ABSTRACT

Title of Document: STREAM RESTORATION IN THE CHESAPEAKE BAY WATERSHED: DATA SYNTHESIS AND ANALYSIS OF INTERVIEWS WITH PRACTITIONERS

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The Chesapeake Bay is the focus of a high profile restoration program and river restoration is one part of the strategy. A comprehensive database of over 4700 stream restoration projects across the watershed was compiled to examine where money is spent, what issues motivate restoration, and what approaches are used. The majority of projects were implemented to restore riparian vegetation and improve water quality. While over $400 million has been spent on stream restoration projects since 1990, less than 6% of written project records indicated that related monitoring had occurred.

Comprehensive interviews with project managers were conducted for a subsample projects to characterize patterns in project goals, design, expenditures, project evaluation, and project success. Interviewed practitioners reported that the majority of projects were initiated to address environmental degradation, 70% were

linked to other projects within the same watershed, and 76% of projects had some form of associated monitoring.

STREAM RESTORATION IN THE CHESAPEAKE BAY WATERSHED: DATA SYNTHESIS AND ANALYSIS OF INTERVIEWS WITH PRACTITIONERS

By

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Thesis submitted to the Faculty of the Graduate School of the
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Preface

This thesis is one contribution to the National River Restoration Science Synthesis (NRRSS) project, a National Center for Ecological Analysis and Synthesis working group. The objectives of the working group were to evaluate the status of river restoration across the United States and assess the ecological success of restoration projects. The group targeted seven regions across the country for in-depth study: Chesapeake Bay, Southeast, Southwest, California, Pacific Northwest, Central U.S. large rivers, and Upper Midwest. Data presented in this thesis are from the Chesapeake Bay region of the project.

The first chapter presents a summary of restoration projects in the Chesapeake Bay watershed. Data were compiled from a broad range of readily available databases as well as collected from individual project records obtained from state and local agencies and private consultants. These data were then incorporated into a common-field database developed by the NRRSS group. The analysis yielded a representation of the status of stream restoration across the watershed: the number of projects completed, project costs, project size, common project goals and activities, and the proportion of projects completing post-restoration monitoring.

The second chapter presents the results of comprehensive interviews with practitioners for a subsample of restoration projects in the watershed. Because the ecological success of stream restoration in the watershed could not be evaluated using available data from the synthesis effort, the NRRSS group developed an interview tool to collect detailed information from project managers. Analysis of the interviews yielded a characterization of project goals, design, and expenditures, trends in project evaluation, and project success as reported by interviewees.

The third chapter presents a more detailed discussion of differences between data from written records and practitioner interviews, and further evaluates the ecological success of stream restoration projects in the Chesapeake Bay watershed.

Acknowledgements

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I am fortunate to have worked with outstanding graduate students, post-doctoral assistants and research assistants over the past several years. I especially want to thank Emily Bernhardt, Shane Brooks, Brad Cardinale, Laura Craig, Lauren Culler, Jason Dittman, Emily Duncan, Evan Grant, Brian Laub, Holly Menninger, Aaron Moore, Jen Morse, Karen Nelson, Suzanne Olyarnik, Chris Patrick, Dave Richardson, Bob Smith, and Chris Swan for their assistance and encouragement.

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I thank all data providers for the Chesapeake Bay restoration database. I am most grateful to all individuals who participated in the interviews and spent time talking with me about their projects.

I wish to thank the Department of Entomology and the Marine, Estuarine, and Environmental Science Program at the University of Maryland for support throughout my graduate education. Funding for the Chesapeake Bay portion of the National River Restoration Science Synthesis project was provided by the U.S. Geological Survey, the David and Lucille Packard Foundation, Altria, the C.S. Mott Foundation, the University of Maryland, the Maryland Department of Natural Resources, the Pennsylvania Department of Environmental Protection, and the William Penn Foundation.

Finally, I would like to thank my family and friends, who have always motivated me to do my best.

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Introduction

The last several years has seen a surge of concern over marine waters fueled by several high profile ocean commission reports as well as news on coastal dead zones (POC 2003, USCOP 2004, MSNBC 2005). Special attention has been given to coastal fisheries that have generated heated debates over the need to relieve pressure on populations through harvesting restrictions and habitat set asides versus the need to reduce non-point source pollution that broadly impairs coastal fisheries (Boesch and Greer 2003). In the Chesapeake Bay Watershed (CBW), where such issues have been debated for many years, inter-state agreements to clean up the Bay and restore fisheries have been forged for over two decades. The 1987 Chesapeake Bay Agreement included provisions to address non-point source pollution by reducing nutrient and sediment loadings by 40%, thereby acknowledging that restoration of the estuary would require watershed-wide implementation efforts, including tributary plans. Specific goals and policy recommendations related to fish passage and riparian buffer restoration were subsequently amended to this agreement. However, it wasn't until the 2000 Chesapeake Bay Agreement that provisions were formulated for the development of guidelines focusing on the aquatic health of stream corridors and local watershed management planning efforts. In October 2004, recommendations for new water quality goals, state-level tributary 'clean-up' plans, and methods to finance the Bay restoration were announced by the Chesapeake Bay Program, the regional government partnership that directs Bay restoration activities (CBP 2005). Individual states within the watershed have now developed plans that include estimated costs for efforts aimed at improving water quality, such as urban and rural stream restoration, forest buffers, and wetland restoration projects, and affiliated best management practices (CBP 2004a, CEC 2004).

The call for tributary strategies for all regions of the CBW is encouraging, particularly since the desire to clean up the Chesapeake Bay led to an initial focus on tidal waters, including the effects of nutrient enrichment on estuarine water quality, the presence of toxic substances in Bay sediments, and the decline of submerged aquatic vegetation (US EPA 1982). However, rivers and streams are critical to the health of estuaries and coastal areas because they integrate the effects of human activities throughout entire watersheds, serve as spawning areas for anadromous species, and provide water for drinking, irrigation, and recreation (Baron *et al.* 2002, Gleick 2003). Nationwide, more than one-third of the rivers are officially listed as impaired and polluted (US EPA 2000). The amount of nitrogen transported via rivers into the oceans has almost doubled since the Industrial Revolution (Caraco and Cole 2001, Howarth 1998, Peierls *et al*. 1991). Sediment delivery via streams and rivers to coastal estuaries in the Mid-Atlantic region, including the Chesapeake Bay, substantially increased following the initial clearing of forest vegetation from the landscape during colonial settlement (Langland and Cronin 2003).

The desire to trap sediments and nutrients before they enter Chesapeake Bay waters led to many riparian restoration initiatives because evidence has accrued that trapping materials generated from hillslopes is enhanced by streamside vegetation, particularly forested stream corridors (Lowrance *et al.*1995, Weller *et al*. 1998, Sweeney *et al*. 2004). Coincident with these findings, government programs like the

Conservation Reserve Enhancement Program (CREP) have been created, a variety of related buffer restoration and protection ordinances have been adopted by local governments, and the 2000 Bay Agreement established a goal of expanding buffer mileage in the Bay watershed (CBP 2003). Riparian buffers are not the only mechanism for reducing the downstream flux of materials. For example, healthy streams play critical roles in processing nitrogen and nitrogen-loss rates in streams decline rapidly with channel size – that is, small, headwater streams are the most efficient at removing nitrogen from stream water (Alexander *et al*. 2000, Peterson 2001). Restoration of degraded streams and riparian buffers has been shown to lead to species recovery, improved inland and coastal water quality, and the creation of habitat for wildlife and recreational activities (Baron *et al*. 2002, Buijse *et al*. 2002, Muotka and Laasonen 2002, Palmer *et al*. 2005).

While there have been sporadic projects that attempted to promote coordination and focus on the collective results of stream restoration in a manner that leads to an improvement in both inland and coastal waterways (Lubbers 1998), no consistent program has been in place to comprehensively guide the physical restoration of the thousands of miles of tributaries to the Chesapeake Bay. In fact, the discipline of stream restoration in the CBW largely grew out of wetland permitting processes that required in-kind replacement of impacted stream lengths. In the early 1990's, emerging techniques to physically rehabilitate channels were controversial, but embraced in many regions of the country, including the CBW (MDE 2000, Malakoff 2004). Thus, the history of stream restoration in the CBW is similar to many other locations in the U.S. in that it has been tightly linked to regulatory programs.

Incentives to restore were tied to administrative mandates for permits and funding sources linked to mitigation projects, most of which can be traced back to highway agencies and developers.

The paucity of information on freshwater restoration activities and their outcomes motivated us to research the status and trends of river and stream restoration projects in the Chesapeake Bay Watershed. Recent results from a large, multi-investigator project (the National River Restoration Science Synthesis, NRRSS) have shown that the *number* of restoration projects on streams and rivers in the 64,000 mi^2 Chesapeake Bay watershed is second nationally only to the number in the Pacific Northwest. In fact, there is a higher *density* of projects (75-150 projects per 1000 river km) in this watershed than anywhere else in the nation (Bernhardt *et al*. 2005). Thus, despite the lack of a coordinated Chesapeake Bay stream restoration program, stream and river projects are quite common. Three questions remain: 1) Are these projects effective at achieving their stated goals? 2) Is there evidence that projects are coordinated across jurisdictional boundaries? 3) To what extent are stream project goals linked to broad Chesapeake Bay Program objectives that include cleaner water and healthier fisheries?

Answering these questions requires an understanding of what types of stream restoration practices have been completed and what we know about their effectiveness. Toward this end, we developed and calibrated a new database of river and stream restoration projects for the Chesapeake Bay watershed to evaluate existing projects. These data are part of a much larger (37,000 projects), national level database produced by the National River Restoration Science Synthesis (NRRSS) project team to examine the current state of river restoration across the country (Palmer *et al*. 2003, Palmer *et al*. 2005, Bernhardt *et al*. 2005). In this paper, we specifically focus on: why and how streams are being restored in the Chesapeake Bay Watershed; if there are written records indicating projects were monitored or their outcome assessed; how much is being spent on these efforts; and if these efforts are focused on streams and rivers that are viewed as high priority sites for restoration. This represents the most comprehensive summary of CBW stream and river restoration efforts to date, synthesizing information on >4700 projects from over 70 sources.

Methods

To populate the database, we first explored existing restoration databases and quickly found that they are highly fragmented, often relying on *ad hoc* or volunteer data entry. Thus we developed methods for the unbiased collection and cataloging of river and stream restoration projects. The database includes all stream and river restoration projects within the CBW that were present in national databases as of July 2004 (see Appendix A) as well as a large sample of river and stream restoration projects from Maryland, Virginia, and Pennsylvania. Use of national coverage data sources ensured inclusion of projects from all Chesapeake Bay states. We chose to collect additional information on three focal states in order to obtain a larger and more representative sample of projects for those regions that have been the most active in developing the Chesapeake 2000 and later agreements.

To ensure a representative sample, we collected information on all restoration projects for which we could obtain written information, regardless of project size, restoration method, implementer, or the perceived success/failure of the project. This sample of projects was obtained from a variety of sources such as permit files, non-governmental organization databases, consulting firms, and state or county agency records in Maryland, Pennsylvania, Virginia, and the District of Columbia (Table 1.1). Projects in the database were implemented by federal, state, and local agencies (e.g., Corps of Engineers, State Highways, County agencies, conservation districts) or by consulting firms or non-profit groups. We included projects in the NRRSS-CB database if they were part of a stream restoration-specific database or data file, or if the project was done specifically to improve the stream (see Appendix B).

Table 1.1 List of major data sources for restoration projects within the Chesapeake Bay watershed.

Entity	Title	# Projects
EPA Office of Water	Projects funded by Five Star Restoration Program	13
Chesapeake Bay Program	Chesapeake Bay Small Watershed Grants Program Awards	42
Maryland Department of the Environment, Water Management Administration	Bureau of Mines Completed Abandoned Mine Reclamation Projects	31
Maryland Department of Natural Resources	Fish Passage Database	72
Maryland State Highways Administration	Stream database	18
Maryland Department of Natural Resources, Watershed Restoration Division	Stream Restoration Tracking Database	456
Environmental Systems Analysis, Inc.	ESA project files	28
United States Army Corps of Engineers	List of 1135 Projects	1
National Park Service	Project Management Information System	13
Coastal America	Coastal America Regional Conservation Projects	2
Virginia Department of Forestry	Virginia DOF Project files	15
Anacostia Watershed Society	Anacostia Watershed Society Event Listing 2001-2003	60
NOAA Fisheries	Community Based Restoration Program, Damage Assessment and Restoration Program	17
Clean Water Action Plan	Clean Water Success Stories	1
USDA Natural Resources Conservation Services	Collection of Buffer Success Stories	1
Hydropower Reform Coalition	FERC completed dam removals	1
United States Fish and Wildlife Service	Division of Bird Habitat Conservation	8
United States Army Corps of Engineers Institute for Water Research	USACE Aquatic Environmental Projects	4
United States Army Corps of Engineers	Water Resource Development Acts of 1986, 1990, 1992, 1996, 1999, 2000, 2002	32

Entity	Title	# Projects
National Transportation Enhancements Clearinghouse	Transportation Enhancements Project Database	7
Montgomery County Department of Environmental Protection	Montgomery County DEP restoration database	7
City of Fairfax	City of Fairfax stream restoration projects	13
Ecotone, Inc.	Ecotone selected projects	5
Maryland Department of Natural Resources- Forestry	Riparian Forest Buffer Site Locations	1544
FishAmerica Foundation	FishAmerica Foundation Funded Projects August 1983- March 2003	13
United States Fish and Wildlife Service, Partners for Fish and Wildlife	HABiTS database	86
National Fish and Wildlife Foundation	National Fish and Wildlife Foundation Grants	47
Southern Alleghenies Conservancy	Southern Alleghenies Conservancy Projects	1
Blair County Conservation District	Stream Restoration email	7
Virginia Department of Conservation and Recreation- DSWC	Virginia Conservation Reserve Enhancement Program Practices	1251
Virginia Department of Game and Inland Fisheries	Dam Removal	2
Arlington Department of Environmental Services	Arlington Department of Environmental Services Stream Restoration Projects	1
U.S. Fish and Wildlife Service	National Fish Passage Program	1
Virginia Department of Environmental Quality	Virginia Coastal Program Funding and Projects	4
Friends of Daniels Run Park	Friends of Daniels Run Park Newsletter	1
Chesapeake Bay Foundation	NON-AG projects 2001-02	16
Chesapeake Bay Foundation	SSP project log	8
Chesapeake Bay Foundation	FSP project log	30
Chesapeake Bay Foundation	DU pship project log	10
Chesapeake Bay Foundation	00-02 Project Tracking Log	261
Chesapeake Bay Foundation	CREP proj log	90

Entity	Title	# Projects
Virginia Department of Transportation	Virginia DOT projects	6
United States Environmental Protection Agency Office of Research and Development	EPA River Corridor and Wetland Restoration Project Directory	48
United States Environmental Protection Agency	Nonpoint Source System Grant Reporting and Tracking System	94+
Baltimore County DEPRM	Current Project Listing	33
Pennsylvania Department of Environmental Protection Stream Releaf Program	Stream Releaf Databas	519
Brodhead Watershed Association	Paradise Streambank Restoration Project	2
Hydropower Reform Coalition	FERC completed dam removals	2
Beaver County Conservation District	Brush Creek Project History	6
Adams County Trout Unlimited	Adams County Restoration History Part 1 & Part 2	15
Natural Stream Channel Design Initiatives in Pennsylvania	Natural Stream Channel Design Initiatives in Pennsylvania	25
Pennsylvania Bureau of Acid Mine Reclamation/ PA DEP	1998 Status Report: AMD Set Aside Program	12
Pennsylvania Fish and Boat Commission	Fish passage projects in Pennsylvania	88
Northern Swatara Creek Watershed Association	Completed Projects Which Have Improved the Water Quality of Swatara Creek	10

The majority (93%) of project information included in the NRRSS-CB database came from some form of spreadsheet or small database (mean size = 18 projects) that was provided after phone contact or visits to an agency, NGO, or other source. Some organizations did not have readily available data for inclusion in the NRRSS-CB database. Full details on the NRRSS database design, calibration, and validation are presented elsewhere (Bernhardt *et al*. 2005).

