to be holistic in the sense that the ultimate objective is returning the system in question to a "self-regulating system that is integrated ecologically with the landscape in which it occurs" (NRC 1992, 18). In keeping with this definition, the objective of restoration efforts in stream environments is to achieve a state of dynamic equilibrium with specific attention towards water and sediment regime, channel geometry, riparian plant community, and aquatic plant and animal communities (NRC 1992).

According to the report, smaller stream systems and systems with protected headwaters are the most likely candidates for successful restoration initiatives. Larger rivers are inherently more difficult to restore because of the scale and complexity of disturbances. However, the committee maintains that the restoration of larger river systems is a priority because they are less common and typically more degraded than smaller systems. Human and ecological values as well as biodiversity are also identified as factors determining which systems take precedence in restoration planning (NRC 1992).

The emphasis on ecosystem imperatives creates a more implicit linkage to the role of physical integrity, otherwise understood as fluvial forms and processes, in driving ecosystem function. Channel and floodplain connectivity determine the patchiness of habitats and the presence of storage zones essential for nutrient cycling. Watershed variables such as land use and sediment supply determine water chemistry and sediment loading which in turn directly dictate habitat availability.   The interplay between ecological systems occurs across scales (Graf 2001).

NRC Report: Adoption

The committee makes several recommendations for restoration projects targeted at stream environments which serve as the framework for restoration practices today. The first is the establishment of reference reaches which ideally would represent examples of every stream order in each of the 76 ecoregions of the United States. Reference reaches are intended to provide a comparable example for which to evaluate and determine the success of restoration projects (NRC 1992). Reference reaches have become popular models for many types of restoration plans (Shields et al 2003; Rosgen 1994).

The second regulatory recommendation relates to adjusting existing state water laws, particularly those in the western United States, in order to establish water rights for in-stream flow in addition to those rights for consumptive use and withdrawal. They also identify the need for data on the relationship between flow and habitat use for sport fish, “keystone species”, and endangered species. Issues such as erosion and deposition as well as low base flow can be mediated through regulatory actions by emphasizing in-stream flow considerations (NRC 1992).

Land use management is the focus of the third recommendation. The regulatory aspects of this recommendation include evaluating existing grazing practices on federal lands and classifying riparian environments and floodplains which “retain their periodic connections to rivers” (NRC 1992, 247). The recommendation also encourages choosing structural improvement strategies to enhance the effects of land use practices as well as the use of “soft” engineering practices whenever possible. Flood control structures that are inefficient or not cost effective should be removed in order to improve hydrological connectivity between the stream, riparian environments and floodplain (NRC 1992). The trend towards “soft” engineering practices and more holistic approaches to watershed management is growing in current literature (Roni et al. 2002).

The fourth set of recommendations recognizes the need for event triggered sampling and monitoring to be included in restoration plans in order to better understand the systems response in light of planned changes. Such sampling should be included in project proposals in advance. The committee places an emphasis on the use of this approach to sampling for projects that in restoration strategies that are designed to address flooding or rely on "letting the river do the work" (NRC 1992).

The fifth recommendation outlines the need for formalizing the ways in which citizens and citizen groups participate in restoration planning. The committee suggests that hydrological advisory services at the state and federal levels should be created in order to aid citizen groups in the identification of impaired stream systems that are suitable for restoration and initiation of those projects. The committee recognizes the importance of the relationship between citizen groups and scientists and acknowledges that those experts in university settings are in a unique position to provide such aid (NRC 1992).

An important outcome related to the two previous recommendations is the importance placed on adaptive management in environmental decision making, particularly in terms of restoration planning (Gerlak 2008). Adaptive management is a flexible decision making process which allows for plan adjustments in light of new evidence or considerations (Holling 1978). While adaptive management is often part of restoration plans, the fragmented nature and lack of monitoring and project assessment make if difficult to put into practice effectively (Downs and Kondolf 2002).

The sixth recommendation suggests the creation of a national inventory and assessment of the nation's rivers be completed. Such an inventory would include items such as the number of miles of streams affected by levees and channelization. The committee's intention is that this list would be collaborative across water resource agencies and would mimic the National Wetland Inventory (NRC 1992).

One initiative that developed as an outcome of this recommendation is the National River Restoration Science Synthesis (NRRSS) database. This effort documents stream and river restoration projects throughout the United States in respect to the number, size and cost of restoration projects. Additional data are collected for seven regions which details aspects of the planning process and project implementation (Bernhardt et al. 2005).

The final recommendation made in the NRC report is for the development of restoration and resource management as an applied discipline. As individuals in disparate fields such as engineering, biology, agricultural sciences and many others participate in water resource issues, there is a need for those individuals to include training in the traditionally unrelated fields of hydrology, fluvial geomorphology and ecology. The committee recommends that this start at the university level with the training of graduate students in order to foster a new generation of restoration scientists (NRC 1992).

NRC Report: Implications

Restoration protocols have begun to shift towards more holistic approaches which draw on principles laid out in fundamental disciplines such as ecology and geomorphology (Palmer and Bernhardt 2006). This trend will continue to influence other aspects of the restoration process, such as permitting and monitoring if individuals working at the forefront of restoration initiatives are trained in and understand the importance of the geomorphological and ecological processes behind system recovery (Palmer 2009).

The framework laid out by the NRC provides several avenues for contributions from geomorphologists. First, and perhaps the most straightforward, is the continued need for research addressing the relationships between impacts and channel dynamics. This work is imperative for restoration planning whether it is informing the appropriate use of reference reaches or contributing to adaptive management efforts. A second opportunity for contribution takes this idea one step further. Geomorphologists can increase the profile of their research by explicitly situating it in the context of contemporary political or management scenarios as well as working across disciplines to generate synthetic understandings of system process. Lastly, geomorphologists have the opportunity to take their research, as well as key disciplinary principles relevant to restoration and water resource management to the public through outreach activities and closer involvement with grassroots organizations.

Restoration Practice and Scale

Stream restoration efforts, like other aspects of water resource management, are intrinsically social enterprises. They are driven by social motivations and are intended to protect or return the value of resources back to society. As such, organization at the institutional level is required in order for projects to be carried to fruition. These institutional structures have evolved into two main forms: large-scale, agency driven collaborations and local, collaborative partnerships involving multiple stakeholders (Gerlak 2008). This section will discuss characteristics of both forms with an emphasis towards the role of science in each type. Restoration projects which are funded and implemented by liable parties in response to degradation they are responsible for will not be covered in this section. Those situations, such as when a mining company must restore a stream damaged by mining activity, have unique funding characteristics (Holl and Howarth 2000) which are less likely to involve the collaboration of diverse stakeholders and therefore independent scientists.

The Institutional Framework of Regional Projects

Large scale restoration projects describe efforts which target complex ecosystems that span large areas often with a significant population base. The social and environmental systems at play in these situations bring a range of stakeholders as well as state and federal agencies together (Heikkila and Gerlak 2005). Examples of large-scale restoration programs include the Florida Everglades Restoration Program, the Chesapeake Bay Program, and the Northwest Power and Conservation Council's Fish and Wildlife Program in the Columbia River Basin (Gerlak and Heikkila 2006).

Regional restoration organizations are authorized by policies at the state or federal level (Gerlak and Heikkila 2006). Because they are driven by high level institutional collaborations, they are usually mandated by Congress and are federally funded (Gerlak 2008). The differences in the scale of restoration projects are evident in the strategies used to pay for restoration techniques (Holl and Howarth 2000). Taxation is the most commonly used technique for financing regional restoration projects since there is likely no single responsible party that can be identified as being responsible for damage (Holl and Howarth 2000).

Regional restoration programs have governing bodies which are usually comprised of political officials and representatives of federal agencies as well as staff to aid in project implementation (Gerlak and Heikkila 2006). While the specific use of science teams can be inconsistent, scientific contributions are most often incorporated in the operations process through the use of advisory boards (Gerlak and Heikkila 2006). Advisory boards are often multidisciplinary and aid the governing body by providing scientific input and helping to guide scientifically based decision making (Gerlak and Heikkila 2006; Van Cleve et al. 2006). Scientific contributions most likely occur in the interpretation of baseline and ecosystem indicators and as part of adaptive management strategies (Van Cleve et al. 2006). The majority of monitoring that occurs during restoration implementation is done in keeping with adaptive management and is thus an important role for science in the restoration process (Gerlak and Heikkila 2006).

The Institutional Framework of Local Projects

Restoration projects which are carried out at the local scale are often done so under the auspices of watershed partnerships. Watershed partnerships include any group of stakeholders which meet to discuss management issues related to a common watershed or stream system (Leach and Pelkey 2001). There are approximately 1000 of these collaborative partnerships throughout the U.S., many of which are very informal with no bylaws or officers (Leach and Pelkey 2001; Gerlak 2008).

Many watershed partnerships operate on financial support from state or federal agencies as well as private donations of money, land and labor (Leach and Pelkey 2001; Holl and Howarth 2000). The close relationship between stakeholders and the nature of the financial support received motivates these groups to be supportive of community involvement and information sharing in order to use their resources most effectively

(Holl and Howarth 2000). These partnerships also create opportunities for public participation much earlier in the planning process as opposed to larger regional, agency driven groups (Leach and Pelkey 2001). The social nature of water resource management requires the integration of both scientific and local knowledge in order to generate successful policies (Rhoads et al. 1999). Watershed partnerships often pursue activities such and public education, grant writing and stakeholder training in order to engage with the public (Leach and Pelkey 2001). Community involvement through volunteer labor increases the sense of stewardship and is therefore critical for the success of restoration projects (Holl and Howarth 2000).

Restoration Strategies and Techniques

As previously mentioned, approaches to river management and restoration specifically are moving away from intensive engineering projects towards projects which allow the river system to correct itself with as little additional disturbance as possible (Gregory 2006). This increased emphasis on stream naturalization encourages management solutions which focus on improvements relative to the current state of the stream as well as the larger watershed system in general with the goal of implementing sustainable projects (Rhoads et al. 1999; Newson 2002). Geomorphology and the systematic treatment of stream systems are consonant with the desire to implement sustainable restoration techniques. This section will review the literature on geomorphological restoration techniques in order to provide a context for potential future contributions to restoration science. In order to clarify the discussion, restoration strategies will be used to refer the end goal of restoration projects while restoration techniques will be used to in reference to specific practices employed during a restoration project.

Table 1. Restoration Strategies and Techniques (adapted from NRC 1992)

Restoration Strategies	**Restoration Techniques**	
Bank stabilization	Structural	Bank armoring, root wads, riprap
Channel Modification		Channel reconstruction, meander creation, dechannelization,
Dam removal/retrofit		Fish ladders, selective water withdrawals
Floodplain reconnection		Levee removal
Habitat Improvement		Snag placement, substrate placement
Species Management	Nonstructural	Reintroduction, spawning and incubation facilities
Riparian Management		Planting and maintaining vegetation, riparian easements
Regulation of land use in watershed		Soil stabilization, development regulations, regulatory floodways
Water quality management		Water temperature modification, storm water management
Flow regulation		Altering dam releases (run of the river)

Stream restoration techniques outlined in the NRC report are divided into two categories: nonstructural and structural (Table 1). Nonstructural techniques are those practices which do not directly change the channel and allow the stream system to recover on its own. Examples include regulatory actions guiding flow regime and land use regulations, riparian planting, and species reintroduction. Structural techniques are those actions which are characterized by direct intervention with the channel and are used to speed the systems recovery time. Examples include channel alterations such as reconstruction and creating meanders as well as the installation of habitat related structures such as fish passageways and screens (NRC 1992).

Structural Techniques

Bank stabilization, channel reconfiguration, dam removal or retrofit, and floodplain reconnection are all examples of restoration approaches which rely on some aspect of channel modification (Bernhardt et al. 2005). There is a strong link between these projects and geomorphology because these approaches are centered around channel forms and processes, even if the execution relies on engineering practices. Approaches to channel modification remain some of the most contested topics in fluvial geomorphology (Simon et al. 2007; Miller and Ritter 1996).

The complexity of channel systems and their responses to disturbance events has motivated the development of classification systems to guide channel modification in restoration projects. The most notable classification scheme is the Rosgen classification system of "natural channel design" (Rosgen 1994, Rosgen 1996). The Rosgen classification system uses a taxonomic key of sorts to divide streams into categories based on hydraulic-geometry relationships as well as bed and bank sediment size. The classification system can be used to predict future channel behavior and prescribe a new channel design for channels that have been highly modified or disturbed (Rosgen 1996).

The Rosgen classification is often required by government agencies funding restoration projects (Malakoff 2004). The classification system is useful for communication because it allows for information to be condensed and fairly replicable and has the added benefit of providing a set of standards for restoration design (Lave 2009). However, there has been heated debate among geomorphologists as to the merit of this classification system. Common criticisms are that the approach relies on channel form and ignores process, has vague and ambiguous key terminology (e.g. bankfull discharge), and that it is not based on rigorous data (Miller and Ritter 1996; Simon et al. 2007). Despite wide criticisms, Rosgens classification system continues to be applied to restoration techniques, included in requests for proposals for restoration funding and is being adapted for other applications such as the Environmental Protection Agency's preferred methods for calculation Total Maximum Daily Loads (TMDLs) (Lave 2009).

Other approaches to stream restoration and channel instability have been suggested but none have received as much support as Rosgen's methods in restoration practice. Alternative, process-based approaches to channel reconstruction have been suggested such as methods which rely on sedimentation analyses and flow mechanics (Simon et al. 2007, Shields et al. 2003). These methods are arguably more complex and require more advanced training and are thus less likely to catch on in the current restoration market.

Habitat improvement is one of the most commonly cited objectives motivating stream restoration throughout the country (Bernhardt et al. 2005). Structural habitat restoration techniques include activities such as instream structure placement, riparian planting, and reconnecting habitats (Roni et al. 2008). For the purposes of this section, only methods which focus on the physical factors producing habitat along stream channels will be covered.

The rehabilitation of woody riparian vegetation is important for improving and maintaining habitat because they provide shaded areas which are particularly important for fish communities as well as a buffer against sediment, nutrients and pesticides and provide sources of large woody debris (Roni et al. 2002; Gregory 2003). Silviculture techniques such as removing understory growth and promoting native tree species growth along banks are thought to have significant impacts on fish populations but more evidence is needed to support that (Roni et al. 2008).

Instream habitat techniques include the placement of various structures in the channel to improve habitat. Structures commonly used include artificial structures such as weirs as well as natural structures such as large woody debris, boulders, and gravel bars. Because of this variety as well as the range of species and ages each technique is applied to it is difficult to generalize on their effectiveness, but there is strong evidence that structural techniques improve spawning conditions (Roni et al. 2008).

Fish passage is an important aspect of habitat restoration, especially in the Pacific Northwest. Structures such as culverts are often designed for fish passage but there effectiveness is difficult to gauge because fish of different ages require different water velocities for migration upstream. Barrier removal has been identified as a successful approach to improving salmon spawning to date (Roni et al. 2002).

Nonstructural Techniques

While structural restoration techniques have the most explicit connection to geomorphology, many nonstructural techniques play an important role in the physical integrity of river systems as well. As mentioned previously, there is substantial overlap between habitat availability and channel forms and process (Frothingham et al. 2002). Variations in the hydrologic regime, in terms of the magnitude, frequency, duration, seasonality, and rates of change of flow conditions, is essential forcing of sediment dynamics and channel form processes (Poff et al. 1997). Geomorphologists should engage in decisions related to nonstructural techniques just as they would for those discussions revolving around structural ones. The geomorphic perspective on stream systems is scalar and holistic and augments principles from other disciplines like ecology and engineering.

Restoration Science: Contributions and Opportunities for Geomorphology

Stream restoration will in all likelihood continue to be employed as a water resource management technique in light of increasing pressures on fresh water systems as well as the political momentum driving their implementation. The disconnect between resources invested in restoration projects and their limited success at improving the conditions of impaired stream systems suggests the ongoing need for scientific contributions. While the science behind restoration is advancing in an interdisciplinary direction, geomorphology is in a position to be a leading disciplinary contributor to project design and implementation.

The research approach towards restoration in geomorphology should be two fold in order to maximize disciplinary contributions. First, research addressing classic issues of channel response and dynamics should be situated directly in the context of current restoration needs. Scientific information is very effective at uniting diverse stakeholders and motivating collaborative action (Heikkila and Gerlak 2005). Managers and policy makers can more easily incorporate sound geomorphic principles in restoration planning if the relevant research is proactively positioned to address explicit management issues. Another aspect of this is the establishment of contacts within the management and political community. Scientific contributions are most effective when there are formal or informal procedures for integrating them into restoration planning (Van Cleve et al. 2006).

The second approach relates to a different approach to situating research. The success of restoration projects are dependant on stakeholder and project planner cooperation as well as the science behind them (Junker and Buchecker 2008). Conflicting expectations of restoration can lead to conflict between public and government (Buijs 2009). The scientific community and geomorphologists in particular, can directly improve the quality of restoration projections by reconciling the needs and desires of the public and management communities. In recent years there has been an increased emphasis placed on public outreach and education within the field of geomorphology as a way of increasing its relevance and engaging populations who may be unfamiliar with its scientific approaches (James and Marcus 2006). These outreach activities coupled with research addressing the intersection between perception and geomorphic forms and processes (e.g. the work done on perceptions of large woody debris by Chin et al. 2008) will also strengthen the contributions of geomorphology in the field of restoration.

Water resource management is transitioning away from its civil engineering roots towards a more politicized structure. This is evident in the growing interest in ecosystem services and stream mitigation banking In the case of ecosystem service markets and stream mitigation banking, policy makers and resource managers are largely responsible for the development and implementation of many strategies (BenDor and Doyle, in press). Geomorphological contributions to restoration will be needed more than ever as management continues in its current direction.

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PART II

Chapter 3

A Case Study: Understanding the Relationship Between Perceptions and Scientific Contributions in Restoration Initiatives in the James River Watershed in Southwest Missouri

Abstract

Stream restoration is a popular management technique for addressing degraded freshwater resources in the United States despite the scientific evidence questioning its effectiveness. The implementation of restoration projects has created the need for administrative structures at the local and regional scale which influence public and scientific contributions in the planning process. This study uses a questionnaire to investigate the perceptions of the public members of a local watershed partnership in southwest Missouri to better understand their awareness and support for restoration projects. The findings indicate that there are significant differences between respondents perceptions when they are divided into groups based on residence area, length of residence in the watershed and level of stream-centered interactions. Respondents who engage in both recreational and work or volunteer activities demonstrated the most complete understanding of stream systems as well as the highest support for restoration activities. The conclusion of this study indicates that while there are conflicts between public perceptions of restoration and stream systems there are also promising avenues for scientific and political resolution which can improve restoration planning and project support.

Introduction

Despite the importance of freshwater resources, surface water systems continue to be degraded at a global scale by human activity (Gleick 2003). According to the EPA, at least 45% of the rivers in the United States are classified as endangered or impaired (EPA 2000). If these systems are to be relied on for the future, system characteristics like water quality and aquatic habitat must be recovered and properly functioning systems must be protected (Bernhardt et al. 2007).

Stream restoration, which has grown to a billion dollar industry since the early 1990's, is the most popular method for addressing impaired stream systems (Bernhardt et al. 2005). Despite the prevalence of restoration and the considerable investment necessary for project implementation, the effectiveness of such efforts are inconsistent and poorly understood (Bernhardt et al. 2007). In order for restoration strategies to improve, the focus of contributing disciplines must shift towards a scientific approach which is explicitly focused on the physical and ecological processes fundamental to watershed systems (Palmer 2009).

Research in fluvial geomorphology is positioned to make unique contributions to restoration science. Geomorphic forms and processes provide the foundation for structural or engineering approaches as well as hydrology centered approaches. Any success of popular restoration techniques such as channel reconfiguration, bank stabilization and floodplain reconnection must rely on sound geomorphic considerations like flow regime, sediment transport dynamics, and the effects of modifying channel shape and planform (Shields et al. 2003). Similarly, geomorphology is complementary to ecological restoration goals in that geomorphic variables can dictate species diversity and habitat availability (Frothingham et al. 2002).

Perspectives from other fields such as ecology, hydrology and engineering are integral to improving the quality of restoration science (Palmer and Bernhardt 2006). However, the geographic tradition underlying geomorphology gives it a disciplinary advantage in studying restoration science in the context of human-environment interactions (Newson and Large 2006). The geomorphic research agenda must acknowledge the social and political component of water resource management in order to maximize contributions to restoration science.

Science is just one component determining the success of restoration science. Policy makers and environmental managers are in control of deciding when restoration strategies are needed as well as which one will be used. They create formal opportunities for scientific contributions such as advisory boards and are responsible for the scienifitic uncertainty inherent in management decisions. Because policy makers and managers are at the forefront of decision making, they are beholden to public desires.

The public plays an important but perhaps more passive role in restoration schemes. Restoration projects are responses to public desires and their success is ultimately determined by public support. The public communicates their interests and desires for restoration by becoming involved in local watershed activities as well as attending community meetings. Very little is understood about what motivates the public's understanding of stream systems.

Successful restoration requires a holistic understanding of the stream system characteristics throughout the watershed as well as aspects of the social system such as land use policies, economic drivers, and historical development (James and Marcus 2006). As restoration, and water resource management in general, becomes more institutionalized the need for understanding the dynamic relationship between human and political action and environmental impacts will increase. Despite this foundation, a greater understanding of the ways in which restoration is initiated and implemented as a management technique is needed in order to identify opportunities for increased scientific contribution in this area of resource decision making.

Study Area

The James River watershed is located in the Ozark region of southwest Missouri (Figure 1). With an area of 1455 square miles, the watershed covers portions of eight counties and ultimately drains into Table Rock Lake. There are approximately 289 miles of permanent streams and approximately 74 miles of intermittent streams in the watershed. The three major metropolitan areas in the watershed are Springfield, Ozark and Nixa. Land uses in the area consists of urban development, agriculture (row crops and livestock), and forest. The James River and several of its tributaries are on the Environmental Protection Agency's (EPA) 303(d) list for impaired water quality, specifically, wastewater and nutrient loads (James River Basin Partnership 2009).

