Compendium of the Results of the 1998 STAR Water and Watershed Grants

Submitted to

U.S. Environmental Protection Agency
Environmental Science Center
701 Mapes Road
Ft. Meade, MD 20755-05350

Submitted by

Perot Systems Government Services
(Formerly Technology Planning & Management Corporation)
Mill Wharf Plaza, Suite 208
Scituate, MA 02066

October 17, 2005

FOREWORD

This report was prepared by Perot Systems Government Services (formerly Technology Planning and Management Corporation) for the U.S. Environmental Protection Agency, National Center for Environmental Research, Science to Achieve Results Program (STAR). PSGS prepared the report under the U.S Environmental Protection Agency National Geospatial Program and Mid-Atlantic Integrated Assessment (MAIA) Pilot Project on a contract with the U.S. Department of Commerce, Commerce Information Technology Solutions (COMMITS) Office Contract No. 50CMAA900065. The mention of trade names, commercial products, or organizations does not imply endorsement by the U.S. Government.

The preferred citation for this report is:

Ghiloni, J.A., Walbeck, E.S., Campbell, J.F. and Holland, M.G. (2004), Compendium of the 1998 STAR Water and Watershed Grants, Prepared by Perot Systems Government Services (formerly Technology Planning and Management Corporation), Scituate, MA, for the U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Research, Science to Achieve Results Program.

TABLE OF CONTENTS

1. INTRODUCTION 1-1

1.1 Background 1-1

1.2 Summary 1-1

2. SUCCESSES, RESULTS, AND FINDINGS 2-1

2.1 STAR Grant R827145: When Do Stakeholder Negotiations Work? A Multiple Lens Analysis of Watershed Restorations in California and Washington. 2-1

2.2 STAR Grant R827146: Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon 2-3

2.3 STAR Grant R827147: Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning 2-5

2.4 STAR Grant R827148: Development of an Integrated Scientific and Technological Framework for Stream Naturalization 2-7

2.5 STAR Grant R827149: Integrating Salmon Habitat Restoration and Flood Hazard Initiatives: Societal/Biophysical Estimators for the Cedar River and Implications for Regional Rivers 2-9

2.6 STAR Grant R827150: Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watersheds: Meeting the Challenge through Science and Policy Analysis 2-12

2.7 STAR Grant R827168: Social Impact Assessment of Human Exposure to Mercury Related to Land Use and Physicochemical Settings in the Alabama-Mobile River System 2-15

2.8 STAR Grant R827169: Whole Watershed Health and Restoration: Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature 2-18

2.9 STAR Grant R827288: Integrating Models of Citizens Perceptions, Metal Contaminants, and Wetlands Restoration in an Urbanizing Watershed 2-20

3. REFERENCES 3-1

APPENDIX A. 1998 WATER AND WATERSHED GRANTS SUMMARY TABLE 4-1

APPENDIX B. 1998 WATER AND WATERSHED GRANTS COMMON THEMES CHART 4-9

APPENDIX C. 1998 WATER AND WATERSHED GRANTS COMMON THEMES 4-10

1. INTRODUCTION

0.0 Background

The Environmental Protection Agency (EPA) STAR (Science to Achieve Results) Grant program funds research in a wide variety of environmental science disciplines. The STAR Water and Watersheds program is unique in that it advocates interdisciplinary research. For the information gathered from this research to be useful to decision-makers, stakeholders, and the science community, it is beneficial to summarize the results into comprehensive and easily accessible documents. In concordance with their commitment to communication, the National Center for Environmental Research (NCER) is supporting a set of documents that highlights research results and successes. The purpose of this project is to develop a compendium of the results of the 1998 STAR Water and Watershed Grants and to produce a document that outlines the results, products produced, and user communities for each of the 1998 Water and Watershed grants.

Because this product will be used directly by EPA, and to avoid any bias associated with the research projects, an extramural contract was chosen as the appropriate vehicle to complete this task.

0.0 Summary

Nine 1998 Water and Watershed EPA STAR Grants were reviewed in detail to determine how results of this research can or are being used by other researchers and decision-makers. Products useful to decision-makers resulting from the nine grants include:

- Nine models
- Several new methods, strategies, processes, and practices
- A series of comprehensive GIS databases and an interactive spatial relational database linked to GIS coverage
- Results of numerous stakeholder surveys and workshops
- Four grant-related websites
- Numerous outreach materials including grade-school and high-school curricula
- Three new institutions including the Watershed Institution, the Wetlands Network, and the New Jersey Council of Watershed Associations.

Each of the nine grants fell into one or more of the following categories or themes (See Appendix B):

- Restoration
- Multi-criteria studies
- Urban
- Economics
- Politics and policies
- Social sciences.

Research results produced two general, yet reoccurring, conclusions:

- Increased urbanization is degrading the surrounding habitat.
- The public at large is in favor of developing ways to protect habitats from further degradation and is willing to contribute funds to support conservation/preservation efforts.

A summary of each of the nine grants (including results, products, user community, and themes) follows. The appendices include: 1) a summary table of each grant, listing grant number, title, principal investigator, common themes, relevance, products, and successes or lessons learned in Appendix A; 2) a table showing which grants had which common themes in Appendix B; and 3) a very brief description of each grant by common theme in Appendix C.

2. SUCCESSES, RESULTS, AND FINDINGS

2.1 STAR Grant R827145

When Do Stakeholder Negotiations Work? A Multiple Lens Analysis of Watershed Restorations in California and Washington

Principal Investigator: Paul Sabatier, University of California – Davis

Successes and Lessons Learned:

- *Trust, funding, and time are the most important factors contributing to stakeholder negotiations and partnership success.*
- *Ideological conflict within a partnership may have a positive impact on agreements, restoration projects, and monitoring (Sabatier et al., 2003).*
- *Partnership success, in terms of reaching agreements and implementing projects, is dependent upon active participation by state and federal agencies (Sabatier et al., 2003).*
- *Stakeholders believe that they have been successful in addressing environmental problems that occur at the local and regional level (Sabatier et al., 2003).*

Products:

- *The Watershed Partnership Program website (http://www.wpp.ucdavis.edu). This site highlights the activities, publication, research materials, and findings of this grant effort.*

User Community:

- *Policy and decision-makers*
- *Social scientists*
- *Agency officials concerned with stakeholder interactions and negotiations*
- *Stakeholders.*

Themes:

Politics and policies, social sciences

Stakeholder-based environmental planning and management has become an increasingly popular strategy nationwide. However, the question remains: how effective is this form of environmental management? Within the context of this research project, investigators have attempted to uncover the factors that impede stakeholder groups and partnerships from effectively resolving environmental management issues. Specifically, researchers sought to:

0. Develop a better understanding of the factors impacting the stakeholder negotiation and plan implementation process.
0. Determine if consensus-based negotiations have been more effective in developing and implementing restoration or management projects.
0. Compare and contrast the strengths and weaknesses of three theoretical frameworks of social interaction and how these frameworks can be used to explain the successes and failures of various stakeholder partnerships. The frameworks included:
    - Elinor Ostrom's Institutional Analysis Framework for management of property resources.
    - Sabatier and Jenkins-Smith's Advocacy Coalition Framework for policy change.
    - Robert Putnam's Framework of social capital.
0. Provide guidance to agency managers on how they can help local partnerships.
0. Identify watershed characteristics that are most amenable to rehabilitation.
(Sabatier et al., 2003)

To achieve these research objectives, researchers developed a study of 50 watershed partnerships within the states of California and Washington. They selected partnerships based on their involvement in the management or restoration of streams, rivers, or watersheds, as well as on the composition of stakeholders in the partnerships. Specifically, each partnership had to involve at least one state or federal agency, a local agency, and two potentially opposing interest groups, such as environmentalists and users (Sabatier et al., 2003). Within each of the 50 partnership study groups, the following tasks were carried out:

0. Three to five key partnership participants were interviewed.
0. Partnership documents, such as meeting minutes and watershed management plans, were reviewed.
0. Questionnaires were provided to members of each participating partnership, as well as to several knowledgeable non-participant observers.
   (Sabatier et al., 2003)

Based on the results of the data collected, researchers made several key findings and successfully achieved most of their research objectives. Investigators discovered that trust, funding, and time are the most important factors driving the success of stakeholder negotiations and plan implementations. In addition, active support and participation from individuals outside of the partnership groups (i.e., state and federal officials) played an important role in the overall success of the partnerships' environmental strategies. Reaching agreements and implementing successful projects also appeared to be highly dependent upon active participation by state and federal agencies (Sabatier et al., 2003). This was due to the critical resources and support (e.g., technical and monetary) that these agencies provided to partnerships (Sabatier et al., 2003). However, investigators found that one of the most fundamental ways in which state and federal agencies can assist partnerships in achieving their management objectives is by showing a vested interest in the partnership, as well as in the needs and concerns of the stakeholders.

Results regarding the strengths and weaknesses of the three theoretical frameworks of social interactions were inconclusive at the time of this publication. Researchers estimated that 30 more partnership case studies needed to be completed to provide adequate insight into this research question. These additional case studies were to be completed in the fall of 2002 as an independent follow-on study.

Many critics of the consensus-based stakeholder approach to decision-making feel that partnerships and stakeholders lack the ability to solve or manage for "real" environmental issues. However, results of this research project suggest that stakeholders do, in fact, devote more effort to serious issues, such as stakeholder conflict resolution, threatened and endangered species, impaired habitats, and poor water quality. Stakeholders in each of the study partnerships firmly believed that they made positive impacts on these issues at both the local and regional scale.

While this research represents one of the most ambitious efforts to compile and analyze detailed case study data across a large number of partnerships (Sabatier et al., 2003), researchers felt it was limited by both geographic representation and time. Research was conducted on the West Coast, and it is unclear how these findings translate to other regions of the country (Sabatier et al., 2003). In addition, researchers felt that data should be measured repeatedly over an extended period of time to more accurately assess the dynamics of partnerships and stakeholder groups.

2.2 STAR Grant R827146

Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon

Principal Investigator: John P. Bolte, Oregon State University

Successes and Lessons Learned:

- *The project documented the landscape change in the Willamette Valley watershed from a historical perspective.*
- *As watershed councils develop, they shift from process concerns to identifying and completing projects (Bolte et al., 2003a).*
- *Water quality is a top priority in the Willamette Basin. Temperature and bacteria are the most important water quality issues for this area.*
- *The water resources agency for the Portland Metro area government, Clean Water Services, has successfully adopted the RESTORE tool developed by this project as their primary tool decision-support tool for watershed analysis and restoration.*
- *The South Santiam Watershed Council, the Long Tom Watershed Council, and the Siuslaw Watershed Council collectively work with landowners and stakeholders in the planning and restoration of various watersheds. Each council actively uses the RESTORE tool as a decision-making support tool.*

Products:

- *The website "Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon" (http://biosys.bre.orst.edu/restore/). From this site, users can access, download, and learn about the RESTORE program.*
- *The RESTORE program.*
- *A species habitat matrix of the Willamette Basin.*
- *A series of GIS datasets of the study watersheds in Willamette Basin.*
- *A technique to enable watershed councils to check how well they represent local interest groups and stakeholders (Bolte et al., 2003a).*

User Community:

- *Policy and decision-makers, including Portland's Clean Water Services*
- *Watershed councils*
- *Stakeholders*

Themes:

Restoration, Economics, Politics and Policies, Multi-criteria Studies, Social Sciences

In order for watershed restoration to be successful, ecological, economic, and social factors influencing the targeted area must be carefully considered. Researchers under this grant sought to better understand these factors and develop a means to integrate them into a tool that could assist stakeholders in identifying restoration priorities and feasible restoration options.