We identified *a priori* 13 categories of restoration and classified each project according to its stated goal (Table 1.2). The NRRSS-CB database was analyzed using a sequence of queries and then summary information was compiled. Because not all 4704 project records in the database contain data in every field, results below are accompanied by the percentage of projects reporting the information of interest. Also, because data on restoration are often organized at state levels but not all parts of each state are within the CBW, we only included data from those counties within each state that fall within the CB watershed (e.g., southeastern and western Pennsylvania projects are not included in our project totals for Pennsylvania since they fall in the Delaware River and Ohio River basins, respectively).

We estimate that >2500 person hours were spent making contacts, acquiring records, and extracting relevant information for the NRRSS-CB database. Obtaining some records required upwards of 10 personal contacts and often included trips to sort through agency, foundation, or consulting firm files. With but a few exceptions, groups were very cooperative in sharing their files but were always very time/personnel limited, making it a strain on them to provide input.

Table 1.2 Definitions for the four dominant goal categories that characterized most CBW stream restoration projects records in the NRRSS database. The remaining goal categories are listed but not described (see Appendix B for full descriptions). Note that some projects listed more than one goal. For each category, the dominant restoration activities that were reported as planned or implemented in project records are shown in Figure 1.3.

Riparian Management*:* Revegetation of riparian zone and/or removal of exotic species (e.g., weeds, cattle). Excludes localized planting only to stabilize bank areas (see *Bank Stabilization*)
Bank stabilization: Practices designed to reduce/eliminate erosion or slumping of bank material into the river channel. This category does not include storm water management (see *Stormwater Management*)
Water Quality Management: Practices that protect existing water quality or change the chemical composition and/or suspended particulate load. Remediation of acid mine drainage falls into this category, as does CSO separation. Excludes urban runoff quantity management (see *Stormwater Management*)
In-stream Habitat Improvement: Altering the structural complexity to increase habitat availability and diversity for target organisms and provision of breeding habitat and refugia from disturbance and predation. (In some cases habitat improvement may be an action with the intent of *In-stream Species Management*, in other cases *Habitat Improvement* may be the intent, and might be accomplished through *Channel Reconfiguration*; be very careful to separate action from intent when deciding whether to select this category.
Remaining goal categories: Aesthetics/Recreation/Education Channel Reconfiguration Dam Removal/Retrofit Fish Passage Floodplain Reconnection Flow Modification In-stream Species Management Land Acquisition Stormwater Management

Results

Number, distribution, and size of projects

The number of stream and river restoration projects completed in the Chesapeake Bay Watershed has increased considerably over the past 10 years (Figure 1.1). While our database captured only 126 projects completed prior to 1995, more than 4700 projects had been completed in the watershed by July 2004. The number of CBW projects varied dramatically by state and county with Maryland having the most projects (2378) followed by Virginia (1403) and Pennsylvania (872) (Figure 1.2).

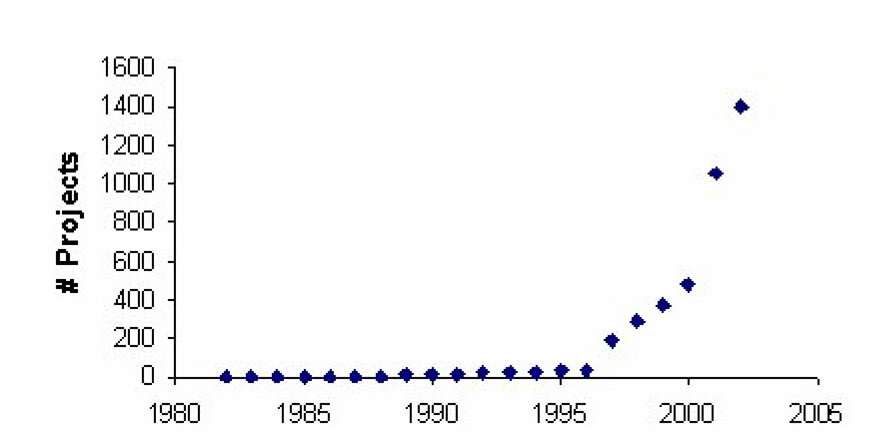


Figure 1.1 Number of projects completed in Chesapeake Bay region. Projects completed in 2003 and 2004 are not shown because there is a time lag in availability of recently completed project information.

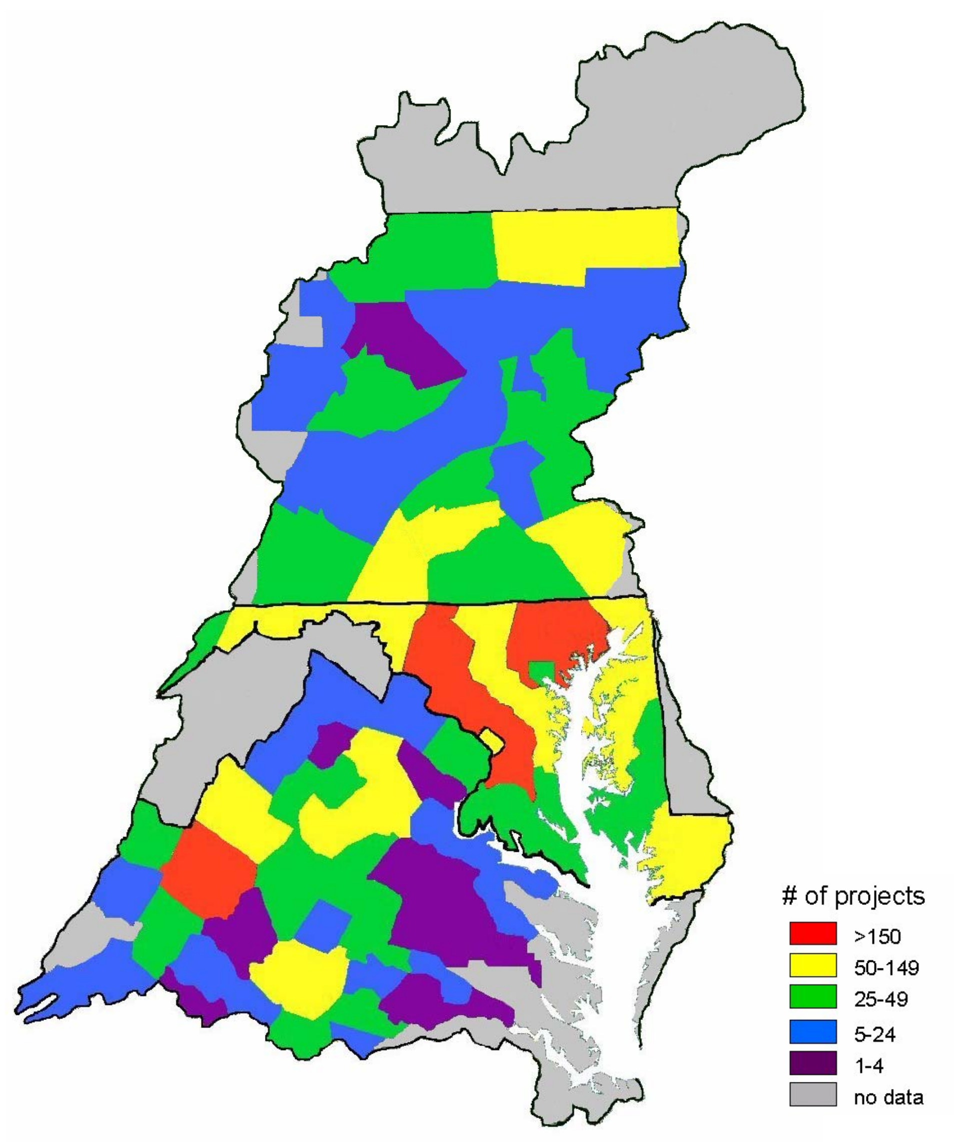


Figure 1.2 Number of stream and river restoration projects in the NRRSS-CB database by county within the Chesapeake Bay Watershed.

The number of projects also varied among counties within states from a low of 1 project per county (Northumberland, County, VA) to a high of > 200 (Augusta County, VA; Harford County, MD; Frederick, MD). Within Virginia, more than 50% of the counties had fewer than 10 projects and 25% of all projects within the state were from only two counties (Augusta and Rockingham); project density by county area varied from 0.005 - 0.25 projects per square mile. Within Maryland, while project density by county area was higher (0.06-0.57 mi^{-2}) and projects were more evenly spread among counties, over 50% of the projects came from 7 counties. Within Pennsylvania, project density by county was (0.004-0.l7 mi^{-2}) and one third of the projects were from only three counties (Lancaster, Bradford and Franklin).

Most projects in the database reported project size based on length of stream restored and for these, the average size was 3200 ft while the median size was 1500 ft. When 20 projects with reported lengths >5 miles were excluded the mean project length was 2600 ft. Approximately 37% of the projects were < 1000 ft in length.

Restoration Project Goals and Activities Implemented or Planned

Watershed-wide goals. Of the 13 categories of project goals, four categories accounted for 60% of the CBW projects (Table 1.2). The most frequently reported goal that appeared in the project records we obtained was riparian zone management (63% of all projects stated this goal) (Figure 1.3). Planting riparian buffers and installing fences to exclude livestock from streams were the two most common activities associated with this restoration goal (Figure 1.4). The second most commonly stated goal (36%) was water quality improvement,

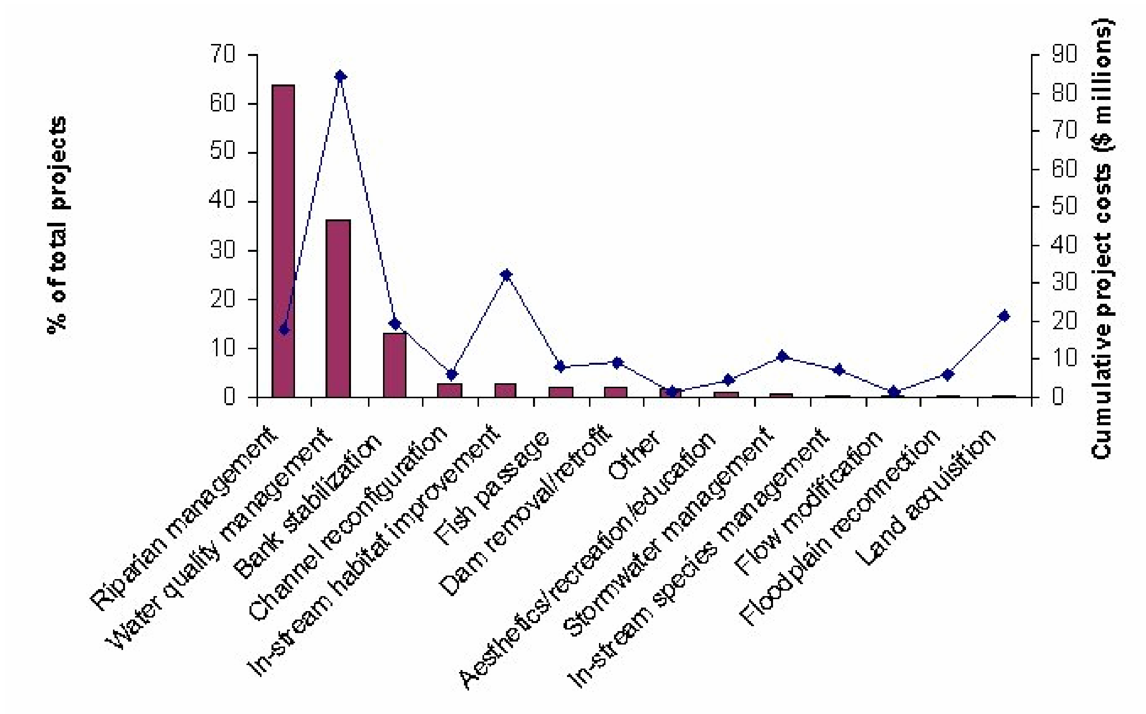


Figure 1.3 Distribution of project goals (N = 4224 projects) and cumulative project costs for each category (N = 1710 projects) on the secondary axis. Riparian management and water quality improvement were the most frequently stated restoration project goals.

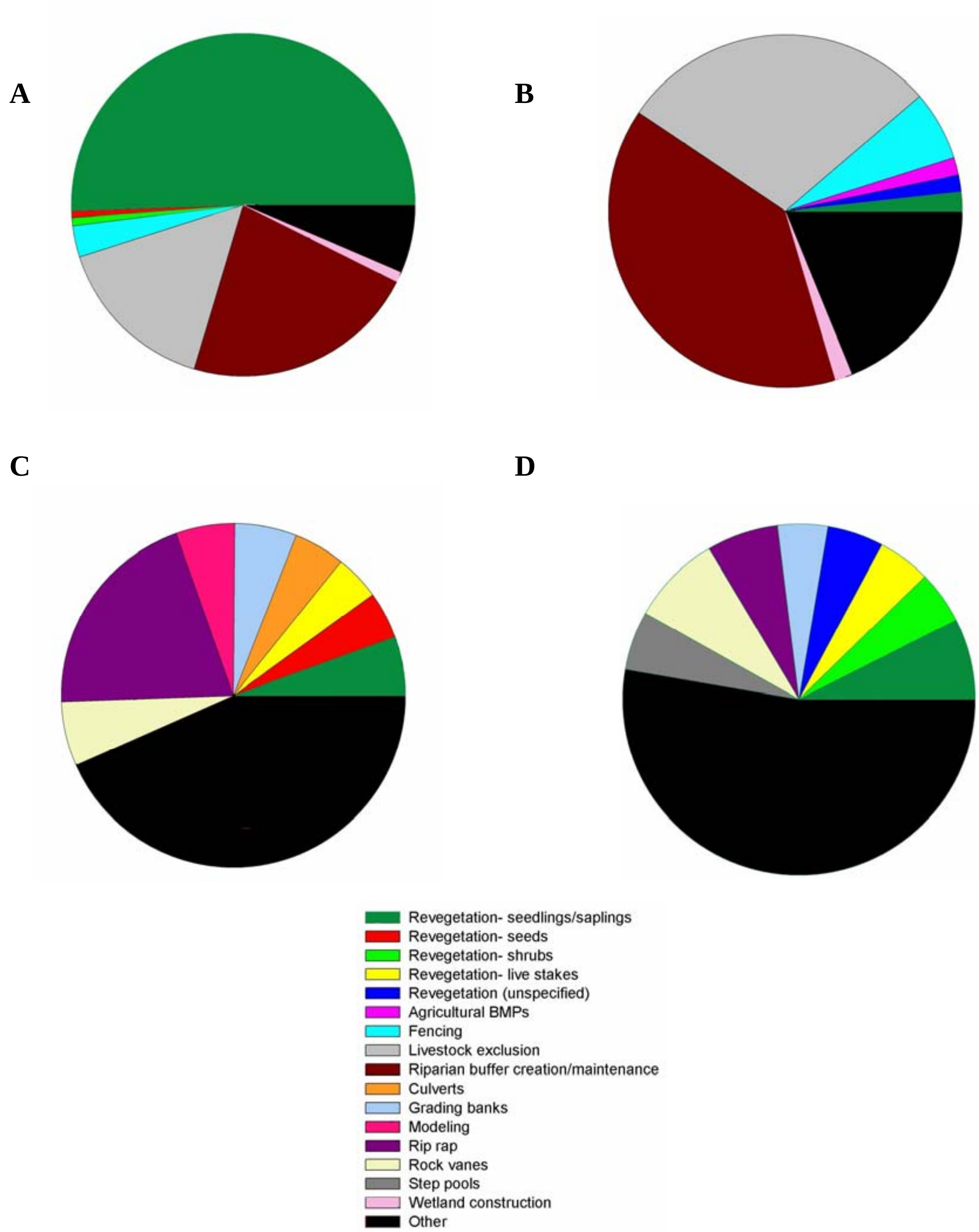


Figure 1.4 Distribution of main activities used in projects stating **A**) riparian management **B**) water quality improvement **C**) bank stabilization and **D**) in-stream habitat improvement as project goals. Note that all individual activities not itemized within each chart are consolidated in the "other" category.

defined as protecting existing water quality or improving the chemical composition or reducing the amount of sediment in suspension. These types of projects cited a wide range of planned actions, including the implementation of agricultural best management practices and the creation of riparian buffers or wetlands. The third most commonly stated goal (13%) for restoring streams and rivers in the Chesapeake Bay watershed was stream bank stabilization and included practices designed to reduce or eliminate erosion or slumping of bank material into the stream channels.