The James River Basin Partnership (JRBP) is a 501(c)3 not-for-profit organization that is dedicated to improving the water quality in the James River watershed. Originally formed in 1997 under the auspices of the Southwest Missouri Resource Conservation and Development program, the JRBP became an independent entity in 1999. The JRBP is a grassroots organization. The Board of Directors consists of volunteers representing various stakeholder groups and each member of the board serves on at least one of the organizations actions committees (James River Basin Partnership 2010).

The JRBP is involved in the management of the James River watershed by sponsoring volunteer events such as stream cleanups and securing funding for initiatives aimed at improving the water quality throughout the basin. The Environmental Protection Agency (EPA) and the Missouri Department of Natural Resources are the primary funding sources.

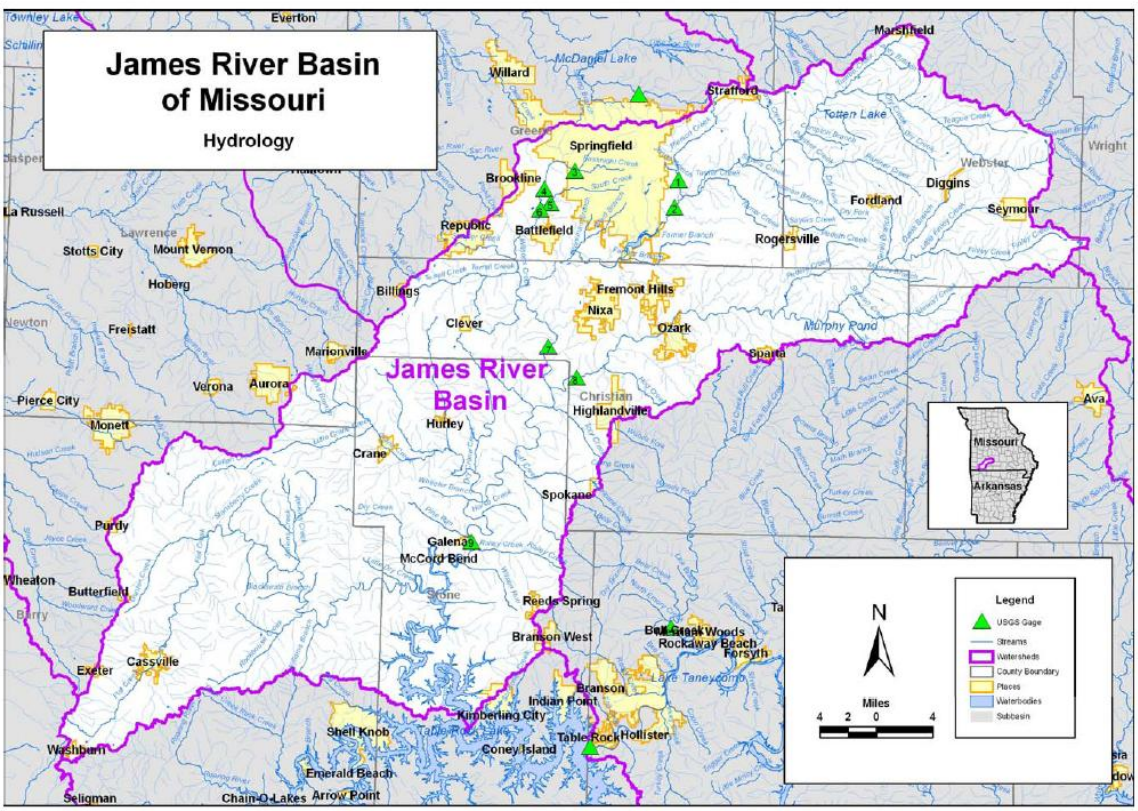

Figure 1. James River Basin (James River Basin Partnership 2009)

The JRBP drafted a watershed management plan for the James River in 2009. This plan identifies the major pressures on the watersheds streams and guides the direction of future projects (Table 2). The survey design for the case study relies heavily on this management plan which is a critical document because it ties together scientific contributions, public concerns and management decisions.

The primary sources of impairment in the watershed are decreased water quality and increased erosion. Suggested strategies for addressing water quality include riparian management and efforts to reduce septic problems in rural areas and to decrease the amount of storm water runoff in urban areas. The strategies for addressing erosion also include riparian management as well as bank stabilization projects and grading regulations.

Restoration Strategy	Technique	Stated Goal/Evaluation
Prioritize and preserve riparian corridor	Determine priority corridors to restore; establish land trusts/conservation easements	
Reduction in gully and stream bank erosion	Stabilize two banks with riparian vegetation; grading permits; stream stabilization projects; establish/maintain riparian buffer	A 25% decrease in sediment load; Sediment loss reduction calculations
Reduce and mitigate storm water runoff	Maintain existing storm water reduction initiatives and continue effort throughout watershed (bio-retention, rain gardens, cisterns); acquire green space	A 25% decrease in storm water runoff; monitor storm water quality
Septic issues	Septic tank pump-out programs; septic problem hotline; track status of septic systems	Surveys to determine reception and value of various septic programs
Educational opportunities	Workshops and field days; county watershed festivals, tv and radio public service announcements; River Rescue events; newsletters and brochures; website; rain garden/rain barrel program	Monitor attendance; surveys to determine reception, educational evaluations; number of materials distributed

Table 2. Restoration strategies and techniques, adapted from the James River watershed management plan (2009).

The scientific contributions to this plan come mainly in the form of data collected by the

USGS and Missouri Department of Natural Resources (MoDNR) as well as several peer-reviewed journal articles. Public stakeholders contributed to the drafting of the management plan as well as through community meetings. Many of the stated goals and evaluations address public response to projects. The level of political involvement is two-fold: the JRBP has taken the active role as a management agency while the EPA and MoDNR act in a primarily funding capacity.

Purpose and Objectives

Water resource policy and management, like other contexts within the environmental sciences, is susceptible to discord between the scientists, policy makers, managers and the public (Rhoads et al., 1999). While the importance of community involvement is recognized, there is little understanding about the nature of the underlying perceptions that constitute local knowledge. It is also not clearly understood how such information can be useful to scientists or incorporated in research in a rigorous way. Further exploration of these perceptions and the ways in which they influence policy as well as the environment will yield valuable information for creating and implementing responsible water resource policy and management decisions.

The purpose of this study is to investigate the perceptions of public members of the JRBP partnership in relationship to stream aesthetics, restoration goals and planning, and stream system function. The objectives are as follows:

1. Describe the characteristics of the public members of the JRBP in terms of demographics, levels of interactions with streams (e.g. recreational activities) and their awareness of restoration efforts in the watershed.
2. Identify public members of the JRBP perceptions of:

i. Aesthetics

1. Stream environment characteristics ascribed with aesthetic value
2. Restoration techniques associated with improving aesthetic value

ii. Restoration Planning and Goals

1. The importance of funding in the success of restoration projects and the agencies responsible for providing funding
2. Necessary considerations that should be accounted for in restoration planning
3. The most desirable objectives for restoration projects

iii. Stream System Function

1. The relationship between scale and restoration efforts
2. Sources most likely to influence water quality and erosion
3. Restoration practices most effective at addressing impaired water quality and increased erosion
4. The most effective restoration practices for given scenarios
5. Visual assessments of photographed stream environments

3. Examine whether differences in perceptions are statistically significant based on three types of participant characteristics:

i. Aesthetics

1. Residence in a rural or urban/suburban area of the watershed (independent samples t-test)
2. Length of residence in the watershed (one way ANOVA)

3. Types of stream-centered activities: no activity, recreation only, or recreation and work/volunteer activities (one way ANOVA)

ii. Restoration Planning and Goals

1. Residence in a rural or urban/suburban area of the watershed (independent samples t-test)
2. Length of residence in the watershed (one way ANOVA)
3. Types of stream-centered activities: no activity, recreation only, or recreation and work/volunteer activities (one way ANOVA)

iii. Stream System Function

1. Residence in a rural or urban/suburban area of the watershed (independent samples t-test)
2. Length of residence in the watershed (one way ANOVA)
3. Types of stream-centered activities: no activity, recreation only, or recreation and work/volunteer activities (one way ANOVA)

Broader Impacts

The dynamics between science, policy, and public contributions is rarely examined in a holistic way in the physical sciences and there are few examples which investigate the conflicts between public perception and scientific understanding in the context of an articulated management scenario. Studies which focus on public perception that are available use convenience samples (Piegay et al. 2005; Chin et al. 2008), compare responses based on standard socioeconomic classes like gender, area of birth and education (Buijs 2009), or do not compare responses between groups of respondents (Junker and Buchecker 2008). The inherent drawback between the past sampling and analysis strategies is that they do not provide information which reflects the intricate ways in which those perceptions are shaped or may influence individual actions.

It is critical to examine differences in perception between groups of participants based on the different capacities in which they perceive stream environments. This study relies on three grouping strategies in order to draw more detailed comparisons between respondents. Hypothesis testing is used to test the significance in differences in means between the groups. A null hypothesis, that there were no statistically significant differences between groups, was the standard in testing all of three of the group combinations. Hypothesis testing is an efficient way to highlight significant differences between group means.

The first group compared is based on the self-described type of residence area. Because of the population distribution of the watershed, two choices were offered in the survey; urban/suburban or rural. These designations are primarily intended to capture the effects of differences in land ownership in shaping perceptions. Restoration initiatives in urban or suburban areas are much less likely to occur on land owned by residents compared with projects in urban areas. Additionally, the nature of the water quality and erosions pressures in the watershed is fundamentally different between the two areas.

The second group of respondents is based on the length of time they have lived in the watershed. Respondents entered in the approximate number of years they have lived in the watershed and the individual groups were classed according to natural breaks. The premise behind this designation is that there is a positive relationship between awareness of watershed issues, namely erosion and impaired water quality, and the years of residence.

The third group of respondents was divided into three classes according to level of activity: no activity, recreational activity only, or work/volunteer activities and recreational activities. Several options for activities were included in the survey ranging from recreational activities to work activities. No activity was also listed as an option and space was included for respondents to enter in activities which were not already listed. Increased activity level implies a more intimate understanding of stream environments as well as potentially different priorities for restoration and preferences in stream environments.

Acknowledging that there are inherent differences in the way that people perceive environments allows a more detailed understanding of the role of the public in implementing restoration initiatives. Dividing respondents into such groups allows scientists to identify specific topics needing improved clarification while simultaneously identifying the groups most in need of that information. Alternatively, managers and policy makers can use this approach to evaluate the effectiveness of policies and outreach activities.

Chapter 4

Literature Review

Introduction

An increasingly popular method for addressing impaired stream systems is restoration. The practice has become one of the most relied upon water resource management techniques since the mid-1990s and has evolved into a billion dollar industry (Bernhardt et al. 2005). Even though the effectives of many restoration techniques remains in question, restoration is still prevalent and genereates considerable financial investment every year (Bernhardt et al. 2007). This creates opportunities for scientific contributions explicitly focused on the physical and ecological processes fundamental to watershed systems (Palmer 2009).

The emphasis of restoration projects is shifting towards relying on the present state of river channels to determine the applied strategies rather than emulating historical scenarios (Newson 2002). The recent trend in geomorphologic contributions to river restoration tends to be evaluative and empirical while accounting for user needs and economic constraints (Gregory 2006). This renewed interest in the relationships between river process and form has drawn increased attention in interdisciplinary attempts at restoration, further increasing the potential for geomorphologists to contribute to such initiatives (Newson 2002).

Contributions from disciplines complementary to geomorphology, such as ecology and engineering, are crucial to the rigor of restoration science (Palmer and Bernhardt 2006). However, geomorphology is in a unique position to address human-environment interactions because of the disciplines heritage as a geographic (Newson and

Large 2006). While restoration efforts must reflect a thorough understanding of hydrologic systems, they will only be successful if they demonstrate an appreciation for the context of social dynamics such as land use policies, economic drivers, and historical development (James and Marcus 2006). The relationship between the physical and social systems dominating restoration efforts will continue to become more important as our reliance on freshwater resources continues.

Water resource management is an inherently social enterprise; therefore, successful water resource management policies require the integration of both scientific and local knowledge (Rhoads et al. 1999). Whether the issue at stake is habitat protection, levees, irrigation, or recreation, water resource policy is vulnerable to discord between the scientific community, policy and management officials, and the public. Yet it is local knowledge that directly influences the implementation of management techniques, regardless of the associated paradigmatic conflicts between parties (Gregory 2006). The scientific community can learn to better navigate this position by situating their research in a socially relevant context and welcoming stakeholders into the decision making process (Rhoads et al. 1999).

Restoration as a Management Technique

River restoration is a widespread practice for addressing impaired freshwater systems in the U.S. Stream restoration, defined by the National Research Council as "the return of an ecosystem to a close approximation of its condition prior to disturbance" can include a variety of activities (NRC 1992, 523; Bernhardt et al. 2007). Like any management technique, the success of restoration projects is driven by decisions made at the planning stage as well as the underlying science behind specific activities.

Goals and Project Planning

To date, the National River Restoration Science Synthesis (NRRSS) working group has undertaken the most comprehensive examination of restoration projects throughout the country. The NRRSS identified projects throughout the country and tracked their number, size, and cost as well as other variables such as stated goals and objectives (Bernhardt et al. 2005). The NRRSS study is also discussed in Chapter Two.

The findings of this effort shed insight into the intricacies of restoration project planning. The primary goals for restoration activities were identified as water quality management, in-stream habitat improvement and riparian management. Most projects were initiated in order to address various forms of river degradation, although the prevalence of legally mandated mitigation projects in the Southeast indicates a degree of geographic variability in motivations (Bernhardt et al. 2007).

Watershed management plans were not identified as a significant motivation for restoration projects but results from the NRRSS interview series suggest that they are important in guiding project implementation. Most projects in the database identified some level of project monitoring but it is unclear whether the monitoring was to secure permits, to evaluate implementation, or to measure project outcomes. Likewise, the types of monitoring (physical, chemical, or biological) was inconsistent (Bernhardt et al. 2007).

Overall, the results of this effort suggest a need for improvements at the administrative level in order to increase the effectiveness of future restoration projects. The authors suggest that increased importance be given to project monitoring and that scientists engage in research relevant to current restoration issues and work directly with project managers. They also note that community involvement can be beneficial in identifying acceptable project goals and activities (Bernhardt et al. 2007).

Geomorphic Approaches to System Function

Geomorphic forms and processes provide the foundation for engineering approaches as well as hydrology and ecology centered approaches and thus is in a unique position to contribute to restoration science. Channel reconfiguration, bank stabilization and floodplain reconnection rely on sound geomorphic considerations like flow regime, sediment transport dynamics, and the effects of modifying channel shape and planform which are at the crux of fluvial geomorphology (Shields et al. 2003). This also holds true when geomorphology is aligned with ecological restoration goals since geomorphic forms provide the foundation for habitat availability (Frothingham et al. 2002).

Approaches to river management and restoration, more specifically, are moving away from intensive engineering projects towards projects which allow the river system to correct itself with as little additional disturbance as possible (Gregory 2006). This increased emphasis on "stream naturalization" encourages management solutions which focus on improvements relative to the current state of the stream as well as the larger watershed system in general with the goal of implementing sustainable projects (Rhoads et al. 1999; Newson 2002). Geomorphology and its systematic treatment of stream systems is congruous with the desire to implement sustainable restoration techniques.

Restoration activities which address channel dynamics are perhaps the easiest to link to geomorphology. Channel response characteristics like erosion and instability can often lead practices intended to restore "stability." Engineering approaches like bank stabilization, channel reconfiguration, dam removal or retrofit, and floodplain reconnection are all examples of channel modification (Bernhardt et al. 2005). Channel modification, perhaps because any such effort is specifically geomorphic in nature, is the most contested topics in fluvial geomorphology (Simon et al. 2007; Miller and Ritter 1996).

Rosgen classification system of "natural channel design" is the most notable example of the channel modification controversy (Rosgen 1994, Rosgen 1996). The Rosgen classification system places streams into various taxonomic categories which are based on hydraulic-geometry relationships and bed and bank sediment size. The system is intended to predict future channel change based on a visual assessment of channel forms and has become a very common approach to modification (Rosgen 1996). Other approaches to stream restoration and channel instability have been suggested but none have received as much support as Rosgen's methods in restoration practice. There are process-based approaches to channel reconstruction that have been suggested as an alternative such as methods which rely on sedimentation analyses and flow mechanics but these have not been as widely adopted (Simon et al. 2007, Shields et al. 2003).

Geomorphic controls on habitat and ecosystem health have been well documented (Frothingham et al. 2002). Habitat improvement is one of the most commonly cited goals motivating stream restoration throughout the country, likely in reponse to legislature such as the Endangered Species Act (Bernhardt et al. 2005). Typical techniques used to improve habitat include instream structure placement, riparian planting, road restoration, reconnecting habitats, and nutrient enrichment (Roni et al. 2008). Woody riparian vegetation and woody debris has been well studied in a geomorphic context because of its importance for improving and maintaining habitat (Roni et al. 2002; Gregory 2003).

The presence of in-channel structures is incredibly important for habitat. In addition to woody debris, other structures frequently used include artificial structures such as weirs and other types of natural structures such as boulders and gravel bars. The range of structures as well as the diversity of species make the effectiveness of this restoration technique hard to assess but evidence points to an overall improvement in habitat quality and spawning conditions (Roni et al. 2008).

The Role of Aesthetics in Environmental Management

The visual assessment of landscapes, or landscape aesthetics, is how the public most immediately judges the quality of the environment. While "scenic beauty" is not traditionally addressed in disciplines such as geomorphology or engineering, it plays an important role in resource management. Legislation such as the National Environmental Policy Act of 1969 and the National Forest Management Act of 1976 include provisions for scenic beauty in management decisions (Ribe 2002). Aesthetic landscape preferences are deeply rooted cognitive processes that are thought to have evolutionary significance (Parsons and Daniel 2002). Vegetation type, landscape variety, and presence of water are all examples of highly valued features of natural landscapes (De Vries et al. 2007).

Visual perception and aesthetic appraisal play a formal role in design and management decisions for city parks, monuments, and land management practices, particularly in the US Forest service (Parsons & Daniel 2002: Ribe 2002). However, such aesthetic value is often at odds with scientific recommendations for ecological health (Gobster et al. 2007). The visual quality of landscapes serves as common ground between public enjoyment and development purposes (Gobster et al. 2007). This applied approach to perception, under the guise of such terms as scenic aesthetics, aesthetic ecology, landscape aesthetics and visual landscapes offers unique perspectives on the role of perception in geomorphology.

The dissonance between public perception and the scientific understanding has been found to have cultural origins. For example, the presence of channelized rivers in the agricultural environments of central Illinois are considered by farmers to be necessary for drainage and communicate order and neatness, therefore they are aesthetically pleasing and seen as essential components of successful farming, regardless of the lasting impacts on the watershed at large (Urban 2005). If environmental policies are to continue being informed on the basis of perception, more information is needed to understand the relationship between aesthetics, and perception more generally, and stream system dynamics.

Watershed Partnerships and Restoration at the Local Scale

Water resource management, and therefore stream restoration, are ultimately social endeavors dictated by social priorities and expectations. Restoration projects are examples of these social motivations in that they are specifically designed to return the value of a resource for the further use or benefit to society. The social nature of these projects requires an institutional structure to be in place in order for projects to be designed and implemented. These institutional structures have evolved into two main forms: large-scale, agency driven collaborations and local, collaborative partnerships involving multiple stakeholders (Gerlak 2008). The majority of restoration projects are undertaken by local watershed partnerships. Watershed partnerships include any group of stakeholders which meet to discuss management issues related to a common watershed or stream system and are often fairly informal when compared to larger, regional restoration projects (Leach and Pelkey 2001; Gerlak 2008). There are approximately 1000 of these collaborative partnerships throughout the U.S. (Leach and Pelkey 2001).

Community participation in watershed management initiatives is increasing because of the improved understanding of social influences in program success as well as support from agencies such as the US Environmental Protection Agency (USEPA) (Junker and Buchecker, 2008; Rhoads et al. 1999). Many watershed partnerships operate on financial support from state or federal agencies as well as private donations of money, land and labor (Leach and Pelkey 2001; Holl and Howarth 2000). The close relationship between stakeholders and the nature of the financial support received motivates partnerships to be supportive of community involvement and information sharing in order to use their resources most effectively (Holl and Howarth 2000). These partnerships create opportunities for public participation much earlier in the planning process as opposed to larger regional, agency driven groups, often pursuing activities such as public education, grant writing, stakeholder training, and volunteer opportunities (Leach and Pelkey 2001). Volunteer labor is another important component of community involvement since it increases the sense of stewardship and is therefore critical for the success of restoration projects (Holl and Howarth 2000).

Restoration and Perception

Commonly held perceptions of river environments can yield powerful information about social expectations of healthy river environments as well as acceptable management techniques (Gregory 2006). Recent literature within geomorphology supports the need for social considerations when making management recommendations (Gregory 2006; Newson 2002; Sheilds et al. 2005). However, there have been very few studies exploring these relationships, especially as they relate to management techniques like restoration.

Buijs (2009) studied public support for river restoration projects in the Netherlands in terms of their influence on scenic beauty, sense of place, intrinsic value of the floodplain, and risk perception. The results indicated that support for restoration was high. Restored floodplains were found to be more aesthetically pleasing, respondents recorded lower place attachment. Perceived risk and the intrinsic value of floodplain were not influenced by restoration (Buijs 2009).