The focus of this research effort was the Willamette Basin in the state of Oregon. The specific objectives of this project included:

- Refining and integrating a set of simplified models relating land use, ecological factors, and watershed hydrology to measure water quality, habitat, and biodiversity endpoints at the watershed level.

- Coordinating with community-based watershed councils to identify and prioritize restoration goals and options for two distinct watersheds within Willamette Basin.
- Characterizing potential restoration strategies from an economic and social perspective.
- Developing a decision-making framework, integrating these models and characterizations, coupled with community-based strategies for generating and prioritizing potential restoration activities.
- Evaluating the impact of using this framework on stakeholder decision-making and transferability of the methodology, using two watersheds within the Willamette Basin.
  (Bolte et al., 2003b)

To accomplish these objectives, researchers developed a decision-making framework and conducted numerous biodiversity, macroinvertebrate, economic, and sociological studies in cooperation with two watershed councils within the Willamette Basin. The decision-making framework they developed consists of three major components:

0. Stakeholder identification and prioritization of restoration alternatives, development of reference condition goals, and identification of criteria for evaluating successful outcomes;
0. A rule-based landscape generator using restoration rules to generate feasible watershed-scale restoration plans using site-level landscape information in conjunction with the goals and objectives developed in the first component;
0. A watershed-scale plan evaluator employing more detailed ecological and socioeconomic models for assessing the plan with respect to water quality, water quantity, social, and economic goals.
   (Bolte et al., 2003b)

Together, these components make up a set of approximately 400 rules that represent the basic state of restoration knowledge within a watershed system. When coupled with various restoration-action scenarios, these rules help identify the restoration alternative that best represents stakeholder objectives. To ensure validity, investigators tested each generated scenario with a WET Hab model, evaluating the restored landscape from a habitat perspective for a wide range of species (Bolte et al., 2003b). They also used the WET Hydro model and WET Temp model to assess hydrology, sediment, and stream temperature of the restored area (Bolte et al., 2003b).

Researchers provided further support for the decision-making framework, using the outcomes of the biodiversity, macroinvertebrate, economic, and sociological research for this study. To evaluate the models, as well as the analysis and mapping conducted of wetland position and location in the two watersheds, researchers developed a draft species-habitat matrix (Bolte et al., 2003a). To provide insight into the biological connectivity between wetlands and adjacent riparian zones, macroinvertebrate studies of various insect groups were conducted in areas that varied by land use type and the degree of passive and active restoration. The economic studies focused on finding the costs of the different restoration activities, including capital and opportunity costs of utilizing land for various restoration scenarios. Lastly, sociological studies focused on the watershed councils and assessed what factors most influenced the councils in their decision-making processes.

The outcome of this research effort was the RESTORE decision support tool. The RESTORE tool utilizes a series of rules that relate specific site-based restoration alternatives, stakeholder goals, and site-specific landscape features to generate feasible restoration plans that reflect stakeholder concerns and evaluate the ecological and economic effectiveness of these strategies (Bolte et al., 2003b). Overall, the RESTORE tool has been well received by stakeholder groups within the Willamette Basin. RESTORE has made it possible for stakeholders and decision-makers to visualize their watershed from numerous perspectives and has allowed them to control and explore the implications that could result from potential restoration plans or management strategies.

2.3 STAR Grant R827147

Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning

Principal Investigator: Marty D. Matlock, Texas A&M University

Successes and Lessons Learned:

- *Stakeholders have increased their knowledge about ecological principles and conditions by participating in the collaborative learning process. As a result, stakeholders have revised their earlier, more negative perceptions of water quality in the San Antonio, Texas, study areas (Matlock et al., 2003a).*
- *The collaborative learning process is now being used as a model throughout the San Antonio area by other watershed groups.*

Products:

- *A Collaborative Learning program for the communities around Salado Creek and Leon Creek in San Antonio*
- *The STELLA Watershed Model (described below)*
- *A simulation model of citizen behavior*
- *Methods for assessing and restoring ecological integrity in watersheds*

User Community:

- *Policy and decision-makers*
- *Stakeholders.*
- *San Antonio River Authority (http://www.sara-tx.org/).*
- *Texas Natural Resource Conservation Commission (www.tnrcc.state.tx.us/).*

Themes:

Multi-criteria studies, politics and policies, restoration, urban, social sciences

Under this grant, investigators successfully developed and tested a method for restoring the ecological integrity of an urban watershed within the areas of Salado Creek and Leon Creek in San Antonio, Texas (Matlock et al., 2003a). To develop this method, researchers utilized the aspects of ecology, engineering, and social sciences to test the following two hypotheses:

0. Risk-based models developed for agricultural nonpoint source pollution management can be applied to urban watersheds.
0. Stakeholders' understanding of a) nonpoint source pollution issues, b) use of systems thinking, c) the ability to use scientific information about Total Maximum Daily Loads, or rehabilitation options, and d) communication competence will increase as a result of the Collaborative Learning (CL) intervention.
   (Matlock et al., 2003a)

Investigations into these hypotheses are what led to the development of an urban watershed model to assist in the evaluation and optimization of ecosystem management strategies (Matlock et al., 2003b). Researchers feel that this risk-based model will be useful in initiating discussions between stakeholders and scientists that will result in informed stakeholder-driven action plans for watershed rehabilitation.

It was vital for investigators to interact with the community surrounding Salado Creek and Leon Creek to meet their research objectives, watershed management needs, and the stakeholders' requirements. To accomplish this, investigators employed a Collaborative Learning (CL) program. This program was composed of stakeholders from varying interest groups and geographic locations, gathered through a series of random surveys and face-to-face meetings. Interest groups were brought together during a series

of workshops and meetings designed to test their knowledge of the issues highlighted above in hypothesis two. The results of these sessions, obtained through a series of pre- and post-test surveys, revealed that through the CL process stakeholders gained valuable knowledge and understanding of nonpoint source (NPS) pollution, Total Maximum Daily Loads (TMDLs), and watershed rehabilitation options. There was clear evidence that participants improved their knowledge about systems thinking in the context of ecosystems management (Matlock et al., 2003a). In addition, CL intervention proved to be successful in changing beliefs about water quality in the study watershed and increased stakeholder confidence in the safety of their water for human and animal uses. Overall, post survey results indicated that significant learning occurred about NPS, ecological principles and dynamics, and rehabilitation principles. Participants also improved communication skills and developed new relationships over the course of the CL process.

The project also assessed changes in ecological services due to urban activities in the San Antonio study areas and overall ecosystem health of the areas. The ecosystem service studies revealed that while the impacts of urban activities and sprawl can cause a decline in ecosystem service values, the negative impacts incurred could be potentially offset by other mitigating changes in land cover (Matlock et al., 2003a). They gained insight into ecosystem health of the study areas by using two integrating ecological indicators, periphyton and bluegill sunfish. The goal for the periphyton analysis was to make periphyton a more effective tool for assessing issues of eutrophication, as well as to illustrate the connectivity between stream riparian habitat and aquatic bioprocesses. Bluegill sunfish were used to measure the effects of in-stream environmental factors on biological health by assessing the physiological health and weight gain of fish over a 14-day study period.

Modeling activities also played a critical role in developing methods for assessing the restoration of ecological integrity to a watershed. Researchers modeled fecal coliform in Salado Creek and riparian zone decline in Leon Creek. They also examined scenarios involving ecosystem restoration using wastewater to restore base-flow in streams to assess the impact on dissolved oxygen concentrations in Leon Creek.

This research culminated in a simulation model of citizen behavior and a STELLA-based watershed model. The simulation model of citizen behavior utilized the outcomes of the research surveys to generate a statistical assessment that could explain citizens' willingness to change attitudes and behaviors towards environmental conditions. In the study location of San Antonio this model indicated that if residents were convinced that changes in their behavior would improve the quality of their watersheds, they would be more likely to make an effort to change (Matlock et al., 2003a). The watershed model using the dynamic computer modeling system STELLA helped facilitate group learning during the CL program by illustrating how changes in watershed condition affect hydrologic response (Matlock et al., 2003a). As a result of this model, stakeholders better understood the connection between various restoration strategies and their potential impacts on the environment. Overall, STELLA helped create more effective communication among citizens, scientists, and policy-makers.

2.4 STAR Grant R827148

Development of an Integrated Scientific and Technological Framework for Stream Naturalization

Principal Investigator: Bruce L. Rhoads, University of Illinois at Urbana

Successes and Lessons Learned:

- *Project efforts increased the aesthetic value of the Chicago River in Northbrook, Illinois.*
- *The abundance of pool habitat available to aquatic species was enhanced greatly by the installation of stream naturalization structures. This resulted in an increase in the number, size, and abundance of fish in the study locations.*

Products:

- *A set of models that can evaluate the geomorphological, ecological, and engineering aspects of stream naturalization efforts and predict the impacts of restoration projects on the environmental quality of stream systems*

User Community:

- *Chicago District Army Corps of Engineer (http://www.lrc.usace.army.mil.)*
- *The Nature Conservancy*
- *Illinois Nature Preserves Commission*

Themes:

Multi-criteria studies, restoration, social sciences, urban

This research focused on the naturalization of human-modified streams. Specific research objectives included:

0. Developing and testing a set of dynamic, processes-based, multi-scale analysis and modeling methods that integrate ecological, geomorphological, and engineering information;
0. Examining the social processes that define the content of a community's environmental vision and that influence the effective incorporation of scientific and technical information in community-based decision-making;
0. Determining the sustainability of specific stream-naturalization strategies that fulfill a community's environmental objectives, given the stream processes and ecological condition of the watershed;
0. Exploring how community-based environmental preferences shape and are shaped by science and technology as preferences emerge and translate into specific environmental designs. (Rhoads et al., 2003)

To achieve these objectives, researchers conducted a series of engineering, geomorphological, habitat, and social analyses in and around three urban streams in the state of Illinois. These areas included portions of the Upper Embarrass River near Urbana-Champaign and two catchments, the northern branch of the Chicago River near Northbrook and Poplar Creek near Elgin. Through the analyses of these locations, researchers sought to develop a method that could better assess and predict the impacts of restoration projects on the environmental quality of stream systems. In addition, researchers hoped to gain insight into how science and technical information is utilized during restoration decision-making processes.

Three years of intensive field investigations were conducted at the Embarrass River location to collect baseline stream data. These data were used to calibrate and verify numerical models used in the development and assessment of naturalization efforts in the two catchments near Chicago. Pool-riffle structures also were constructed and studied at this location. Researchers have used this location to monitor and assess the effectiveness of stream naturalization efforts.