Many projects had more than one stated restoration goal. For the 34% of project records with multiple goals, most (86%) included either or both riparian management or water quality improvement. Bank stabilization projects most often listed channel reconfiguration, habitat improvement and water quality management as accompanying goals.

Although riparian management projects were numerically dominant, the vast majority of these projects were small in scale and costs (average cost ~$6000), and many may involve little more than the planting of a few trees in the riparian zone (e.g., to replace trees lost during the restoration implementation process). Most of the restoration funding is aimed at more expensive projects (Figure 1.3). Water quality improvement projects (average cost ~$58,700) accounted for 43% of all restoration expenditures (Figure 1.3). Seventeen percent of total restoration funding was spent on improving in-stream habitat (average cost ~$462,000). Land acquisition directly related to stream restoration was relatively rare but expensive (11% of all funds were directed to 12 projects with an average cost of $1.8 million) (Figure 1.3). The other most expensive project types were floodplain reconnection (average cost ~$422,000) and in-stream species management (average cost ~$358,000) projects, yet these project goals were relatively uncommon within the CBW.

Regional goals

Project goals varied considerably among counties that are dominated by rural vs. urban regions. In metropolitan counties (as classified by the USDA, Economic Research Services' rural-urban continuum codes, ERS 2003), including the Baltimore, Washington D.C., and Richmond regions, riparian management (59%), water quality improvement (27%) and bank stabilization (23%) projects were the dominant types of restoration. These projects were typically smaller in scale (median project length ~ 1100 linear feet for the 1685 projects that reported length) and the median cost for these types of projects was $12,400 (95% CI = $115,700 ± 55,000 N = 652 projects). In non-metropolitan counties that were primarily rural (i.e., no cities with >2500 people), the vast majority of project records (92%) listed riparian management as a goal but water quality control was also common (55%). The median length of projects in non-metro areas was ~ 2100 feet (1352 projects reported length), and the median cost for these projects was $6,700 (95% CI = $34,500 ± 14,000 N = 1156 projects). The median length of restoration projects using some form of livestock exclusion was 2500 linear feet (N = 489 projects). In urban areas, riparian management projects were substantially smaller. The median length of an urban riparian management project was 928 linear feet (N = 238 projects) and the median area was 2 acres (N = 234 projects).

Project Costs

Only 40% of the project records reported costs but the total expenditures for these exceeded $194 million (Table 1.3). Between 1990 and 2003 alone, more than $158 million was spent. For the three focal states, expenditures for that 13-year time period were $71.2

Table 1.3 Summary data for restoration projects within each stated goal category. For details on goal definitions see Appendix B.

Intent	# Projects	Total Cost ($millions)	% Reporting Cost	Mean Cost ($millions)	Median Cost ($millions)	Total Length (miles)	% Reporting Length
Aesthetics/ Recreation/ Education	56	4.8	23	0.37	0.025	8	14
Bank Stabilization	611	19.4	18	0.17	0.061	94	86
Channel Reconfiguration	136	6.2	52	0.33	0.14	27	85
Dam Removal/ Retrofit	88	9	64	0.16	0.017	0.02	2
Fish Passage	96	8.3	8	1.0	1.3	2.6	12.5
Floodplain Reconnection	15	6.3	73	0.57	0.39	5.4	40
Flow Modification	18	1.3	39	0.19	0.050	2.4	72
Instream Habitat Improvement	128	32.3	55	0.46	0.087	41	56
Instream Species Management	21	7.5	86	0.41	0.076	0.5	5
Land Acquisition	14	21.5	86	1.8	0.75	0.25	7
Riparian Management	2991	18	43	0.014	0.006	1334	75
Stormwater Management	45	10.7	66	0.36	0.21	10	33
Water Quality	1701	84	84	0.058	0.008	727	49

for Maryland, $31.1 million for Pennsylvania, and $34.4 million for Virginia. The average cost of a restoration project in the CBW regardless of goal was $86,700.

Expenditures within the bay account for <5% of estimated national expenditures on river restoration since 1990 (data from Bernhardt *et al*. 2005), despite the fact that the Chesapeake Bay region has the highest project density of any region in the U.S. The average project costs within the CBW are an order of magnitude lower than the national average cost for river restoration projects ($360,842 for ~37,000 projects). This discrepancy between the CBW and the rest of the U.S. is likely due to the large number for CBW projects derived from three large databases on riparian reforestation projects (59% of total projects, representing Conservation Reserve Enhancement Program funded by the US Farm Service Agency in Maryland and Virginia and the Pennsylvania Stream ReLeaf database). It is currently impossible to determine if the CBW region is doing disproportionately large amounts of riparian re-vegetation or if CBW agencies are merely doing a better job recording these activities.

Most funding for stream and river restoration in the CBW comes from state or federal sources, but other sources of funding, such as nonprofit organizations and private companies, were also occasionally reported. Cumulative expenditures for the projects in our database exceeded $194 million. However, because only 40% of project records included some information on project costs, expenditures were surely much higher. When estimated costs are extrapolated[1] to include the total number of projects in the database from 1990-2003, an estimated $426 million had been spent on

[1] To estimate costs for the 4528 project records in our database that occurred between 1990-2003 (date of completion, implementation, or permitting fell within this time period), we multiplied the number of records without cost data (N=2670) by the average project cost for records that included cost information (N=1858; mean project cost $86,763), giving us an estimated $231 million in unrecorded costs

stream restoration within the Chesapeake Bay watershed. This suggests an average project cost of $94,000. If we exclude the 25 most expensive projects (costing $1 million or greater, together totaling $86.4 million), the average per project cost is approximately $41,000.

Project monitoring and assessment

Only 5.4% of project records in the database indicate that some type of project monitoring was performed. Excluding projects from the large riparian re-vegetation databases, 17% of project records indicated monitoring. The proportion monitored varied depending on the data source: 16% of project records that were from agency summaries and 22% of project records obtained from progress reports indicated some form of monitoring was completed. However, agency summaries and progress reports made up only 2% of our total database. For projects that did report monitoring, rarely (<1%) were the extent or the duration of monitoring reported in the project records. While the overall fraction of projects monitored is quite low, this fraction did vary across project goals (Figure 1.5). Fish passage and floodplain reconnection projects were most likely to be monitored (73% of 111 projects). Forty-two percent of storm water management projects (N = 45) indicated monitoring. Only 1% of riparian management projects stated that monitoring was performed. For all projects that were monitored (N = 257), most (59%) of the planned or completed monitoring was biological (e.g., sampling fish, macroinvertebrates, plants, etc.). Only 36% of the 257 monitored projects had evaluated water chemistry and only 24% assessed physical structure.

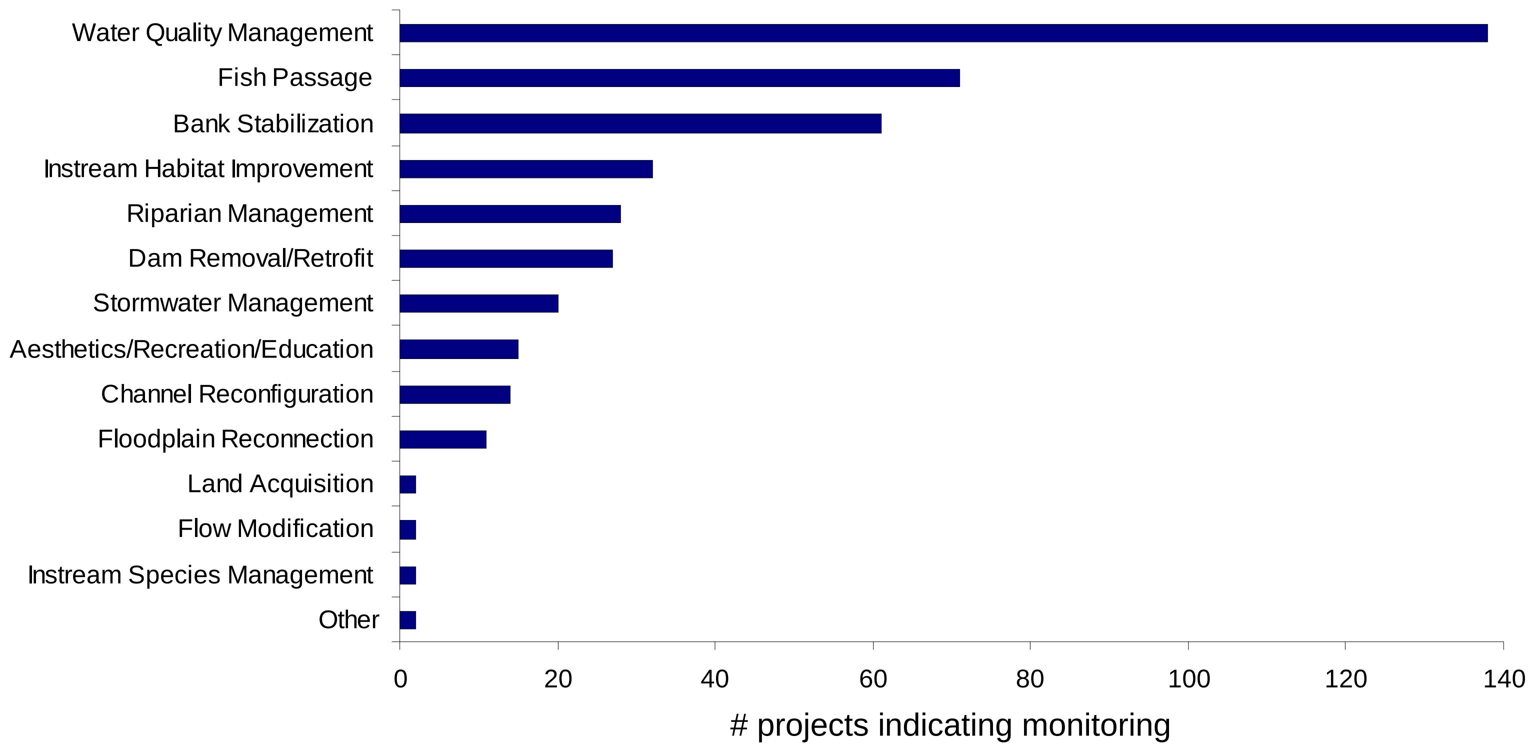


Figure 1.5 Distribution of monitored projects across the thirteen goal categories. Note that most projects (93%) gave no indication of whether or not monitoring was completed.

Discussion

Restoration of coastal waters is a high priority regionally and globally yet only recently have such efforts adopted whole watershed approaches which include the restoration of streams and rivers flowing to coastal areas (e.g., Williams *et al*. 1997, Lamy *et al*. 2002). A coordinated watershed-wide stream restoration program in the Chesapeake Bay region does not yet exist; however, our results documenting vigorous efforts at many localities are very encouraging (Figures 1.1 and 1.2). An exceptionally large number of projects have been initiated in the CBW compared to other basins in the nation of comparable size and that number is growing (Bernhardt *et al*. 2005). Certainly this has been influenced by the fact that restoration of the Chesapeake Bay has received much national attention as well as direct congressional funding. Notably, we found that in general, the goals for projects in our database match fairly well with the Chesapeake Bay Program goals – 70% of the stream restoration project records we obtained target improved water quality or riparian habitat. The former is an explicitly stated priority of the CBP and the latter is one of several recommended strategies associated with that priority.

The large number of projects in the CBW is extremely good news if these projects are effective at achieving the stated goals. While we know of a few projects in our respective regions that have been rigorously monitored, only 5.5% of the project records in the database indicated that assessment or monitoring was planned or completed. For riparian management, less than 1% of the project reports indicated assessment. These percentages are lower than found for other regions in the United States that Bernhardt *et al*. (2005) evaluated using identical data collection methods.

The low rate of recorded monitoring activity may result from the fact that several major project databases do not track monitoring activity or that monitoring information is not always tied to specific projects. For example, tree survival from riparian plantings has recently been rigorously evaluated at 130 randomly selected sites in Maryland (Pannill *et al*. 2001) and a smaller number of sites in Virginia (Hariston-Strang, MD Department of Natural Resources – Forest Service, *personal communication*). Further, some jurisdictions have regional monitoring plans that cover areas in which restoration projects had occurred (Boward *et al*. 1999). However, these caveats are also true for many other parts of the country where Bernhardt *et al*. (2005) found significantly higher reported rates of restoration assessment. Thus, a central finding of our work to date is that assessment and monitoring of a large fraction of projects that may lead to restoration of the Chesapeake Bay Watershed are lagging behind many regions of the country.

Detailed interviews with project managers and field evaluations of past restoration sites will be needed to determine the effectiveness of various restoration approaches. However, even without this additional work, this database represents a valuable resource for the future planning of where new projects should be implemented, what information could be required to improve future tracking efforts watershed-wide, and how monitoring efforts and reporting can be strengthened. Further, because so many projects have been completed in the CBW *and* these projects span diverse goals and approaches that are used all over the U.S., this watershed could be a "testing ground" for determining what stream and river restoration approaches are most effective. There is relatively good information on where projects are located or planned and what activities were or will be done to implement them. With this database, we are poised to identify project types or regions that should be further investigated. For example, it may be important to begin by conducting effectiveness studies on completed project types that are the most costly or the most interventionist to determine their environmental value relative to less expensive or simpler approaches (e.g., habitat improvement or channel reconfiguration vs. riparian planting alone). It may also be useful to look at project density by basin or by location within a basin to determine if restoration project siting compliments efforts in other regions of the watershed.

Typically, monitoring and assessment efforts require small monetary investments compared to the cost of restoration implementation. Thus, well-planned studies of project effectiveness would not be extremely costly, but the findings from such studies would help inform emerging restoration efforts in other regions of the country (e.g., there is current interest in developing coordinated restoration programs for tributaries of the Great Lakes and Gulf of Mexico). In short, by investing a small amount relative to total project costs, we could evaluate the local and regional benefits of different restoration practices. This information could not only inform future restoration efforts in the CBW but efforts throughout the nation.

Number, distribution, and size of projects in the CBW

Far more projects were implemented in Maryland than in Virginia or Pennsylvania, and within Maryland just a few counties (e.g., Harford, Frederick, Baltimore, Montgomery) contained the vast majority of project records we obtained. Recent findings suggest that explaining regional differences in restoration efforts anywhere in the U.S. requires a complex analysis of socio-cultural, economic, policy, and environmental factors (D. Norton, Environmental Protection Agency, Office of Wetlands, Ocean and Watersheds, *personal communication*). For some regions, strong local interest, economic and employment conditions, or effective leadership can explain differences between minimal resource allocations to restoration vs. major initiatives (Nolan 2004).