Junker and Buchecker (2008) examined the relationship between public aesthetic preference and the ecological and geomorphological quality, perceived naturalness, and perceived satisfaction of needs of various restoration scenes in Switzerland. Their results indicated that restoration scenes that appeared more natural and scenes with a high level of ecological and geomorphological quality were found to be the most aesthetically pleasing. Restoration scenes which were perceived to be most suitable for leisure and recreation were also rated high for aesthetics (Junker and Buchecker 2008).

Both of these studies address restoration projects in general but the relationship between perception and more discrete geomorphic features integral to system form and function remains unclear. This dynamic is at the heart of a series of papers by Piegay et al. (2005) and Chin et al. (2008) which explore perception and the presence of woody debris in stream channels. Both studies indicate a common negative perception among non-scientists of the presence of large woody debris in river channels despite the scientifically understood ecological and structural benefits. Wood in stream channels is generally perceived as less aesthetically pleasing, hazardous, and requiring improvement which creates obstacles for specific management objectives aimed at improving ecological and geomorphological conditions within streams (Chin et al. 2008).

Chapter 5

Surveying Members of the James River Basin Partnership

Research Design

This research relies on a quantitative, case study approach towards understanding environmental perception as it relates to stream restoration. Similar studies exploring aspects of perception as it relates to stream restoration have employed surveys either alone or in conjunction with interviews in order to characterize and assess the attitudes of the study participants in the context of a unique management scenario (Junker and Buchecker 2008). The public members of the James River Basin Partnership were queried on topics related to their perceptions of stream restoration projects undertaken within the James River Watershed. A questionnaire (Appendix D), was used to collect data from respondents. Research design, mailing protocol, sampling strategy, questionnaire structure and development, data collection and analysis are presented in this chapter.

As discussed in the previous chapter, the James River watershed is unique because of the presence of the James River Basin Partnership (JRBP), a non-profit environmental organization whose mission is to improve water quality throughout the watershed. The JRBP has a public presence through various outreach and volunteer activities such as stream cleanups and educational fairs. The JRBP is also involved in the creation and implementation of many management strategies in the watershed by designing and securing funding for initiatives as well as providing personnel and resources to complete projects. Some examples of JRBP sponsored programs include riparian corridor restoration and protection easements, rain barrel distribution, and septic system replacement cost sharing. Because the nature of the survey was in line with the JRBP's mission, the director agreed to provide access to the member email list for the purposes of this project.

A self-administered online survey was used for this study. Surveys are well suited for sample sizes over thirty people and allow for comparisons to be drawn across demographic groups. The disadvantage to using a survey for a study of this nature is that the questions may be unclear or misunderstood if the respondent is not familiar with the background information for the survey. Additionally, the data collected is often limited in its specificity because respondents typically must choose between answers that are already provided (Sommer and Sommer 2002).

The questionnaire was designed in order to gauge the participant's perceptions and understanding of restoration projects. Stream restoration is defined in the questionnaire as "any activity designed and implemented for the purpose of improving the conditions of a stream." Questions were grouped categorically in order to address the concept of restoration as well as the implementation of restoration projects. Each category represents explicit themes evident in the existing environmental restoration literature: aesthetics, other restoration goals such as recreation and conservation, and stream system function.

Sampling Strategy

Holly Neill, the director of the JRBP was contacted in early September of 2009 about potential collaboration. The JRBP circulates a quarterly newsletter via email to its member base as well as individuals who have signed up through the organizations website. The executive director offered the organization's email list as a strategy to recruit participants. While emails have been collected at various events organized by the partnership since 1997 as well as through the website, no supplementary information regarding the demographics of those people included in the email list currently exists. The survey was sent to all of the addresses on the email list.

The population sampled in this study consists of public members of the JRBP as well as individuals who have signed up to receive email newsletters from the organization. Due to the local presence of the JRBP, it is assumed that most of the email addresses are from those who live or have lived in the James River watershed since 1997. Because each email address was voluntarily given to the JRBP, it is also assumed that each email address belongs to someone who is familiar with the area. Based on the information provided by the JRBP, it is impossible to know how many email addresses are out of date or belong to individuals who no longer live in the area.

The sample is therefore biased towards individuals living in James River watershed who have internet access and at least a basic understanding of where the James River watershed is located as well as the general water resource issues present in the watershed. A drawback to using such a list is that the results of the survey are specific to this population and cannot be extrapolated to the general public, other public members of other environmental organizations, or other areas. However, the results of such a specific sample could potentially be used in future studies to help calibrate survey instruments intended for the general public or members of other organizations.

Questionnaire Structure and Development

Due to the access to email addresses of JRBP members, it was decided that a web survey would be the most efficient way to reach the largest number of members. The questionnaire is 20 screens long and consists of 36 questions. To ground the questions in the context of the local watershed, questions specifically referenced the water quality issues and restoration approaches outlined in the James River Basin Partnership Watershed Management Plan. The survey was pretested by the faculty and graduate students in the Department of Geography at the University of Missouri on March 9, 2010. This section will outline the survey questions as they relate to participant demographics as well as the themes outlined in the research questions: aesthetics, restoration goals, and system function (table 3).

Table 3. General research questions and their relationship to specific survey questions.

Aesthetics				
A	What characteristics of stream environments do members of the JRBP ascribe with aesthetic value?			
System Function				
B	What are members of the JRBP percecptions and understanding of stream system function?			
Restoration Goals				
C	What are members of the JRBP perceptions of the restoration objectives and goals?			
Survey Question		Research Question		
		A	B	C
1	Have you ever heard of any efforts to improve the conditions of streams within the James River watershed			
2	To the best of your knowledge, how successful have these efforts been at improving streams			
3	Please indicate how long you have been a member of the James River Basin Partnership			
4	What types of activities sponsored by the James River Basin Partnership have you attended			
5	If you said other, please specify			
6	What are the ways that you interact with stream environments			
7	If you said other, please specify			
8	How often would you estimate that you have interacted with stream environments?			
	In the past year			
	In the past month			
9	To what extent can erosion be decreased by…		X	
	…actions taken throughout the watershed		X	
	…actions taken along the channel		X	
10	To what extent can water quality be improved by…		X	
	…actions taken throughout the watershed		X	
	…actions taken along the channel		X	
11	In order for stream restoration projects to be successful, they must be fully funded			X
12	Please indicate all of the sources you think are responsible for funding restoration projects			X
	The state government			X
	The local government			X
	The national government			X
	Donations			X
	Private Industries			X
	Private Non-profit organizations			X
13-20	Please answer the questions as they relate to the accompanying picture		X	
	This stream appears to lack biodiversity.		X	
	This stream appears to be susceptible to erosion.		X	
	This stream appears to have impaired water quality.		X	
	This stream appears to have an increased chance of flood risk.		X	
	This stream appears to be unstable.		X	

Table 3 continued. General research questions and their relationship to specific survey questions.

Survey Question		Research Question		
		A	B	C
21	...the stream banks are shaded with trees, brush, and other vegetation.	X		
	...there is woody debris in the channel.	X		
	...there are large boulders in the stream channel.	X		
	...the banks are regularly mowed and cleared.	X		
	...the stream channel is clear of any obstructions.	X		
	...the water in the stream is clear.	X		
	...the stream is straight.	X		
	...the stream is meandering.	X		
22	Please rank the sources most likely to affect water quality		X	
	Runoff from urban areas		X	
	Runoff from rural areas		X	
	Waste water treatment		X	
	Storm water management practices		X	
	Lack of vegetation along stream channels		X	
23	Please rank the sources most likely to affect erosion		X	
	Increased precipitation		X	
	Lack of vegetation along streams		X	
	Increased sediment from land use practices (construction)		X	
	Livestock grazing practices		X	
	Removing sediment from the stream		X	
24	Rank the strategies that are most effective at improving water quality in an urban setting		X	
	Planting and maintaining vegetation along the stream banks		X	
	Stabilizing the stream banks through engineering methods		X	
	Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)		X	
	Stormwater capture practices (e.g. rain barrels, cisterns, etc.)		X	
	Raising awareness about water quality		X	
25	Rank the strategies that are most effective at decreasing erosion in an urban setting		X	
	Planting and maintaining vegetation along the stream banks		X	
	Stabilizing the stream banks through engineering methods		X	
	Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)		X	
	Increasing sediment and erosion control regulations		X	
	Raising awareness about water quality		X	
26	Rank the strategies that are most effective at improving water quality in a rural setting		X	
	Planting and maintaining vegetation along the stream banks		X	
	Stabilizing the stream banks through engineering methods		X	
	Increasing regulations on animal grazing practices		X	
	Increased regulations on fertilizer application		X	
	Raising awareness about water quality		X	

Table 3 continued. General research questions and their relationship to specific survey questions.

Survey Question		Research Question		
		A	B	C
27	Rank the strategies that are most effective at decreasing erosion in a rural setting		X	
	Planting and maintaining vegetation along the stream banks		X	
	Stabilizing the stream banks through engineering methods		X	
	Increasing regulations on animal grazing practices		X	
	Increasing regulations on fertilizer application		X	
	Raising awareness about water quality		X	
28	An effective restoration technique for improving how a stream looks is…	X		
	...planting trees, brush, and other vegetation along stream banks.	X		
	...adding woody debris in the channel.	X		
	...adding large boulders in the stream channel.	X		
	...keeping the banks mowed.	X		
	...removing obstructions from the channel.	X		
	...straightening the channel.	X		
	...adding curves to the river channel.	X		
29	In your opinion, how important is it for restoration plans to account for…			X
	...community priorities.			X
	...opportunities to interact with streams.			X
	...the cost effectiveness of the proposed project.			X
30	It is acceptable for streams to be restored for the primary purpose of…			X
	...improving the way they look.			X
	...improving opportunities to interact with streams.			X
	...improving biodiversity of aquatic species.			X
	...flood control.			X
	...protecting human health and safety.			X
31	Please tell us where, in general you live in the James River watershed (City/Town; ZIP/Postal Code)			
32	How long have you been residing in the James River watershed?			
33	How would you describe the area where you live (Urban/Suburban; Rural)			
34	Are you age 18 or older			
35	What is your gender (Male; Female)			

Participant Characteristics

Two sets of questions are included in the questionnaire to account for the characteristics of the participants. First, demographic variables such as approximate location and length of residence in the James River Watershed, general description of the area the participant resides in (urban or rural), whether the participant was older than 18 years of age (to identify if the participant was eligible to participate in the study), and gender are used to define the basic structure of the respondents. These questions were placed at the end of the questionnaire (#31-36).

The second set of questions (#1-8) addressing demographics explicitly focuses on the familiarity of the participants with the James River watershed and the JRBP. Specific questions include whether participants have heard of stream restoration efforts and how successful those efforts have been in the James River Watershed as well as their level and length of involvement in the James River Basin Partnership. The questions in this section are mostly multiple choice. One free response question is included to allow respondents to account for JRBP sponsored activities that they have participated in. Two questions are also included to assess the types and frequency of stream-related recreation. This set of questions is one multiple choice question followed by two free response questions to indicate types and frequency of stream interaction.

Aesthetics

The perceived role of aesthetics in restoration projects is addressed through two primary questions. The first question focuses on the aesthetic value of stream characteristics while the second question addresses the effectiveness of restoration techniques at improving aesthetic value.

First, a five point Likert scale is used to measure the stream characteristics perceived to hold the most aesthetic value to the participant. There are eight different features related to the shape of the channel (meandering or straight), the presence or absence of channel obstructions, and the presence or absence of woody riparian vegetation. Additionally, restoration techniques associated with improving aesthetic quality are also measured using a five point Likert scale. The restoration scenarios listed in the questions are based on issues outlined in the watershed management plan and include variables related to riparian vegetation, the addition and removal of channel obstructions, and the engineered channel form.

Restoration Goals

The last section of the survey addresses restoration goals (Table 3, #11, 12, 29, and 30). The importance of funding for the success of restoration projects is measured using a five point Likert scale. Agencies and groups responsible for providing funding for restoration projects are measured using multiple response choices. Respondents also ranked the importance of accounting for community priorities, recreation, and cost effectiveness in restoration planning. Finally, a five point Likert scale question is included to determine whether objectives such as recreational considerations, aesthetics, biodiversity, flood control and human health and safety warrant stream restoration.

System Function

A large portion of the survey is dedicated to questions related to aspects of stream system function (Table 3, #9, 10, 13-20, 22-27). The purpose of these questions is to assess how well the respondents understand the role of fundamental forms (e.g., stream banks, channel form) and processes (e.g., the effects of restoration programs at the stream reach or watershed scale) within the context of the James River watershed. This section of questions addresses system function as an area of overlap between public understanding and current management practices. The participants' understanding of basic stream system dynamics and the effects of restoration strategies on those systems is relevant because the member base of the JRBP is critical to the implementation of restoration initiatives.

These questions draw directly from the James River Basin Management Plan and focus heavily on erosion and impaired water quality since they are the two sources of concern throughout the watershed. This set of questions uses self-ranking to determine the perceived scale at which these erosion and impaired water quality can effectively be addressed through restoration; the most likely sources contributing to impaired water quality and erosion; the influence of various sources on water quality and erosion in both urban and rural environments as well as the effectiveness of various restoration strategies intended to address water quality, erosion, and aesthetic value. The scenarios listed in the questions are based on issues outlined in the watershed management and include variables such as riparian vegetation, the effects of land use, and the effects of current water management and mitigation practices in the area. These hypothetical situations are useful in framing the questions so that they remain relevant to the James River watershed as well as the management techniques used in the area and the resulting answers can be compared to actual practices.

A second means of assessing stream function is a set of questions paired with a series of photographs taken of different stream environments within the watershed. The photographs were taken by the researcher in late February 2010. The photographs are different combinations of three stream environment variables: appearance of banks, amount of woody riparian vegetation, and surrounding environment (urban or rural). Each scene is framed so that the differences between each photograph are the combination of variables. The purpose of pairing the photographs with questions is to assess the respondents' perceived understanding of system function based on three of the dominant forms found in stream environments. The accompanying questions assess which stream environment variables influenced water quality, erosion, biodiversity, flood risk, and stability. The questions use five point Likert scales to determine the degree to which participants agree or disagree with definitive statements pertaining to each picture.

Mailing Protocol

The specific mailing protocol used followed the Dillman (2007) method for multiple contact mailings in order to enhance response rates (table 4). Members of the James River Basin Partnership were first notified of the study through an email sent by the project director Tiffany Frey on behalf of the organization. This initial contact explained the purpose and importance of the study and that the questionnaire would be distributed through email (Appendix A).

The web-based program Survey Monkey was used to design and administer the questionnaire. Survey Monkey allows researchers to create their own web surveys with a variety of questions and also manages the email lists and responses. The email list was uploaded to the Survey Monkey website so that the program could send scheduled emails on behalf of the researcher as well as keep track of those who had responded and those who had not. The first solicitation of members was sent to the entire email list while subsequent requests were sent to only those addresses who had not replied to previous emails. Initial contact was sent through the Survey Monkey program via the researcher's school email address in order to indicate that the email was not from the JRBP (Appendix B). Reminder emails were also sent through Survey Monkey in the same manner (Appendix C).

Table 4. Mailing order protocol used for contacting participants (Dillman 2007).

Date	Mailing order	Type	# of items mailed	Responses	Bounced Emails
February 23	1	Pre-notification email sent by JRBP			
March 15	2	Survey invitation email	562	82	55
March 23	3	Survey reminder email	485	40	55
April 1	4	Survey reminder email	445	26	55
April 14	5	Survey reminder email	419	11	55

Data Collection and Statistical Analysis

A total of 598 email addresses were supplied by the James River Basin Partnership. Survey Monkey identified 36 as being invalid after the list was uploaded. Of the remaining 562 email addresses, 55 were returned to the researcher's email account as undeliverable after every mailing resulting in an adjusted sample size of 507. Five people chose to opt out of the survey and were removed from the email list. A total of 106 surveys were completed (20.9% response rate).

The survey responses were downloaded as a Microsoft Office Excel spreadsheet from the Survey Monkey website program. Returned surveys which were less than 60% complete were not included in the analysis. Descriptive and inferential statistics were calculated using Statistical Package for Social Sciences (SPSS). Descriptive statistics were used to determine the means, frequencies, percentages, standard deviation, central tendency and variability of the responses. Independent samples t-test and ANOVA were used in order to determine the significance of group differences in the perceptions and understanding of restoration practices. An alpha level of 0.05 was used in all t-test and ANOVA analyses.

Chapter 6

Survey Results

The survey entitled "Stream Restoration in the James River Watershed" (Appendix A) was sent to 507 email addresses. A total of 106 questionnaires were completed (20.9% response rate). Descriptive statistics were calculated for demographic characteristics, perceived aesthetic value of stream features, perceptions and understanding of stream system function and perceptions of restoration objectives and goals. Inferential statistics (one-way ANOVA and independent samples t-test) were used to determine the significance of group differences between the independent variables (length of residence in watershed, types of stream interaction, and residence in an urban/suburban or rural area) and dependant variables such as perceived aesthetic value of stream environments, understanding of stream system function, and perceptions of restoration objectives and goals.

Participant Characteristics

In general, the portrait of respondents reflected long-time residents of the area who engaged in activities which brought them into regular contact with streams in the James River watershed. The majority (57.5%) of members in the sample were male (Table 5). Respondents lived in the area for an average of 20 years (*M*=20.46, SD=16.102) and most described the area where they currently live as urban/suburban (62.6%). Most of the respondents indicated that they were exposed to stream environments in some way. Floating or canoeing and walking on paths along streams were the most popular activities (83.0% of the sample for both activities). Less than half of the respondents claimed to have participated in stream cleanup activities (47.2%). The activities identified by respondents that marked "other" (20.8%) were work related such as water quality monitoring and surveying (7.5%), observing streams (4.7%), camping (3.7%), and swimming (1.8%) while three respondents listed boating as an activity. Respondents indicated that they participated in the listed activities an average of 32.05 times in the past year (*M*=32.05, SD=66.143) and 6.04 times in the past month (*M*=6.04, SD=36.613) (Table 6).

Just over half of the respondents have been members of the JRBP between 1 and 5 years (51.9%). The most popular events for respondents to participate in were River Rescue events (45.3%) and informational sessions (43.4%). Less than a quarter (24.5%) or respondents participated in membership meetings. Of those who selected "other" (21.7%) for participation in JRBP events, eight individuals (7.5%) listed board meetings as activities and five individuals (4.7%) indicated that they had not participated in any JRBP events (Table 7). The majority of respondents (93.4%) were aware of restoration efforts in the James River watershed. The overall perception of the success of those efforts was somewhat successful (*M*=3.68, SD=0.925) (Table 8).

Table 5. Summary Profile of respondents

Question	Attribute	n	%
Gender	Male	61	57.5
	Female	37	34.9
	Missing	8	7.5
Length of Residence in watershed (years)	0-5	16	15.1
	6-15	33	31.1
	16-29	21	19.8
	30-65	25	23.6
	missing	11	10.3
Description of area where respondent lives	Urban/Suburban	62	62.6
	Rural	37	37.4
	Missing	7	6.6
Types of interaction	Fishing	51	48.1*
	Floating or canoeing	88	83.0*
	Walking near streams	88	83.0*
	Riding bikes near streams	36	34*
	Participating in stream cleanup activities	50	47.2*
	Other	22	20.8*

*Percent of total sample

Table 6. Frequency of interaction

Question	Attribute	n	*M*	SD
Frequency of interaction	In the past year	102	32.05	66.143
	In the past month	100	6.04	36.613

Table 7. Membership characteristics

Question	Attribute	n	%
Length of Membership	Less than 1 year	17	16.0
	1 to 5 years	55	51.9
	6 to 10 years	23	21.7
	Over 10 years	8	7.5
	Missing	3	2.8
Paticipation in JRBP activities	Membership meetings	26	24.5*
	Informational sessions	46	43.4*
	River Rescue events	48	45.3*
	Watershed Festivals	29	27.4*
	Other	23	21.7*
Heard of efforts to improve stream conditions in watershed	Yes	99	93.4
	No	6	5.7
	Missing	1	0.9

*Percent of total sample

Table 8. Perceived success of restoration activities*

Question	n	*M*	SD
Success of projects at improving stream conditions	105	3.68	0.925

*Coded 1=unsuccessful to 5=very successful

Aesthetics

One component of the questionnaire examined the perceived role of aesthetics in restoration projects. Two questions addressed a total of 14 attributes. The first question focused on specific features of stream environments (Table 9). Stream banks shaded by trees, brush and other vegetation was rated the highest (*M*=4.24, SD=0.849) for aesthetics, followed by clear stream water (*M*=4.24, SD=0.885), and meandering channels (*M*=4.04, SD=0.909). Straight stream channels (*M*=1.83, SD=0.736) and mowed stream banks ranked the lowest.

The second question asked the respondent to gauge the effectiveness of certain restoration techniques at improving the aesthetic quality of stream environments. Planting riparian vegetation was found to be the most effective technique (*M*=4.43, SD=0.817) for improving stream aesthetics. Straightening stream channels (*M*=1.67, SD= 0.817) and mowing stream banks (*M*=1.88, SD=0.895) were ranked the least effective at improving stream aesthetics (Table 10).