In addition to field investigation data, engineering analyses were conducted in both the study catchments at Northbrook and at Poplar Creek in preparation for experimental naturalization. Studies at the Northbrook site focused on developing and testing a naturalized pool-riffle design for straight urban streams. Experiments at this location were used to compare the project's engineered pool-riffle design to that of natural pool and riffle stream habitats (Rhoads et al., 2003). Using the engineering analyses of the Poplar Creek location, researchers assessed the effectiveness of project efforts to re-meander a channelized section of the creek. They used the MEANDER model to conduct numerical simulation models of four different re-meandering scenarios. The results were provided to the Chicago District Army Corps of Engineers to develop design plans and construction specifications for the actual re-meandering effort in Poplar Creek.

Geomorphological analyses were conducted to further support engineering and design efforts. The geomorphological studies at the Northbrook site included:

- Surveying channel conditions
- Utilizing geomorphological principles to design pool-riffle structures
- Analyzing the engineered pool-riffle structures.

Based on these analyses, researchers discovered that the installation of the engineered pool-riffle structures greatly enhanced the abundance of pool habitat within the study area (Rhoads et al., 2003). At Poplar Creek, the geomorphological analyses assessed the channel positions and overall stream stability. This was achieved through the use of geographic information system (GIS) analysis and historical digital aerial photographs.

Researchers also conducted detailed habitat assessments in the two study catchments. At the Northbrook site, assessment of the impacts of the pool-riffle structures on the fish community showed that prior to the construction of the pool-riffle structures, fish communities at this location were lacking in both abundance and species representation, but that installation of the pool-riffles enhanced the number, size, and diversity of the fish within the area (Rhoads et al., 2003). Fish community assessments were also conducted at Poplar Creek. These investigations focused on gathering general information about the fish community living within this study location.

To better understand the relationship between the local community and its environment, researchers conducted various social analyses. These included open-ended interviews with key stakeholders within the Northbrook community (including town planners, municipal officials, prominent business people, and involved citizens). Findings indicated that the community viewed the portion of the Chicago River running through Northbrook as a focus and center point for a broader restructuring effort within their downtown area (Rhoads et al., 2003). These findings supported the fact that this natural system has been effectively seized by the local political process as a vehicle for improvement of the community's physical environment. Results of the social analyses at Poplar Creek suggested that the provisions of natural resources were not meeting the expectations of local citizens.

The results of this project laid the foundation for an integrated scientific and technical framework for stream naturalization in urban settings (Rhoads et al., 2003). Researchers successfully developed a suite of modeling and analysis tools that can be used to evaluate, in an integrated fashion, geomorpholical, ecological, and engineering aspects of stream naturalization. In addition, social analyses helped researchers establish a better link between the social and scientific elements driving and/or hindering such environmental rehabilitation efforts.

2.5 STAR Grant R827149

Integrating Salmon Habitat Restoration and Flood Hazard Initiatives: Societal/Biophysical Estimators for the Cedar River and Implications for Regional Rivers

Principal Investigator: Robert C. Wissmar, University of Washington – Seattle

Successes and Lessons Learned:

- *In the state of Washington's Cedar River Basin, historical forest harvest and settlement patterns and recent urban expansion in terms of land conversions, flow regulation, flood control and transportation facilities have caused increases in peak flow events, changes in fish and wildlife communities and extensive losses of aquatic and riparian habitats (Wissmar et al., 2004a).*
- *Citizens of the Cedar River Basin have mixed opinions as to why the conditions in the river have declined (Wissmar et al., 2004b).*
- *Cumulative effects from increased urban development may compromise King County's goal to protect and restore aquatic resources in watersheds (Daily 2002, as cited in Wissmar et al., 2004b).*
- *Most citizens of the Cedar River Basin area indicated they would endorse strategies for land purchase, protection, and active restoration to help improve conditions of the river (Wissmar et al., 2004b).*

Products:

- *Social Value Judgments Survey*
- *Historical Events and Cumulative Impacts Survey*
- *Flood Control and Restoration Policies Survey.*
- *Perceptions and Opinions of Restoration and Protection Survey*
- *A new model to understand and assess changes in land-usage*
- *Modified land-cover classification model for impervious areas*
- *Modified spatial hydrology model to study the effects of land-uses on hydrology*
- *A new spatial landscape model to assist in the prioritization on areas for restoration*
- *A new spatial landscape model to assist in the identification of variable riparian protection widths*
- *A new spatial landscape, hydrologic process model to assess channel-floodplain habitat responses*
- *A new multiple logistic regression model to assess the effects of habitat factors on fish*
- *Literature on restoration discourse, watershed hydrology, and fish uses of restored habitats (Wissmar et al., 2004b*)
- *Criteria for cumulative impact assessments (Wissmar et al., 2004b*)
- *Analysis of institutions acting to preserve salmon and their habitats (Wissmar et al., 2004b*)
- *Information on public perceptions towards preservation and restoration management activities within the Cedar River drainage (Wissmar et al., 2004b*).

User Community:

- *Cedar River Council (CRC) (The research team provided periodic reports and conducted presentations.)*
- *Friends of the Cedar River Watershed (The research team published survey results in public newsletters.)*
- *Watershed property owners*
- *Citizen and stakeholders*

Themes:

Restoration, social sciences, urban

Over the years, the Cedar River Drainage Basin in King County, Washington, has experienced both habitat modification and degradation due to urban development and human activities. To improve conditions in the Basin, the Cedar River and Nonpoint Pollution Action Plan was initiated. To evaluate the impacts of this plan, researchers under this grant conducted an interdisciplinary project, designed to

gain insight into the societal and biophysical factors driving public perspectives and habitat management activities. Specifically, researchers sought to:

- Understand how retrospective and contemporary societal, policy and management influenced the river environment;
- Develop the ability to assess and anticipate biophysical and human systems' responses; and
- Examine the effectiveness of policies for restoring damaged river and floodplain ecosystems (Wissmar et al., 2004b).

This research project consisted of two major components, a watershed study component and a human and societal study component.

To gain insight into the major functions of watersheds, as well as channels, fish habitats and riparian-floodplains in the Cedar River Basin, researchers developed and modified a series of land-use, hydrology and habitat models. These models were used to assess the vulnerabilities of target watershed features to changing land cover conditions related to land use changes (Wissmar et al., 2004b). Results showed that historical forest harvest and settlement patterns — along with recent urban expansion in terms of land conversions, flow regulation, flood control and transportation facilities — have caused increases in peak flow events, changes in fish and wildlife communities, and extensive losses of aquatic and riparian habitats (Wissmar et al., 2004a).

To study the human factors and policy management strategies impacting the Cedar River environment, researchers conducted a series of interviews with local citizens, met with politicians and management agencies, established focus groups and developed mail surveys. Research objectives of the human component of this study sought to:

0. Obtain an understanding of the history of societal, institutional and policy forces that have shaped current environmental conditions and concepts of restoration in the lower Cedar River Basin.
0. Understand the influences of social and political institutions on salmon habitat protection and restoration practices in the Cedar River.
   (Wissmar et al., 2004a)

Results of the social surveys indicated that citizens of the Cedar River Basin perceived a decline in river health (Wissmar et al., 2004b). In general, participants had mixed opinions concerning the causes for river decline; however, many indicated they would endorse strategies for land purchase, protection, and active restoration strategies.

Researchers conducted a companion study to the human/societal component of the project to obtain more in-depth societal opinions about environmental degradation in relation to protection and restoration (Wissmar et al., 2004b). As a result, researchers discovered that the cumulative effects from increased urban development may compromise King County's goal to protect and restore aquatic resources in watersheds (Daily 2002, as cited in Wissmar et al., 2004b). Study results also allowed researchers to produce a set of criteria to help evaluate the cumulative impacts of development projects on water and habitat quality (Daily 2002, as cited in Wissmar et al., 2004b). In addition, researchers produced a series of recommendations for regulatory and management changes that could help develop better protection and restoration management practices (Daily 2002, as cited in Wissmar et al., 2004b).

As a conclusion to this grant effort, research linked the outcomes of the biophysical watershed studies to those of the human/societal studies. By linking study outcomes, researchers were able to provide greater insight into the factors most needed to improve the management of interacting human and environmental systems (Wissmar et al., 2004b). The products and literature produced as a result of this effort have the

potential to help improve both decision-making and the environmental planning processes (Wissmar et al., 2004a).

2.6 STAR Grant R827150

Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watersheds: Meeting the Challenge through Science and Policy Analysis

Principal Investigator: Thomas Maddock, University of Arizona

Successes and Lessons Learned:

- *A groundwater pumping experiment conducted in the San Pedro River Basin that simulated the draw-down of water in an aquifer indicated that the draw-down of moisture from the saturated soil above the aquifer continued even after pumping of the underlying aquifer stopped (Maddock et al., 2002). This could be a factor contributing to the degradation of riparian areas.*
- *Residential development in close proximity to riparian areas was found to be desirable from a societal point of view, because it increases the average property value.*
- *Results in the study watersheds suggest that switching to higher value crops could reduce irrigated acreage and the volume of water used in crop production without sacrificing economic returns and farm income (Maddock et al., Undated).*
- *Economic-based research helped identify the importance of riparian habitat to local communities and businesses and highlighted the economic linkages to nature-oriented tourism in rural economics (Maddock et al., Undated).*
- *The average willingness to pay for riparian habitat preservation by residents of the San Pedro and Kerns River watersheds was determined to be approximately $75 per person.*
- *The amount of money tourists and visitors of riparian areas are willing to pay to travel to these types of areas is positively linked to their willingness to pay for its preservation (Maddock et al., Undated)*

Products:

- *RIP-ET software package that estimates the amount of surface water lost through evapotranspiration.*
- *A Riparian Condition Index*
- *Estimates of indirect costs of ecosystems damage*
- *A guide to the law governing water use and riparian ecosystem preservation*
- *Data from the study was contributed to the U.S. Army Corps of Engineers' Hydraulic Engineering Center's River Analysis System (HEC-RAS).*
- *A GIS-base conceptual model of the South Fork Kern Valley*
- *A GIS-based hydrologic model, the Automated Geospatial Watershed Assessment, which analyzes discrete portions of the watershed that can characterize flow plains*
- *A Groundwater Modeling System (GMS) to provide groundwater simulations.*

User Community:

- *Policy and decision-makers of the states of California and Arizona, as well as those of other arid regions throughout the United States*
- *Resource mangers at the community and state level*
- *U.S. Army Corps of Engineers Hydraulic Engineering Center*
- *U.S. Geological Survey*
- *U.S. Environmental Protection Agency*
- *Environmental and watershed groups and associations*
- *Concerned citizens*

Themes:

Economics, politics and policies, restoration, social sciences, urban

The use of fresh water to support agricultural-based economies and expanding urban populations has become a significant cause of environmental degradation in the United States. Specifically, the increased use of groundwater to support agricultural and urban purposes has affected on the ecological integrity of many riparian ecosystems significantly. Riparian areas are considered some of the most productive and biologically diverse habitats. However, due to the effects of human induced hydrologic changes, these ecosystems are experiencing effects ranging in magnitude from complete loss of riparian function to various types of physiological stress (Maddock et al., Undated).