While many projects are being completed in the CBW, most of these are quite small (median size = 1500 ft of stream length). This raises the concern that if numerous small projects are not coordinated using a watershed perspective, they may not be very effective (Bohn and Kershner 2002; Roni *et al*. 2002). In some cases, large-scale constraints are so severe (e.g., large amounts of impervious cover leading to flooding and erosion of downstream restored reaches) that one must question whether restoration of single reaches is an appropriate use of valuable resources (Palmer *et al*. 2005). However, with sufficient watershed planning, the cumulative effects of multiple projects may yield great ecological benefits. These benefits may be particularly significant if they include prioritization of highly degraded (e.g., 303d listed streams) or ecologically sensitive (e.g., headwater streams) regions of the watershed. While we do not have information on stream size in the present database, we did compare our records to state level 303d listings and found that in Maryland and Pennsylvania, 64 and 67 (respectively) restoration records in our database were for projects on waterways that are 303d listed with developed TMDLs. However, this information must be cautiously interpreted because listing streams as impaired is based on criteria and standards that are unique to each state; it is extremely difficult to make cross-state comparisons.

Restoration project goals and activities implemented or planned

Riparian management was the most common explicitly stated goal in project records and typically included re-vegetating areas by planting saplings, seedlings, seeds, or live stakes. Since re-vegetation was also an activity reported in projects with the goal of stabilizing banks, improving water quality, or in-stream habitat (Figure 1.3), one could argue that the focus on restoring riparian zones is even more common than at first glance. Indeed, 72% of all projects report re-vegetation, riparian buffer creation, or riparian management. This likely reflects the widely held view that replanting of the riparian zone will have multiple benefits from reducing sediment and pollutant run-off, to increasing biodiversity and creating wildlife habitat (Naiman *et al*. 2005). However, recent work has shown that replanting riparian vegetation is not a panacea – while continuous, forested buffers may reduce nutrient levels in agricultural streams (Weller *et al*. 1998) and may enhance biodiversity, even in urban streams (Moore and Palmer 2005), grass buffers may be far less effective at reducing nutrient loads (Sweeney *et al*. 2004) and we do not yet know if any form of buffer in urban settings with complex storm water infrastructure can effectively reduce nutrient loads to streams. Further, we do not know what fraction of the CBW riparian projects consist only of preventing mowing (and thus created grassy buffers). We do know from the study of Pannill *et al*. (2001) that in Maryland, tree survival rate after 1-3 years is about 60%; the next step is to follow tree survival over much longer time periods and determine the direct water quality and habitat benefits.

Lessons learned and conclusions

Our analysis indicates that stream and river restoration efforts are quite numerous in the Chesapeake Bay Watershed and that recent efforts to develop tributary strategies for the region may enhance those efforts. Our database of 4700 projects is the most comprehensive to date and indicates large regional differences in restoration activities but commonalities in goals. The goals of improving water quality and managing riparian zones fit in quite nicely with the goals that have been set via interstate agreements aimed at restoring the Chesapeake Bay. However, monitoring rates appear to be quite low and are often directed at merely determining if the project remains 'intact' (e.g., to determine if bank stabilization structures are still in place months to a year after implementation).

Explanations for the low rate of monitoring in the CBW compared to other regions of the country can be partly derived by considering the government policies that have provided the sources of funding for projects. Two policy initiatives have resulted in the majority of related monetary support. These include the use of riparian reforestation to address nonpoint source pollution problems in the CBW and the regulatory approval of physical stream rehabilitation as mitigation for stream impacts associated with development. For the case of riparian reforestation, the large spatial scale of implementation has led to the assumption of water quality benefits to the Chesapeake Bay estuary using monitoring results from a small number of research sites (Lowrance *et al*. 1995). For the case of physical stream rehabilitation, projects are often focused on the resolution of regulatory permitting issues, which emphasizes the satisfactory construction and not the long-term physical or ecological performance of a proposed channel design. The fact that the water quality and habitat benefits from stream restoration may not be attained for a decade or more has further complicated the development of long-term monitoring initiatives and related funding sources.

While there has been a historical focus on restoring tidal waters and shorelines along the Chesapeake Bay, emerging science documenting the benefits of upland restoration indicates that the development of a coordinated stream and river restoration program would be beneficial. Entities such as the Chesapeake Bay Program are poised to provide leadership in this arena. In particular, it is essential that efforts be made to encourage common criteria for tributary strategies and to encourage the linkage of strategies across state lines when sub-watersheds cross these lines. If the Chesapeake Bay Agreement signatory states have unique strategies that are based on different endpoints and different assessment tools, then progress in improving inland and coastal waters in the CBW will be hindered. In much the same way that 303d listings are difficult to compare across states, accomplishments (or lack there of) linked to tributary strategies will also not be comparable.

Agencies working within the Chesapeake Bay watershed can provide a progressive example of integrated watershed management a model for truly integrated watershed management and restoration. This requires a centralized tracking system for nontidal river and stream restoration in a manner that expands the scope of activities to include those associated with the rehabilitation of ecological functions. Optimally, tracking should involve 1) cataloging project location data, 2) implementing consistent project performance evaluations, and 3) analyzing data from individual project monitoring. Although an expanded water quality monitoring network has been proposed (CBP 2004b), given the importance of holistic stream and river restoration to the health of tidal ecosystems, an evaluation of progress and coordination of efforts at the whole-watershed scale will be difficult without improved tracking capabilities. Further, far more substantial investments in performance monitoring need to be made, particularly for those projects that are highly interventionist (e.g., re-configuring channels) or expensive. Since the performance of restoration practices can vary with the landscape setting, tracking how restoration actions function in different locations is critical. If even a small percentage of the total restoration dollars spent annually throughout the CBW were devoted to comprehensive monitoring and reporting results, significant advances could be made in targeting projects and accounting for their cumulative benefits. Monitoring the outcome of restoration efforts is the only way to identify the most effective strategies given limited financial resources.

Chapter 2: Evaluating stream restoration in the Chesapeake Bay watershed through practitioner interviews

Introduction

I have already presented results from the first comprehensive study of non-tidal river and stream restoration in the Chesapeake Bay watershed (Chapter 1). The results were based on analysis of 4700 written records for restoration projects completed within the Bay watershed over the past two decades. These records were collected as part of the National River Restoration Science Synthesis (NRRSS) project (Bernhardt *et al*. 2005) which was focused on documenting the number, types, costs, and outcomes of restoration projects throughout the country. We found that the density of river restoration projects per river mile is higher for the Chesapeake Bay watershed than for the rest of the country. Most projects within the Chesapeake Bay watershed were implemented to manage riparian zones and/or improve water quality. An explicit goal of the NRRSS project was to identify what factors were linked to stream restoration effectiveness. Such information could inform future efforts and lead to more ecologically beneficial and cost-effect restoration programs (Palmer *et al*. 2005). Unfortunately, we found that written project records were not adequate to evaluate project effectiveness (Bernhardt *et al*. 2005, Hassett *et al*. 2005). Less than 10% of the project records indicated that project monitoring was planned or implemented and, if monitoring had been done, the results were not documented in writing or were not publicly accessible.

Since we could not evaluate project success based on written records, we took an interview-based research approach to collect information directly from restoration project managers or the person most closely involved with a particular project. We viewed this additional research as critical because of the urgent need for information on restoration effectiveness (Powledge 2005). The Chesapeake Bay has been in serious ecological decline over the past century (EPA 1982, Kemp *et al*. 2005) and much of this has been attributed to non-point source runoff that reaches the Bay via the many stream and river tributaries (Boesch *et al*. 2001, Fisher *et al*. 2006). Stream restoration and watershed management are integral parts of the Bay restoration program (CBP 2003, CEC 2004, CBP 2005), and, each state within the Bay drainage has been required to develop strategies for improving water quality in its tributaries (CBP 2005). Knowledge about the most effective restoration approaches should inform those strategies.

The need for information on restoration effectiveness is not unique to this watershed (Palmer *et al*., *in review*). Demonstrating successful restoration has been widely discussed in the scientific literature and certainly much of the focus has been on demonstrating ecological 'improvements' (Bradshaw 1996, Cairns 2000, Ehrenfeld and Toth 2001, Ward *et al.* 2001, Hobbs 2003, Gillilan *et al*. 2005, Jansson *et al*. 2005, Palmer *et al*. 2005). Documenting improvements following restoration may take many forms and a variety of biological, chemical, and physical monitoring protocols exist (e.g., Barbour *et al*. 1999, Kayzak 2001, Roper *et al*. 2002). Verifying improvements in these parameters can be difficult because ecological systems are highly variable and the time to ecosystem recovery can be quite long (Lewis *et al*. 1996, Shields *et al*. 2003). For these reasons, progress must be measured relative to some existing or preferred reference state or relative to prior condition. Recognizing this complexity, we worked with a large group of scientists and practitioners to develop general criteria for judging ecological success in restoration (Palmer *et al*. 2005). Those criteria emphasize that restoration is a process rather than a fixed endpoint, thus if monitoring demonstrates that a restored stream is on the desired restoration *trajectory* (e.g., biodiversity or nutrient loads are becoming more similar to reference sites), the project should be considered successful (Bradshaw 1996, Lockwood and Pimm 1999, Jungwirth *et al.* 2002). Our criteria also emphasize that judgments of restoration 'success' could go beyond evaluation of ecosystem improvement to consider how well the stream project was linked to other efforts within the watershed or if the project contributed to advancing the field of restoration.

Because of the paucity of published monitoring data (Roni *et al*. 2005), other than for a few highly documented projects, (e.g., Kondolf *et al*. 2001, Smith and Prestegaard 2005), we asked restoration practitioners and managers to evaluate success based on their experience with individual projects and then we considered their responses in relation to the five success criteria proposed in Palmer *et al*. (2005). Evaluating achievements or accomplishments using self-reported data from oral interviews is common in the social sciences (Heppner *et al*.1992, Leong and Austin 1996, R.E. Fassinger, *personal communication*) but quite rare for the non-medical physical and biological sciences. Thus, we began this study cognizant of potential biases in the data we collect (e.g., interviewees may interpret project process and outcome in a more positive light than deserved; see McFall *et al*., *in review*). The results we report are expressions of interviewees' views on project success and while they do not replace results of a rigorous effectiveness monitoring program, they are a rich source of information because those we interviewed have had extensive experience with restoration.

I analyzed 47 independent phone interviews conducted with project managers or other individuals who were closely associated with overseeing different stream restoration projects within the Chesapeake Bay Watershed. I used a carefully designed and calibrated interview protocol (Appendix C; description in Bernhardt *et al*., *in review*) that consisted of 90 questions within five areas spanning the verification of basic project information, project design and implementation, monitoring, and evaluation of project outcomes. I use the data gathered from the interviews to: 1) characterize patterns in project goals, design, and expenditures; 2) determine what fraction of the projects were evaluated (monitored) and what criteria project managers used to evaluate restoration success; and, 3) characterize project success as reported by interviewees and ask if success is related to project goals, design, or monitoring.

Methods

A stratified, random subsample of projects was selected from the Chesapeake Bay data ("summary database"; see Chapter 1) within the national NRRSS database as candidates for interviews. Projects were eligible to be selected from the database if they i) occurred within the geographic boundaries of the Chesapeake Bay watershed; ii) were implemented or completed between 1996-2002; iii) had project contact information (e.g., an individual or agency name allowing for follow-up); iv) listed at least one of the four specific project goals that the NRRSS group chose to examine at the national level (water quality improvement, in-stream habitat improvement, riparian management, or channel reconfiguration). Within each goal category, all projects meeting the above eligibility requirements were randomly assigned numbers and 12 projects were selected from each of the four goal categories. Attempts were made to schedule an interview with the project contact beginning with the lowest assigned number in each category. Once an interview was conducted, the project record was removed from the pool of candidate projects so no project could be selected multiple times for an interview. I was unable to conduct interviews on 109 of the projects that were randomly selected because: efforts to locate or contact the project manager were unsuccessful (N = 44 projects), the contact person for a project had previously been interviewed about another project (N = 43), the project had not yet been completed (N = 16), or the project contact was unable or unwilling to participate in an interview (N = 6). The target was to complete 48 phone interviews, with 12 from each goal category; however, for one category I was only able to conduct 11 interviews.

After more than a year in development and calibration, the interview format was completed in May 2004 and subsequently underwent Institutional Review at the University of Maryland. The full set of NRRSS interview questions and the protocol is in Appendix C. Questions were related to one of five topics: project design, implementation, coordination, monitoring, and evaluation. I conducted interviews by telephone, as prior studies suggested that subjects provide more “honest” responses in telephone interviews as compared to mail or face to face surveys and response rates are generally higher (Yu and Cooper 1983). Telephone interviews were logistically preferable to interviewing practitioners in person.

Interviews were completed during the April through August 2005. At the first contact, the interviewee was told the goals of the NRRSS project and the objectives of the interview. If they agreed to participate in the interview, they were sent a one-page summary of the interview topics along with a confidentiality agreement explaining that their name and any identifying information would not be retained and that all project results would be discussed in aggregate form. Each phone interview was taped with the knowledge and consent of each subject to facilitate data entry and quality assurance. Interviews typically lasted between 20 and 45 minutes and every subject was asked questions in the same order from a script. Through an initial calibration process (Bernhardt *et al.*, *in review*), the NRRSS interviewers developed standard prompts for defining terms or clarifying questions when asked by the interviewee. For most questions, I asked the question and allowed an open-ended response, which was then categorized. Thus the data consist of categorical responses to questions about project design, implementation and evaluation and open text descriptions of monitoring methods and lessons learned.

Once phone interviews were completed, data were entered into a Microsoft Access database and analyzed using queries to summarize trends in responses to individual and related questions. All information that would identify a specific project or interviewee was removed from the database as required by Institutional Review Board guidelines, thus results ("interview database") are discussed only in aggregate form.

Interview results represent data from 11 projects in Virginia, 15 projects in Pennsylvania and 21 projects in Maryland. Interview participants identified their roles in the projects as: manager/coordinator (79%), designer (25%), implementer (25%), evaluator (11%), consultant (4%) and funder (2%); some interviewees classified themselves in more than one category. Restoration projects were conducted in watersheds that interviewees characterized as urban (20%), suburban (20%), agricultural

(20%), mixed land use watersheds (20%), as well as in undeveloped watersheds (15%). One half of the projects occurred on privately owned land.

Results

Project Goals, Design and Funding

Most (91%) projects for which interviews were completed had more than one goal, and often including goals other than the four categories we used to initially select projects for interviews. The most common project goals interviewees reported were water quality improvement, in-stream habitat management, riparian management, bank stabilization and channel reconfiguration (Figure 2.1). When multiple goals were named, I asked the interviewee to identify the *primary* goal. The most common primary project goal reported was to improve water quality (30%); the other frequent primary goals were bank stabilization (19%) and channel reconfiguration (19%) (Figure 2.1). Interviewees indicated that 57% of projects were initiated because of environmental degradation (Figure 2.2A). Only 4 projects were implemented due to mitigation requirements and most (64%) of the projects were prioritized over other possible restoration projects because of ecological concerns (Figure 2.2B). Land availability (36%) and concerns about deteriorating infrastructure (26%), such as bridges, roads, culverts, sewer outfalls, were also common reasons why restoration projects were prioritized within the watershed (Figure 2.2B). Over 70% of the individuals I interviewed reported that their projects were linked to other planned or completed projects on the same river and one-third of the projects were part of a watershed management plan. Half of the projects included some form of watershed assessment.