Table 9. Aesthetic value of stream environments*

Attribute	n	*M*	SD
...the stream banks are shaded with trees, brush, and other vegetation.	105	4.24	0.849
...there is woody debris in the channel.	106	2.78	1.121
...there are large boulders in the stream channel.	106	3.28	0.923
...the banks are regularly mowed and cleared.	106	1.9	0.915
...the stream channel is clear of any obstructions.	105	2.7	1.11
...the water in the stream is clear.	105	4.21	0.885
...the stream is straight.	106	1.83	0.736
...the stream is meandering.	105	4.04	0.909

*Coded 1=strongly disagree to 5=strongly agree

Table 10. Aesthetic value and restoration techniques*

Attribute	n	*M*	SD
...planting trees, brush, and other vegetation along stream banks.	101	4.43	0.817
...adding woody debris in the channel.	97	2.59	0.910
...adding large boulders in the stream channel.	100	3.12	0.924
...keeping the banks mowed.	99	1.88	0.895
...removing obstructions from the channel.	98	2.77	1.073
...straightening the channel.	100	1.67	0.817
...adding curves to the river channel.	100	3.29	1.018

*Coded 1=strongly disagree to 5=strongly agree

Restoration Goals

Another group of questions pertained to their perception of restoration planning and desired goals. Overall, respondents were neutral (*M*=3.76, SD=1.056) concerning the importance of funding for the success of restoration projects (Table 11). The majority of respondents identified the state government (93.4%) should be responsible for funding restoration projects while the national government was the least likely to be held responsible for funding projects (Table 12). Health and human safety was ranked the highest (*M*=4.43, SD=0.787) as a primary restoration objective while aesthetics was ranked the lowest primary objective (*M*=3.11, SD=1.095). All attributes were ranked favorably except aesthetics, which was ranked as neutral (Table 11). Recreational opportunities ranked that highest (*M*=4.42, SD=0.563) out of considerations necessary for restoration planning (Table 13).

Table 11. Restoration project success and objectives*

Attribute	n	*M*	SD
In order for stream restoration projects to be successful, they must be fully funded	106	3.76	1.056
It is acceptable for streams to be restored for the primary purpose of…			
...improving the way they look.	101	3.11	1.095
...improving opportunities to interact with streams.	103	4.00	0.792
...improving biodiversity of aquatic species.	102	4.37	0.795
...flood control.	103	4.16	0.801
...protecting human health and safety.	103	4.43	0.787

*Coded 1=strongly disagree to 5=strongly agree

Table 12. Funding Sources*

Attribute	n	%
The state government	99	93.4*
The local government	90	84.9*
The national government	84	79.2*
Donations	92	86.8*
Private Industries	86	81.1*
Private Non-profit organizations	92	86.8*

*Percent of total sample

Table 13. Considerations in restoration planning*

Attribute	n	*M*	SD
In your opinion, how important is it for restoration plans to account for…			
...community priorities.	102	4.03	0.880
...opportunities to interact with streams.	102	4.42	0.563
...the cost effectiveness of the proposed project.	102	4.30	0.728

*Coded 1=unimportant to 5=very important

System Function

The largest component of the questionnaire included questions examining perceptions of stream system function. Respondents ranked restoration actions taken at the watershed scale slightly more effective than actions at the reach scale for decreasing erosion (*M*=2.57, SD=0.856) as well as improving water quality (*M*=2.87, SD=0.621) (Table 14). Lack of vegetation was ranked as the most to degrade water quality (*M*=2.55, SD=1.435) while runoff from urban areas was ranked as the most likely to degrade water quality (*M*=3.95, SD=1.082) (Table 15). Stabilizing stream banks through engineering methods was ranked as the least effective (*M*=2.35, SD=1.31) technique for improving water quality in urban areas as well as rural areas (*M*=2.01, SD=1.298) while planting vegetation was found to be the most effective technique (*M*=3.81, SD=1.14) for improving water quality in urban areas as well as rural areas (*M*=3.94, SD=1.153) (Table 16). Increased precipitation was ranked as the least likely (*M*=2.12, SD=1.743) to influence erosion while lack of vegetation was ranked as the most likely source influencing erosion (*M*=4.02, SD=1.109) (Table 17). Planting and maintaining vegetation along the stream bank was ranked as the most effective technique for decreasing erosion in urban (*M*=3.83, SD=1.134) and rural areas (*M*=4.31, SD=0.933). Raising awareness about water quality was ranked as the least effective technique at decreasing erosion in urban areas (*M*=2.45, SD=1.340) and increasing regulations on fertilizer application was ranked as the least effective technique in rural areas (*M*=1.90, SD=1.171) (Table 18.)

Photographs

Eight photographs of different stream environments throughout the watershed were paired with questions in order to examine respondents' perceptions of the relationship between environmental characteristics (woody riparian vegetation, stream banks, and surrounding area) and system function (biodiversity, erosion, water quality, flood risk, and stability). Certain photographs elicited distinct responses from the group assessed (or something like that to preface the notion that you are going to indicate which photos stood out as clearly defining something specific to the respondents) Respondents ranked photograph 14, showing an urban stream with woody riparian vegetation and unexposed banks, as having the highest level of biodiversity (*M*=2..81, SD=1.147), the least susceptible to erosion (*M*=2.24, SD=0.670), the highest level of water quality (*M*=2.56, SD=0.748), the lowest flood risk (*M*=2.72, SD=1.021) and the most stable (*M*=2.42, SD=0.850). Photograph 18, showing a stream in a rural area with woody riparian vegetation and unexposed banks also ranked high in terms of greater biodiversity (*M*=2.89, SD=0.939) and stability (*M*=2.8, SD=0.960). Photograph 19, showing a rural stream with woody riparian vegetation and exposed banks, was also ranked as having a lower chance of erosion (*M*=2.47, SD=0.501) and higher water quality (*M*=2.58, SD=0.533) (Table 19).

Photograph 13, showing an urban stream without woody riparian vegetation and with unexposed banks, ranked as having the lowest biodiversity (*M*=4.00, SD=0.926), as the most susceptible to erosion (*M*=3.84, SD=0.833), the most impaired water quality (*M*=3.69, SD=0.773), and the second highest chance of flood risk (*M*=3.72, SD=0.966). Photograph 15, showing an urban stream with woody riparian vegetation and exposed banks ranked as having the highest flood risk (*M*=3.71, SD=0.829) and as being the most unstable (*M*=3.82, 0.753). Photograph 20, showing a rural stream without woody riparian vegetation and exposed banks also ranked as having lower biodiversity (*M*=4.0, SD=0.683) (Table 19).

Table 14. Restoration and scale*

Attribute	n	*M*	SD
To what extent can erosion be decreased by…			
…actions taken throughout the watershed	104	2.57	0.856
…actions taken along the channel	103	2.48	0.927
To what extent can water quality be improved by…			
…actions taken throughout the watershed	105	2.87	0.621
…actions taken along the channel	102	2.60	0.847

*Coded 1=not at all to 4=completely

Table 15. Perceived sources influencing water quality*

Attribute	n	*M*	SD
Runoff from urban areas	99	3.95	1.082
Runoff from rural areas	97	2.76	1.223
Waste water treatment	105	3.30	1.480
Storm water management practices	102	2.67	1.359
Lack of vegetation along stream channels	96	2.55	1.435

*Coded 1=least likely to 5= most likely to degrade water quality

Table 16. Perceived efficacy of strategies for improving water quality*

Attribute	n	*M*	SD
Improving water quality in urban areas			
Planting and maintaining vegetation along the stream banks	97	3.81	1.140
Stabilizing the stream banks through engineering methods	102	2.35	1.310
Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)	98	3.49	1.286
Stormwater capture practices (e.g. rain barrels, cisterns, etc.)	104	2.50	1.365
Raising awareness about water quality	101	3.07	1.402
Improving water quality in rural areas			
Planting and maintaining vegetation along the stream banks	97	3.94	1.153
Stabilizing the stream banks through engineering methods	99	2.01	1.298
Increasing regulations on animal grazing practices	97	2.87	1.213
Increased regulations on fertilizer application	94	3.34	1.418
Raising awareness about water quality	100	3.08	1.277

*Coded 1= least effective to 5= most effective in improving water quality

Table 17. Perceived sources influencing erosion*

Attribute	n	*M*	SD
Increased precipitation	100	2.12	1.743
Lack of vegetation along streams	102	4.02	1.109
Increased sediment from land use practices (construction)	95	3.38	1.727
Livestock grazing practices	101	3.12	1.486
Removing sediment from the stream	102	2.62	1.783

*Coded 1=least likely to 5= most likely to increase erosion

Table 18. Perceived efficacy of strategies for decreasing erosion*

Attribute	n	*M*	SD
Decreasing erosion in urban areas*			
Planting and maintaining vegetation along the stream banks	99	3.83	1.134
Stabilizing the stream banks through engineering methods	103	2.53	1.392
Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)	99	3.09	1.371
Increasing sediment and erosion control regulations	97	3.23	1.381
Raising awareness about water quality	102	2.45	1.340
Decreasing erosion in rural areas*			
Planting and maintaining vegetation along the stream banks	96	4.31	0.933
Stabilizing the stream banks through engineering methods	100	2.88	1.350
Increasing regulations on animal grazing practices	95	2.98	1.238
Increasing regulations on fertilizer application	93	1.90	1.171
Raising awareness about water quality	98	3.04	1.243

*Coded 1=least effective to 5= most effective in decreasing erosion

Table 19. Stream photographs and perceived system function*

Question	Attribute	n	*M*	SD
13 Urban area, no woody riparian buffer, banks not exposed	Lacking biodiversity.	106	4.00	0.926
	Susceptible to erosion.	105	3.84	0.833
	Impaired water quality.	106	3.69	0.773
	Increased chance of flood risk.	105	3.72	0.966
	Unstable.	105	3.49	0.867
14 Urban area, presence of woody riparian buffer, banks not exposed	Lacking biodiversity.	106	2.81	1.147
	Susceptible to erosion.	106	2.24	0.670
	Impaired water quality.	104	2.56	0.748
	Increased chance of flood risk.	106	2.72	1.021
	Unstable.	106	2.42	0.850
15 Urban area, presence of woody riparian buffer, banks are exposed	Lacking biodiversity.	106	3.87	0.840
	Susceptible to erosion.	105	3.45	0.855
	Impaired water quality.	106	3.57	0.781
	Increased chance of flood risk.	105	3.71	0.829
	Unstable.	106	3.82	0.753
16 Urban area, lack of woody riparian buffer, banks are exposed	Lacking biodiversity.	106	3.32	0.879
	Susceptible to erosion.	104	2.89	0.799
	Impaired water quality.	106	2.7	0.620
	Increased chance of flood risk.	106	3.05	0.888
	Unstable.	105	2.89	0.870
17 Rural area, lack of woody riparian buffer, banks are not exposed	Lacking biodiversity.	106	3.67	0.848
	Susceptible to erosion.	105	2.91	0.774
	Impaired water quality.	105	3.00	0.707
	Increased chance of flood risk.	106	3.41	0.848
	Unstable.	106	3.15	0.892
18 Rural area, presence of woody riparian buffer, banks are not exposed	Lacking biodiversity.	106	2.89	0.939
	Susceptible to erosion.	106	3.05	0.980
	Impaired water quality.	105	3.44	0.919
	Increased chance of flood risk.	105	3.05	0.984
	Unstable.	106	2.80	0.960
19 Rural area, presence of woody riparian buffer, banks are exposed	Lacking biodiversity.	105	3.20	0.965
	Susceptible to erosion.	105	2.47	0.501
	Impaired water quality.	105	2.58	0.553
	Increased chance of flood risk.	106	2.75	0.739
	Unstable.	106	2.75	0.682
20 Rural area, lack of woody riparian buffer, banks are exposed	Lacking biodiversity.	104	4.0	0.683
	Susceptible to erosion.	104	3.36	0.869
	Impaired water quality.	105	3.13	0.809
	Increased chance of flood risk.	104	3.67	0.875
	Unstable.	105	3.30	0.900

*Coded 1=strongly disagree to 5=strongly agree

Hypothesis Testing

Residential area and Aesthetics

$H_0 1$: There is no significant difference between respondents who live in urban/suburban and rural areas and their perceptions of aesthetic value and stream environments.

$H_0 1$: Rejected

This hypothesis was tested using an independent samples t-test comparing respondents' residential area (urban/suburban or rural) with perceived aesthetic value of stream environments. There were no differences between urban/suburban and rural residents and their appraisal of stream environment aesthetics (Table 20). However, there was a statistically significant difference at the 0.05 level in terms of effective restoration techniques for improving aesthetics. Rural residents rated the addition of boulders to stream channels to be more effective at improving the aesthetic quality of stream environments than urban/suburban residents (*M*=3.39, *M*=2.95, respectively) (Table 21).

Table 20. Independent samples t-test comparing residential area and aesthetic value of stream environments*

Attribute	Area	N	*M*	t	df	p
...the stream banks are shaded with trees, brush, and other vegetation.	Urban/suburban	61	4.33	1.524	96	0.131
	Rural	37	4.05			
...there is woody debris in the channel.	Urban/suburban	62	2.81	0.339	97	0.735
	Rural	37	2.73			
...there are large boulders in the stream channel.	Urban/suburban	62	3.34	0.220	97	0.826
	Rural	37	3.3			
...the banks are regularly mowed and cleared.	Urban/suburban	62	1.84	-0.575	97	0.567
	Rural	37	1.95			
...the stream channel is clear of any obstructions.	Urban/suburban	61	2.69	-0.183	96	0.855
	Rural	37	2.73			
...the water in the stream is clear.	Urban/suburban	61	4.31	1.534	96	0.128
	Rural	37	4.03			
...the stream is straight.	Urban/suburban	62	1.82	-0.445	97	0.658
	Rural	37	1.89			
...the stream is meandering.	Urban/suburban	61	4.08	0.161	96	0.872
	Rural	37	4.05			

*Coded 1=strongly disagree to 5=strongly agree

Table 21. Independent samples t-test comparing residential area and aesthetic value and restoration techniques*

Attribute	Area	n	*M*	t	df	p
...planting trees, brush, and other vegetation along stream banks.	Urban/suburban	61	4.43	-0.259	93	0.796
	Rural	34	4.47			
...adding woody debris in the channel.	Urban/suburban	59	2.54	-1.201	89	0.230
	Rural	32	2.78			
...adding large boulders in the stream channel.	Urban/suburban	61	2.95	-2.245	92	0.027
	Rural	33	3.39			
...keeping the banks mowed.	Urban/suburban	60	1.87	-0.370	91	0.712
	Rural	33	1.94			
...removing obstructions from the channel.	Urban/suburban	60	2.77	0.449	91	0.654
	Rural	33	2.67			
...straightening the channel.	Urban/suburban	61	1.66	-0.235	92	0.815
	Rural	33	1.70			
...adding curves to the river channel.	Urban/suburban	61	3.25	-0.403	92	0.688
	Rural	33	3.33			

*Coded 1=strongly disagree to 5=strongly agree

Residential Area and Restoration Goals

$H_0$2: There is no significant difference between respondents who live in urban/suburban and rural areas and their perceptions of restoration priorities and goals.

$H_0$2: Rejected

This hypothesis was tested using an independent samples t-test comparing respondents' residential area (urban/suburban or rural) with perceptions of restoration priorities and goals. There were statistically significant differences at the 0.05 level in terms of acceptable primary restoration objectives. Urban/suburban residents rated improving opportunities to interact with stream environments (*M*=4.16) and improving biodiversity of aquatic species (*M*=4.52) higher than rural residents in both instances (*M*=3.74, *M*=4.12, respectively) (Table 22).

Table 22. Independent samples t-test comparing residential area and restoration priorities and goals

Attribute	Area	n	*M*	t	df	p
In order for stream restoration projects to be successful, they must be fully funded*	Urban/suburban	62	3.92	1.730	97	0.087
	Rural	37	3.54			
It is acceptable for streams to be restored for the primary purpose of…[†]						
...improving the way they look.	Urban/suburban	61	3.16	0.818	93	0.415
	Rural	34	2.97			
...improving opportunities to interact with streams.	Urban/suburban	62	4.16	2.553	95	0.012
	Rural	35	3.74			
...improving biodiversity of aquatic species.	Urban/suburban	62	4.52	2.398	94	0.018
	Rural	34	4.12			
...flood control.	Urban/suburban	62	4.23	1.492	95	0.139
	Rural	35	3.97			
...protecting human health and safety.	Urban/suburban	62	4.45	0.811	95	0.419
	Rural	35	4.31			
In your opinion, how important is it for restoration plans to account for…*						
...community priorities.	Urban/suburban	62	4.08	0.982	94	0.329
	Rural	34	3.88			
...opportunities to interact with streams.	Urban/suburban	62	4.53	1.879	94	0.063
	Rural	34	4.24			
...the cost effectiveness of the proposed project.	Urban/suburban	62	4.27	-0.586	94	0.559
	Rural	34	4.38			

*Coded 1=strongly disagree to 5=strongly agree
[†]Coded 1=unimportant to 5=very important

Residential Area and System Function

$H_0$3: There is no significant difference between respondents who live in urban/suburban and rural areas and their perceptions of stream system function.

$H_0$3: Rejected

This hypothesis was tested using an independent samples t-test comparing respondents' residential area (urban/suburban or rural) with perceptions of stream system function. Statistically significant differences at the 0.05 level in terms of stream system function were found and the hypothesis was rejected. Urban/suburban residents rated actions taken throughout the watershed as being less effective at decreasing erosion (*M*=2.72) and improving water quality (2.62) than rural residents (*M*=2.28 and *M*=2.32, respectively) (Table 23).

There were also statistically significant differences between the groups in the results of the photograph section of the questionnaire. Photograph 14 shows an urban stream with a woody riparian buffer and unexposed stream banks which urban/suburban residents rated higher (*M*=2.37) than rural residents (*M*=2.76) for assessment of water quality. Photograph 18 shows a rural stream with a woody riparian buffer and unexposed stream banks which urban/suburban residents ranked lower (*M*=3.24) than rural residents (*M*=3.24) in terms of perceived biodiversity (Table 24).

Statistically significant differences were also found between urban/suburban and rural respondents ratings of restoration practices in urban environments. Rural residents rated stabilizing stream banks as more effective at improving water quality (*M*=2.91) than urban residents (*M*=2.12). Urban/suburban residents rated storm water capture techniques as more effective at improving water quality (*M*=2.69) than rural residents (*M*=2.09) (Table 26). However, there were no statistical differences in the perceived sources impairing waters quality and increasing erosion (Table 25) or restoration techniques in rural areas (Table 27).

Table 23. Independent samples t-test comparing residential area and system function*

Attribute	Area	n	*M*	t	df	p
To what extent can erosion be decreased by…						
…actions taken throughout the watershed	Urban/suburban	61	2.72	2.468	95	0.015
	Rural	36	2.28			
…actions taken along the channel	Urban/suburban	59	2.61	1.441	94	0.153
	Rural	37	2.32			
To what extent can water quality be improved by…						
…actions taken throughout the watershed	Urban/suburban	62	2.98	2.200	97	0.030
	Rural	37	2.70			
…actions taken along the channel	Urban/suburban	60	2.63	0.122	94	0.903
	Rural	36	2.61			

*Coded 1=not at all to 4=completely

Table 24. Independent samples t-test comparing residential area and system function using photographs*

Attribute	Area	n	*M*	t	df	p
13 Urban area, no woody riparian buffer, banks not exposed						
Susceptible to erosion.	Urban/suburban	62	4.03	0.027	97	0.978
	Rural	37	4.03			
Lacking biodiversity.	Urban/suburban	61	3.87	0.329	96	0.743
	Rural	37	3.81			
Impaired water quality.	Urban/suburban	62	3.76	0.998	97	0.321
	Rural	37	3.59			
Increased chance of flood risk.	Urban/suburban	62	3.69	-0.272	96	0.786
	Rural	36	3.75			
Unstable.	Urban/suburban	62	3.52	0.087	96	0.931
	Rural	36	3.50			
14 Urban area, presence of woody riparian buffer, banks not exposed						
Susceptible to erosion.	Urban/suburban	62	2.65	-1.260	97	0.211
	Rural	37	2.95			
Lacking biodiversity.	Urban/suburban	62	2.19	-0.555	97	0.580
	Rural	37	2.27			
Impaired water quality.	Urban/suburban	60	2.37	-2.660	95	0.009
	Rural	37	2.76			
Increased chance of flood risk.	Urban/suburban	62	2.60	-1.132	97	0.260
	Rural	37	2.84			
Unstable.	Urban/suburban	62	2.32	-1.229	97	0.222
	Rural	37	2.54			
15 Urban area, presence of woody riparian buffer, banks are exposed						
Susceptible to erosion.	Urban/suburban	62	3.87	0.185	97	0.854
	Rural	37	3.84			
Lacking biodiversity.	Urban/suburban	61	3.41	0.025	96	0.980
	Rural	37	3.41			
Impaired water quality.	Urban/suburban	62	3.52	-0.313	97	0.755
	Rural	37	3.57			
Increased chance of flood risk.	Urban/suburban	62	3.71	0.086	96	0.932
	Rural	36	3.69			
Unstable.	Urban/suburban	62	3.87	0.909	97	0.366
	Rural	37	3.73			
16 Urban area, lack of woody riparian buffer, banks are exposed						
Susceptible to erosion.	Urban/suburban	62	3.37	0.548	97	0.585
	Rural	37	3.27			
Lacking biodiversity.	Urban/suburban	61	2.98	1.379	95	0.171
	Rural	36	2.75			
Impaired water quality.	Urban/suburban	62	2.66	-0.940	97	0.349
	Rural	37	2.78			
Increased chance of flood risk.	Urban/suburban	62	3.11	0.755	97	0.452
	Rural	37	2.97			
Unstable.	Urban/suburban	62	2.95	0.635	96	0.527
	Rural	36	2.83			

Table 24 continued. Independent samples t-test comparing residential area and system function using photographs*