In order to better understand and address the complex relationships between hydrology, riparian communities, urban and agricultural consumption and societal needs, researchers under this grant established four teams (a hydrology team, an ecology team, an economics team, and a law team) to study two endangered arid watersheds in western United States. These watersheds included the South Fork of the Kerns River in California and the Upper Region of the San Pedro River in Arizona. By studying these two watersheds, investigators hoped to develop tools that not only could help prevent further degradation of critical riparian habitats within these two areas, but also help restore the ecosystem health of arid regions as a whole.

To gain a better understanding of the riparian wetland system, members of the hydrology team conducted extensive field studies through the San Pedro and Kerns River watersheds. The main objective was to establish a more accurate understanding of groundwater/surface water interactions and their effect on riparian vegetation (Maddock et al., 2003).

Results of the hydrology team's field investigations were used to develop the Riparian Evapotranspiration Package (RIP-ET). This software package enhances the current U.S. Geological Survey's groundwater-flow model, MODFLOW, and allows researchers to simulate riparian and wetland evapotranspiration (the evaporation of water from both vegetation and the soil). The RIP-ET tool can be used by resource managers to deepen understanding of the link between groundwater and vegetation, helping them to better protect and restore critical riparian ecosystems.

Prior to this study, no standard index existed for assessing the condition of riparian ecosystems (Stromberg, Undated). As a result of the ecology team's efforts, an index of riparian condition has been established. This Riparian Condition Index is based on a series of vegetation traits, also referred to as indicators, which were selected based on the results of field investigations conducted along the San Pedro River. Each indicator is sensitive to stream flow and/or groundwater conditions and represents adequate measures of species composition, species diversity and biomass structure (Stromberg, Undated). Using these indicators, the Index rates riparian condition on a range from 1 to >3 and places the site being assessed into one of four condition classes. Each condition class is associated with a particular vegetation structure, level of functional capacity, and range of hydrologic conditions (Stromberg, Undated). Although based on research conducted in the San Pedro River Watershed, the index can be applied to multiple riparian regions throughout the United States. Researcher feel the Index provides resource managers and decision-makers with a tool that will greatly enhance their ability to analyze the ecological impact of water policy decisions (Maddock et al., Undated).

The economic portion of this study assessed the economic value of riparian habitat within the two study watersheds from the following perspectives:

- The impact of riparian habitation on surrounding property values;

- Local business activity stimulated by the expenditures of visitors (e.g., tourist, naturalists, bird watchers) of local riparian sites;
- Net farm income from agricultural use of water and the likely costs of leasing or purchasing water from farmers to maintain riparian habitat;
- Site visitor's willingness to donate funds to help preserve and maintain the riparian habitat they choose to frequent (Maddock et al., 2003).

Researchers on the economics team believed that obtaining a better understanding of the economic value of riparian habitats from a range of perspectives would give policy makers the ability to more carefully weigh trade-offs among competing water uses. This would aid them in identifying water management strategies that balance competing values (Maddock et al., Undated).

Based on the outcome of their economic analyses, the economics team developed a number of potential policy instruments that can be used to help protect and maintain riparian habitats in the San Pedro and Kerns River watersheds. The instruments included the establishment of a regulatory and a market system that will allow communities to develop a combination of water uses that can satisfy their environmental and economic goals (Maddock et al., Undated).

The legal context of protection and restoration efforts within the San Pedro and Kerns River watersheds was the focus of the law team's research efforts. The emphasis of this team's research was on uncovering and understanding the water and environmental laws most likely to impact future restoration and/or development of the riparian habitats in the study watershed areas (Maddock et al., 2003).

The product of the law team's efforts was the development of a guide of state and federal laws guiding water use and ecosystem protection in San Pedro and Kerns River. According to researchers, this guide offers an excellent starting place for parties interested in investigating the legal context of water management in arid region riparian ecosystems (Maddock et al., Undated). In addition, this guide provides decision-makers with an improved framework for examining alternative land and river management practices. It also allows them to more appropriately assess risks to the overall health of riparian ecosystems associated with human-induced alterations to riparian hydrology and ecology.

As a result of this multi-faceted research effort, resource managers and decision-makers in the San Pedro and Kerns River Watersheds now have an improved understanding of the hydrological, ecological, economic, and legal aspects of groundwater management, as well as riparian protection and restoration. The products developed under this grant will not only enhance the ability of managers to make informed decisions about how to manage water resources and restore degraded riparian ecosystems, but also structure water policy that will better facilitate restoration and the preservation of local economies (Maddock et al., 2003).

2.7 STAR Grant R827168

Social Impact Assessment of Human Exposure to Mercury Related to Land Use and Physicochemical Settings in the Alabama-Mobile River System

Principal Investigator: Jean-Claude J. Bonzongo, University of Florida

Successes and Lessons Learned:

- *Certain human-related activities and natural settings could favor the production of methyl-mercury, regardless of the amount of inorganic mercury initially present in the sediments. (Methyl-mercury is a highly toxic form of mercury that can cause adverse effects to central nervous systems when absorbed into the human bloodstream.)*
- *Biomagnification of methyl-mercury was significant in aquatic organisms; tissue samples taken from largemouth bass contained methyl-mercury levels of more than 1 million times the levels found in the waters in which they reside.*
- *Weathering of rocks and minerals and atmospheric deposition are the primary sources of mercury in the Mobile Alabama River Basin.*
- *Based on calculations, approximately 90 percent of the mercury entering the Mobile Alabama River Basin from the atmosphere is retained within the watershed.*
- *Mercury loading is an important factor governing the production of methyl-mercury (MeHg)*
- *Nutrient additions to sediments had a profound impact on methyl-mercury (MeHg) production from inorganic mercury already present in the sediments.*
- *The highest sediment concentrations of both total mercury and methyl-mercury were found in tributaries draining mining impacted sites, where there were high sulfate concentrations, and in small catchments impacted by agriculture and/or wetlands.*
- *The project team's work with citizens and local officials has helped bridge the gap between research science and policy decisions. (Bonzongo et al., 2003)*
- *Data from this grant and researcher interaction with policy and decision-makers has increased agency focus on mercury contamination in fish and how officials should define risk.*
- *The freshwater findings of this grant were included in the National Mercury Forum.*

Products:

- *Public outreach tools, including the newsletter "Mercury News," a message-oriented telephone hotline "Mercury Project Line," and a project website*
- *A spatial relational database linked to GIS coverage that can be queried to obtain information about mercury contamination levels in the Mobile Alabama River Basin*
- *Regression models to relate land use and in-stream nutrient (nitrogen and phosphorus) concentrations*
- *University of Florida graduate-level course entitled "Environmental Biogeochemisty of Trace Metals."*

User Community:

- *Policy and Decision-Makers, including the Alabama Department of Public Health, Department of Environmental Management, Department of Conservation and Natural Resources, U.S. Fish and Wildlife Service, and the U.S. Geological Survey*
- *Not for Profit Organizations, including the Black Warrior River Keepers, Bama Environmental News, Nature Conservancy, Mobile Bay Watch, Alabama Environmental Council, Alabama Rivers Alliance, McIntosh Environmental Justice Task Force*
- *Stakeholders and citizens, including anglers and angler associations, commercial fishermen, and industry representatives.*
- *Researchers*

Themes:

Politics and Policies, Multi-criteria Studies, Social Sciences

The Mobile Alabama River Basin (MARB), located in the southeastern region of the United States, is one of the largest drainage basins to the Gulf of Mexico and is considered to be the fourth largest river in the United States in terms of stream flow. Over the past decade elevated levels of mercury (Hg) concentrations in the basin have become a concern for both human health and aquatic life. Investigators under this project believe that both natural and human factors have played a role in causing the MARB to become vulnerable to mercury contamination. Specifically investigators hypothesized that:

- Nutrient loading from certain land-use activities and increased sedimentation above water impoundments develop conditions favorable for methyl-mercury (MeHg) production.
- Increased sulfate loading from mining operations result in increased MeHg production.
- Abundant wetlands within the MARB contribute to MeHg loads downstream and in fish.
- Fish tissue levels of MeHg are related to water levels and net rates of MeHg production in sediments (Bonzongo et al., 2003).

To test these hypotheses researchers investigated Hg conditions across 52 sites within the MARB study location. The objectives of these investigations were to:

- Determine the levels and speciation of Hg in different compartments of various aquatic systems.
- Develop a better understanding of the linkage between land-use types or wetlands and the role of microorganisms in the production of MeHg.
- Use geographic information systems (GIS) to spatially represent and arrange data to aid in the prediction of Hg levels in fish.
- Involve and engage key stakeholders and local decision-makers to help increase public understanding and support for Hg policies (Bonzongo et al., 2003).

The first three objectives of this research project where achieved over a two-phase process. Phase 1 consisted of a series of surveys to collect data on Hg distributions throughout the MARB study location. Distribution data were collected for water, sediments, and largemouth bass. The data obtained in these surveys were then combined with National Atmospheric Deposition Program-Mercury Deposition Network data to achieve a general understanding of the overall Hg distributions across the MARB. Results of Total Hg (THg) studies in water and sediments revealed that natural weathering (the breaking down of rocks and/or minerals through natural chemical processes) and atmospheric deposition are the primary sources of Hg found in MARB (Bonzongo et al., 2003). In addition, sediment studies showed that the highest amounts of THg and MeHg were found in tributaries draining from mining sites with high levels of sulfate, in smaller catchments impacted by agriculture and/or wetland runoff, and in creeks retaining fine particles and organic matter (Bonzongo et al., 2003). However, while sulfate levels seemed to correlate to high Hg and MeHg sediment levels, water and fish tissue samples in these areas showed low Hg levels. Experimental results obtained using sediment collected from the MARB suggested that in this aquatic system sulfate may not stimulate MeHg production if iron oxides are present, and that in sediment slurries Hg methylation would proceed under sulfate limited conditions. Thus, the effect of sulfate on MeHg production and propagated effects on Hg bioaccumulation in this dynamic and iron-rich river system are not straightforward.

Phase 1 largemouth bass studies produced results that exactly matched the average Hg concentration level obtained by the U.S. Environmental Protection Agency's National Mercury Survey (Bonzongo et al., 2003). Only 12% of the fish sampled had concentration levels high enough to invoke consumption advisories (Bonzongo et al., 2003). However, despite this low percentage, researchers discovered that biomagnification of MeHg was significant in aquatic organisms. Typical tissue samples taken from

largemouth bass contained MeHg levels of more than 1 million times the levels found in the waters in which they reside (Bonzongo et al., 2003).

Phase 2 of the study assessed the effects of human-imposed and natural conditions on the production and accumulation of MeHg within the MARB. These studies involved both intensive field investigations and laboratory experiments. Laboratory experiments were designed to simulate the various impacts of land-uses on the production of MeHg from natural Hg already existing in basin sediments. Results of these experiments showed that organic matter and nutrient additions of nitrogen and phosphorus had the most pronounced effect on MeHg production in MARB sediments (Bonzongo et al., 2003). Land cover/land use was also found to play a significant role in MeHg production, as it tends to dictate the type and amounts of nutrients impacting a water body.