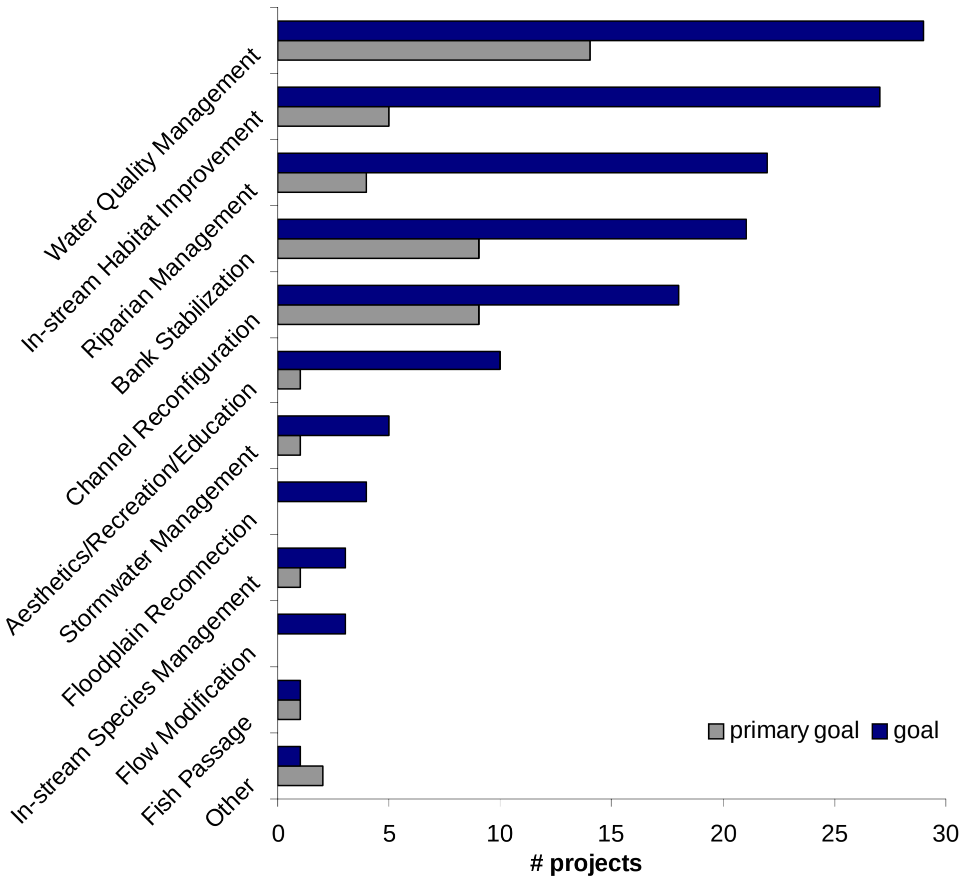


Figure 2.1 Project goals as reported by practitioners for 47 projects. The top bar (black) contains all goals of the project while the lower bar (gray) second data series contains the primary goal identified by the interviewee.

A

B

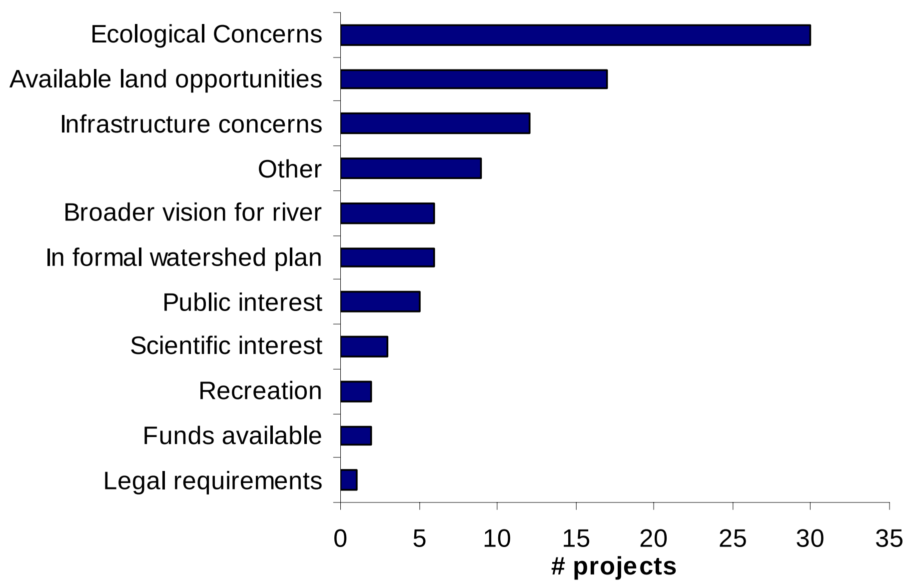


Figure 2.2 Reasons for project initiation and factors influencing project prioritization. (**A**) Interviewee responses when asked why projects were initiated. 12 projects indicated various reasons ("other") that could not be broken into smaller categories. (**B**) Factors that influenced prioritizing projects over other possible restoration projects.

With respect to project design, interviewees reported that they relied on knowledge from a wide range of disciplines and a wide range of people or agencies in developing their design. Previous experience with other restoration projects was the most common information used to design projects. Agency guidelines and expertise in geomorphology, engineering and hydrology were also frequent knowledge sources cited by interviewees as useful in restoration project design. Specific areas of expertise cited by practitioners did not differ significantly among the different project goals. Private consultants designed 49% of the surveyed projects, while the remaining project designers were equally distributed among state agencies, city or county agencies, or local or regional authorities, such as soil and water conservation districts. When provided a list of possible factors influencing project design, survey participants chose “ecological opportunities” to be most important in determining the final project design (Figure 2.3). The definition of ecological opportunities was not provided, nor was the definition of “ecological impacts,” another factor frequently chosen as important to design. Although some participants asked for clarification on the difference between the terms, the working group had not developed standardized definitions of each. Interviewees reported that “location-specific limitations” and “project costs” were also highly influential in determining final designs (Figure 2.3). Other options interviewees were provided for answering this question included: “requirements/mandates”, “stakeholder preferences”, “available expertise”, and “other.”

Federal and state agencies were the most frequent primary funders of restoration projects in both the summary and interview database (Figure 2.4). Costs reported in the interviews were significantly higher than was reported for the same projects in written

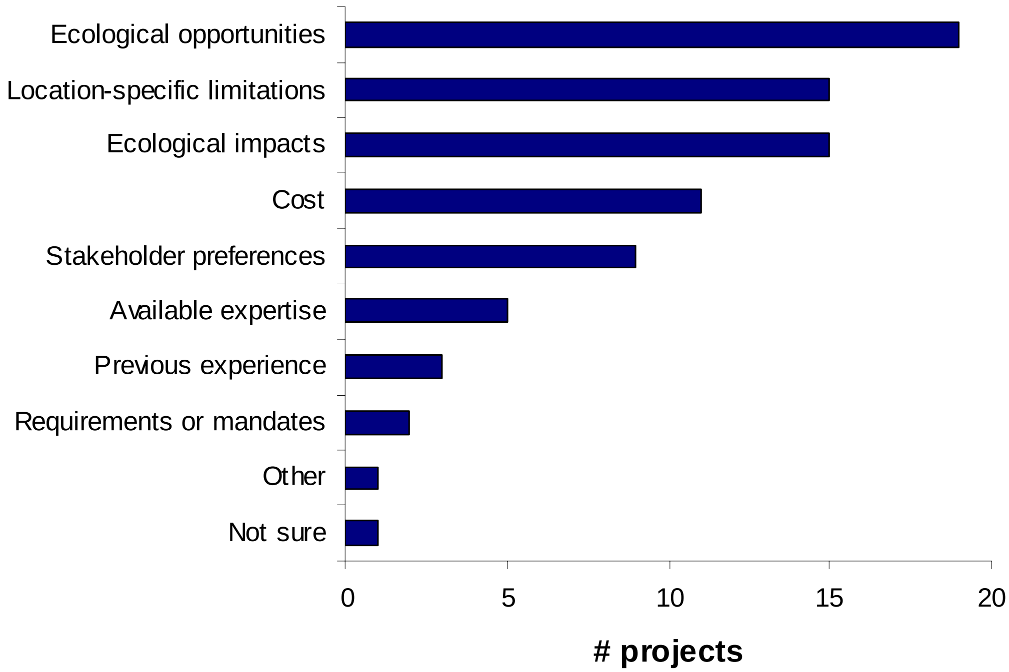


Figure 2.3 Interviewee responses when asked what factors influenced final project design. Note that interview subjects were asked to choose one or two categories from the provided list.

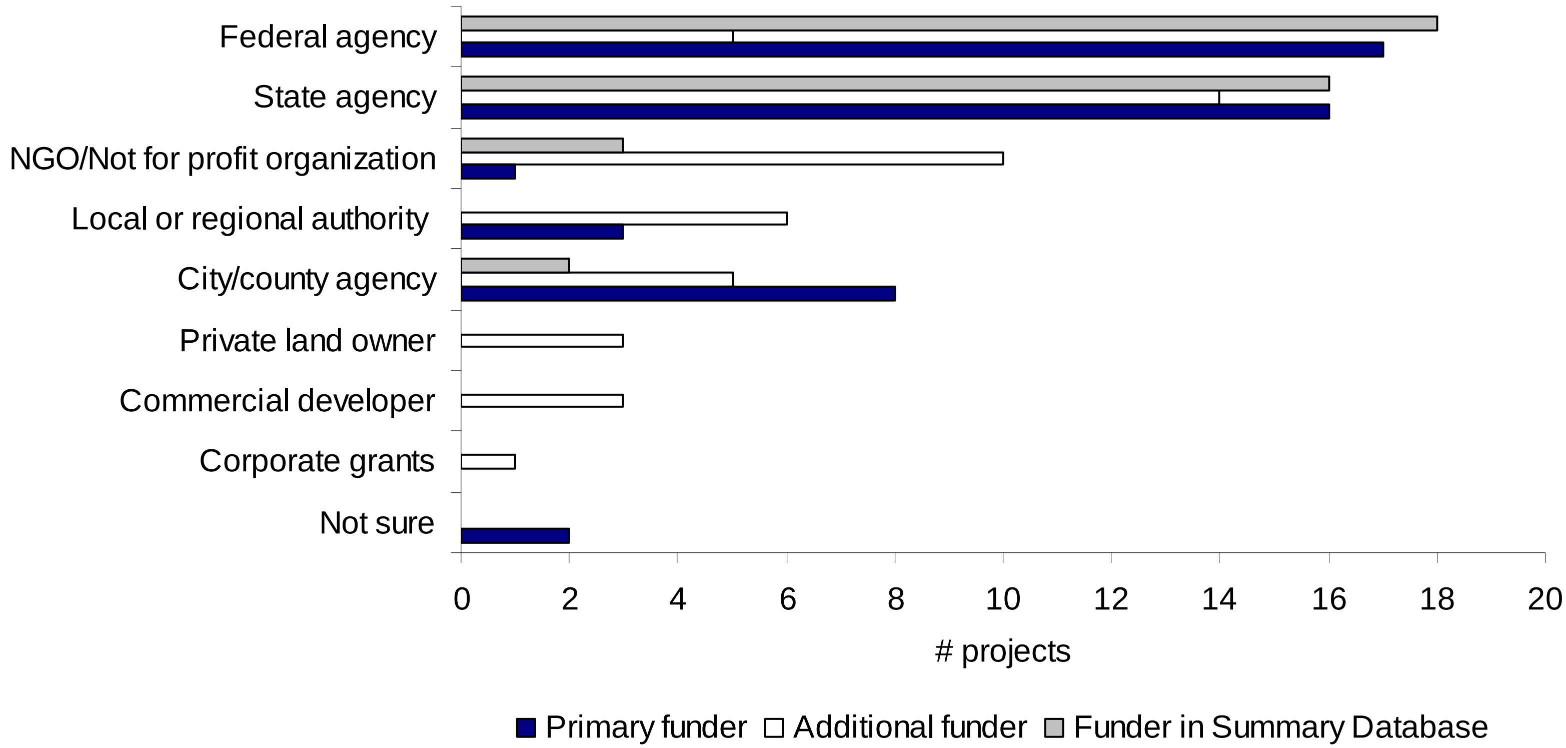


Figure 2.4 Distribution of project funders. Organizations identified as primary project funder in the survey are represented separately from entities identified as secondary, or additional, funders. This is compared to funding information in written records from the Summary Database (Chapter 1).

records. The mean and median costs for those projects for which I conducted interviews were $308,909 and $150,963, whereas the mean and median costs for the same set of projects as reported in the written records (summary database; Chapter 1) were $269,350 and $97,348, respectively. In terms of financing projects, the written records and interview data were consistent in that federal and state agencies played an important role; however, written records did not give the appropriate credit for project funding by local, non-governmental or non-profit organizations.

Evaluation Criteria and Monitoring

Project monitoring can provide quantitative documentation of ecosystem response to restoration efforts, but it can be time-consuming and expensive. The most common factors that enabled monitoring were personal commitment to monitor (reported by 50% of those interviewed), an ongoing regional monitoring effort (30%), and local volunteer interest (25%). Most of the interviewees (76%) reported that their projects were monitored in some form; 40% of these measured three or more types of variables, with biological, physical and chemical monitoring being most common (Table 2.1). Data were collected for a total period of 2-5 years for most (60%) monitored projects; many

		Project Success, according to interviewee			
Type of Monitoring	*Total projects*	None	Partial	Too soon to tell	Complete
Biological	24	0	2	1	21
Chemical	18	0	3	0	15
Photo	6	0	2	1	3
Physical	27	1	4	2	20
Observation	6	0	0	0	6

Table 2.1 Categories of variables monitored in survey projects and corresponding success evaluation according to survey participant.

(14%) collected only post-restoration data for monitored variables (the remaining projects collected a mixture of pre- or post- restoration data). Of the 36 monitored projects, 8 also (58%) collected data before and after restoration for *all* monitored variables, while some monitored a reference or control site before and after project implementation (2 additional projects used a reference only before restoration occurred). For those projects that were not monitored, or were constrained from doing additional monitoring, survey participants said monitoring was limited due to lack of funding (72%) or not enough people or time (38%).

Protocols for monitoring were determined in multiple ways: 32% of projects used state monitoring protocols, while 23% of projects chose a monitoring protocol because it had been used for previously collected data. A local or regional conservation group developed the protocol for 19% of the projects and expert advice was cited as useful for choosing 19% of monitoring protocols. While the majority of interviewees indicated they collected monitoring data, only 27 of the 47 interviewed said they analyzed the monitoring results. Of those that did complete an analysis, most (59%) visually compared post-restoration to pre-restoration or reference site data. One fourth (9/36) of the interviewees who monitored projects indicated that statistical analysis was used and monitoring results were reported to an agency or funder for 21 of the projects that were monitored.

Project Success

When asked whether they considered their project successful, 78% of interviewees responded that their projects were completely successful. However, only half of those interviewees reported that they had measurable project objectives (success criteria) explicitly stated during the project design process. Of those with stated objectives, 65% reported meeting these objectives. Fifteen percent of the interviewees considered their projects only partially successful, and only one interviewee reported their project as unsuccessful. If monitoring data were available, they were used to evaluate success in all but 7 cases; for projects not using monitoring data, project success was usually evaluated with observations (17 of 18 projects) (Figure 2.5).