17 Rural area, lack of woody riparian buffer, banks are not exposed						
Susceptible to erosion.	Urban/suburban	62	3.65	-0.170	97	0.865
	Rural	37	3.68			
Lacking biodiversity.	Urban/suburban	61	3.02	1.766	96	0.081
	Rural	37	2.73			
Impaired water quality.	Urban/suburban	62	3.06	0.797	96	0.427
	Rural	36	2.94			
Increased chance of flood risk.	Urban/suburban	62	3.37	-0.042	97	0.967
	Rural	37	3.38			
Unstable.	Urban/suburban	62	3.27	1.782	97	0.078
	Rural	37	2.95			
18 Rural area, presence of woody riparian buffer, banks are not exposed						
Susceptible to erosion.	Urban/suburban	62	2.94	0.632	97	0.529
	Rural	37	2.81			
Lacking biodiversity.	Urban/suburban	62	3.24	2.870	97	0.005
	Rural	37	2.68			
Impaired water quality.	Urban/suburban	62	3.53	1.624	96	0.108
	Rural	36	3.22			
Increased chance of flood risk.	Urban/suburban	62	3.08	0.519	96	0.605
	Rural	36	2.97			
Unstable.	Urban/suburban	62	2.89	0.932	97	0.354
	Rural	37	2.70			
19 Rural area, presence of woody riparian buffer, banks are exposed						
Susceptible to erosion.	Urban/suburban	61	3.16	-0.122	96	0.903
	Rural	37	3.19			
Lacking biodiversity.	Urban/suburban	62	2.45	-0.319	96	0.751
	Rural	36	2.50			
Impaired water quality.	Urban/suburban	62	2.53	-0.668	96	0.506
	Rural	36	2.64			
Increased chance of flood risk.	Urban/suburban	62	2.76	-0.142	97	0.887
	Rural	37	2.78			
Unstable.	Urban/suburban	62	2.66	-1.331	97	0.186
	Rural	37	2.89			
20 Rural area, lack of woody riparian buffer, banks are exposed						
Susceptible to erosion.	Urban/suburban	61	4.07	0.871	95	0.386
	Rural	36	3.94			
Lacking biodiversity.	Urban/suburban	60	3.43	0.922	95	0.359
	Rural	37	3.27			
Impaired water quality.	Urban/suburban	61	3.25	1.601	96	0.113
	Rural	37	2.97			
Increased chance of flood risk.	Urban/suburban	61	3.70	0.358	95	0.721
	Rural	36	3.64			
Unstable.	Urban/suburban	61	3.36	0.334	96	0.739
	Rural	37	3.30			

*Coded 1=strongly disagree to 5=strongly agree

Table 25. Sources influencing water quality and erosion

Attribute	Area	n	*M*	t	df	p
Water quality						
Runoff from urban areas	Urban/suburban	58	4.10	1.977	91	0.051
	Rural	35	3.66			
Runoff from rural areas	Urban/suburban	56	2.75	0.054	88	0.957
	Rural	34	2.74			
Waste water treatment	Urban/suburban	61	3.15	-1.092	96	0.277
	Rural	37	3.49			
Storm water management practices	Urban/suburban	59	2.69	0.387	93	0.700
	Rural	36	2.58			
Lack of vegetation along stream channels	Urban/suburban	55	2.60	-0.150	87	0.881
	Rural	34	2.65			
Erosion						
Increased precipitation	Urban/suburban	58	2.03	-0.697	91	0.488
	Rural	35	2.23			
Lack of vegetation along streams	Urban/suburban	59	4.05	0.101	93	0.920
	Rural	36	4.03			
Increased sediment from land use practices (construction)	Urban/suburban	55	3.35	0.009	88	0.993
	Rural	35	3.34			
Livestock grazing practices	Urban/suburban	58	3.31	1.942	92	0.055
	Rural	36	2.81			
Removing sediment from the stream	Urban/suburban	60	2.57	-0.648	94	0.519
	Rural	36	2.75			

*Coded 1=least likely to 5= most likely

Table 26. Restoration techniques in urban areas*

Attribute	Area	n	*M*	t	df	p
Improving water quality in urban areas						
Planting and maintaining vegetation along the stream banks	Urban/suburban	57	3.72	-0.877	89	0.383
	Rural	34	3.94			
Stabilizing the stream banks through engineering methods	Urban/suburban	60	2.12	-2.924	93	0.004
	Rural	35	2.91			
Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)	Urban/suburban	57	3.63	1.662	89	0.100
	Rural	34	3.18			
Stormwater capture practices (e.g. rain barrels, cisterns, etc.)	Urban/suburban	62	2.69	2.150	95	0.034
	Rural	35	2.09			
Raising awareness about water quality	Urban/suburban	59	3.12	0.486	92	0.628
	Rural	35	2.97			
Decreasing erosion in urban areas						
Planting and maintaining vegetation along the stream banks	Urban/suburban	58	3.86	0.279	90	0.781
	Rural	34	3.79			
Stabilizing the stream banks through engineering methods	Urban/suburban	62	2.35	-1.759	94	0.082
	Rural	34	2.88			
Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)	Urban/suburban	58	3.03	-0.388	90	0.699
	Rural	34	3.15			
Increasing sediment and erosion control regulations	Urban/suburban	57	3.39	1.479	89	0.143
	Rural	34	2.94			
Raising awareness about water quality	Urban/suburban	60	2.52	0.707	93	0.481
	Rural	35	2.31			

*Coded 1=least effective to 5= most effective

Table 27. Restoration techniques in rural areas*

Attribute	Area	n	*M*	t	df	p
Improving water quality in rural areas						
Planting and maintaining vegetation along the stream banks	Urban/suburban	58	3.86	-0.422	89	0.674
	Rural	33	3.97			
Stabilizing the stream banks through engineering methods	Urban/suburban	58	2.05	0.287	91	0.775
	Rural	35	1.97			
Increasing regulations on animal grazing practices	Urban/suburban	57	2.96	0.742	89	0.460
	Rural	34	2.76			
Increased regulations on fertilizer application	Urban/suburban	54	3.26	-0.965	86	0.337
	Rural	34	3.56			
Raising awareness about water quality	Urban/suburban	61	3.10	0.357	92	0.722
	Rural	33	3.00			
Decreasing erosion in rural areas						
Planting and maintaining vegetation along the stream banks	Urban/suburban	55	4.35	0.393	87	0.695
	Rural	34	4.26			
Stabilizing the stream banks through engineering methods	Urban/suburban	60	2.90	0.276	91	0.783
	Rural	33	2.82			
Increasing regulations on animal grazing practices	Urban/suburban	57	3.12	1.238	87	0.219
	Rural	32	2.78			
Increasing regulations on fertilizer application	Urban/suburban	56	1.75	-1.939	86	0.056
	Rural	32	2.25			
Raising awareness about water quality	Urban/suburban	59	3.08	0.655	89	0.514
	Rural	32	2.91			

*Coded 1=least effective to 5= most effective

Length of Residence and Aesthetics

$H_0$4: There is no significant difference between respondents' years of residence and their perceptions of aesthetic value and stream environments.

$H_0$4: Accepted

This hypothesis was tested using a one way ANOVA to compare respondents' length of residence within the watershed and their perceptions of the aesthetic qualities of stream environments (Tables 28 and 29). The results of these tests show that there are no statistically significant differences between the groups at the 0.05 level for this category of questions.

Table 28. One way ANOVA comparing years of residence and aesthetic value of stream environments*

Attribute	Residence (years)	n	*M*	df	F	p
...the stream banks are shaded with trees, brush, and other vegetation.	0-5	16	4.00	93	1.291	0.282
	6-15	33	4.12			
	16-29	21	4.24			
	30-65	24	4.50			
...there is woody debris in the channel.	0-5	16	2.75	94	0.369	0.776
	6-15	33	2.82			
	16-29	21	2.86			
	30-65	25	2.56			
...there are large boulders in the stream channel.	0-5	16	3.56	94	0.780	0.508
	6-15	33	3.24			
	16-29	21	3.48			
	30-65	25	3.2			
...the banks are regularly mowed and cleared.	0-5	16	1.81	94	0.559	0.643
	6-15	33	2.06			
	16-29	21	1.81			
	30-65	25	1.80			
...the stream channel is clear of any obstructions.	0-5	16	3.19	93	1.176	0.323
	6-15	32	2.59			
	16-29	21	2.67			
	30-65	25	2.68			
...the water in the stream is clear.	0-5	16	4.13	93	0.849	0.471
	6-15	32	4.06			
	16-29	21	4.43			
	30-65	25	4.32			
...the stream is straight.	0-5	16	1.81	94	1.093	0.356
	6-15	33	1.73			
	16-29	21	1.81			
	30-65	25	2.08			
...the stream is meandering.	0-5	15	3.80	93	0.646	0.588
	6-15	33	4.15			
	16-29	21	4.05			
	30-65	25	4.12			

*Coded 1=strongly disagree to 5=strongly agree

Table 29. One way ANOVA comparing residential area and the effectiveness of restoration techniques at improving the aesthetic value or stream environments*

Attribute	Residence (years)	n	*M*	df	F	p
...planting trees, brush, and other vegetation along stream banks.	0-5	15	4.40	90	0.753	0.524
	6-15	33	4.55			
	16-29	19	4.21			
	30-65	24	4.50			
...adding woody debris in the channel.	0-5	15	2.27	86	1.434	0.239
	6-15	30	2.67			
	16-29	19	2.89			
	30-65	23	2.52			
...adding large boulders in the stream channel.	0-5	15	2.87	89	1.060	0.371
	6-15	32	3.09			
	16-29	19	3.00			
	30-65	24	3.38			
...keeping the banks mowed.	0-5	15	1.73	88	0.604	0.614
	6-15	31	2.03			
	16-29	19	1.74			
	30-65	24	1.96			
...removing obstructions from the channel.	0-5	15	3.00	88	1.204	0.313
	6-15	32	2.91			
	16-29	18	2.44			
	30-65	24	2.63			
...straightening the channel.	0-5	15	1.80	89	0.779	0.509
	6-15	33	1.64			
	16-29	19	1.47			
	30-65	23	1.83			
...adding curves to the river channel.	0-5	15	3.07	89	0.405	0.749
	6-15	32	3.31			
	16-29	19	3.21			
	30-65	24	3.42			

*Coded 1=strongly disagree to 5=strongly agree

Length of Residence and Restoration Goals

$H_0$5: There is no significant difference between respondents' years of residence and their perceptions of restoration planning and goals.

$H_0$5: Accepted

This hypothesis was tested using a one way ANOVA to compare respondents' length of residence within the watershed and their perceptions of restoration planning and goals (Table 30). The results of these tests show that there are no statistically significant differences at the 0.05 level between the groups for this category of questions. .

Table 30. One way ANOVA comparing residential area and restoration goals

Attribute	Residence (years)	n	*M*	df	F	p
In order for stream restoration projects to be successful, they must be fully funded*	0-5	16	3.88	94	0.927	0.431
	6-15	33	3.67			
	16-29	21	4.10			
	30-65	25	3.64			
It is acceptable for streams to be restored for the primary purpose of…[†]						
...improving the way they look.	0-5	15	2.93	90	0.508	0.678
	6-15	33	3.18			
	16-29	19	2.95			
	30-65	24	3.29			
...improving opportunities to interact with streams.	0-5	15	3.93	92	0.160	0.923
	6-15	33	3.97			
	16-29	20	4.10			
	30-65	25	4.04			
...improving biodiversity of aquatic species.	0-5	15	4.33	91	0.955	0.418
	6-15	33	4.45			
	16-29	20	4.15			
	30-65	24	4.54			
...flood control.	0-5	15	4.20	92	0.162	0.921
	6-15	33	4.06			
	16-29	20	4.20			
	30-65	25	4.16			
...protecting human health and safety.	0-5	15	4.33	92	0.877	0.456
	6-15	33	4.58			
	16-29	20	4.45			
	30-65	25	4.24			
In your opinion, how important is it for restoration plans to account for…*						
...community priorities.	0-5	15	3.93	91	0.324	0.808
	6-15	33	3.88			
	16-29	20	4.10			
	30-65	24	4.08			
...opportunities to interact with streams.	0-5	15	4.20	91	1.866	0.141
	6-15	33	4.27			
	16-29	20	4.65			
	30-65	24	4.58			
...the cost effectiveness of the proposed project.	0-5	15	4.40	91	0.355	0.786
	6-15	33	4.21			
	16-29	20	4.45			
	30-65	24	4.29			

*Coded 1=strongly disagree to 5=strongly agree
[†]Coded 1=unimportant to 5=very important

Length of Residence and System Function

H_06: There is no significant difference between respondents' years of residence and rural areas and their perceptions of stream system function.

H_06: Rejected

This hypothesis was tested using a one way ANOVA to compare respondents' length of residence within the watershed and their perceptions of stream system function. Statistically significant differences at the 0.05 level in terms of stream system function and the sources influencing erosion (Table 33) as well as restoration strategies for improving water quality in urban areas (Table 35) were found and the hypothesis was rejected. As the length of residence increased between groups, removing sediment from streams was ranked as more likely to increase erosion (p=0.014) (Table 36). In terms of restoration practices, residents who had lived in the watershed between 0 to 5 years and 30 to 65 years found rain barrels to be more effective (M=3.00 and M=2.92, respectively) than residents who had lived in the watershed between 6 to 15 years and 16 to 29 years (M=2.25 and M=2.05, respectively (Table 30). No statistically significant difference were found when length of residence was compared with the scale of system function (Table 31), perceived function based on photographs (Table 32), or restoration techniques in rural areas (Table 36).

Table 31. One way ANOVA comparing years of residence and scale of stream system function*

Attribute	Residence (years)	n	*M*	df	F	p
To what extent can erosion be decreased by…						
…actions taken throughout the watershed	0-5	16	2.75	92	1.454	0.233
	6-15	32	2.31			
	16-29	21	2.76			
	30-65	24	2.58			
…actions taken along the channel	0-5	16	2.38	91	0.347	0.791
	6-15	33	2.45			
	16-29	19	2.68			
	30-65	24	2.54			
To what extent can water quality be improved by…						
…actions taken throughout the watershed	0-5	16	3.00	94	1.206	0.312
	6-15	33	2.76			
	16-29	21	3.05			
	30-65	25	2.80			
…actions taken along the channel	0-5	16	2.25	91	1.192	0.318
	6-15	31	2.68			
	16-29	20	2.75			
	30-65	25	2.68			

*Coded 1=not at all to 4=completely

Table 32. One way ANOVA comparing years of residence and perceived system function using stream photographs*

Attribute	Residence (years)	n	M	df	F	p
13 Urban area, no woody riparian buffer, banks not exposed						
Susceptible to erosion.	0-5	16	4.06	94	1.320	0.273
	6-15	33	3.97			
	16-29	21	3.81			
	30-65	25	4.32			
Lacking biodiversity.	0-5	16	3.81	93	1.247	0.298
	6-15	33	3.79			
	16-29	20	3.60			
	30-65	25	4.08			
Impaired water quality.	0-5	16	3.63	94	1.325	0.271
	6-15	33	3.88			
	16-29	21	3.48			
	30-65	25	3.80			
Increased chance of flood risk.	0-5	16	3.75	93	1.214	0.309
	6-15	33	3.76			
	16-29	20	3.35			
	30-65	25	3.88			
Unstable.	0-5	16	3.50	93	1.139	0.338
	6-15	32	3.69			
	16-29	21	3.24			
	30-65	25	3.56			
14 Urban area, presence of woody riparian buffer, banks not exposed						
Susceptible to erosion.	0-5	16	2.88	94	0.371	0.774
	6-15	33	2.64			
	16-29	21	2.67			
	30-65	25	2.92			
Lacking biodiversity.	0-5	16	2.00	94	0.924	0.432
	6-15	33	2.30			
	16-29	21	2.33			
	30-65	25	2.20			
Impaired water quality.	0-5	15	2.27	92	0.920	0.435
	6-15	33	2.64			
	16-29	21	2.52			
	30-65	24	2.46			
Increased chance of flood risk.	0-5	16	2.81	94	0.822	0.485
	6-15	33	2.85			
	16-29	21	2.67			
	30-65	25	2.44			
Unstable.	0-5	16	2.38	94	0.364	0.779
	6-15	33	2.52			
	16-29	21	2.38			
	30-65	25	2.28			

*Coded 1=strongly disagree to 5=strongly agree

Table 32 continued. One way ANOVA comparing years of residence and perceived system function using stream photographs*

Attribute	Residence (years)	n	M	df	F	p
15 Urban area, presence of woody riparian buffer, banks are exposed						
Susceptible to erosion.	0-5	16	3.81	94	0.035	0.872
	6-15	33	3.88			
	16-29	21	3.81			
	30-65	25	3.84			
Lacking biodiversity.	0-5	16	3.47	93	0.234	0.991
	6-15	33	3.39			
	16-29	21	3.48			
	30-65	25	3.28			
Impaired water quality.	0-5	16	3.81	94	0.828	0.482
	6-15	33	3.45			
	16-29	21	3.48			
	30-65	25	3.48			
Increased chance of flood risk.	0-5	16	3.81	93	0.316	0.814
	6-15	32	3.72			
	16-29	21	3.67			
	30-65	25	3.56			
Unstable.	0-5	16	3.94	94	0.431	0.731
	6-15	33	3.73			
	16-29	21	3.90			
	30-65	25	3.76			
16 Urban area, lack of woody riparian buffer, banks are exposed						
Susceptible to erosion.	0-5	16	3.25	94	1.062	0.369
	6-15	33	3.36			
	16-29	21	3.57			
	30-65	25	3.12			
Lacking biodiversity.	0-5	16	3.13	92	0.863	0.463
	6-15	33	2.76			
	16-29	21	2.95			
	30-65	23	3.00			
Impaired water quality.	0-5	16	2.88	94	2.266	0.086
	6-15	33	2.48			
	16-29	21	2.86			
	30-65	25	2.76			
Increased chance of flood risk.	0-5	16	2.94	94	1.164	0.328
	6-15	33	3.15			
	16-29	21	3.29			
	30-65	25	3.06			
Unstable.	0-5	16	2.81	93	2.331	0.080
	6-15	33	2.82			
	16-29	20	3.35			
	30-65	25	2.90			

*Coded 1=strongly disagree to 5=strongly agree

Table 32 continued. One way ANOVA comparing years of residence and perceived system function using stream photographs*

Attribute	Residence (years)	n	M	df	F	p
17 Rural area, lack of woody riparian buffer, banks are not exposed						
Susceptible to erosion.	0-5	16	3.56	94	0.647	0.587
	6-15	33	3.79			
	16-29	21	3.52			
	30-65	25	3.52			
Lacking biodiversity.	0-5	16	3.25	93	1.846	0.144
	6-15	33	2.70			
	16-29	21	2.95			
	30-65	24	2.96			
Impaired water quality.	0-5	15	3.13	93	1.048	0.375
	6-15	33	2.85			
	16-29	21	3.00			
	30-65	25	3.16			
Increased chance of flood risk.	0-5	16	3.38	94	0.069	0.976
	6-15	33	3.30			
	16-29	21	3.38			
	30-65	25	3.40			
Unstable.	0-5	16	3.13	94	0.322	0.809
	6-15	33	3.09			
	16-29	21	3.29			
	30-65	25	3.04			
18 Rural area, presence of woody riparian buffer, banks are not exposed						
Susceptible to erosion.	0-5	16	3.13	94	0.989	0.402
	6-15	33	2.70			
	16-29	21	2.95			
	30-65	25	3.04			
Lacking biodiversity.	0-5	16	3.19	94	1.485	0.224
	6-15	33	2.88			
	16-29	21	3.38			
	30-65	25	2.88			
Impaired water quality.	0-5	16	3.38	94	1.181	0.321
	6-15	33	3.33			
	16-29	21	3.76			
	30-65	25	3.32			
Increased chance of flood risk.	0-5	15	3.13	93	0.754	0.523
	6-15	33	2.94			
	16-29	21	2.90			
	30-65	25	3.28			
Unstable.	0-5	16	3.06	94	0.499	0.684
	6-15	33	2.76			
	16-29	21	2.71			
	30-65	25	2.88			

*Coded 1=strongly disagree to 5=strongly agree

Table 32 continued. One way ANOVA comparing years of residence and perceived system function using stream photographs*

Attribute	Residence (years)	n	M	df	F	p
19 Rural area, presence of woody riparian buffer, banks are exposed						
Susceptible to erosion.	0-5	16	3.44	93	0.521	0.669
	6-15	33	3.18			
	16-29	21	3.05			
	30-65	24	3.13			
Lacking biodiversity.	0-5	15	2.20	93	1.957	0.126
	6-15	33	2.36			
	16-29	21	2.62			
	30-65	25	2.68			
Impaired water quality.	0-5	16	2.63	93	0.515	0.673
	6-15	32	2.44			
	16-29	21	2.67			
	30-65	25	2.64			
Increased chance of flood risk.	0-5	16	2.88	94	0.190	0.903
	6-15	33	2.82			
	16-29	21	2.76			
	30-65	25	2.68			
Unstable.	0-5	16	3.00	94	0.824	0.484
	6-15	33	2.64			
	16-29	21	2.86			
	30-65	25	2.68			
20 Rural area, lack of woody riparian buffer, banks are exposed						
Susceptible to erosion.	0-5	16	4.19	92	1.548	0.208
	6-15	31	4.10			
	16-29	21	3.76			
	30-65	25	4.00			
Lacking biodiversity.	0-5	16	3.44	92	0.929	0.430
	6-15	32	3.38			
	16-29	21	3.10			
	30-65	24	3.50			
Impaired water quality.	0-5	16	3.19	93	0.086	0.967
	6-15	32	3.13			
	16-29	21	3.19			
	30-65	25	3.08			
Increased chance of flood risk.	0-5	16	3.75	92	0.883	0.453
	6-15	31	3.61			
	16-29	21	3.48			
	30-65	25	3.88			
Unstable.	0-5	16	3.06	93	0.491	0.690
	6-15	32	3.34			
	16-29	21	3.29			
	30-65	25	3.40			