Using data from both Phase 1 and Phase 2 studies, researchers attempted to determine the correlation between MeHg production rates, basin water levels, and fish tissue contamination. However, due to natural events, such as storms and flooding, that occur throughout the basin and the migratory nature of fish, researchers were unable to develop a successful relational conclusion.

The forth and final objective of this research project was accomplished through the active engagement of citizens and key stakeholders. Throughout the project, citizens and stakeholders were fully informed of the project's goals and objectives. They also were informed of all progress and findings through a series of public meetings and project newsletters, developed and sponsored by the research team. Through this means of interaction, researchers developed several potential watershed management strategies and conducted a social impact assessment of the MARB area. Using the results of the social impact assessment and input from a public policy meeting held to discuss the potential management strategies, investigators discovered that education appears to be a key ingredient in obtaining effective support from the general public for environmental management policy alternatives (Bonzongo et al., 2003).

Through this research, investigators made some important discoveries regarding the potential sources, processes, and impacts of Hg and MeHg in the MARB. This project also illustrated how engaging and educating the public during a research effort can influence both public perception and public policy and can lead to improved environmental management awareness and action.

2.8 STAR Grant R827169

Whole Watershed Health and Restoration: Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature

Principal Investigator: Robert Costanza, University of Maryland

Successes and Lessons Learned:

- *The Hunting Creek Watershed Model (HCM) was successfully applied to Maryland's Hunting Creek and successfully assisted the Commissioners of Calvert County with the environmental evaluation of the effects of proposed land-use rezoning scenarios.*
- *The revised Patuxent Landscape Model (PLM) appears to have become the most advanced model of its type for application at the regional watershed scale (Costanza et al., 2003).*
- *The high data requirements and computational complexities of the PLM have caused the development of additional application versions of this model to be costly and time consuming.*
- *A high school science curriculum was introduced at Calverton School (Huntingtown, MD) to introduce high school students to watershed dynamics and modeling.*

Products:

- *A revised version of the Patuxent Landscape Model (PLM)*
- *The General Human Model (GHM)*
- *Two modified version of the PLM, the Gwynns Falls Landscape Model (GFLM) and the Hunting Creek Watershed Model (HCM), for the assessment of the areas of Gywnns Falls (Baltimore, MD) and Hunting Creek (Calvert County, MD)*
- *The Patuxent Landscape Model Website (http://www.uvm.edu/giee/PLM/)*
- *The Hunting Creek Educational Program (http://www.uvm.edu/giee/AV/EDU/SWN/)*

User Community:

- *Policy and decision-makers: Calvert County, Maryland, Division of Planning and Zoning (www.co.cal.md.us) and Baltimore City, Maryland, Departments of Housing and Community Development, Planning, Public Works, and Recreation and Parks*
- *Educational institutions*
- *Stakeholders: Parks and People, The Foundation for Baltimore Recreation and Parks (www.parksandpeople.org)*
- *This work is in conjunction with and being used by the Baltimore Ecosystem Study, a National Science Foundation Long-Term Ecological Research site www.beslter.org.*

Themes:

Restoration, Politics and Policies, Multi-criteria Studies, Social Sciences

Under a previous U.S. Environmental Protection Agency STAR Grant, a landscape model of Maryland's Patuxent Watershed, the Patuxent Landscape Model (PLM), was developed as a tool to help enhance stakeholder understanding of human influences on the Patuxent watershed system. Under this STAR Grant, researchers further developed the existing PLM to create a new tool that could be utilized for whole watershed analysis and restoration efforts (Costanza et al., Undated). Using the modified PLM, researchers hope to assist policy and decision-makers in the areas of Gwynns Falls and Hunting Creek, Maryland, with the selection and implementation of restoration and planning policies that will better balance human land-use needs with ecosystem health and function.

Two software packages developed by the research team during a previous effort, the Spatial Modeling Environment (SME) and the Library of Hydro-Ecological Modules (LHEM), have been used to redesign the PLM with capabilities that allow the model to simulate aspects of hydrology, nutrients, plants, animal populations, and human economic systems, as well as perform analyses of various land-use change

scenarios. One unique aspect of the PLM is that both the ecological and economic components of the model have been linked. By linking these components, the model can integrate the current understanding of ecological and economic processes at a site and/or landscape scale, as well as generate estimates of the effects of various land-use or management strategy changes (Costanza et al., 2003). The model also has the ability to highlight areas where information is lacking and where further research should be targeted (Costanza et al., 2003).

To better understand the interactions of humans in the watershed system, researchers developed a General Human Model (GHM) component to be integrated into the revised PLM. This GHM component has the ability to recognize and simulate the four different stocks of human wealth (built capital, human capital, natural capital, and social capital) that contribute to a community's and/or individual's wellbeing (Costanza et al., 2003). This modeling component of the PLM has proven important in communicating with stakeholders and has helped researchers assist stakeholders with establishing environmental priorities.

Once modified, the PLM data components were adjusted for application at the two study locations, Gwynns Falls and Hunting Creek. In order to meet stakeholder needs at these two study sites, workshops were held to determine the most appropriate uses for these models (Costanza et al., 2003). The two new PLM applications that were created during this effort are called the Gwynns Falls Landscape Model (GFLM) and the Hunting Creek Watershed Model (HCM).

In collaboration with Maryland's Calvert County Planning Commission, a case study of the HCM was conducted at Hunting Creek to assess the environmental effects of various land-use rezoning scenarios. Using the HCM, planners and decision-makers were able to see how the different densities of dwelling units provisioned under their new alternative zoning plans could potentially result in changes in the nutrient concentrations at Hunting Creek (Costanza et al., 2003; USEPA, 2002). In addition, the HCM also was used to develop a high school education program focused on landscape ecology and watershed dynamics. Under this school program, students take an active role in the collection and monitoring of water-quality and land-use data. This data is then applied to the HCM to help them understand the link between land-use and water quality.

The models modified and produced under this research grant have provided stakeholders and decision-makers with valuable tools for understanding the dynamics of watershed systems. Using these tools as part of their decision-making process, planners and managers can develop land-use strategies that allow for better protection of watershed health.

2.9 STAR Grant R827288

Integrating Models of Citizens' Perceptions, Metal Contaminants, and Wetlands Restoration in an Urbanizing Watershed

Principal Investigator: Robert K. Tucker, Stony Brook-Millstone Watershed Association

Successes and Lessons Learned:

- *It was initially discovered that local and county officials felt they had little responsibility for wetlands protection.*
- *Many citizens and public officials are aware of the importance of wetland and watershed health and are concerned for the protection and wellbeing of these resources.*
- *The Stony Brook-Millstone Watershed Association has been awarded the Dr. Ruth Patrick Excellence in Environmental Education Award because of the environmental and outreach programs developed as part of this research effort.*
- *The characterization of the sub-watersheds of Beden Brook and Rocky Brook has provided citizens and local officials with valuable information on the impacts of wetland development and wetland loss.*
- *This research has demonstrated that much can be done at the local level to protect wetlands; however, if actions are to be successful, citizens and local officials must be educated about the resource and the ways to protect it.*
- *On January 29 -30, 2001 a Land Use Planning and Policy Workshop was held at Princeton University for municipal officials and planners. More than 280 attended this workshop.*
- *Data from this research have assisted in the revision of the New Jersey Freshwater Wetlands Protection Act rules (Tucker et al., 2004).*
- *Citizens in the Montgomery Township were able to utilize the data from this research grant to persuade their planning commission to require a reevaluation of a major roadway extension through a wetland of exceptional quality and home to several threatened and endangered species (Tucker et al., 2004).*

Products:

- *The Watershed Institute (http://www.thewatershedinstitute.org/)*
- *The Natural Lands Network (http://www.thewatershed.org/WSM/nln.html)*
- *The Wetlands Primer, a web-based educational resource*
- *The New Jersey Council of Watershed Associations (http://www.thewatershed.org/)*
- *High school level environmental science curriculum*

User Community:

- *Policy and decision-makers at both the state and local levels.*
  Citizens in the Montgomery Township
- *Educational Institutions.*
- *Environmentalists engaged in wetland protection and restoration.*
- *New Jersey Department of Environmental Protection.*
  -This department has recently adopted regulations requiring extensive riparian buffers to be established and maintained in New Jersey. This regulation is considered to be one of the most stringent in the nation. Researchers believe that the information from this grant effort has contributed to these improved regulatory actions.

Themes:

Multi-criteria studies, politics and policies, social sciences

The goal of the research conducted under this grant and its role in overall watershed health was to educate the public and increase local understanding of the importance of wetlands. To accomplish this,

researchers conducted a series of ecological, chemical, and sociological studies in New Jersey's Stony Brook-Millstone watershed.

The focus areas for this study were two sub-watersheds within the Stony Brook-Millstone watershed, Beden Brook and Rocky Brook. With assistance from the Stony Brook-Millstone Watershed Association (SBMWA), data and information were collected on the following:

- Soil types
- Geology
- Land-use change
- Water quality
- Rare and/or endangered species
- Wetland plants
- Pollution impacts
- Critical habitats
- Population change

Based on the data collected, it was discovered that in Beden Brook increased urbanization has degraded the surrounding habitat, and the sub-watershed no longer supports the breadth and diversity of aquatic life representative of a healthy stream ecosystem (Tucker et al., 2004). Researchers found the Rocky Brook sub-watershed to be experiencing similar development pressure. Biological and chemical tests of this sub-watershed revealed that water quality has become moderately impaired due to nonpoint source pollution (Tucker et al., 2004).

Several laboratory experiments were conducted to gain better insight into the role of wetland vegetation and sediments in the removal of potentially toxic metal contaminants from the water column. Using the results of these laboratory tests, a mathematical simulation model was developed to help assess the dynamics of trace metals in wetland sediments and their influences on water quality. This is a tool that can be used by decision-makers to assess strategies for managing point and nonpoint source pollution.

An intensive social science study was conducted in the Stony Brook-Millstone watershed to identify the beliefs and attitudes of local citizens and public officials regarding the role of wetlands in watershed health and their views on the need to protect this ecological resource. Studies included a random survey of citizens and local officials in the 28 townships surrounding the watershed. Results from this survey found that two-thirds of local officials were aware of the importance of wetlands and wetland processes. The public was found to be slightly less aware of the importance, but they still viewed the existence of wetlands as important. When asked in the survey their stand on developing and/or preserving wetlands, more than 80 percent of both groups chose preservation (Tucker et al., 2004).

In order to better inform the public and gain additional support from policy and decision-makers, researchers in partnership with the SBMWA launched numerous education and outreach efforts. Data and information regarding this research effort were included in the SBMWA's quarterly newsletter, *The Wellspring*. The Natural Lands Network (NLN) was founded as the networking, educational, and advocacy branch of the SBMWA. The NLN was used to share results of this project, assist in the education of municipal officials and local residents, and help citizens with environmental and land-use decisions (Tucker et al., 2004). Web-based educational materials, including a Wetlands Primer, also have been made available to the public. The Wetlands Primer contains educational information, such as relevant watershed and wetland definitions, plant and animal information, and interactive GIS maps that contain information regarding land use and land-use change, population and population change, and protected open space (Tucker et al., 2004). In addition, a full high school level environmental science

curriculum has been created that uses school sites as laboratories to engage, educate, and activate students to realize their interdependent relationship with the environment (Tucker et al., 2004).