Analysis of the interview results to determine if specific factors were associated with project success was difficult because most projects were judged successful by the interviewees. Thus, we found no relationship between reported project success and project goals (Table 2.2), dominant land use in the project watershed, or the role of the interviewee in the project. Interview subjects most frequently said projects were successful in improving habitat, channel morphology or water quality (Figure 2.6). Subjects who considered their projects only partially successful or completely unsuccessful reported that success was impeded because the ecosystem didn’t respond as expected (29%), there was a structural failure (29%), natural disturbance (29%) or public disapproval (42%).

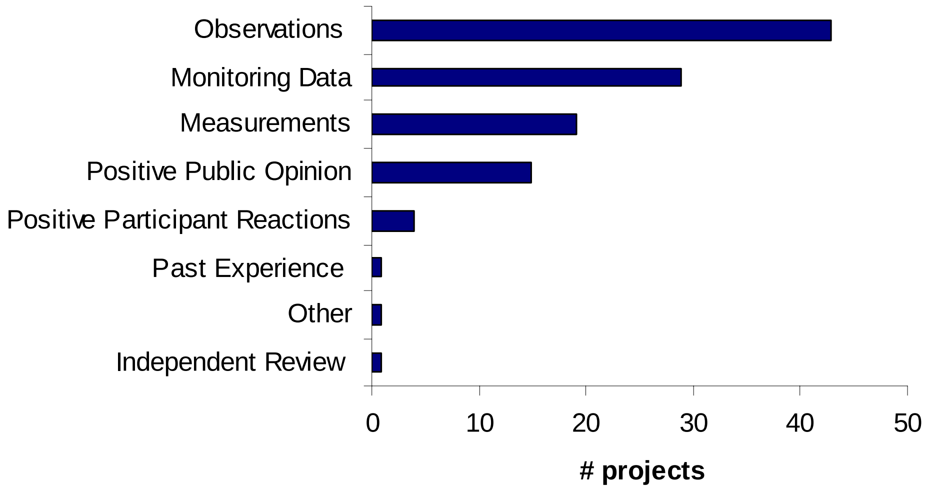


Figure 2.5 Criteria used to evaluate restoration project success as reported by interviewees. Note that 36 projects collected and 29 projects used monitoring data to evaluate success.

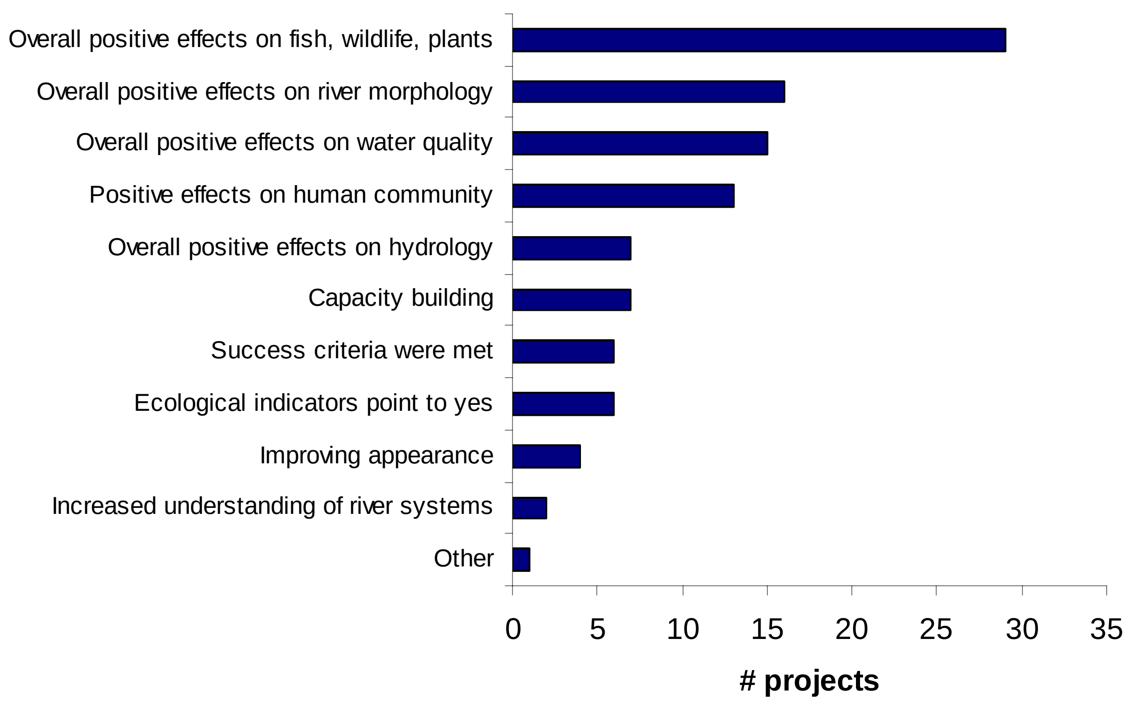


Figure 2.6 Successful aspects of projects considered completely or partially successful by interview subjects.

		Project Success, according to interviewee			
Project Intent	*Total Projects*	None	Partial	Too soon to tell	Complete
Aesthetics/ Recreation/ Education	*10*	1	0	1	8
Bank Stabilization	*21*	0	3	2	16
Channel Reconfiguration	*18*	1	4	1	12
Fish Passage	*1*	0	0	0	1
Floodplain Reconnection	*4*	0	0	0	4
Flow Modification	*3*	0	0	0	3
Instream Habitat Improvement	*27*	0	4	2	21
Instream Species Management	*3*	0	0	0	3
Other	*1*	0	0	1	0
Riparian Management	*22*	1	2	0	19
Stormwater Management	*5*	0	1	1	3
Water Quality Management	*29*	0	4	1	24

Table 2.2 Success of projects containing stated goals, as judged by survey participant.

Discussion

While the remarkably high rate at which project managers report that projects were completely successful was unexpected, it is very encouraging because the need for ecologically effective stream and river restoration has never been greater in the U.S. The result was unexpected because I assumed there would be little documentation of success since written records indicated that only a small fraction (5 -10%) of stream restoration projects in the Chesapeake Bay watershed were monitored (Chapter 1). While interviewees reported that 76% of the projects were monitored in some form, the rigor of monitoring could take many forms (see Bernhardt *et al*., *in review),* ranging from visual observation to statistically analyzing pre- and post- restoration monitoring data from the project site as well as a reference site. Clearly, interviews provide a distinctly different picture of stream restoration in the Chesapeake watershed than accessible written project records (see summary data in Chapter 1).

It is possible that interviewees have a tendency to report an optimistic picture of project outcome – not necessarily intentionally, but perhaps because they aren't enough removed from the project. This form of bias is well recognized by social scientists (Leong and Austin 1996) and its existence in the interview data is suggested by the fact that while 78% of the projects (N = 37) were identified as completely successful, only about half of them (N = 18) had measurable objectives that were identified for the project. Further, of that half only 65% said they met these objectives; thus, only 9 of the 47 projects had clearly defined objectives that were met. At this time, there is no way to evaluate the accuracy of interviewee accounts short of establishing a massive effort to conduct *post facto* field evaluations of their projects. Given how untenable that is, I analyzed the responses of interviewees to the question: "would you make changes to any of the following aspects of the project: partners/team/personnel; project management process; funding sources and their associated requirements; design process; implementation process; permitting; monitoring; evaluation; public involvement; and size of the project." Subjects said they would have changed the design process (34%), project monitoring (62%), evaluation (53%), and public involvement (33%) most often. While identifying desired changes retrospectively does not indicate projects weren't completely successful, it suggests that the projects may not have been as successful as indicated by a simple response to the question: "was your project successful?"

Learning from interviewing practitioners

Despite the shortcomings of any study based purely on interviews, the interviews provided a wealth of information as the practitioners shared their stories and knowledge with me. Clearly there is a great deal of institutional knowledge both of restoration practices and of individual projects in particular. Detailed interviews provide rich information about projects that is not captured in standard restoration databases and yet should be gathered in some in some written form before those with vast restoration project experience exit the industry or retire.

At the end of the interview I asked participants if there was anything they learned that they would like to share with other practitioners. Several themes were recurrent, such as insights on the design and implementation processes and wisdom about implementing specific types of structures or activities. One-fifth of interview participants mentioned the role of stakeholder participation in projects and the need for improved communication among the involved parties. Several people stressed the need for initiatives to increase funding for monitoring studies. A few interviewees commented that while there were frustrating aspects of the restoration process, they were still motivated to continue with other projects.   Many interviewees stressed the need for patience and persistence: “you start at the top and work down; it's not an exact science.” One particularly insightful comment emphasizes the main underlying principle in stream restoration: “nothing is as powerful as nature; you can design around it but you may not be able to change it or harness it.”

The interviews clearly demonstrated that the project contacts had a solid understanding of the stream restoration process. It is encouraging that interviewees reported that 76% of the projects were monitored, that the primary motivation for the projects was related to environmental concerns, and that 70% of their projects were linked to other projects or to larger scale watershed management issues. However, the extent of monitoring, the specific reason why particular projects were prioritized over others and the level of watershed planning was highly variable among projects in the dataset. Scientifically evaluating the ecological effectiveness of the selected projects proved extremely difficult, as many projects did not specify explicitly quantifiable project objectives with corresponding monitoring data. Given that previous experience was incorporated the design and implementation of two-thirds of the projects, and that many interviewees mentioned the learning curve involved in stream restoration, evaluating and communicating the effective aspects of projects among all disciplines in the field is vital to future restoration success.

Chapter 3: Insights and further discussion of interview data

The purpose of this chapter is to further discuss differences between data from written records and practitioner interviews, and to further evaluate the ecological success of stream restoration projects in the Chesapeake Bay watershed. I begin by discussing potential bias in the subsample of projects for which interviews were conducted. I then use inconsistencies between the written records and interviews for reported monitoring to estimate and extrapolate the amount of completed monitoring for restoration projects in the Chesapeake Bay watershed. I conclude the chapter by discussing a weighting scheme that uses interview responses to evaluate the ecological effectiveness of projects in the interview database.

The interviews with practitioners demonstrated a different picture of stream restoration in the Chesapeake Bay watershed than was apparent through analyzing the written records. The interviews suggested that projects are designed with more objectives and undergo more monitoring than the written records indicate. This contrast is worth exploring along many avenues. Whereas the summary database was an attempt to compile data on many restoration projects throughout the watershed, the interview dataset contained detailed information for only 1% of the summary database. Further, that 1% does not represent a truly random sample of projects. Although project selection for interviews was random by design, about 70% of the randomly selected projects could not be included in the interview process because I could not locate project contact persons, I had already interviewed the project contact for another project, or the contact was unwilling or unable to be interviewed. Thus the sample set was biased toward projects in which there was a substantial amount of information already available in the written records and there was a project contact person who had remained in their current position since completing the project and was willing to talk with me about it.

Evaluating differences between interview data and written records

The striking contrasts between the written records and the interviews raise the question of which dataset is the more accurate portrayal of restoration in the Chesapeake Bay watershed. This is especially pertinent for evaluating how much project monitoring is actually being carried out: 5.4% in written records versus 76% in interviews. The very low monitoring rate from the written records may be a consequence of data sources that are unlikely to ever report monitoring even if it was done at a later date.

As a thought exercise, I made a simple calculation to compare monitoring rates between the interviews and written records for each type of data source to account for possible differences in data quality. For example, permit files do not typically indicate whether monitoring occurred, whereas data from project reports usually include some monitoring information.

I calculated a correction factor for each type of data source, which gave an indication of the potential underestimate of monitoring in the written records. This was done by finding the ratio of the number of monitored projects in interviews to the number of monitored projects in the summary database. The ratio was then multiplied by the number of projects in the summary database to get a correction factor *for each type of data source*:

$$\text{correction factor} = \left(\frac{[\#\,\text{monitored projects in interviews}]}{[\#\,\text{monitored projects in written records}]} \right) * [\#\,\text{projects in summary database}]$$

When the calculated correction factors from the interview database were applied to the summary database, the upper bound of monitored projects in the written record database was 54% (Table 3.1). This is significantly higher than the 5.4% indicated from the written records obtained for the summary database, but may still represent a best-case scenario.

The difference between the two databases highlights the need for information on monitoring in project-tracking databases. Currently, even if monitoring is reported, most databases do not provide enough information to adequately evaluate ecological success. When I revisited the summary database records for projects that interviewees told me were monitored, there was typically no indication of monitoring and certainly no statement on project outcome. Monitoring information is crucial for evaluating project success, but it must be accessible to be useful.

Evaluating ecological success

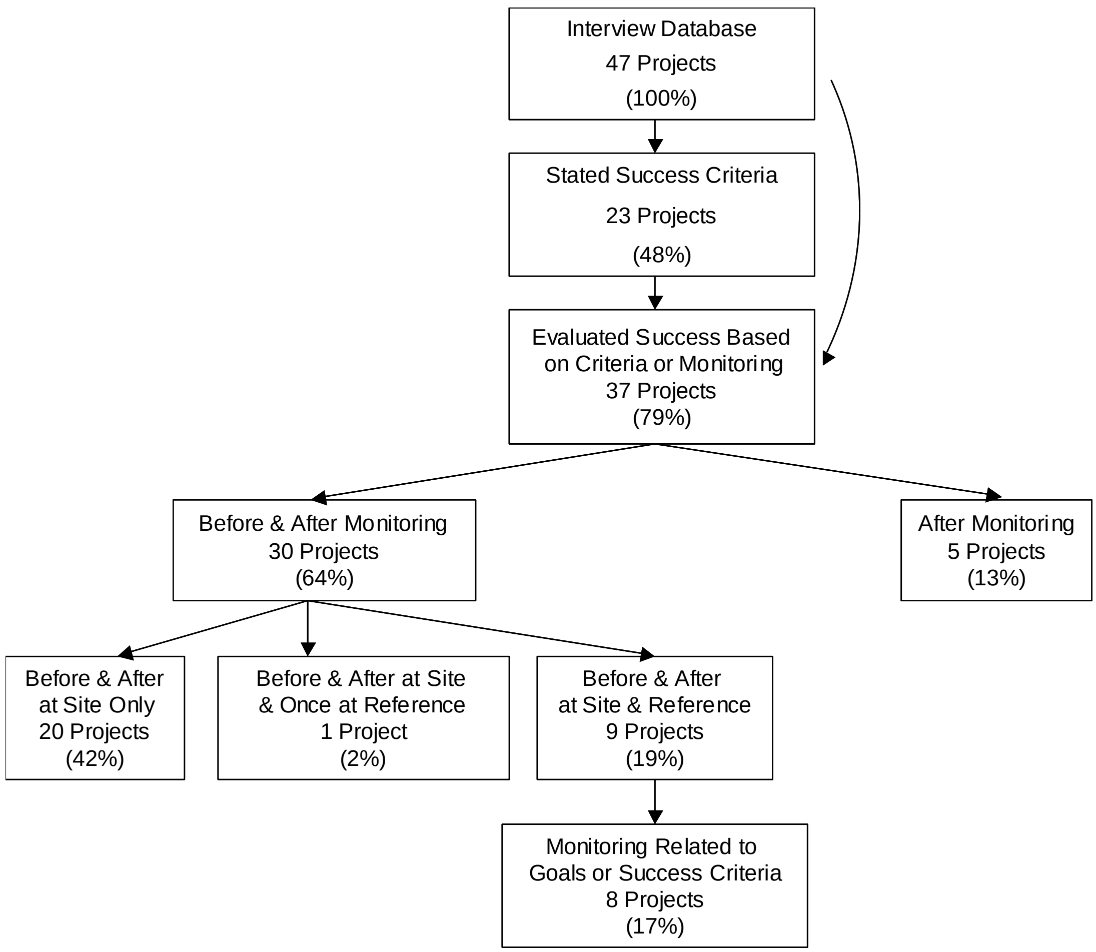
Although the interviews indicated that 76% of projects in the sample had completed project monitoring, the rigor of assessment differed among individual projects. Twenty projects only monitored variables at the site before and after restoration had occurred (Figure 3.1), whereas some projects did additional monitoring at a reference site. Only 8 projects had monitoring that was: (1) completed before and after restoration, (2) performed at the project site as well as a reference or control site, and (3) was related to project goals or objectives (Figure 3.1). This level of rigor represents an idealized restoration process that should enable valid project evaluation.