*Coded 1=strongly disagree to 5=strongly agree

Table 33. Sources influencing water quality and erosion*

Attribute	Residence (years)	n	*M*	df	F	p
Water quality						
Runoff from urban areas	0-5	16	4.31	88	1.100	0.354
	6-15	32	3.72			
	16-29	19	4.00			
	30-65	22	3.91			
Runoff from rural areas	0-5	15	3.13	85	0.654	0.583
	6-15	31	2.61			
	16-29	20	2.85			
	30-65	20	2.65			
Waste water treatment	0-5	16	2.88	93	1.437	0.237
	6-15	33	3.73			
	16-29	21	3.14			
	30-65	24	3.29			
Storm water management practices	0-5	16	2.06	90	1.559	0.205
	6-15	33	2.52			
	16-29	20	2.95			
	30-65	22	2.82			
Lack of vegetation along stream channels	0-5	15	2.80	84	0.668	0.574
	6-15	30	2.60			
	16-29	19	2.21			
	30-65	21	2.76			
Erosion						
Increased precipitation	0-5	15	2.33	88	0.323	0.809
	6-15	32	2.16			
	16-29	21	2.14			
	30-65	21	1.90			
Lack of vegetation along streams	0-5	16	4.56	90	1.760	0.161
	6-15	32	4.03			
	16-29	20	3.95			
	30-65	23	3.78			
Increased sediment from land use practices (construction)	0-5	15	3.60	85	1.551	0.208
	6-15	32	3.53			
	16-29	20	2.85			
	30-65	19	3.11			
Livestock grazing practices	0-5	16	2.88	89	2.451	0.069
	6-15	31	2.81			
	16-29	20	3.30			
	30-65	23	3.65			
Removing sediment from the stream	0-5	15	1.73	92	3.759	0.014
	6-15	33	2.58			
	16-29	21	2.86			
	30-65	24	3.08			

*Coded 1=least likely to 5= most likely

Table 34. Post Hoc Student-Newman-Keuls (Sources influencing water quality and erosion)

Attribute	Activity	n	*1*	*2*
Erosion				
Removing sediment from the stream	0-5	15	1.73	
	6-15	33		2.58
	16-29	21		2.86
	30-65	24		3.08
		(1) Sig. 1.000; (2) Sig 0.393		

Table 35. Restoration techniques in urban areas*

Attribute	Residence (years)	n	M	df	F	p
Improving water quality in urban areas						
Planting and maintaining vegetation along the stream banks	0-5	16	3.50	86	0.558	0.644
	6-15	32	3.72			
	16-29	21	3.76			
	30-65	18	4.00			
Stabilizing the stream banks through engineering methods	0-5	16	2.75	90	0.382	0.766
	6-15	32	2.31			
	16-29	20	2.45			
	30-65	23	2.39			
Raising awareness about water quality	0-5	16	2.50	89	1.074	0.365
	6-15	32	3.19			
	16-29	21	3.29			
	30-65	21	3.10			
Decreasing erosion in urban areas						
Planting and maintaining vegetation along the stream banks	0-5	16	3.44	87	0.915	0.437
	6-15	32	3.97			
	16-29	20	3.95			
	30-65	20	3.95			
Stabilizing the stream banks through engineering methods	0-5	16	2.56	91	0.430	0.732
	6-15	32	2.78			
	16-29	21	2.43			
	30-65	23	2.39			
Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)	0-5	16	3.13	87	0.207	0.891
	6-15	32	2.94			
	16-29	20	2.95			
	30-65	20	3.20			
Increasing sediment and erosion control regulations	0-5	16	3.69	86	0.936	0.427
	6-15	31	3.06			
	16-29	20	3.35			
	30-65	20	3.00			
Raising awareness about water quality	0-5	16	2.19	90	1.096	0.355
	6-15	33	2.27			
	16-29	20	2.40			
	30-65	22	2.86			

*Coded 1=least effective to 5= most effective

Table 36. Restoration techniques in rural areas*

Attribute	Residence (years)	n	M	df	F	p
Improving water quality in rural areas						
Planting and maintaining vegetation along the stream banks	0-5	16	3.88	86	0.171	0.916
	6-15	31	3.81			
	16-29	20	3.75			
	30-65	20	4.00			
Stabilizing the stream banks through engineering methods	0-5	16	1.88	88	0.202	0.895
	6-15	32	2.13			
	16-29	19	2.00			
	30-65	22	2.18			
Increasing regulations on animal grazing practices	0-5	16	2.88	86	0.174	0.914
	6-15	32	2.78			
	16-29	19	3.00			
	30-65	20	3.00			
Increased regulations on fertilizer application	0-5	16	3.69	83	0.614	0.608
	6-15	30	3.13			
	16-29	18	3.56			
	30-65	20	3.35			
Raising awareness about water quality	0-5	16	2.69	89	1.133	0.341
	6-15	31	3.32			
	16-29	20	2.85			
	30-65	23	3.17			
Decreasing erosion in rural areas						
Planting and maintaining vegetation along the stream banks	0-5	16	3.88	86	0.171	0.916
	6-15	31	3.81			
	16-29	20	3.75			
	30-65	20	4.00			
Stabilizing the stream banks through engineering methods	0-5	16	1.88	88	0.202	0.895
	6-15	32	2.13			
	16-29	19	2.00			
	30-65	22	2.18			
Increasing regulations on animal grazing practices	0-5	16	2.88	86	0.174	0.914
	6-15	32	2.78			
	16-29	19	3.00			
	30-65	20	3.00			
Increasing regulations on fertilizer application	0-5	16	3.69	83	0.614	0.608
	6-15	30	3.13			
	16-29	18	3.56			
	30-65	20	3.35			
Raising awareness about water quality	0-5	16	2.69	89	1.133	0.341
	6-15	31	3.32			
	16-29	20	2.85			
	30-65	23	3.17			

*Coded 1=least effective to 5= most effective

Types of Activities and Aesthetics

H_07: There is no significant difference between respondents' types of activities and their perceptions of aesthetic value and stream environments.

H_07: Rejected

This hypothesis was tested using a one way ANOVA to compare respondents' of stream related activity and their perceptions of the aesthetic qualities of stream environments. Statistically significant differences at the 0.05 level in terms of aesthetic qualities of stream environments (Table 37) and the effectiveness of restoration techniques at improving aesthetic value (Table 39) were found and the hypothesis was rejected. The rankings for the aesthetic value of features such as banks shaded with vegetation (p=0.026), the presence of woody debris in the channel (p=0..015), regularly mowed banks (p=0.004), channel clear of any obstructions (p=0.04) and straight channels (p=0.001) were all found to have significant differences between group means (Table 37). The rankings for the effectiveness of restoration techniques at improving the aesthetic quality of streams such as planting riparian vegetation (p=0.005), adding boulders to the stream (0.034), mowing stream banks (p=0.036), removing obstructions from the channel (0.001), and straightening the channel (p=0.001) were also found to have significant differences between group means (Table 39).

Table 37. One way ANOVA comparing level of stream-related activity and aesthetic value of stream environments*

Attribute	Activity	n	*M*	*df*	*F*	*p*
...the stream banks are shaded with trees, brush, and other vegetation.	No activity	17	4.06	104	3.795	0.026
	Recreation only	44	4.05			
	Recreation and Work/Volunteer	44	4.50			
...there is woody debris in the channel.	No activity	17	2.35	105	4.354	0.015
	Recreation only	44	2.59			
	Recreation and Work/Volunteer	45	3.13			
...there are large boulders in the stream channel.	No activity	17	3.41	105	0.197	0.821
	Recreation only	44	3.25			
	Recreation and Work/Volunteer	45	3.27			
...the banks are regularly mowed and cleared.	No activity	17	2.53	105	5.730	0.004
	Recreation only	44	1.86			
	Recreation and Work/Volunteer	45	1.69			
...the stream channel is clear of any obstructions.	No activity	17	3.12	104	3.313	0.040
	Recreation only	43	2.84			
	Recreation and Work/Volunteer	45	2.40			
...the water in the stream is clear.	No activity	17	4.29	104	0.098	0.906
	Recreation only	44	4.20			
	Recreation and Work/Volunteer	44	4.18			
...the stream is straight.	No activity	17	2.24	105	7.059	0.001
	Recreation only	44	1.95			
	Recreation and Work/Volunteer	45	1.56			
...the stream is meandering.	No activity	17	3.94	104	0.947	0.391
	Recreation only	44	3.93			
	Recreation and Work/Volunteer	44	4.18			

*Coded 1=strongly disagree to 5=strongly agree

Table 38. Post Hoc Student-Newman-Keuls (stream-related activity and aesthetic value of stream environments)

Attribute	Activity	n	*1*	*2*
...the stream banks are shaded with trees, brush, and other vegetation.	No activity	17	4.06	
	Recreation only	44	4.05	
	Recreation and Work/Volunteer	44	4.50	
			Sig. 0.098	
...there is woody debris in the channel.	No activity	17	2.35	
	Recreation only	44	2.59	2.59
	Recreation and Work/Volunteer	45		3.13
			(1) Sig. 0.407; (2) Sig. 0.061	
...the banks are regularly mowed and cleared.	No activity	17		2.53
	Recreation only	44	1.86	
	Recreation and Work/Volunteer	45	1.69	
			(1) Sig. 0.450; (2) Sig 1.000	
...the stream channel is clear of any obstructions.	No activity	17		3.12
	Recreation only	43	2.84	2.84
	Recreation and Work/Volunteer	45	2.40	
			(1) Sig. 0.130; (2) sig. 0.330	
...the stream is straight.	No activity	17		2.24
	Recreation only	44		1.95
	Recreation and Work/Volunteer	45	1.56	
			(1) Sig. 1.000; (2) sig. 0.129	

Table 39. One way ANOVA comparing level of stream-related activity and the effectiveness of restoration techniques at improving the aesthetic value or stream environments*

Attribute	Activity	n	M	df	F	p
...planting trees, brush, and other vegetation along stream banks.	No activity	16	4.31	100	5.537	0.005
	Recreation only	42	4.17			
	Recreation and Work/Volunteer	43	4.68			
...adding woody debris in the channel.	No activity	14	2.07	96	2.784	0.067
	Recreation only	42	2.64			
	Recreation and Work/Volunteer	41	2.71			
...adding large boulders in the stream channel.	No activity	15	3.67	99	3.502	0.034
	Recreation only	42	2.95			
	Recreation and Work/Volunteer	43	3.09			
...keeping the banks mowed.	No activity	15	2.20	98	3.448	0.036
	Recreation only	42	2.02			
	Recreation and Work/Volunteer	42	1.62			
...removing obstructions from the channel.	No activity	15	3.47	97	7.630	0.001
	Recreation only	41	2.93			
	Recreation and Work/Volunteer	42	2.36			
...straightening the channel.	No activity	15	2.33	99	7.485	0.001
	Recreation only	42	1.67			
	Recreation and Work/Volunteer	43	1.44			
...adding curves to the river channel.	No activity	15	3.20	99	0.400	0.671
	Recreation only	42	3.21			
	Recreation and Work/Volunteer	43	3.40			

*Coded 1=strongly disagree to 5=strongly agree

Table 40. Post Hoc Student-Newman-Keuls (stream-related activity and the effectiveness of restoration techniques at improving the aesthetic value or stream environments)

Attribute	Activity	n	*1*	*2*
...planting trees, brush, and other vegetation along stream banks.	No activity	16	4.31	4.31
	Recreation only	42	4.17	
	Recreation and Work/Volunteer	43		4.72
(1) Sig. 0.492; (2) Sig. 0.056				
...adding large boulders in the stream channel.	No activity	15		3.67
	Recreation only	42	2.95	
	Recreation and Work/Volunteer	43	3.09	
(2) Sig. 0.572; (2) Sig. 1.000				
...keeping the banks mowed.	No activity	15		2.20
	Recreation only	42	2.02	2.02
	Recreation and Work/Volunteer	42	1.62	
(2) Sig. 0.097; (2) Sig 0.467				
...removing obstructions from the channel.	No activity	15		3.47
	Recreation only	41		2.93
	Recreation and Work/Volunteer	42	2.36	
(2) Sig. 0.100; (2) sig. 0.055				
...straightening the channel.	No activity	15		2.33
	Recreation only	42	1.67	
	Recreation and Work/Volunteer	43	1.44	
(2) Sig. .291; (2) sig. 1.000				

Types of Activities and Restoration Goals

$H_0$8: There is no significant difference between respondents' level of activity and their perceptions of restoration goals.

$H_0$8: Rejected

This hypothesis was tested using a one way ANOVA to compare respondents' of stream related activity and their perceptions of restoration planning and goals. Statistically significant differences at the 0.05 level in terms of acceptable objectives for restoration projects and important considerations during the planning process were found and the hypothesis was rejected. Improving opportunities to interact with streams and the diversity of aquatic species were the two restoration objectives where the group means were found to be statistically significant (p=0.000 and p=0.001, respectively). The ranking for considering opportunities to interact with streams in the restoration planning process was found to be significant (p=0.019) (Table 41).

Table 41. One way ANOVA comparing level of stream-related activity and restoration planning and goals

Attribute	Activity	n	M	df	F	p
In order for stream restoration projects to be successful, they must be fully funded*	No activity	17	3.35	105	1.642	0.199
	Recreation only	44	3.80			
	Recreation and Work/Volunteer	45	3.89			
It is acceptable for streams to be restored for the primary purpose of…[†]						
...improving the way they look.	No activity	17	3.12	100	0.256	0.775
	Recreation only	43	3.02			
	Recreation and Work/Volunteer	41	3.20			
...improving opportunities to interact with streams.	No activity	17	3.35	102	8.680	0.000
	Recreation only	43	4.02			
	Recreation and Work/Volunteer	43	4.23			
...improving biodiversity of aquatic species.	No activity	16	4.00	101	7.358	0.001
	Recreation only	43	4.19			
	Recreation and Work/Volunteer	43	4.70			
...flood control.	No activity	17	4.24	102	0.242	0.785
	Recreation only	43	4.19			
	Recreation and Work/Volunteer	43	4.09			
...protecting human health and safety.	No activity	17	4.29	102	0.371	0.691
	Recreation only	43	4.49			
	Recreation and Work/Volunteer	43	4.42			
In your opinion, how important is it for restoration plans to account for…*						
...community priorities.	No activity	17	3.76	101	1.628	0.201
	Recreation only	42	3.95			
	Recreation and Work/Volunteer	43	4.21			
...opportunities to interact with streams.	No activity	17	4.12	101	4.114	0.019
	Recreation only	42	4.31			
	Recreation and Work/Volunteer	43	4.65			
...the cost effectiveness of the proposed project.	No activity	17	4.18	101	0.374	0.689
	Recreation only	43	4.38			
	Recreation and Work/Volunteer	41	4.28			

*Coded 1=strongly disagree to 5=strongly agree
[†]Coded 1=unimportant to 5=very important

Table 42. Post Hoc Student-Newman-Keuls(stream-related activity and restoration planning and goals)

Attribute	Activity	n	*1*	*2*
...improving opportunities to interact with streams.	No activity	17	3.35	
	Recreation only	43		4.02
	Recreation and Work/Volunteer	43		4.23
(1) Sig. 1.000; (2) Sig. 0.287				
...improving biodiversity of aquatic species.	No activity	15	4.00	
	Recreation only	42	4.19	
	Recreation and Work/Volunteer	43		4.70
(1)Sig. 0.359; (2) Sig. 1.000				
In your opinion, how important is it for restoration plans to account for…*				
...opportunities to interact with streams.	No activity	17	4.12	
	Recreation only	42	4.31	4.31
	Recreation and Work/Volunteer	43		4.65
(1) Sig. 0.097; (2) Sig 0.467				

Types of Activities and System Function

$H_0$9: There is no significant difference between respondents' types of activities and their perceptions of stream system function.

$H_0$9: Rejected

This hypothesis was tested using a one way ANOVA to compare respondents' level of stream related activity and their perceptions of stream system function. Statistically significant differences at the 0.05 level in terms of assessing stream system function through photographs, perceived sources influencing water quality, and restoration strategies in urban and rural areas were found and the hypothesis was rejected. No statistically significant differences were found when activity was compared with the scale of system function (Table 43).

There are significant differences (p=0.002) in the mean rankings of the likelihood for erosion in photograph 14. The rankings for photograph 20 were also significantly different. The susceptibility to erosion (p=0.029), level of biodiversity (p=0.007), chance of flood risk (p=0.036) and stability (p=0.045) were all found to have significant differences between group means (Table 44). The sources perceived as most likely to influence water quality which were found to be statistically significant were waste water treatment (p=0.047) and lack of vegetation along stream channels (p=0.011) (Table 46). The mean rank for stabilizing stream banks was the only urban restoration technique which was found to be significant (p=0.031) (Table 48). The method of raising public awareness about water quality concerns in response to water quality and erosion issues was statistically significant only for for rural areas (p=0.022 and p=0.025) (Table 50).

Table 43. One way ANOVA comparing level of stream-related activity and scale of system function*

Attribute	Activity	n	M	df	F	p
To what extent can erosion be decreased by…						
…actions taken throughout the watershed	No activity	17	2.18	103	2.797	0.066
	Recreation only	44	2.55			
	Recreation and Work/Volunteer	43	2.74			
…actions taken along the channel	No activity	17	2.24	102	1.016	0.366
	Recreation only	43	2.44			
	Recreation and Work/Volunteer	43	2.60			
To what extent can water quality be improved by…						
…actions taken throughout the watershed	No activity	17	2.59	104	2.221	0.114
	Recreation only	44	2.95			
	Recreation and Work/Volunteer	44	2.89			
…actions taken along the channel	No activity	17	2.59	101	0.220	0.803
	Recreation only	44	2.66			
	Recreation and Work/Volunteer	41	2.54			

*Coded 1=not at all to 4=completely

Table 44. One way ANOVA comparing level of stream-related activity and perceived system function using photographs*

Attribute	Activity	n	M	df	F	p
13 Urban area, no woody riparian buffer, banks not exposed						
Susceptible to erosion.	No activity	17	3.94	105	0.357	0.701
	Recreation only	44	3.93			
	Recreation and Work/Volunteer	45	4.09			
Lacking biodiversity.	No activity	17	3.53	104	2.130	0.124
	Recreation only	43	3.79			
	Recreation and Work/Volunteer	45	4.00			
Impaired water quality.	No activity	17	3.76	105	0.360	0.698
	Recreation only	44	3.61			
	Recreation and Work/Volunteer	45	3.73			
Increased chance of flood risk.	No activity	17	3.59	104	1.786	0.173
	Recreation only	44	3.57			
	Recreation and Work/Volunteer	44	3.93			
Unstable.	No activity	17	3.47	104	1.098	0.338
	Recreation only	43	3.35			
	Recreation and Work/Volunteer	45	3.62			

*Coded 1=strongly disagree to 5=strongly agree

Table 44 continued. One way ANOVA comparing level of stream-related activity and perceived system function using photographs*

Attribute	Activity	n	M	df	F	p
14 Urban area, presence of woody riparian buffer, banks not exposed						
Susceptible to erosion.	No activity	17	3.47	105	6.844	0.002
	Recreation only	44	2.98			
	Recreation and Work/Volunteer	45	2.40			
Lacking biodiversity.	No activity	17	2.53	105	2.883	0.061
	Recreation only	44	2.27			
	Recreation and Work/Volunteer	45	2.09			
Impaired water quality.	No activity	17	2.71	103	0.459	0.633
	Recreation only	44	2.50			
	Recreation and Work/Volunteer	43	2.56			
Increased chance of flood risk.	No activity	17	3.00	105	2.530	0.085
	Recreation only	44	2.86			
	Recreation and Work/Volunteer	45	2.47			
Unstable.	No activity	17	2.65	105	1.547	0.218
	Recreation only	44	2.50			
	Recreation and Work/Volunteer	45	2.27			
15 Urban area, presence of woody riparian buffer, banks are exposed						
Susceptible to erosion.	No activity	17	3.71	105	0.579	0.562
	Recreation only	44	3.84			
	Recreation and Work/Volunteer	45	3.96			
Lacking biodiversity.	No activity	17	3.29	104	1.107	0.334
	Recreation only	44	3.59			
	Recreation and Work/Volunteer	45	3.36			
Impaired water quality.	No activity	17	3.47	105	0.210	0.811
	Recreation only	44	3.61			
	Recreation and Work/Volunteer	45	3.56			
Increased chance of flood risk.	No activity	16	3.81	104	0.358	0.700
	Recreation only	44	3.64			
	Recreation and Work/Volunteer	45	3.76			
Unstable.	No activity	17	3.76	105	0.068	0.934
	Recreation only	44	3.82			
	Recreation and Work/Volunteer	45	3.84			

*Coded 1=strongly disagree to 5=strongly agree

Table 44 continued. One way ANOVA comparing level of stream-related activity and perceived system function using photographs*

Attribute	Activity	n	M	df	F	p
16 Urban area, lack of woody riparian buffer, banks are exposed						
Susceptible to erosion.	No activity	17	3.18	105	0.476	0.623
	Recreation only	44	3.41			
	Recreation and Work/Volunteer	45	3.29			
Lacking biodiversity.	No activity	17	3.00	103	0.182	0.834
	Recreation only	44	2.86			
	Recreation and Work/Volunteer	43	2.88			
Impaired water quality.	No activity	17	2.76	105	0.156	0.856
	Recreation only	44	2.70			
	Recreation and Work/Volunteer	45	2.67			
Increased chance of flood risk.	No activity	17	3.12	105	0.124	0.883
	Recreation only	44	3.00			
	Recreation and Work/Volunteer	45	3.07			
Unstable.	No activity	17	2.71	104	0.504	0.606
	Recreation only	43	2.88			
	Recreation and Work/Volunteer	45	2.96			
17 Rural area, lack of woody riparian buffer, banks are not exposed						
Susceptible to erosion.	No activity	17	3.35	105	1.450	0.239
	Recreation only	44	3.75			
	Recreation and Work/Volunteer	45	3.71			
Lacking biodiversity.	No activity	16	2.81	104	0.751	0.475
	Recreation only	44	3.02			
	Recreation and Work/Volunteer	45	2.84			
Impaired water quality.	No activity	17	3.00	104	0.179	0.836
	Recreation only	43	3.05			
	Recreation and Work/Volunteer	45	2.96			
Increased chance of flood risk.	No activity	17	3.41	105	0.716	0.491
	Recreation only	44	3.30			
	Recreation and Work/Volunteer	45	3.51			
Unstable.	No activity	17	2.94	105	1.110	0.334
	Recreation only	44	3.09			
	Recreation and Work/Volunteer	45	3.29			