Due to this STAR Grant effort, the awareness of local citizens and public officials about the importance of watersheds and wetland preservation has been greatly enhanced. As a result of this project, two organizations, The Watershed Institute and the New Jersey Council of Watershed Associations, have been established to support watershed protection and issues of environmental concern. Already this research team and its partners have been able to cause the reevaluation of various land-development projects and have played an important role in the revision of the New Jersey Freshwater Wetlands Protection Act rules.

3. REFERENCES

STAR GRANT 82-7145

Sabatier, P., Quinn, J., Pelkey, N. and Leach, W. (2003). "Final Report: When Do Stakeholder Negotiations Work? A Multiple Lens Analysis of Watershed Restorations in California and Washington," U.S. Environmental Protection Agency, National Center for Environmental Research, September 2003 (September 9, 2003: *http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/838/report/F*).

STAR GRANT 82-7146

Bolt, J.P., Santelmann, M., Jepson, P.C., Smith, C., and Li, J.L. (2003a). "1999 Progress Report: Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon," U.S. Environmental Protection Agency, National Center for Environmental Research, September 9, 2003: (*http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/1010/report/1999*).

Bolt, J.P., Santelmann, M., Jepson, P.C., Smith, C., and Li, J.L. (2003b). "Final Report: Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon," U.S. Environmental Protection Agency, National Center for Environmental Research, December 17, 2003: *http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/1010/report/F*).

STAR GRANT 82-7147

Samuelson, C.D., Matlock, M.D., Peterson, T.R, Kenimer, A.L., Whitten, G.D. and Neill, W.H., (2003a). "Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning," Final Report Executive Summary, Texas A&M University, College Station, TX, June 2003.

Matlock, M.D., Samuelson, C.D., Neill, W.H., Peterson, T.R., Kenimer, A.L. and Whitten, G.D. (2003b). "Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning," U.S. Environmental Protection Agency, National Center for Environmental Research, September 2003 (September 10, 2003: *http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/1011/report/0*).

STAR GRANT 82-7148

Rhoads, B.L., Herricks, E.E., Wilson, D. and Garcia, M. (2003). "Final Report: Development of an Integrated Scientific and Technological Framework for Stream Naturalization," U.S. Environmental Protection Agency, National Center for Environmental Research, September 2003 (September 10, 2003: *http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/1012/report/F*).

STAR GRANT 82-57149

Wissmar, R.C., Timm, R.K., Leschine, T.M., Montgomery, M. and Flulharty (2004a). "Effects of Societal and Biophysical Factors on River Ecology and Habitat Management: Cedar River Drainage, Washington,

Part I: Summary Report," U.S. Environmental Protection Agency, National Center for Environmental Research, April 2004.

Wissmar, R.C., Timm, R.K., Leschine, T.M., Montgomery, M. and Flulharty (2004b). "Effects of Societal and Biophysical Factors on River Ecology and Habitat Management: Cedar River Drainage, Washington, Part II: Final Technical Report," U.S. Environmental Protection Agency, National Center for Environmental Research, April 2004.

STAR GRANT 82-7150

Maddock, T. III, Biard, K., Baker, V., Colby, B. Glennon, R. and Stromberg, J. (Undated). "Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watershed: Meeting the Challenges Through Science and Policy Analysis," Executive Summary Report, University of Arizona, Undated.

Maddock, T. III, Biard, K., Baker, V., Colby, B. Glennon, R. and Stromberg, J. (2002). "Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watershed: Meeting the Challenges Through Science and Policy Analysis," Annual Summary Report to the U.S. Environmental Protection Agency, University of Arizona , May 2002.

Maddock, T. III, Biard, K., Baker, V., Colby, B. Glennon, R. and Stromberg, J. (Undated). "Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watershed: Meeting the Challenges Through Science and Policy Analysis," Final Report Executive to the U.S. Environmental Protection Agency, University of Arizona, January 2003.

Stromberg, J.C., Lite, S., Bagstad, K., Johnson, H., Tiller, R. and Williams, K. (Undated). "Riparian Vegetation Water Needs: Stressor-Response Model for Assessing Riparian Ecosystem Condition, Case Study of the San Pedro River, Arizona, USA," University of Arizona, Undated.

STAR GRANT 82-7168

Bonzongo, J-C.J., Roden, E.E., Lyons, W.B., Ward, M.G., Chaubey, I. and Bryan C.H. (2003). "Final Report: Social Impact Assessment of Human Exposure to Mercury Related to Land Use and Physicochemical Settings in the Alabama-Mobile River System," U.S. Environmental Protection Agency, National Center for Environmental Research, September 2003 (September 10, 2003: *http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/589/report/F*).

STAR GRANT 82-7169

USEPA (2002). "Calvert County, Maryland's Success in Controlling Sprawl 2002", EPA/903/F-02/004, U.S. Environmental Protection Agency, Region 3, Philadelphia, PA.

Costanza, R., Boumans, R., Maxwell, T., Villa, F., Vionov, A. and Wainger, L. (2003). "Whole Watershed Health and Restoration: Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature," Final Report Executive Summary, University of Maryland, College Park, MD, June 2003.

Costanza, R., Vionov, A., Boumans, R., Maxwell, T., Villa, F., Voinov and Farley, J. (Undated). "Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature," University of Maryland, Undated.

STAR GRANT 82-7288

Tucker, R.K., PFlugh, K.K., Jaffe, P.R., Johnson, B.B. and Hawkins, G.S., Choi, J.H., MacKay, N., Yergeau, S., Hajdusek, J. Altomari, C., Sankalia, P. and Rowan A. (2004). " Final Report: Integrating Models of Citizens' Perceptions, Metal Contaminants, and Wetlands Restoration in an Urbanizing Watershed," U.S. Environmental Protection Agency, National Center for Environmental Research, January 7, 2004: *http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/585/report/F*).

APPENDICES

APPENDIX A 1998 WATER AND WATERSHED GRANTS SUMMARY TABLE

Grant Numbers	Grant Title	Principal Investigator	Common Themes	Relevance	Products	Successes/ Lessons Learned
-R827**145**	When Do Stakeholder Negotiations Work? A Multiple Lens Analysis of Watershed Restorations in California and Washington.	Sabatier, P. – University of California – Davis	• Politics and Policies • Social Sciences	• Investigated the effectiveness of stakeholder-driven environmental action plans.	• The Watershed Partnership Program Website (http://www.wpp.ucdavis.edu) . This site highlights the activities, publication, research materials, and findings of this grant effort.	• Trust, funding, and time are the most important factors contributing to stakeholder negotiations and partnership success. • Ideological conflict within a partnership may have a positive impact on agreements, restoration projects, and monitoring (Sabatier et al., 2003). • Partnership success in terms of reaching agreements and implementing projects is dependent upon active participation by state and federal agencies (Sabatier et al., 2003). • Stakeholders believe that they have been successful in addressing environmental problems that occur at the local and regional level (Sabatier et al., 2003).

Grant Numbers	Grant Title	Principal Investigator	Common Themes	Relevance	Products	Successes/ Lessons Learned
-R827**146**	Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon	Bolte, J.P. – Oregon State University	• Restoration • Economics • Politics and Policies • Multi-criteria Studies • Social Sciences	• Explored the ecological, economic, and social factors influencing watershed restoration and integrated these factors into a tool to help stakeholders identify restoration priorities.	• The website *Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon* (http://biosys.bre.orst.edu/restore/). From this site, users can access, download, and learn about the RESTORE program. • The RESTORE program. • A species habitat matrix of the Willamette Basin. • A series of GIS datasets of the study watersheds in Willamette Basin. • A technique to enable watershed councils to check how well they represent local interest groups and stakeholders (Bolte et al., 2003a).	• The project documented the landscape change in the Willamette Valley watershed from a historical perspective. • As watershed councils develop, they shift from process concerns to identifying and completing projects (Bolte et al., 2003a). • Water quality is a top priority in the Willamette Basin. Temperature and bacteria are the most important water quality issues for this area.
-R827**147**	Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning	Matlock, M.D. –Texas A&M University	• Restoration • Urban • Politics and Policies • Multi-criteria Studies • Social Sciences	• Researchers developed a method for restoring the ecological integrity of an urban watershed and assisted stakeholders with the development of watershed rehabilitation plans.	• A collaborative learning program for the Salado and Leon Creek communities in San Antonio, Texas. • The STELLA Watershed Model. • A simulation model of citizen behavior. • Methods for assessing and restoring ecological integrity in watersheds.	• Stakeholders have increased their knowledge about ecological principles and conditions by participating in the collaborative learning process. As a result, stakeholders have revised their earlier, more negative perceptions of water quality in the San Antonio, TX study areas (Matlock et al., 2003a). • The Collaborative Learning process is now being used as a model throughout the San Antonio area by other watershed groups.

Grant Numbers	Grant Title	Principal Investigator	Common Themes	Relevance	Products	Successes/ Lessons Learned
-R827**148**	Development of an Integrated Scientific and Technological Framework for Stream Naturalization	Rhoads, B.L. – University of Illinois at Urbana	• Restoration • Urban • Multi-criteria Studies • Social Sciences	• Researchers conducted a series of analyses and engineering projects in human-modified streams to determine the success and influence of stream naturalization on stream habitat quality.	• A set of models that can evaluate the geomorphological, ecological, and engineering aspects of stream naturalization efforts and predict the impacts of restoration on the environmental quality of streams.	• Project efforts in Northbrook, IL have increased the aesthetic value of the Chicago River at this location. • The abundance of pool habitats available to aquatic species has been greatly enhanced by the installation of stream naturalization structures. This has caused an increase in the number, size, and abundance of fish in the study locations.