The interview process attempted to answer the question of whether stream restoration throughout the region is ecologically successful. The interviews did not

Data Source	# interviews	# with monitoring (as in written records)	# with monitoring (from interview)	Correction factor	# projects in database of written records	Fraction with monitoring (as in written records)	Extrapolated # monitored projects
Database	31	8	23	12.9	4395	0.04	2283
Agency Summary	4	1	4	4	91	0.10	100
Third Party Document	3	1	2	2	20	0.20	13
Other (email, web)	4	2	4	2	107	0.37	89
Phone Conversation	5	3	3	1	40	0.25	37

Table 3.1 Evaluation of differences in reported extent of monitoring among different data sources. For each type of data source, a correction factor was calculated based on the ratio of monitored projects in interviews to monitored projects in written records. The total number of projects of each type of data source was then multiplied by the correction factor to get an extrapolated estimate of the number of monitored projects in the summary dataset.

Figure 3.1 The idealized restoration process, showing the proportion of projects within the Chesapeake Bay watershed interview dataset that met increasing levels of rigor in their design and evaluation. Percentages represent the proportion of the initial set of projects in the database (N = 47).



demonstrate a relationship between project success and land use, type of project, or cost. Roni et al. (2005) also attempted to relate project outcome to project type using project evaluations from the published literature. Although they found examples that certain techniques were clearly more effective than others at improving habitat or fish abundance, their small sample size also led to the conclusion that it is not yet known what types of projects in which settings are most successful.

I attempted to use the responses from interviews to evaluate ecological success with criteria proposed by Palmer *et al*. (2005). Specific questions in the interview allowed me to assess three criteria of ecologically successful restoration: (1) a guiding image (or desired model) for the project was identified, (2) an ecological assessment was performed, and (3) ecosystem improvement was shown.

I evaluated the first condition, whether a model or guiding image for the project was present, using responses to interview questions about how the project was integrated into watershed management plans, why the project was prioritized, and whether success criteria, or measurable project objectives, were stated in the project designs. Although several projects were initiated because they were in a river management plan (N = 11), only half of these were prioritized for restoration because of an extensive plan for the river. While many interviewees reported that success criteria were stated in the project design plan (N = 23), most of these criteria were not quantifiable project objectives. Half of the project objectives reported by interviewees were only measurable based on whether the project was completed (e.g., “plant 50 trees”). Many of the stated success criteria were along the lines of “improving” water quality or habitat (N = 12) without including measurable targets. Only 2 projects specified rigorously quantifiable objectives that could utilize post-project data to ascertain success.

Regarding the second requirement, that an ecological assessment was performed, interviewees reported that most projects attempted to complete some form of ecological assessment, in the form of post-project monitoring (76%) or a watershed assessment (51%).

However, in addressing the third criterion, relatively few projects clearly demonstrated that the ecosystem was improved. Although over 60% of interviewees said that there was a positive effect on fish, wildlife or plants, only 10% confirmed that the ecosystem had improved by citing evidence of positive trends in their monitoring data.

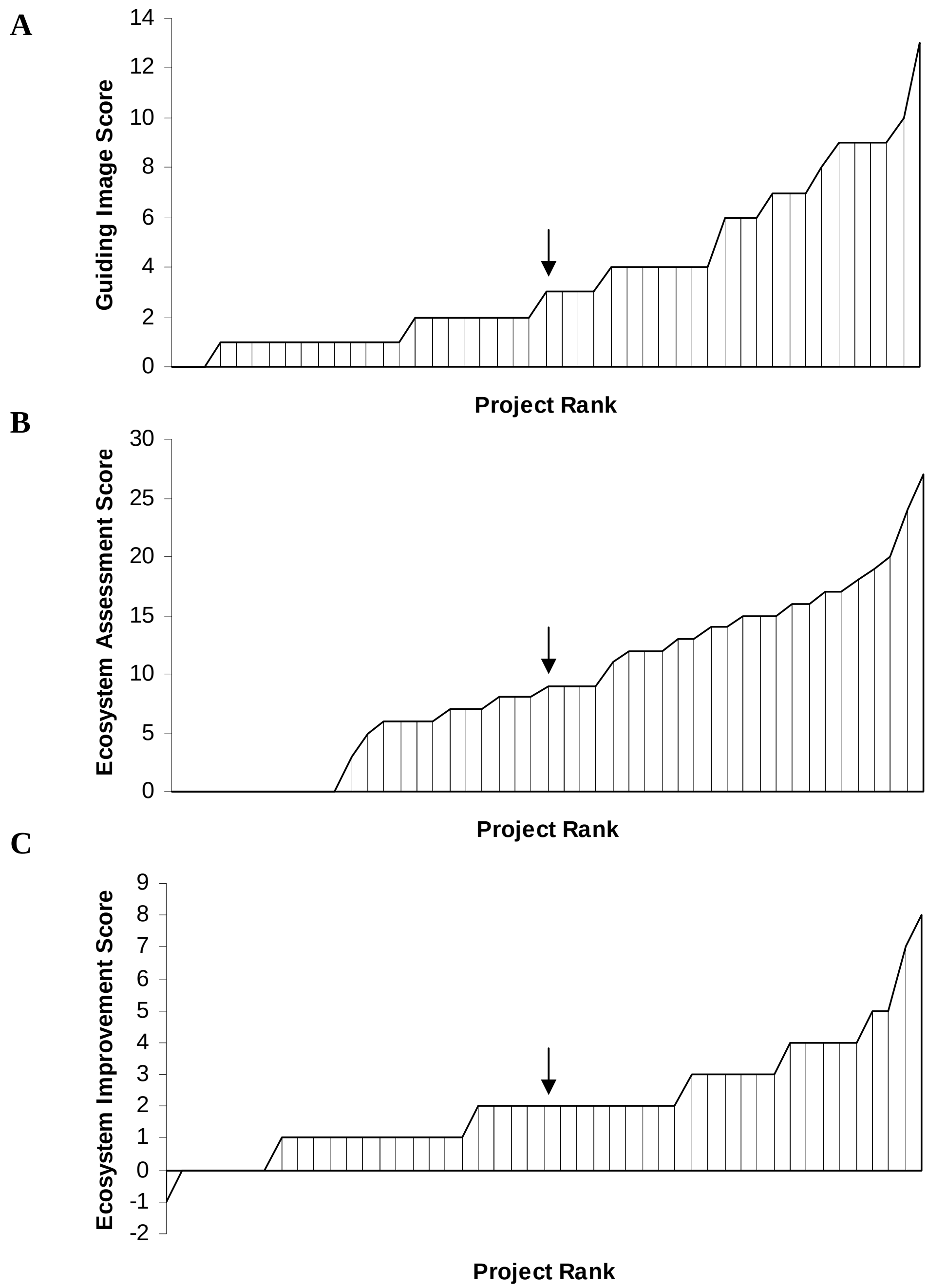
Weighting scheme for evaluating ecological success

The interview questions described above were used to create a weighting scheme for ranking the effectiveness of projects in using a guiding image, conducting an ecological assessment, and demonstrating that ecological improvement occurred. The objective of creating a composite score was to analyze responses for a group of questions for each project rather than examining each question individually. A ranking of 0 to 13 in this category was given for each project. Points were scored in the "guiding image" category for projects that: were based on a river management plan; had a watershed assessment and management plan; prioritized restoration based on a broader vision for the river; designed the project based on ecological impacts and opportunities; and had clearly stated project objectives. If the stated project objectives were quantifiable (e.g., "reduce nitrate concentration by 1.5 mg/L"), additional points were awarded.

Projects were ranked in the "ecological assessment" category according to the number and type of variables monitored, the frequency and duration of monitoring, whether these data were compared to baseline or reference conditions, whether data were analyzed and reported, and whether monitoring data were used to evaluate project success. Because points were given based on the frequency and duration of each variable that was monitored, there was no limit to the highest possible score. Likewise, the highest possible score for the "ecosystem improvement" category was dependant on the number of variables monitored that demonstrated measurable improvement. Projects were ranked for meeting stated ecological project objectives, demonstrating positive trends in monitoring data following restoration, and for the interviewee indicating that the project was successful in improving ecological indicators (water quality, hydrology, geomorphology, plants or wildlife). It is important to note that projects could have points subtracted if negative impacts were observed.

The weighting scheme was an attempt to quantify and create a composite score for the categorical interview data. Although around half of the interviews did not indicate that projects were informed by an overall vision for the watershed, 8 projects incorporated watershed planning, ecological opportunities and specific objectives into the project design (Figure 3.2A). Even though 25% of projects received zero points in the ecosystem assessment ranking (Figure 3.2B), the composite score further confirmed that a lot of monitoring and evaluation occurred for the selected restoration projects. However, it is less clear from the interviews whether ecosystems were measurably improved. Only one-third of the projects demonstrated that the ecosystem had indeed

Figure 3.2 The distribution of effectiveness scores along 3 scales of ecological success for restoration projects. Each frequency histogram gives the scores from left to right for projects ranked low to high in the category. The arrow points to the median score in each category. For Guiding Image (**A**) projects were ranked based on whether explicit success criteria were stated and whether project goals were linked with watershed planning. For Ecosystem Assessment (**B**) projects were ranked based on the extent, duration, frequency and statistical rigor with which project monitoring was performed. For Ecosystem Improvement (**C**) projects were ranked based on whether the interviewee said that measurable improvements had occurred following restoration.



positively responded to the restoration (Figure 3.2C), and one project even had a negative impact.

Although scores along the ecological success axes are by no means comparable to performing formal post-project appraisals (e.g. Downs and Kondolf 2002), they do provide one estimate of project achievement. The distributions are another way of describing the median, or specific percentile, restoration project in the region. The median project along the guiding image axis was linked to other projects in the watershed, was designed to reduce ecological impacts and had stated project objectives. The highest scoring project had incorporated wide-range design, such as completing a watershed assessment, linkage to other projects in the watershed with overlapping goals, developing a broader vision for the river, quantifiable, rigorous project objectives, and prioritizing ecological opportunities. Thus, projects in the interview dataset exhibited a wide range of rigor in stating objectives and incorporating broad-scale principles.

The distribution of ecosystem assessment scores shows that although 11 projects had no success in evaluation, and two projects completed high levels of assessment, 70% of projects fall somewhere in the middle. The median project monitored 4 variables (2 biological, 2 physical) annually, before and after project construction, reported data to another agency, and used data to evaluate the project. However, the median project did not demonstrate a high level of ecological improvement; much like the assessment scores, the rankings of ecosystem improvement show that there are a few projects achieving high levels of improvement whereas most others are positioned somewhere between scores of 1 and 4. This translates to showing positive trends in monitoring data, or accomplishing quantifiable project objectives. Thus, while many projects completed ecological assessments, relatively few succeeded in demonstrating large amounts of improvement.

The moderate amount of ecosystem improvement following restoration can be interpreted in several ways. Projects that scored highly on the improvement axis typically had positive trends in many of the monitored variables, which may have been a function of the interviewee being very familiar with the monitoring data or having a project report accessible during the interview. Conversely, a project that scored low on the improvement axis may have been improved, but the interview questions were not successful in determining that. Nevertheless, determining the ecological success of restoration projects remains a difficult task. Evaluating projects using composite scores for interviews is an additional method for analyzing categorical interviews, but does not replace thorough monitoring, analysis and reporting by project teams.

Conclusions

This project demonstrated that there is an incredible amount of stream restoration being done in the Chesapeake Bay watershed, but the written records do not provide enough details to evaluate project effectiveness. Projects are being done to satisfy multiple objectives and are most often undertaken as a result of environmental degradation or motivated by ecological concerns. The interviews suggested that many projects have watershed-scale planning and a large amount of ecosystem assessment, but it is still not fully clear to what degree these projects are improving the ecosystem. Because stream restoration is integral to many watershed management plans, it would be beneficial for managers to objectively evaluate the ecological effectiveness of projects over extended periods of time.

Appendix A. Notes on NRRSS methodology

What was included: The following key was included in the metadata and used to determine whether a project would be included in the NRRSS database.
(DNI = Do Not Include)

Project record is part of a stream restoration specific database or data file….Go to 1

-OR-

Project record is part of a database or data file that is not specific to stream restoration.………………………………………………………..Go to 4

1.
  a) Project is fundamentally concerned with community education and does NOT include field efforts to improve stream condition………………………...DNI
  b) Project is fundamentally concerned with community education and does include field efforts to improve stream condition………………….Include / 2

2.
  a) Land acquisition is the only restoration focus of the project……………..DNI
  b) Land acquisition is a focus of the project, but is specifically performed to improve stream condition.…………………………………….Include / 3

3.
  a) Project is a site or watershed study intended to guide restoration efforts…..DNI
  b) Project implemented, regardless of the paucity of information…….…….Include

4.
  a) Project has no statement of intent or activities…………………...…………DNI

b) Project contains either a statement of intent or activities……………Include / 5

5.

a) Project record does NOT explicitly state stream restoration as intent…...DNI

b) Project record merely states “stream restoration”, even if record contains no additional information………………………………………………Include / 6

6.

a) Upland (non-riparian), wetland, estuary, or land acquisition as the only focus/foci of restoration……………………………………………...DNI

b) Upland (non-riparian), wetland, estuary, or land acquisition as the focus/foci of restoration, but is specifically performed to improve stream condition.....Include

The definitions of "project" and "stream restoration" were left up to the data source—no judgments were made of the validity of the term "stream restoration" and there was no standardized size or cost unit for projects.

Calibration

Metadata were developed for all database fields to ensure consistency, repeatability, and utility of the data. Calibration of data entry for the database was done initially by the entire working group. All members received the same ten example project files which they entered into the database following the metadata. After this round, the group met to discuss differences in the entries and to modify the metadata to eliminate confusion. All persons responsible for data entry completed three additional rounds of calibration with 10 different projects in each round in which the only field completed was the categorization of stated project goals, objectives, or purposes into the intent categories, the only subjective field in this database. There was some concern during development about the difficulty and inconsistency of inferring intent from project documentation; for this reason, our intent field is only a categorization of the stated goals, objectives, or purposes in the documentation based on the definitions of the intents in the metadata.

Removal of Duplicates

Because the data were obtained from a large variety of sources on a federal, state, and local scale and including funders, designers, implementers, and regulators, duplication of some projects within the database was inevitable. To remove duplicate projects, we sorted the data by location information and looked for projects with the same name and those done on the same stream, in the same area, with the same completion year and the same intents. Because projects may have multiple phases or adjacent, follow-up projects, we only removed projects from the database where they were clearly duplicates.

Validation

Creating a complete database of all stream restoration projects in the country was not a realistic goal. Some data was only available by contacting individual consulting firms for their files, and in some cases government agencies were unwilling or unable to share their data. For these reasons, the goal of NRRSS was to achieve a database that was representative of the goals and geographic variability of stream restoration activities within the seven nodes rather than a comprehensive database.

Validation of the database was done separately for each node. Data were summarized by cost, % monitored, and intent categories as well as geographically, generally on a county or watershed scale. These summaries, along with a list of data sources used, were submitted to “stream restoration experts” in each node. These were people knowledgeable about stream restoration for a particular portion of the node who had not been involved directly in the overall data gathering for that node. They were asked to assess the completeness of data sources accessed and the representativeness by location and intent category of the NRRSS database for their particular geographic area of expertise. Experts who saw a weakness in the completeness or representativeness of the data were asked to provide suggestions of further data sources or contacts which the working group members then followed up on to complete the database. In some cases, this added only a few projects in a particular location or intent category, while in other cases new, large databases were discovered as a result of the validation process.