*Coded 1=strongly disagree to 5=strongly agree

Table 44 continued. One way ANOVA comparing level of stream-related activity and perceived system function using photographs*

Attribute	Activity	n	M	df	F	p
18 Rural area, presence of woody riparian buffer, banks are not exposed						
Susceptible to erosion.	No activity	17	3.12	105	1.036	0.359
	Recreation only	44	2.75			
	Recreation and Work/Volunteer	45	2.93			
Lacking biodiversity.	No activity	17	2.94	105	0.482	0.619
	Recreation only	44	2.98			
	Recreation and Work/Volunteer	45	3.16			
Impaired water quality.	No activity	17	3.53	104	0.121	0.886
	Recreation only	43	3.44			
	Recreation and Work/Volunteer	45	3.40			
Increased chance of flood risk.	No activity	16	3.00	104	0.071	0.931
	Recreation only	44	3.02			
	Recreation and Work/Volunteer	45	3.09			
Unstable.	No activity	17	3.00	105	0.746	0.477
	Recreation only	44	2.68			
	Recreation and Work/Volunteer	45	2.84			
19 Rural area, presence of woody riparian buffer, banks are exposed						
Susceptible to erosion.	No activity	17	3.35	104	0.306	0.737
	Recreation only	44	3.14			
	Recreation and Work/Volunteer	44	3.20			
Lacking biodiversity.	No activity	17	2.41	104	0.157	0.855
	Recreation only	43	2.51			
	Recreation and Work/Volunteer	45	2.44			
Impaired water quality.	No activity	16	2.50	104	0.693	0.502
	Recreation only	44	2.68			
	Recreation and Work/Volunteer	45	2.51			
Increased chance of flood risk.	No activity	17	2.82	105	0.232	0.793
	Recreation only	44	2.80			
	Recreation and Work/Volunteer	45	2.69			
Unstable.	No activity	17	2.76	105	0.116	0.891
	Recreation only	44	2.80			
	Recreation and Work/Volunteer	45	2.71			

*Coded 1=strongly disagree to 5=strongly agree

Table 44 continued. One way ANOVA comparing level of stream-related activity and perceived system function using photographs*

Attribute	Activity	n	M	df	F	p
20 Rural area, lack of woody riparian buffer, banks are exposed						
Susceptible to erosion.	No activity	17	3.65	103	3.673	0.029
	Recreation only	43	3.98			
	Recreation and Work/Volunteer	44	4.16			
Lacking biodiversity.	No activity	17	2.76	103	5.177	0.007
	Recreation only	44	3.43			
	Recreation and Work/Volunteer	43	3.51			
Impaired water quality.	No activity	17	2.94	104	0.645	0.527
	Recreation only	44	3.20			
	Recreation and Work/Volunteer	44	3.14			
Increased chance of flood risk.	No activity	16	3.31	103	3.429	0.036
	Recreation only	44	3.57			
	Recreation and Work/Volunteer	44	3.91			
Unstable.	No activity	17	2.82	104	3.205	0.045
	Recreation only	44	3.34			
	Recreation and Work/Volunteer	44	3.45			

*Coded 1=strongly disagree to 5=strongly agree

Table 45. Post Hoc Student-Newman-Keuls (level of stream-related activity and perceived system function using photographs)

Attribute	Activity	n	*1*	*2*
14 Urban area, presence of woody riparian buffer, banks not exposed				
Susceptible to erosion.	No activity	17		3.47
	Recreation only	44		2.98
	Recreation and Work/Volunteer	45	2.40	
(1) Sig. 1.000; (2) Sig 0.088				
20 Rural area, lack of woody riparian buffer, banks are exposed				
Susceptible to erosion.	No activity	17	3.65	
	Recreation only	43	3.98	3.98
	Recreation and Work/Volunteer	44		4.16
(3) Sig. 0.064; (2) Sig 0.302				
Lacking biodiversity.	No activity	17	2.76	
	Recreation only	44		3.43
	Recreation and Work/Volunteer	43		3.51
(2) Sig. 1.000; (2) Sig. 0.719				
Increased chance of flood risk.	No activity	16	3.31	
	Recreation only	44	3.57	3.57
	Recreation and Work/Volunteer	44		3.91
(3) Sig. 0.268; (2) Sig. 0.140				
Unstable.	No activity	17	2.82	
	Recreation only	44		3.34
	Recreation and Work/Volunteer	44		3.45
(1) Sig. 1.000; (2) Sig. 0.626				

Table 46. One way ANOVA comparing level of stream-related activity and sources influencing water quality and erosion *

Attribute	Activity	n	M	df	F	p
Water quality						
Runoff from urban areas	No activity	17	3.59	98	1.338	0.267
	Recreation only	40	3.95			
	Recreation and Work/Volunteer	42	4.10			
Runoff from rural areas	No activity	16	3.19	96	2.058	0.133
	Recreation only	38	2.87			
	Recreation and Work/Volunteer	43	2.51			
Waste water treatment	No activity	17	4.06	104	3.156	0.047
	Recreation only	43	3.28			
	Recreation and Work/Volunteer	45	3.02			
Storm water management practices	No activity	17	2.53	101	0.204	0.816
	Recreation only	42	2.76			
	Recreation and Work/Volunteer	43	2.63			
Lack of vegetation along stream channels	No activity	16	1.69	95	4.714	0.011
	Recreation only	38	2.50			
	Recreation and Work/Volunteer	42	2.93			
Erosion						
Increased precipitation	No activity	16	2.31	99	0.205	0.815
	Recreation only	40	2.10			
	Recreation and Work/Volunteer	44	2.07			
Lack of vegetation along streams	No activity	16	3.69	101	1.060	0.350
	Recreation only	41	4.02			
	Recreation and Work/Volunteer	45	4.13			
Increased sediment from land use practices (construction)	No activity	16	3.13	94	0.802	0.452
	Recreation only	36	3.28			
	Recreation and Work/Volunteer	43	3.56			
Livestock grazing practices	No activity	17	3.18	100	0.392	0.676
	Recreation only	39	3.23			
	Recreation and Work/Volunteer	45	3.00			
Removing sediment from the stream	No activity	17	2.88	101	2.314	0.104
	Recreation only	41	2.85			
	Recreation and Work/Volunteer	44	2.30			

*Coded 1=most likely to 5= least likely

Table 47. Post Hoc Student-Newman-Keuls (stream-related activity and sources influencing water quality and erosion)

Attribute	Activity	n	*1*	*2*
Water quality				
Waste water treatment	No activity	17	3.02	
	Recreation only	43	3.28	
	Recreation and Work/Volunteer	45		4.06
				(1) Sig. 0.503; (2) Sig 1.000

Table 48. One way ANOVA comparing level of stream-related activity and restoration activities in urban areas*

Attribute	Activity	n	M	df	F	p
Improving water quality in urban areas						
Planting and maintaining vegetation along the stream banks	No activity	15	3.93	96	0.118	0.889
	Recreation only	38	3.76			
	Recreation and Work/Volunteer	44	3.82			
Stabilizing the stream banks through engineering methods	No activity	16	2.56	101	2.298	0.106
	Recreation only	41	2.61			
	Recreation and Work/Volunteer	45	2.04			
Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)	No activity	16	3.00	97	1.475	0.234
	Recreation only	38	3.53			
	Recreation and Work/Volunteer	44	3.64			
Stormwater capture practices (e.g. rain barrels, cisterns, etc.)	No activity	16	2.31	103	0.187	0.830
	Recreation only	43	2.51			
	Recreation and Work/Volunteer	45	2.56			
Raising awareness about water quality	No activity	16	3.19	100	0.066	0.936
	Recreation only	40	3.05			
	Recreation and Work/Volunteer	45	3.04			
Decreasing erosion in urban areas						
Planting and maintaining vegetation along the stream banks	No activity	16	3.63	98	0.365	0.695
	Recreation only	39	3.82			
	Recreation and Work/Volunteer	44	3.91			
Stabilizing the stream banks through engineering methods	No activity	16	3.19	102	3.603	0.031
	Recreation only	42	2.67			
	Recreation and Work/Volunteer	45	2.18			
Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)	No activity	16	3.19	98	0.175	0.840
	Recreation only	39	3.15			
	Recreation and Work/Volunteer	44	3.00			
Increasing sediment and erosion control regulations	No activity	16	2.75	96	1.665	0.195
	Recreation only	38	3.16			
	Recreation and Work/Volunteer	44	3.47			
Raising awareness about water quality	No activity	16	2.41	101	0.032	0.968
	Recreation only	38	2.43			
	Recreation and Work/Volunteer	43	2.49			

*Coded 1= least effective to 5 = most effective

Table 49. Post Hoc Student-Newman-Keuls (stream-related activity and restoration activities in urban areas)

Attribute	Activity	n	*1*	*2*
Decreasing erosion in urban areas				
Stabilizing the stream banks through engineering methods	No activity	16		3.19
	Recreation only	42	2.67	2.67
	Recreation and Work/Volunteer	45	2.18	
		(1) Sig. 0.184; (2) Sig 0.157		

Table 50. One way ANOVA comparing level of stream-related activity and restoration activities in rural areas*

Attribute	Activity	n	M	df	F	p
Improving water quality in rural areas						
Planting and maintaining vegetation along the stream banks	No activity	15	4.07	96	0.883	0.417
	Recreation only	41	3.76			
	Recreation and Work/Volunteer	41	4.07			
Stabilizing the stream banks through engineering methods	No activity	16	2.19	98	1.339	0.267
	Recreation only	40	2.20			
	Recreation and Work/Volunteer	43	1.77			
Increasing regulations on animal grazing practices	No activity	16	2.75	96	0.088	0.916
	Recreation only	39	2.90			
	Recreation and Work/Volunteer	42	2.88			
Increased regulations on fertilizer application	No activity	15	3.73	93	2.551	0.084
	Recreation only	38	3.58			
	Recreation and Work/Volunteer	41	2.98			
Raising awareness about water quality	No activity	15	2.47	99	3.980	0.022
	Recreation only	42	2.93			
	Recreation and Work/Volunteer	43	3.44			
Decreasing erosion in rural areas						
Planting and maintaining vegetation along the stream banks	No activity	16	4.56	95	1.149	0.321
	Recreation only	38	4.16			
	Recreation and Work/Volunteer	42	4.36			
Stabilizing the stream banks through engineering methods	No activity	15	2.80	99	1.162	0.317
	Recreation only	41	3.12			
	Recreation and Work/Volunteer	44	2.68			
Increasing regulations on animal grazing practices	No activity	15	3.07	94	0.360	0.699
	Recreation only	38	3.08			
	Recreation and Work/Volunteer	42	2.86			
Increasing regulations on fertilizer application	No activity	15	2.00	92	1.053	0.353
	Recreation only	37	2.08			
	Recreation and Work/Volunteer	41	1.71			
Raising awareness about water quality	No activity	15	2.60	97	3.853	0.025
	Recreation only	39	2.79			
	Recreation and Work/Volunteer	44	3.41			

*Coded 1= least effective to 5 = most effective

Table 51. Post Hoc Student-Newman-Keuls (stream-related activity and restoration activities in rural areas)

Attribute	Activity	n	*1*	*2*
Decreasing erosion in urban areas				
Raising awareness about water quality	No activity	16	2.47	
	Recreation only	42	2.93	2.93
	Recreation and Work/Volunteer	45		3.44
		(2) Sig. 0.179; (2) Sig 0.136		
Decreasing erosion in rural areas				
Raising awareness about water quality	No activity	15	2.60	
	Recreation only	39	2.79	2.79
	Recreation and Work/Volunteer	44		3.41
		(2) Sig. 0.562; (2) Sig 0.069		

Chapter 7

Discussion

The majority of respondents in the sample were male (57.5%) who identified themselves as living in an urban or suburban area. Most respondents (74.5%) have lived in the watershed for more than 6 years and indicated that they frequently interact with streams in a variety of ways, particularly walking along streams (83.0 of total sample) and floating or canoeing (83.0% of total sample). It is important to reiterate that these characteristics are unique to members of the JRBP; therefore it is not expected or assumed that these traits represent the average resident in the area.

Of the entire sample, only 17 respondents have been members of the JRBP for less than one year. Even though less than half of respondents participate in informational sessions and River Rescue events (43.4% and 45.3%, respectively), the majority of respondents (93.4%) have heard of restoration efforts taking place in the watershed. The mean ranking for the success of projects indicates that they are perceived to be between somewhat and very successful (M = 3.68). It is not clear where respondents are learning about restoration activities in the watershed. All of the respondents who participated in this study receive the JRBP newsletters through email which may explain the awareness in projects. Media coverage of restoration efforts might also play a role since many of the issues within the James River Watershed effect Table Rock Lake, a popular recreation center in the area.

Perceptions of Aesthetics and the James River Watershed

The presence of diverse riparian vegetation and meanders in the stream channel were ranked as the most aesthetically pleasing characteristics of stream channels (*M*=4.24 and 4.04, respectively) as well as most effective at restoring the aesthetic quality of stream environments (*M*=4.43 and 3.29, respectively). Straight channels, mowed banks, and the presence of woody debris were the lowest ranked aesthetic characteristics (*M*=1.83, 1.9, and 2.78, respectively) and were the least likely to restore the aesthetic quality of stream environments (*M*=1.67, 1.88, and 2.59, respectively). These findings are consistent with theories of landscape aesthetics which identify water features and surrounding woody vegetation as being aesthetically pleasing as well as separate studies showing the negative effect of woody debris on aesthetics in the American Midwest (De Vries et al. 2007; Chin et al. 2008). This dichotomy of aesthetic preferences could signal a conflict between what respondents feel streams "should" look like and common stream conditions in the area. Straight channels and mowed banks might be found to be less aesthetically pleasing because they convey evidence of human modification.

Hypotheses one, four, and seven tested the differences between groups of respondents and their perceptions of aesthetics. There were no significant statistical differences between the responses for residents who lived in urban or suburban areas compared with those living in rural areas with one exception. The technique of adding large boulders to the stream channel ($p=0.027$) was found to increase aesthetic quality by rural residents while decreasing aesthetic quality by urban or suburban residents. Boulders are commonly found features in this region and one explanation for the difference in responses could be that urban/suburban residents view the boulder as a potential hazard during flood conditions. There were no significant differences between respondents' years of residence and their perceptions of stream aesthetics. One explanation for the general lack of differences could be that the watershed is not very large and is in an area with relatively low population density so members are being exposed to very similar stream types.

Hypothesis seven, comparing responses based on the level of their stream-centered activities resulted in a number of significant differences. The categories were delineated in to three groups: respondents who do not engage in recreational or work/volunteer activities that involve streams, respondents who only engage in recreational activities that involve streams and respondents who engage in both recreational and work/volunteer activities involving streams. There were significant differences for the aesthetic values of woody riparian vegetation, the presence of woody debris, mowed banks, clear channels, and straight channels. Respondents who engage in both recreation and work/volunteer activities ranked riparian vegetation as having a higher aesthetic value than the other categories of respondents. While the mean for all three groups indicated that mowed stream banks and straight channels had a negative impact on aesthetics, members who do not engage in any stream-related activities were more likely to rank these two characteristics higher.

They also ranked the presence of woody debris as having positive aesthetic value while the respondents from the other two groups ranked it as lowering the aesthetic value. Respondents who do not engage in stream-centered activities ranked channels which were clear of obstructions as having a positive aesthetic value while members of the two other groups ranked the same category as having a negative effect on aesthetic value.

Perceptions of channel obstructions, particularly the presence of woody debris, are consistent with previous findings suggesting the importance of familiarity with perceptions of in-channel woody debris. Both Piegay et al. (2005) and Chin et al. (2008) found that students from a range of areas perceived the presence of wood in channels to be unaesthetic, hazardous and in need of cleaning with the exception of students in from areas with strong histories of forestry (Oregon and Sweden) (Piegay et al. 2005; Chin et al. 2008).

The differences between these groups could indicate that exposure to stream environments influences the aesthetic appraisal of some stream features. This could signal important management implications if it is assumed that the average resident of the James River watershed does not have extensive contact with area streams. Techniques which may have scientific support such as biotechnical bank stabilization techniques such as the placement root wads (Li and Eddelman 2002) may not be well received or supported by residents if they are perceived in a negative light. Additionally, policy makers and managers may feel pressure from the public to achieve a certain look in their restoration practices. Scientists should work directly with policy makers and managers to clarify the relationships between common aesthetic desires and any conflicts with system function. The relationship between aesthetics and geomorphic forms presents a fruitful area for future research.

Perceptions of Restoration Planning and Goals and the James River Watershed

The attitudes regarding restoration projects were all positive. The lowest ranking objective for restoration was aesthetics which was still ranked positively (*M*=3.11).

Projects with objectives related to health and human safety were ranked as the most favorable reason to restore streams (M=4.43) followed by projects aimed at improving biodiversity (M=4.37). This positive response to restoration is likely unique to the study sample since their membership in the JRBP implies that they are invested in the local streams in the first place.

Adequate funding was identified as being critical for the success of restoration projects (M=3.76). In terms of funding sources, the state government was found to be the most responsible for paying for restoration projects (93.4%) while the national government was the least responsible (79.2% of total sample). It is federal agencies, namely the U.S. Army Corps of Engineers and the Environmental Protection Agency which are tasked with enforcing the Clean Water Act and Endangered Species Act and the EPA has funded several of the JRBP's initiatives. The low score may indicate a disconnect between the members understanding of local water resource issues and the role of the federal government. The mean rankings for including community priorities, opportunities for interaction with the stream, and cost effectiveness were all high (M=4.03, 4.42, and 4.30, respectively).

Hypotheses two, five and eight compared the responses for restoration goals and planning between the three group types. There were significant differences in the mean scores for the project objectives of improving opportunities to interact with streams and improving biodiversity of aquatic habitat for residents who live in urban/suburban and rural areas. While rural residents ranked both of these objectives as being acceptable objectives, their rankings were lower than urban/suburban residents. One possible explanation for this could be that restoration projects in rural areas are more likely to impact individual property owners when compared with urban projects which typically occur on city or state owned property. However, while there are a number of explanations for this difference, there is not enough information to definitely identify a specific reason. There were no significant differences found between the respondents' years of residence in the watershed and their responses for the restoration goals and planning question set.

Significant differences were found between the level of respondents' activity and their perceptions of restoration project goals and planning. Improving opportunities to interact with streams and improving biodiversity were ranked positively in all groups but respondents who are exposed to streams through recreation as well as work or volunteer activities rated them much higher. Additionally, they ranked the importance of accounting for opportunities to interact with streams in restoration planning significantly higher than the other two groups. This group is inherently invested in streams through their recreation activities. However, this finding could also indicate that working or volunteering in stream environments develops a sense of stewardship which would explain the importance placed on recreation opportunities. Managers and scientists alike should take advantage of outreach activities as ways to increase support for initiatives.

Perceptions of System Function and the James River Watershed

The mean responses for the questions addressing system function indicate that the respondents' understanding of stream system function is complex and inconsistent at times. As explained earlier, this set of questions is divided into two groups: those specifically addressing water quality and erosion and those questions addressing stream form and function more generally. This section will discuss the results of the mean responses and hypothesis testing for each group of questions separately.

Water quality and erosion

The mean responses for the questions addressing water quality and erosion and their relationship to scale were similar for both actions taken at the watershed as well as actions taken along the channel. However, the mean responses for the perceived sources of erosion and water quality are slightly inconsistent with these answers. Increased precipitation (M=2.12) was ranked as the least likely cause of erosion while lack of vegetation along the stream channel (M=4.02) was ranked as the most likely cause of erosion. Lack of vegetation along the stream channel (M=2.55) was ranked as the least likely of impaired quality while runoff from urban areas (M=3.95) was ranked as the most likely cause. These ranking seem to reflect a general understanding of the differences in watershed and channel scale even though the specific responses, such as the conflicting ranking for riparian vegetation, might be misunderstood.

Planting and maintaining riparian vegetation also received the highest rankings for restoration strategies addressing water quality and decreasing erosion in both urban and rural areas. Stabilizing stream banks was ranked the lowest for improving water quality in both urban and rural areas. Raising awareness about water quality was ranked the lowest for decreasing erosion in urban areas but the second highest for rural areas. This category was actually an error on the survey: it was intended to read "raising awareness about erosion".

Hypothesis three tested whether there were differences in the responses for system function and rural and urban/suburban residents. There were significant differences for both questions related to scale. Residents in urban/suburban areas rated actions taken at the watershed scale higher than rural residents for both decreasing erosion and improving water quality. There were no statistical differences in the responses for the sources contributing to erosion, the sources contributing to water quality or restoration techniques addressing erosion and water quality in rural areas. However, the differences in responses for the effectiveness of stabilizing stream banks and implementing stormwater capture practices were significant. Rural residents ranked bank stabilization higher than urban/suburban residents and urban/suburban residents ranked stormwater capture practices higher. The JRBP sponsors both types of inititatives so it follows that residents would choose the method which is most emphasized for their environment (James River Basin Partnership 2010).

Hypothesis six tested the differences in response based on the length of residence in the watershed. There were no significant differences for the questions related to scale or for the questions related to sources and restoration techniques for addressing erosion and water except for two categories. Residents who have lived in the watershed less than five years ranked removing sediment as having less of an effect on erosion than residents who have been residing in the watershed for longer periods. While sediment dynamics can be very complex, there is a history of gravel mining throughout the area. Removal of sediment from the stream can increase erosion and it is possible that members that have resided in that area recognize this problem. The same group rated stormwater capture practices higher for their effect on improving water quality in urban areas than the other groups. The JRBP currently has a rain barrel program that it is promoting. In addition to the benefits of reducing the demand on the public water supply, the organization is also promoting the barrels as a way to reduce pollution, flooding, and erosion by reducing storm water runoff (James River Basin Partnership 2010).