Grant Numbers	Grant Title	Principal Investigator	Common Themes	Relevance	Products	Successes/ Lessons Learned
-R827**149**	Integrating Salmon Habitat Restoration and Flood Hazard Initiatives: Societal/Biophysical Estimators for the Cedar River and Implications for Regional Rivers	Wissmar, R.C. –University of Washington - Seattle	• Restoration • Urban • Social Sciences	• To evaluate the impacts of the Cedar River Action Plan, researchers conducted an interdisciplinary project to gain insight into the societal and biophysical factors driving public perspectives and habitat management activities.	• Social Value Judgments Survey. • Historical Events and Cumulative Impacts Survey. • Flood Control and Restoration Policies Survey. • Perceptions and Opinions of Restoration and Protection Survey. • A new model to understand and assess changes in land-uses. • Modified land-cover classification model for impervious areas. • Modified spatial hydrology model to study the effects of land-uses on hydrology. • A new spatial landscape model to assist in the prioritization on areas for restoration. • A new spatial landscape model to assist in the identification of variable riparian protection widths. • A new spatial landscape, hydrologic process model to assess channel-floodplain habitat responses. • A new multiple logistic regression model to assess the effects of habitat factors on fish. • Contributed to literature on restoration discourse, watershed hydrology, and fish uses of restored habitats. • Established criteria for cumulative impact assessments. • Compiled an analysis of institutions acting to preserve salmon and their habitats. • Compilation of information on public perceptions towards preservation and restoration management activities within the Cedar River drainage.	• In the state of Washington's Cedar River Basin, historical forest harvest and settlement patterns and recent urban expansion in terms of land conversions, flow regulation, flood control and transportation facilities have caused increases in peak flow events, changes in fish and wildlife communities and extensive losses of aquatic and riparian habitats (Wissmar et al., 2004a). • Citizens of the Cedar River Basin have mixed opinions as to why the conditions in the river have declined (Wissmar et al., 2004b). • Cumulative effects from increased urban development may compromise King County's goal to protect and restore aquatic resources in watersheds (Daily 2002, as cited in Wissmar et al., 2004b). • Most citizens of the Cedar River Basin area indicated they would endorse strategies for land purchase, protection, and active restoration to help improve conditions of the river (Wissmar et al., 2004b).

Grant Numbers	Grant Title	Principal Investigator	Common Themes	Relevance	Products	Successes/ Lessons Learned
-R827**150**	Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watersheds: Meeting the Challenge through Science and Policy Analysis	Maddock, T. – University of Arizona	• Restoration, Urban • Politics and Policies • Economics • Social Sciences	• To better understand and address the complex relationships between hydrology, riparian communities, urban and agricultural consumption and societal needs in arid watersheds.	• RIP-ET software package that estimates the amount of surfacewater lost through evapotranspiration. • A Riparian Condition Index • Estimates of indirect costs of ecosystems damage • A guide to the law governing water use and riparian ecosystem preservation • Data from the study was contributed to the U.S. Army Corps of Engineers' Hydraulic Engineering Center's River Analysis System (HEC-RAS). • A GIS-base conceptual model of the South Fork Kern Valley • A GIS-based hydrologic model, the Automated Geospatial Watershed Assessment, which analyzes discrete portions of the watershed that can characterize flow plains. • A Groundwater Modeling System (GMS) to provide groundwater simulations.	• A groundwater pumping experiment that simulated the draw-down of water in an aquifer in the San Pedro River Basin indicated that the draw-down of moisture from the saturated soil above the aquifer continued even after pumping of the underlying aquifer stopped (Maddock et al., 2002). • Residential development in close proximity to riparian areas was found to be desirable from a societal point of view, because it increases the average property value. • An analysis of crop choices indicated that the net returns per acre are greater for non-traditional crops (i.e., fruits and vegetables) compared to more traditional crop choices (i.e., pasture and alfalfa). These results suggest that switching to higher value crops could reduce irrigated acreage and, therefore, the volume of water used in crop production without sacrificing economic returns and farm income in the study watersheds (Maddock et al., Undated). • Economic-based research helped identify the importance of riparian habitat to local communities and businesses and highlighted the economic linkages to nature-oriented tourism in rural economics (Maddock et al., Undated) • The average willingness to pay for riparian habitat preservation by residents of the San Pedro and Kerns River watersheds was determined to be approximately $75 per person. • The amount of money tourists and visitors of riparian areas are willing to pay to travel to these types of areas is positively linked to their willingness to pay for its preservation (Maddock et al., Undated)

Grant Numbers	Grant Title	Principal Investigator	Common Themes	Relevance	Products	Successes/ Lessons Learned
-R827**168**	Social Impact Assessment of Human Exposure to Mercury Related to Land Use and Physicochemical Settings in the Alabama-Mobile River System	Bonzongo, J-C. J. – University of Florida	• Politics and Policies • Multi-criteria Studies • Social Sciences	• Investigated the potential human and natural factors influencing mercury and methyl-mercury levels in the Mobile Alabama River Basin. Researchers also studied the impacts of education and its influence on public policy and environmental management strategies.	• Public outreach tools including the newsletter "Mercury News," message oriented telephone hotline "Mercury Project Line," and a project website. • A spatial relational database linked to GIS coverage that can be queried to obtain information about mercury contamination levels in the Mobil Alabama River Basin. • Regression models to relate land use and in-stream nutrients (nitrogen and phosphorus) concentrations.	• Certain human related activities and natural settings could favor the production of methyl-mercury (methyl-mercury is a highly toxic form of mercury that can cause adverse effects to central nervous systems when absorbed into the human bloodstream) regardless of the amount of inorganic mercury initially present in the sediments (Bonzongo et al., 2003). • Biomagnification of methyl-mercury was significant in aquatic organisms; tissue samples taken from largemouth bass contained methyl-mercury levels of more than 1 million times the levels found in the waters in which they reside (Bonzongo et al., 2003). • Weathering of rocks and minerals and atmospheric deposition are the primary sources of mercury in the Mobile Alabama River Basin. • Based on calculations, approximately 90 percent of the mercury entering the Mobile Alabama River Basin from the atmosphere is retained within the watershed. • Mercury loading is an important factor governing the production of methyl-mercury (MeHg). • Nutrient additions to sediments had a profound impact on methyl-mercury (MeHg) production from inorganic mercury already present in the sediments (Bonzongo et al., 2003). • The highest sediment concentrations of both total mercury and methyl-mercury were found in tributaries draining mining impacted sites, where there were high sulfate concentrations, and in small catchments impacted by agriculture and/or wetlands. • The project team's work with citizens and local officials has helped bridge the gap between research science and policy decisions.

Grant Numbers	Grant Title	Principal Investigator	Common Themes	Relevance	Products	Successes/ Lessons Learned
-R827**169**	Whole Watershed Health and Restoration: Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature	Costanza, R. – University of Maryland	• Restoration • Politics and Policies • Multi-criteria Studies • Social Sciences	• Researchers expanded the capabilities of the existing Patuxent Landscape Model (PLM) to create a new tool that can be used for whole watershed assessment and analysis efforts.	• A revised version of the Patuxent Landscape Model (PLM). • The General Human Model (GHM). • Two modified version of the PLM, the Gwynns Falls Landscape Model (GFLM) and the Hunting Creek Watershed Model (HCM), for the assessment of the areas of Gywnns Falls (Baltimore, MD) and Hunting Creek (Calvert County, MD). • The Patuxent Landscape Model Website (http://www.uvm.edu/giee/PLM/). • The Hunting Creek Educational Program (http://www.uvm.edu/giee/AV/EDU/SWN/).	• The Hunting Creek Watershed Model (HCM) was successfully applied to Maryland's Hunting Creek and successfully assisted the Commissioners of Calvert County with the environmental evaluation of the effects of proposed land-use rezoning scenarios. • The revised Patuxent Landscape Model (PLM) appears to have become the most advanced model of its type for application at the regional watershed scale (Costanza et al., 2003). • The high data requirements and computational complexities of the PLM have caused the development of additional application versions of this model to be costly and time consuming.

Grant Numbers	Grant Title	Principal Investigator	Common Themes	Relevance	Products	Successes/ Lessons Learned
-R827**288**	Integrating Models of Citizens' Perceptions, Metal Contaminants, and Wetlands Restoration in an Urbanizing Watershed	Tucker, R.K. – Stony Brook-Millstone Watershed Association	• Politics and Policies • Urban • Multi-criteria Studies • Social Sciences	• Researchers conducted a series of ecological, chemical, and sociological analyses to gather information to educate the public and increase local understanding of the importance of wetlands and its role in watershed health.	• The Watershed Institute (http://www.thewatershedinstitute.org/). • The Natural Lands Network (http://www.thewatershed.org/WSM/nln.html). • The Wetlands Primer, a web-based educational resource. • The New Jersey Council of Watershed Associations (http://www.thewatershed.org/). • High school level environmental science curriculum.	• It was initially discovered that local and county officials felt they had little responsibility for wetlands protection. • Many citizens and public officials are aware of the importance of wetland and watershed health and are concerned for the protection and wellbeing of these resources. • The Stony Brook-Millstone Watershed Association has been awarded the Dr. Ruth Patrick Excellence in Environmental Education Award because of the environmental and outreach programs developed as part of this research effort. • The characterization of the sub-watersheds of Beden Brook and Rocky Brook has provided citizens and local officials with valuable information on the impacts of wetland development and wetland loss. • This research has demonstrated that much can be done at the local level to protect wetlands; however, if actions are to be successful citizens and local officials must be educated about the resource and the ways to protect it.

APPENDIX B. 1998 WATER AND WATERSHED GRANTS COMMON THEMES CHART

	Restoration	Multi-criteria Studies	Urban	Social Sciences	Economics	Politics and Policies
R827**145**				X		X
R827**146**	X	X		X	X	X
R827**147**	X	X	X	X		X
R827**148**	X	X	X	X		
R827**149**	X		X	X		
R827**150**	X		X	X	X	X
R827**168**		X		X		X
R827**169**	X	X		X		X
R827**288**		X	X	X		X

APPENDIX C. 1998 WATER AND WATERSHED GRANTS COMMON THEMES

Restoration:

R827146 - **Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon** - Bolte, J.P.
For watershed restoration to be successful, ecological, economic, and social factors influencing the targeted area must be carefully considered. Researchers under this grant sought to better understand these factors and to develop a means for integrating them into a tool that could assist stakeholders in identifying restoration priorities and feasible restoration options.

R827147 - **Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning** - Matlock, M.D.
Investigators successfully developed and tested a method for restoring the ecological integrity of an urban watershed. The STELLA-based Watershed Model that was developed allows stakeholders to better understand the connection between various restoration strategies and their potential impacts to the environment.

R827148 - **Development of an Integrated Scientific and Technological Framework for Stream Naturalization** - Rhoads, B.L.
Researchers attempted to naturalize human-modified streams in the state of Illinois by designing and constructing various pool-riffle habitats in straight urban streams and re-meandering a channelized section of a creek.

R827149 - **Integrating Salmon Habitat Restoration and Flood Hazard Initiatives: Societal/Biophysical Estimators for the Cedar River and Implications for Regional Rivers** - Wissmar, R.C.
Researchers developed and/or modified a series of models and surveys to assist in the assessment of habitat changes and to help decision-makers and environmental planners prioritize areas for potential restoration based upon both societal and environmental needs.

R827150 - **Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watersheds: Meeting the Challenge through Science and Policy Analysis** - Maddock, T.
Researchers studied the aspects of hydrology, ecology, economics, and law to gain insight into the complex relationships between hydrology, riparian communities, urban and agricultural consumption, and societal needs. Through this research, investigators compiled information and developed tools that will increase the ability of resource managers and decision-makers to properly restore, maintain, and protect threatened riparian ecosystems.

R827169 - **Whole Watershed Health and Restoration: Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature** - Costanza, R.
The models modified and produced under this research grant have provided stakeholders and decision-makers with valuable tools for understanding the dynamics of watershed systems. Using these tools as part of their decision-making process, planners and managers can develop land-use strategies that allow for better protection and restoration of watershed environments.