Hypothesis nine evaluated the differences in responses based on the respondents' activity level. There were no significant differences between the groups for the questions related to scale. Respondents who do not engage in stream-centered activity ranked waste water treatment practices as having a larger effect on water quality than the other two groups. Alternatively they ranked lack of vegetation along the stream bank as less likely to influence water quality when compared with the other groups. There were no significant differences between the groups when comparing the responses for sources of erosion. The responses for restoration techniques yielded only one significant difference. Respondents who do not engage in stream-centered activities ranked stabilizing stream banks as more effective at decreasing erosion in urban areas. The only significant differences for the responses related to restoration in rural areas were for raising public awareness about water quality. Respondents who engage in stream-centered work or volunteer related activities as well as recreational activities rated raising public awareness as a much more effective practice than the other groups.

Again, the group responses for the different levels of activity imply that members who work or volunteer in stream environments have a greater understanding of stream systems as well as a stronger appreciation for outreach techniques. Riparian management is a major initiative being promoted by the JRBP yet those that have limited exposure to stream environments do not seem to recognize the relationship between riparian vegetation and stream health. Support for stream bank stabilization is also contradictory to current trends in restoration techniques. Overall, the responses are fairly consistent with the initiatives set forth by the JBRP yet those that are most engaged with stream environments seem to have a better understanding of stream systems. This suggests that strategies other than educational outreach might be useful for reaching those individuals who do not engage directly with stream environments.

Stream form and function

The other set of questions addressing stream function did so using photographs of local stream conditions as a basis to assess water quality, flood risk, biodiversity, erosion and stability. The photograph in question 13, which shows an urban stream without any riparian vegetation and unexposed banks was ranked as having the lowest biodiversity and water quality, the highest chance of flood risk, and being the most susceptible to erosion. The photograph used in question 15, which shows an urban stream with woody riparian vegetation and exposed banks was ranked as being the most unstable as well as having a high flood risk. Photograph 20, which shows a rural stream with a lack of woody riparian vegetation and exposed banks was also ranked as having low biodiversity. Photograph 14 and photograph 19 ranked as having the highest biodiversity and water quality, the lowest chance of flood risk, the least susceptible to erosion and as being the most stable. Photograph 14 shows an urban stream with woody riparian vegetation and unexposed and photograph 19 shows a rural stream with woody riparian vegetation and exposed banks.

The hypothesis testing comparing rural and urban/suburban residents resulted in very few significant differences. Rural residents ranked photograph 14 as having slightly higher water quality compared to urban/suburban residents. Alternatively, rural residents ranked photograph 18, which depicts a rural stream with woody riparian vegetation and unexposed banks as having lower biodiversity than urban/suburban residents. The hypothesis testing comparing group responses by years of residence did not result in any significant differences.

The hypothesis testing comparing the responses between groups based on activity level resulted in significant differences for all of the characteristics except water quality for question 20. Respondents who do not engage in stream centered activity ranked the scene in that photo, which shows a rural stream with a lack of woody riparian vegetation and exposed banks, as being less susceptible to erosion, as having higher biodiversity a lower chance of flood risk and as being more stable than members of the other two groups. Respondents who engage in work or volunteer activities as well as recreation activities had the highest ratings for those same categories. Additionally, there was a significant difference in the way that erosion was assessed for photograph 14. That scene was rated highest for susceptibility to erosion by respondents who do no interact with stream environment while respondents who engage in work or volunteer activities as well as recreation rated that scene as having a lower susceptibility to erosion.

The results of the photograph set of questions suggests that in general, members recognize the extreme ends of the spectrum in terms of stream health but that subtle differences are overlooked. The responses for photograph 13 are a good example. This photograph was by far the most extreme stream environment in that it had the most obvious modifications. Another example is the differences in responses for water quality across the photographs. The JRBP management plan identifies impaired water quality from both urban and rural runoff as a major issue throughout the watershed. The organization also has a number of programs in place such as grants for riparian easements that are designed to address this issue. Yet the presence of roads and fields immediately adjacent to the stream did not trigger a marked response. The ratings for erosion are more inconsistent. Photographs of streams with exposed and unexposed banks were rated as being susceptible to erosion and it is unclear why.

Conclusion

In many ways, public stakeholders are the lynchpin between the political structures responsible for implementing restoration projects and the science informing them. Restoration is fundamentally motivated by social concerns with the inherent purpose of returning or improving the value of an ecosystem back to society (Gerlak 2008). However, restoration projects rely on social support to be successful. Local restoration projects, which comprise the majority of such efforts, are particularly susceptible to conflicts between policy, science, and the greater public. Each of these parties has a unique understanding of stream systems as well as different values and priorities which are reflected in their contributions to the decision making process. Discord between parties is more likely to be dampened in regional restoration projects because of the bureaucratic structure. However, local watershed partnerships are characterized by closer interactions between stakeholders and scientists.

As this study shows, public support for restoration activities can be positive even though there is a systemic misunderstanding as to the nature of restoration projects and their impacts on stream systems. As stated previously, it is likely that support for restoration and understanding of stream environments is overestimated because of the sample used. However, public members of watershed partnerships such as the JRBP present a unique opportunity for both political and scientific collaboration.

Several management recommendations are supported by this research. The first recommendation is to target outreach activities towards groups engaging in different activity levels. There was a relationship between those who engaged in the highest level of stream activities and improved understanding of stream systems as well as an aesthetic appreciation for more diverse stream channels. This group of individuals can be effectively reached through traditional education strategies. Individuals who do not engage in stream-related activities might be more effectively reached through hands-on approached to environmental education and outreach activities.

The second recommendation is to target the community's sense of place to foster environmental stewardship. Length of residence as well as residence area both had an effect on support for restoration programs and stream system understanding. However, residence area seemed to have a bigger influence on these categories. Acknowledging that rural and urban and suburban residents face different property ownership pressures can be useful in framing and communicating restoration ideas.

The final recommendation concerns research design. The benefits to email surveys are that they are convenient and low cost. However, the response rate for this study could have likely been improved through supplemental mail surveys. Additionally, interview techniques present a promising research technique for eliciting more nuanced data concerning perceptions as well as increased interactions with the watershed partnership or stakeholder group of interest.

Future research should address attitudes towards environmental systems and those elements at the core of restoration activities more explicitly. One fruitful direction would be to explore the expectations the public has regarding restoration projects. The results of this study suggest that there can be conflicts between aesthetic preferences and expectations. Additionally, common educational and outreach activities might not be entirely effective at raising awareness about restoration practices. Studies comparing educational techniques with hands-on experiences would be another approach to uncovering the dynamics between policy, science and the public in the context of restoration. Additional research on the relationships between stakeholders and science is crucial for improving the efficacy of restoration projects, especially as they continue to be used as a primary mitigation technique for fresh water resources.

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Appendix A

PRE-NOTIFICATION EMAIL

Dear Member,

Next week you will be receiving an email with a link to a survey which is intended to measure your perceptions of stream restoration projects. This survey is part of a Master's thesis project taking place at the University of Missouri-Columbia and will help us understand more about public attitudes towards restoration activities in the area. Your responses are greatly appreciated!

Sincerely,

Claire Ruffing, Graduate Student
University of Missouri-Columbia

Appendix B

SURVEY INVITATION EMAIL

Dear James River Basin Partnership Member:

The James River Watershed, located in southwest Missouri, has a history of impairment. Over the past few years, restoration activities have been implemented throughout the watershed in order to improve its conditions. Understanding your perceptions of stream restoration projects is critical in order to improve public support for these projects.

We ask that you complete this short online questionnaire which should take about 15 minutes. All of the information you provide is completely voluntary, confidential, and anonymous. Once our mailing procedures are complete, your name and information will be destroyed. If you have any questions or concerns about the survey, please feel free to phone me at XXX.XXX.XXXX or email me at XXXXX@XXXXXX.

Here is a link to the survey:

Thank you for your participation,

Claire Ruffing, Graduate Student
Dept. of Geography
University of Missouri-Columbia

If you wish to decline participation in this survey, please click the link below.
[RemoveLink]

Appendix C

SURVEY REMINDER EMAIL

Dear James River Basin Partnership Member:

Recently, you were asked to complete a survey about stream restoration projects in the James River Watershed. This information is needed in order to improve public support for these projects. Your response is very important.

We ask that you complete this short online questionnaire which should take about 15 minutes. All of the information you provide is completely voluntary, confidential, and anonymous. Once our mailing procedures are complete, your name and information will be destroyed. If you have any questions or concerns about the survey, please feel free to phone me at XXX.XXX.XXXX or email me at XXXXX@XXXXXX.

Here is a link to the survey:

Thank you for your participation,

Claire Ruffing, Graduate Student
Dept. of Geography
University of Missouri-Columbia

If you wish to decline participation in this survey, please click the link below.
[RemoveLink]

Appendix D

QUESTIONAIRRE

Stream Restoration in the James River Watershed

This survey addresses stream restoration issues in the James River Watershed. Restoration strategies are any activities designed and implemented for the purpose of improving the conditions of a stream. The questions in the survey cover topics ranging from your own experience with stream environments to which restoration practices are acceptable given certain conditions. Thanks in advance for participating!

The first few questions are about restoration projects in the James River Watershed.

1. Have you ever heard of any efforts to improve the conditions of streams within the James River Watershed?

- ◯ Yes
- ◯ No

2. To the best of your knowledge, how successful have these efforts been at improving streams?

- ◯ Unsuccessful
- ◯ Not very successful
- ◯ Somewhat successful
- ◯ Very successful
- ◯ Not sure
- ◯ Have not heard of any restoration efforts

Stream Restoration in the James River Watershed

The next questions are about your involvement with the James River Basin Partnership.

3. Please indicate how long you have been a member of the James River Basin Partnership.

- ◯ Less than 1 year
- ◯ 1 to 5 years
- ◯ 6 to 10 years
- ◯ Over 10 years

4. What types of activites sponsored by the James River Basin Partnership have you attended? Please check all that apply.

- ☐ Membership meetings
- ☐ Informational sessions
- ☐ River Rescue events
- ☐ Watershed Festivals
- ☐ Other

5. If you said "other" for activities, please specify:

Next, a few questions about how you interact with streams. The term "stream environments" is used to refer to any setting where a stream is a major component of the scenery.

6. What are the ways in which you interact with stream environments? Please check all that apply.

- [ ] Fishing
- [ ] Floating or Canoeing
- [ ] Walking along paths near streams
- [ ] Riding bikes along paths near streams
- [ ] Participating in stream cleanup activities
- [ ] Other

7. If you said "other" for the ways you interact with streams, please specify:

8. How often would you estimate that you have interacted with stream environments? Please enter a number value only to indicate the frequency you have been in a stream environment.

In the past year

In the past month

These questions ask your opinion of the conditions necessary for restoration projects to be successful.

9. Please indicate the extent to which you believe the following issue can be addressed.

To what extent can erosion be decreased by...

	not at all	somewhat	greatly	completely	don't know
...actions taken throughout the watershed	◯	◯	◯	◯	◯
...actions taken along the channel	◯	◯	◯	◯	◯

10. Please indicate the extent to which you believe the following issue can be addressed.

To what extent can water quality be improved by...

	not at all	somewhat	greatly	completely	don't know
...actions taken throughout the watershed	◯	◯	◯	◯	◯
...actions taken along the channel	◯	◯	◯	◯	◯

11. Please indicate the extent you agree or disagree with the following statement:

In order for stream restoration projects to be successful, they must be fully funded.

◯ Strongly disagree ◯ Disagree ◯ Neutral ◯ Agree ◯ Strongly agree ◯ Don't know

12. Please indicate the all of the sources you think are responsible for funding restoration projects. Choose all that apply.

- ☐ The local government (e.g., individual towns or counties)
- ☐ The state government (e.g., Missouri Department of Conservation)
- ☐ The national government (e.g., United States Army Corps of Engineers)
- ☐ Donations
- ☐ Private Industries
- ☐ Private Non-profit organizations

This next 8 pages will show pictures of various stream environments and then ask several questions related to the picture.

Please answer the questions as they relate to the accompanying picture.

13. Please indicate the extent to which you agree or disagree with the following statements as they relate to this picture.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
This stream appears to be unstable.	◯	◯	◯	◯	◯
This stream appears to have an increased chance of flood risk.	◯	◯	◯	◯	◯
This stream appears to be susceptible to erosion.	◯	◯	◯	◯	◯
This stream appears to have impaired water quality.	◯	◯	◯	◯	◯
This stream appears to lack biodiversity.	◯	◯	◯	◯	◯

Please answer the questions as they relate to the accompanying picture.

14. Please indicate the extent to which you agree or disagree with the following statements as they relate to this picture.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
This stream appears to have impaired water quality.	◯	◯	◯	◯	◯
This stream appears to have an increased chance of flood risk.	◯	◯	◯	◯	◯
This stream appears to be susceptible to erosion.	◯	◯	◯	◯	◯
This stream appears to lack biodiversity.	◯	◯	◯	◯	◯
This stream appears to be unstable.	◯	◯	◯	◯	◯

Please answer the questions as they relate to the accompanying picture.

15. Please indicate the extent to which you agree or disagree with the following statements as they relate to this picture.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
This stream appears to lack biodiversity.	◯	◯	◯	◯	◯
This stream appears to have impaired water quality.	◯	◯	◯	◯	◯
This stream appears to have an increased chance of flood risk.	◯	◯	◯	◯	◯
This stream appears to be unstable.	◯	◯	◯	◯	◯
This stream appears to be susceptible to erosion.	◯	◯	◯	◯	◯

Please answer the questions as they relate to the accompanying picture.

16. Please indicate the extent to which you agree or disagree with the following statements as they relate to this picture.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
This stream appears to be susceptible to erosion.	◯	◯	◯	◯	◯
This stream appears to be unstable.	◯	◯	◯	◯	◯
This stream appears to lack biodiversity.	◯	◯	◯	◯	◯
This stream appears to have impaired water quality.	◯	◯	◯	◯	◯
This stream appears to have an increased chance of flood risk.	◯	◯	◯	◯	◯

Please answer the questions as they relate to the accompanying picture.

17. Please indicate the extent to which you agree or disagree with the following statements as they relate to this picture.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
This stream appears to be unstable.	◯	◯	◯	◯	◯
This stream appears to have an increased chance of flood risk.	◯	◯	◯	◯	◯
This stream appears to lack biodiversity.	◯	◯	◯	◯	◯
This stream appears to have impaired water quality.	◯	◯	◯	◯	◯
This stream appears to be susceptible to erosion.	◯	◯	◯	◯	◯

Please answer the questions as they relate to the accompanying picture.

18. Please indicate the extent to which you agree or disagree with the following statements as they relate to this picture.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
This stream appears to have an increased chance of flood risk.	◯	◯	◯	◯	◯
This stream appears to be unstable.	◯	◯	◯	◯	◯
This stream appears to be susceptible to erosion.	◯	◯	◯	◯	◯
This stream appears to have impaired water quality.	◯	◯	◯	◯	◯
This stream appears to lack biodiversity.	◯	◯	◯	◯	◯

Please answer the questions as they relate to the accompanying picture.

19. Please indicate the extent to which you agree or disagree with the following statements as they relate to this picture.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
This stream appears to be unstable.	◯	◯	◯	◯	◯
This stream appears to be susceptible to erosion.	◯	◯	◯	◯	◯
This stream appears to have impaired water quality.	◯	◯	◯	◯	◯
This stream appears to lack biodiversity.	◯	◯	◯	◯	◯
This stream appears to have an increased chance of flood risk.	◯	◯	◯	◯	◯

Please answer the questions as they relate to the accompanying picture.

20. Please indicate the extent to which you agree or disagree with the following statements as they relate to this picture.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
This stream appears to be susceptible to erosion.	◯	◯	◯	◯	◯
This stream appears to have an increased chance of flood risk.	◯	◯	◯	◯	◯
This stream appears to have impaired water quality.	◯	◯	◯	◯	◯
This stream appears to lack biodiversity.	◯	◯	◯	◯	◯
This stream appears to be unstable.	◯	◯	◯	◯	◯

This question is about how different conditions influence a streams appearance.

21. Please indicate how much you agree or disagree with the following statements:

A stream looks best when...

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Don't Know
...the water in the stream is clear.	◯	◯	◯	◯	◯	◯
...there are large boulders in the stream channel.	◯	◯	◯	◯	◯	◯
...there is woody debris in the channel.	◯	◯	◯	◯	◯	◯
...the banks are regularly mowed and cleared.	◯	◯	◯	◯	◯	◯
...the stream banks are shaded with trees, brush, and other vegetation.	◯	◯	◯	◯	◯	◯
...the stream channel is clear of any obstructions.	◯	◯	◯	◯	◯	◯
...the stream is meandering.	◯	◯	◯	◯	◯	◯
...the stream is straight.	◯	◯	◯	◯	◯	◯

This question is about the influence of various sources on water quality and erosion.

22. The following list identifies sources that can affect water quality. Please rank the sources in order from those most likely to degrade water quality to those least likely to degrade water quality (most likely = 1, least likely =5).

	1 (most likely)	2	3	4	5 (least likely)
Lack of vegetation along stream channels	○	○	○	○	○
Runoff from rural areas	○	○	○	○	○
Runoff from urban areas	○	○	○	○	○
Storm water management practices	○	○	○	○	○
Waste water treatment	○	○	○	○	○

23. The following list identifies sources that can affect erosion. Please rank the sources in order from those most likely to increase erosion to those least likely to increase erosion (most likely = 1, least likely = 5).

	1 (most likely)	2	3	4	5 (least likely)
Increased precipitation	○	○	○	○	○
Increased sediment from land use practices (construction)	○	○	○	○	○
Lack of vegetation along streams	○	○	○	○	○
Livestock grazing practices	○	○	○	○	○
Removing sediment from the stream	○	○	○	○	○

Now, a few questions related to restoration strategies in urban stream environments. Urban stream environments refer to any stream that drains a town or city.

24. Rank the strategies that are most effective at improving water quality in an urban setting (most effective = 1, least effective = 5).

	1 (most effective)	2	3	4	5 (least effective)
Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)	◯	◯	◯	◯	◯
Planting and maintaining vegetation along the stream banks	◯	◯	◯	◯	◯
Raising awareness about water quality	◯	◯	◯	◯	◯
Stabilizing the stream banks through engineering methods	◯	◯	◯	◯	◯
Stormwater capture practices (e.g. rain barrels, cisterns, etc.)	◯	◯	◯	◯	◯

25. Rank the strategies that are most effective at decreasing erosion in an urban setting (most effective = 1, least effective = 5).

	1 (most effective)	2	3	4	5 (least effective)
Increasing absorbent surfaces throughout the watershed (e.g. rain gardens)	◯	◯	◯	◯	◯
Increasing sediment and erosion control regulations	◯	◯	◯	◯	◯
Planting and maintaining vegetation along the stream banks	◯	◯	◯	◯	◯
Raising awareness about water quality	◯	◯	◯	◯	◯
Stabilizing the stream banks through engineering methods	◯	◯	◯	◯	◯

Next, a few questions related to restoration strategies in rural stream environments. Rural stream environments refer to any stream that drains an area that is mostly forested or agricultural and has a low population density.

26. Rank the strategies that are most effective at improving water quality in an rural setting (most effective = 1, least effective = 5).

	1	2	3	4	5
Increased regulations on fertilizer application	○	○	○	○	○
Increasing regulations on animal grazing practices	○	○	○	○	○
Planting and maintaining vegetation along the stream banks	○	○	○	○	○
Raising awareness about water quality	○	○	○	○	○
Stabilizing the stream banks through engineering methods	○	○	○	○	○

27. Rank the strategies that are most effective at decreasing erosion in an rural setting (most effective = 1, least effective = 5).

	1	2	3	4	5
Increasing regulations on animal grazing practices	○	○	○	○	○
Increasing regulations on fertilizer application	○	○	○	○	○
Planting and maintaining vegetation along the stream banks	○	○	○	○	○
Raising awareness about water quality	○	○	○	○	○
Stabilizing the stream banks through engineering methods	○	○	○	○	○

28. Please indicate how much you agree or disagree with the following statements:

An effective restoration technique for improving how a stream looks is...

	Stongly disagree	Disagree	Neutral	Agree	Strongly agree
...adding curves to the river channel.	◯	◯	◯	◯	◯
...adding woody debris in the channel.	◯	◯	◯	◯	◯
...adding large boulders in the stream channel.	◯	◯	◯	◯	◯
...keeping the banks mowed.	◯	◯	◯	◯	◯
...removing obstructions from the channel.	◯	◯	◯	◯	◯
...planting trees, brush, and other vegetation along stream banks.	◯	◯	◯	◯	◯
...straightening the channel.	◯	◯	◯	◯	◯

These questions are about restoration planning and priorities.

29. Please indicate how much you agree or disagree with the following statements:

In your opinion, how important is it for restoration plans to account for...

	Unimportant	Not very important	Neutral	Somewhat important	Very important
...community priorities.	◯	◯	◯	◯	◯
...opportunities to interact with streams.	◯	◯	◯	◯	◯
...the cost effectiveness of the proposed project.	◯	◯	◯	◯	◯

30. Please indicate how much you agree or disagree with the following statements:

It is acceptable for streams to be restored for the primary purpose of...

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
...improving the way they look.	◯	◯	◯	◯	◯
...improving opportunities to interact with streams.	◯	◯	◯	◯	◯
...improving biodiversity of aquatic species.	◯	◯	◯	◯	◯
...flood control.	◯	◯	◯	◯	◯
...protecting human health and safety.	◯	◯	◯	◯	◯

Finally, a few questions about yourself.

31. Please tell us where, in general, you live in the James River Watershed.

City/Town:

ZIP/Postal Code:

32. How long have you been residing in the James River Watershed area?

Number of Years

33. How would you describe the area where you live?

- Urban/Suburban
- Rural

* 34. Are you age 18 or older?

- Yes
- No

35. What is your gender?

- Male
- Female

36. Do you have any comments that you would like to include?