Multi-criteria Studies:

R827146 - **Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon** - Bolte, J.P.
Researchers conducted numerous biodiversity, macroinvertebrate, economic, and sociological studies to support a decision-making framework that includes a watershed-scale evaluator that can provide a detailed assessment of potential watershed restoration strategies.

R827147 - **Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning** - Matlock, M.D.
Researchers utilized aspects of ecology, engineering, modeling, and social sciences to gain insight into the ecological health and services of an urbanizing watershed. Data from these studies have allowed researchers to better understand stakeholder needs and perceptions about ecosystem health, and develop appropriate methods for restoring the ecological integrity of a watershed.

R827148 - **Development of an Integrated Scientific and Technological Framework for Stream Naturalization** - Rhoads, B.L.
Researchers conducted a series of engineering, geomorphological, habitat, and social analyses in and around three urban streams in the state of Illinois. Based on the data collected, researchers have successfully developed a suite of modeling and analysis tools that can be used to evaluate stream naturalization in an urbanized area.

R827168 - **Social Impact Assessment of Human Exposure to Mercury Related to Land Use and Physicochemical Settings in the Alabama-Mobile River System** - Bonzongo, J-C.J.
Researchers conducted numerous studies to assess the impacts of various land uses on mercury and methyl-mercury levels in the water column and sediments of the Mobile Alabama River Basin, located in the southeastern region of the United States. Fish tissue analyses and social science studies also were conducted.

R827169 - **Whole Watershed Health and Restoration: Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature** - Costanza, R.
The modified Patuxent Landscape Model (PLM) required data and information to be collected on ecology, hydrology, economics, and human well being.

R827288 - **Integrating Models of Citizens' Perceptions, Metal Contaminants, and Wetlands Restoration in an Urbanizing Watershed** - Tucker, R.K.
Researchers conducted a series of ecological, chemical, and sociological studies in New Jersey's Stony Brook-Mill Watershed to obtain information that could be used to educate the public and increase their understanding wetlands importance and its role in overall watershed health.

Urban:

R827147 - **Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning** - Matlock, M.D.
Investigators successfully developed and tested a method for restoring the ecological integrity of an urban watershed within the areas of Salado and Leon Creek in San Antonio, Texas.

R827148 - **Development of an Integrated Scientific and Technological Framework for Stream Naturalization** - Rhoads, B.L.
Project efforts have laid the foundation for an integrated scientific and technical framework for stream naturalization in urban settings (Rhoads et al., 2003).

R827149 - **Integrating Salmon Habitat Restoration and Flood Hazard Initiatives: Societal/Biophysical Estimators for the Cedar River and Implications for Regional Rivers** - Wissmar, R.C.
Researchers conducted a companion study that produced results indicating that the cumulative effects of increased urban development could negatively impact the ability of environmental planners and decision-maker to protect and restore aquatic resources throughout the Cedar River Basin.

R827150 - **Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watersheds: Meeting the Challenge through Science and Policy Analysis -** Maddock, T.
Researches conducted studies that focused on gaining understanding and insight into the effects of urban development on riparian communities. In addition, researchers assessed the economic drivers of urban development in riparian areas.

Economics:

R827146 - **Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon** - Bolte, J.P.
In order for watershed restoration to be successful it is important to understand the economic effects of the proposed restoration strategy. Researchers of this grant developed a decision-making framework that incorporated economic data that assessed the costs of different restoration activities, including capital and opportunity costs of utilizing land for various restoration scenarios. These data are useful in helping to identify the restoration alternative that best represents stakeholder objectives.

Politics and Policies:

R827145 - **When Do Stakeholder Negotiations Work? A Multiple Lens Analysis of Watershed Restorations in California and Washington -** Sabatier, P.
Stakeholder-based environmental planning and management has become an increasingly popular strategy nationwide. Within the context of this research project, investigators have attempted to uncover the factors that drive and/or impede stakeholder groups and partnerships from effectively resolving environmental management issues. Researchers composed a study consisting of 50 watershed partnerships within the states of California and Washington. Each of the selected partnerships had to involve at least one state or federal agency, a local agency, and two potentially opposing interest groups.

R827146 - **Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon** - Bolte, J.P.
The outcome of this research effort was the RESTORE decision support tool. The RESTORE tool utilizes a series of rules that relate specific site-based restoration alternatives, stakeholder goals, and site-specific landscape features to generate feasible restoration plans that reflect stakeholder concerns and evaluates the ecological and economic effectiveness of these strategies (Bolte et al., 2003b). RESTORE has made it possible for stakeholders and decision-makers to visualize their watershed from numerous perspectives and allow them to control and explore the implications that could result from potential restoration plans or management strategies.

R827147 - **Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning** - Matlock, M.D.
The watershed modeling tool, STELLA, has been designed to help initiate discussions between stakeholders and scientists that will result in informed stakeholder-driven action plans for watershed rehabilitation. As a result of this model, stakeholders are now able to better understand the connection between various restoration strategies and their potential impacts to the environment. Overall, STELLA has helped to create a more effective communication interface between citizens, scientists, and policy makers (Matlock et al., 2003a).

R827150 - **Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watersheds: Meeting the Challenge through Science and Policy Analysis -** Maddock, T.
Researchers under this grant established an economics team to assess the economic value of riparian habitats within the San Pedro and Kerns River watersheds from a number of perspectives. Based on the outcome of their economic analyses, the economics team developed a number of potential policy instruments that can be used to help protect and maintain riparian habitats in both the watersheds.

R827168 - **Social Impact Assessment of Human Exposure to Mercury Related to Land Use and Physicochemical Settings in the Alabama-Mobile River System** - Bonzongo, J-C.J.
Researchers actively interacted with citizens and local officials and establish several watershed management strategies for the Mobile Alabama River Basin. Strategies were discussed and assessed during a project-sponsored public policy meeting to develop viable options for the community. This project has also illustrated how actively engaging the public and local officials can influence public policy and lead to improved environmental management awareness and action.

R827169 - **Whole Watershed Health and Restoration: Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature** - Costanza, R.
The Modified Patuxent Landscape Model (PLM) established under this grant can assist policy and decision-makers in the areas of Gwynns Falls and Hunting Creek (both in Maryland) with the selection and implementation of restoration and planning policies that will better balance human land-use needs with ecosystem health and function.

R827288 - **Integrating Models of Citizens' Perceptions, Metal Contaminants, and Wetlands Restoration in an Urbanizing Watershed** - Tucker, R.K.
This grant effort increased the awareness of local citizens and public officials about the importance of watersheds and wetland preservation. As a result of this project, two organizations, The Watershed Institute and the New Jersey Council of Watershed Associations, have also been established to support watershed protection and support issues of environmental concern. Already, this research team and its partners have been able to cause the reassessment of various land-development projects and have played an important role in the revision of the New Jersey Freshwater Wetlands Protection Act rules.

Social Sciences

R827145 - **When Do Stakeholder Negotiations Work? A Multiple Lens Analysis of Watershed Restorations in California and Washington** - Sabatier, P.
Stakeholder-based environmental planning and decision-making has become an increasingly popular environmental management strategy nationwide. Researchers under this grant studied social interactions of 50 watershed partnerships within the states of California and Washington in order to uncover the social factors that may drive and/or impede stakeholder groups and partnerships from effectively resolving environmental issues.

R827146 - **Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon** - Bolte, J.P.
Social factors and interactions play an integral role in successful watershed management and restoration. Researchers under this grant sought to better understand these factors and integrate them into a decision-support tool that would better assist stakeholders in developing appropriate restoration strategies and options.

R827147 - **Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning** - Matlock, M.D.
In an effort to develop appropriate restoration strategies for an urbanized watershed in San Antonio, TX, researchers became involved in the watershed's surrounding community. Researchers employed a Collaborative Learning (CL) program to educate the public about watershed needs and concerns and create outlets for active communications between stakeholders and decision-makers. Results of this research produced a simulation model of citizens' behavior that could generate a statistical assessment of variables to explain citizens' willingness to change attitudes and behaviors towards environmental conditions.

R827148 - **Development of an Integrated Scientific and Technological Framework for Stream Naturalization** - Rhoads, B.L.

Researchers sought to examine the social processes that define a community's environmental vision and that influence the effective incorporation of scientific and technical information in community-based decision-making (Rhoads et al., 2003). Researchers also explored how community-based environmental preferences shape and are shaped by science and technology (Rhoads et al., 2003). Social science studies were conducted through a series of open-ended interviews with the key stakeholders in the study watersheds of Poplar Creek, near Elgin, Illinois, and the West Fork of the North Branch of the Chicago River in Northbrook, Illinois.

R827149 - **Integrating Salmon Habitat Restoration and Flood Hazard Initiatives: Societal/Biophysical Estimators for the Cedar River and Implications for Regional Rivers -** Wissmar, R.C.

Researchers studied human factors and policy management strategies affecting the Cedar River environment. Investigators conducted a series of interviews with local citizens, met with politicians and management agencies, established focus groups and developed mail surveys. Through these focus groups and surveys research gained insight into the history of societal, institutional and policy forces that have shaped environmental conditions and concepts of restoration in the lower Cedar River Basin. In addition, researchers gained a better understanding of the influences of both social and political institutions on salmon habitat protection and restoration in the Cedar River.

R827150 - **Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watersheds: Meeting the Challenge through Science and Policy Analysis -** Maddock, T.

Researchers under this grant assessed the value of riparian areas to local residents, businesses, tourists, and the community as whole to determine willingness to contribute to the conservation and/or restoration of riparian habitats in the San Pedro and Kerns River watersheds.

R827168 - **Social Impact Assessment of Human Exposure to Mercury Related to Land Use and Physicochemical Settings in the Alabama-Mobile River System** - Bonzongo, J-C.J.

During this research grant, citizens and stakeholders within the Mobile Alabama River Basin study location fully informed of all research objectives and findings. Newsletters were developed and a series of public meetings were held to engage stakeholder groups. The results of these efforts were a series of citizen- and stakeholder-supported watershed management strategies. The outcome of this project showed how actively engaging and educating the public throughout a research effort can influence both public perception and public policy and lead to improved environmental management.

R827169 - **Whole Watershed Health and Restoration: Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature** - Costanza, R.

To better understand the interactions of humans in a watershed system, researchers developed a General Human Model (GHM). This model has the ability to recognize and simulate the four different stocks of human wealth (built capital, human capital, natural capital, and social capital) that contribute to a community's and/or individual's wellbeing (Costanza et al., 2003). A useful tool for communicating with stakeholders, this model i helped researchers assist stakeholders with establishing environmental priorities.

R827288 - **Integrating Models of Citizens' Perceptions, Metal Contaminants, and Wetlands Restoration in an Urbanizing Watershed** - Tucker, R.K.

To understand the beliefs and attitudes of citizens and public officials regarding the role of wetlands in watershed health and the need to preserve them, researchers conducted intensive social science studies. Studies consisted of random surveys of citizens and local officials in 28 towns within the study watershed of Stony-Brook Millstone, New Jersey. As a result, researchers were able to develop tools and provide information that would help enhance the

awareness of local citizens and public officials about the importance of watershed and wetland protection.