Appendix B. Metadata for Classification of Project Goals/Intents

All metadata and fields available at:

http://nrrss.nbii.gov/cgi in/user_area/sample_input_form.cgi

Notes: instructions for data entry Select one to many from list of alternatives defined below. Intent should capture only what is stated as a goal/objective/purpose in source documentation.

Do not infer intent. When you are reading a long document (more than a 1 paragraph project description) only use sections that explicitly describe objectives/goals/purposes/intents, do not read the full document and then attempt to summarize the purpose yourself. Some projects will require multiple selections due to overlapping categories (e.g. some dam removals are for fish passage, some dam outlet retrofits are water quality management). If the project intent is impossible to classify in one of our 13 categories, select other and type in the intent as written in the documentation. If there are sufficient cases falling into a new category, we will add that category to the official database. [categorical]

Bank Stabilization: Practices designed to reduce/eliminate erosion or slumping of bank material into the river channel. This category DOES NOT include stormwater management, see next intent category.

Stormwater Management: Special case of *Flow Modification* that includes the construction and management of structures (ponds, wetlands and flow regulators) in urban areas to modify the release of storm runoff into waterways from watersheds with elevated imperviousness into waterways. These practices/structures generally aim to reduce peak flow magnitudes and extend flow duration. For the purposes of NRRSS *Stormwater Management* refers to water quantity not quality. Urban sediment, litter and temperature control should be categorized as *Water Quality Management*.

Flow Modification: Practices that alter the timing and delivery of water quantity (DOES NOT include *Stormwater Management*). Typically, but not necessarily associated with releases from impoundments and constructed flow regulators.

Channel Reconfiguration: Alteration of channel plan form or longitudinal profile and/or day-lighting (converting culverts and pipes to open channels). Includes stream meander restoration and in-channel structures that alter the thalweg of the stream. Note that many instream structures also claim to improve habitat. For NRRSS the intent declared in the source document must be used.

Fish Passage: Removal of barriers to upstream/downstream migration of fishes. Includes the physical removal of barriers and also construction of alternative pathways. Includes migration barriers placed at strategic locations along streams to prevent undesirable species from accessing upstream areas.

Riparian Management: Revegetation of riparian zone and/or removal of exotic species (e.g. weeds, cattle). Excludes localized planting only to stabilize bank areas (see *Bank Stabilization*)**.**

In-stream Species Management: Practices that directly alter aquatic native species distribution and abundance through the addition (stocking) or translocation of animal and plant species and/or removal of exotics. Excludes physical manipulations of habitat/breeding territory (see *In-stream Habitat Improvement***)**

Dam Removal/Retrofit: Removal of dams and weirs or modifications/retrofits to existing dams to reduce negative ecological impacts. Excludes dam modifications that are simply for improving *Fish Passage*.

Floodplain Reconnection: Practices that increase the flood frequency of floodplain areas and/or promote flux of organisms and material between riverine and floodplain areas.

In-stream Habitat Improvement: Altering structural complexity to increase habitat availability and diversity for target organisms and provision of breeding habitat and refugia from disturbance and predation. (In some cases habitat improvement may be an action with the intent of *In-stream Species Management*, in other cases *Habitat Improvement* may be the intent, and might be accomplished through *Channel Reconfiguration*, be very careful to separate action from intent when deciding whether to select this category.

Aesthetics/Recreation/Education: Activities that increase community value: use, appearance, access, safety, knowledge.

Water Quality Management: Practices that protect existing water quality or change the chemical composition and/or suspended particulate load. Remediation of acid mine drainage falls into this category as does CSO separation. Excludes urban runoff quantity management (see *Stormwater Management*).

Land Acquisition: Practices that obtain lease/title/easements for stream-side land for the explicit purpose of preservation or removal of impacting agents and/or to facilitate future restoration projects. Note: Simple purchase and preservation to prevent potential future land conversion is insufficient for inclusion in the NRRSS database. NRRSS projects should demonstrate intended or actual cessation of detrimental activities in acquired land or active restoration components.

Other: Specify the project intent that differs from the choices provided. If there is no intent stated you should not select or enter any information in this section. If the intent is the generic “stream restoration” then this section should be left blank

Appendix C. Interview Script

NOTE: Where multiple choice answers exist, unless otherwise stated the project contact will be asked the question, and the interviewer will be responsible for selecting the appropriate answers from the full list. Prompting with examples may be necessary.

Part I. Verification

Prior to beginning the survey check for errors in our project records (from verification sheet) and fill in all unknown values.

Q1) Please provide a 1-2 sentence project description?*[Text]*

Q2) Based on the information available to us on the project we categorized the project goal(s)
as: **[listed goals from project record database]**.

Q2a) Does this accurately reflect the goals of the project? Yes/No/I don't know

If "NO"
Q2bi) What were the actual goals of the project? TEXT (interviewer classifies)

If "YES"
Q2bii) Were there additional goals that were not listed? TEXT (interviewer classifies)
Please do not provide examples. It is important to have NRRSS folks making this classification rather than the project contacts.

- Water Quality Management
- Riparian Management
- Stormwater Management
- In-stream Habitat Improvement
- Bank Stabilization
- Fish Passage
- Flow Modification
- Channel Reconfiguration
- Floodplain Reconnection
- Dam Removal/Retrofit

- Land Acquisition
- In-stream Species Management
- Aesthetics/Recreation/Education
- Other

Q2c) Which of these was the primary goal for this project? [Categories]

- Water Quality Management
- Riparian Management
- Storm Water Management
- In-stream Habitat Improvement
- Bank Stabilization
- Fish Passage
- Flow Modification
- Channel Reconfiguration
- Floodplain Reconnection
- Dam Removal/Retrofit
- Land Acquisition
- In-stream Species Management
- Aesthetics/Recreation/Education
- Other
- No primary goal

Q2d) Why was [XXXXX from Q2c] considered the main goal for this project? *If the project contact does not respond to or understand the question, then say "Was there a reason why this project needed to be done?" If still no response, then say "for example was the project done b/c of a funding priority or to address public safety concerns"*

- Addressing greatest factor influencing river degradation
- legal requirements
- focus for which funding was available
- public demand and/or safety
- problem that could be most easily addressed
- other?______________________________
- I don't know

Q3) Project Activities:

If listed in our database: Our records indicate that the project included [**list of activities from project record database**]

Q3a) Does this accurately reflect the activities of the project? [Yes/No/I don't know]

Q3b) If no, or if no activities listed in our database, what project activities implemented?

Q4) Was this a mitigation project? [yes/no/I don't know]
You should clarify that by mitigation, you mean that this project w as legally mandated

Q5) What is the dominant land-use within the project watershed?
Be sure the contact is describing the watershed as a whole rather than just the adjacent

land-use

- Urban
- Suburban
- Agricultural
- Undeveloped
- Protected
- Wildland
- Other
- I don't know

Q6) What role did you play in this restoration project? *[check all that apply]*

- manager/coordinator
- consultant
- designer
- implementer
- evaluator
- permitter
- funder
- other? [TEXT]

Q7) Who initiated the project? *[check all that apply]*

- agency staff
- land owner
- watershed council, environmental NGO, or other citizen interest [TEXT]
- other citizen interest
- other? [TEXT]
- I don't know

Q8) Why was this project initiated? *[check all that apply. Prompt with examples.]*

- public safety concerns
- project was part of a larger river management plan
- environmental degradation
- agency mission
- regulatory mandate
- mitigation project

- funding opportunity
- other? [TEXT]
- I don't know

For next 3 questions only ask the subject to classify the entity if it is not obvious, otherwise just clarify (e.g. if they answer that the project was funded by MD DNR just confirm that this is a state agency)

Q9) Who was the primary funder of the project?

- Private land owner
- Commercial developer
- City/county agency
- Local or regional authority (e.g., Conservation District, Water Management Authority)
- State agency
- Federal agency
- Non-governmental/Not for profit organization
- Other?
- I don't know

Q10) Were their additional funders? *[enter the # of such entities if not 0]*

- ☐ Subject's Organization
- ☐ Private land owner
- ☐ Commercial developer
- ☐ City/county agency
- ☐ Local or regional authority (e.g., Conservation District, Water Management Authority)
- ☐ State agency
- ☐ Federal agency
- ☐ Volunteers
- ☐ Non-governmental/Not for profit organization
- ☐ Other [TEXT]
- ☐ I don't know

Q11) Were there in-kind contributions to this project? [yes/no/I don't know]

Q11a) If yes, who provided these contributions? *[enter the # of such entities if not 0]*

- ☐ Subject's Organization
- ☐ Private land owner
- ☐ Commercial developer
- ☐ City/county agency
- ☐ Local or regional authority (e.g., Conservation District, Water Management Authority)

☐ State agency
☐ Federal agency
☐ Volunteers
☐ Non-governmental/Not for profit organization
☐ Other [TEXT]
☐ I don't know

Q12) Who designed the project? *[enter the # of such entities if not 0]*

☐ Subject's Organization
☐ Private land owner
☐ Private consultant
☐ Commercial developer
☐ City/county agency
☐ Local or regional authority (e.g., Conservation District, Water Management Authority)
☐ State agency
☐ Federal agency
☐ Volunteers
☐ Non-governmental/Not for profit organization
☐ Other [TEXT]
☐ I don't know

Q13) Were there other partners that haven't been mentioned yet? *[enter the # of such entities if not 0]*

By partners we mean any entities that were involved in any aspect of the project that have not been mentioned in previous questions

☐ Subject's Organization
☐ Private land owner
☐ Private consultant
☐ Commercial developer
☐ City/county agency
☐ Local or regional authority (e.g., Conservation District, Water Management Authority)
☐ State agency
☐ Federal agency
☐ Volunteers
☐ Non-governmental/Not for profit organization
☐ Other [TEXT]
☐ I don't know

Part II. Project Design, Implementation & Coordination

Q14) Has a watershed assessment been completed on said stream/river?
By watershed assessment we mean "are there formal regional agreements about watershed protection or conservation goals"

☐ yes ☐ no ☐ I don't know

Q15) Was this project part of a watershed management plan for the catchment?

☐ yes ☐ no ☐ I don't know

Q13a) (if yes) Do the goals for the project overlap with the goals for the watershed?

☐ not at all ☐ partially ☐ completely

Q16) Is this project linked to other restoration projects that have been conducted or that are
planned within this river segment?
If subject does not understand say " by linked I mean that the project design was influenced by awareness of other projects in the same watershed or river"

☐ yes ☐ no ☐ I don't know

Q17) There are lots of streams that need restoration, what factors led to the prioritization of this site over other possible restoration locations? *[check all that apply]*

- funds available
- public interest
- scientific interest
- ecological concerns
- infrastructure concerns
- legal requirements
- in formal watershed plan
- part of a broader vision for river
- recreation
- available land opportunities
- other

Q17a) Which of these factors was most important?

Q18) What factors were the most important in determining the final project design? I am going to read you the full list and I would like you to tell me which 1 or 2 were most important. *[check no more than 2 categories]*

- cost
- requirements or mandates
- location-specific limitations
- ecological impacts
- ecological opportunities
- stakeholder preferences

- previous experience
- available expertise
- other
- I don't know

Q19) Were citizens' groups involved in this restoration project?
☐ yes ☐ no ☐ I don't know

Q19a) If yes, how much impact did citizen input have at each of the following stages?

	None	Some	Substantial
Project Initiation			
Project Implementation			
Project Evaluation			

Q20) Who owned the land on which the project was implemented? *[Check all that apply]*
- Private
- City
- County
- State
- Federal
- Tribal
- Other
- I don't know

Q21) What sources of knowledge were used in creating, implementing, and evaluating the design plan that was selected? *[Check all that apply]*
- Past experience
- Workshops or short courses
- Manual/Book/Report/ Government agency guidelines
- Peer-reviewed journal
- Models or project site analysis
- Individuals (If so, what area(s) of expertise?)
    - Hydrology
    - Biology
    - Ecology
    - Geomorphology
    - Engineering
    - Other: [TEXT]
    - I don't know

Q21a) [If more than one was checked above] Was one of these resources particularly influential? ☐ yes ☐ no ☐ I don't know

Q21b) If yes, what? [TEXT]

Q22) Is there a formal advisory committee associated with this project?
[*If necessary define 'formal advisory committee' as a selected group of people convened to discuss the project on a regular basis; not the day-to-day project management.*]

☐ yes ☐ no ☐ I don't know

Q22a) if yes, what kinds of members: *[Check all that apply]*

- o Members of the public
- o NGOs
- o Tribal representatives
- o Academics
- o Agency scientists
- o Consultants
- o Industry representatives
- o Other
- o I don't know

Q23) What efforts, if any, did you make to minimize the impact of project construction? *[prompt with examples: Timing, Vegetation removal/impacts, Channel dewatering/rerouting, Topsoil removal, Dredging, Species relocation, Turbidity/sediment increase – THE INTERVIEWER MUST CLASSIFY THE ANSWER INTO THE FOLLOWING CATEGORIES]]*

☐ yes, efforts made ☐ no effort made ☐ subject doesn't know
if yes, optional [Text]

Q24) Was funding available for project maintenance?

☐ yes ☐ no ☐ I don't know ☐ initially, no but funds/volunteers were later acquired

Q25) What follow-up maintenance occurred? (Check all that apply)

- o Structural reinforcement *(additional structures added to protect existing project elements)*
- o planting
- o seeding
- o Additional substrate
- o Watering
- o Invasive species removal
- o Removal of debris jams
- o Structural elements relocated or replaced
- o Entire project redone
- o Other? [TEXT]
- o I don't know
- o None

Q26) Do you anticipate a need for on-going maintenance for the project?

☐ yes ☐ no ☐ I don't know

Q26a) At what frequency?

- o Once
- o Monthly
- o Annually
- o After major disturbance
- o Other? [text]

PART III – MONITORING

Q27) Did your organization or some other entity collect monitoring data specific to this project?

☐ yes ☐ no ☐ I don't know

IF YES TO Q27 PROCEED TO Q28; IF NO, FINISH Q27a-b AND GO TO Part V.

Q27a) What constraints prevented you from collecting data in order to evaluate the restoration project? *[check all that apply]*

- o Lack of funding
- o Lack of people power or staff time
- o Lack of materials needed for data collection
- o Lack of technology for data analysis
- o Not hired to do data collection
- o Not part of organizational mission
- o Other [TEXT]

Q27b) What would you have monitored if constraints had not existed? *[Check all that apply]*

- o Physical
- o Chemical
- o Biological *(does not include monitoring of vegetation)*
- o Vegetation
- o Photo monitoring
- o Nothing
- o Other [TEXT]

Q28) Who performed the monitoring and evaluation component of this project? *[performed = what entity was responsible for conducting the monitoring], [Check all that apply]*

- o agency staff
- o volunteers
- o scientists

- university students/professors
- non-profit/watershed group staff
- for profit/consultant
- Other [TEXT]

Q29) We’re finding that only a small portion of projects do monitoring. What factors enabled your team to monitor this project? *[check all that apply]*

- Pursuit of additional funds
- Funding mandate
- Local volunteer interest
- Interested expert
- Academic researcher involvement
- Ongoing regional effort
- Legal requirement
- Personal commitment
- Other [TEXT]

Q30) What type(s) of monitoring was (were) conducted? ☐ I don't know OR fill out table below

Note to interviewers: Please use the chart below to indicate what monitoring was done in relation to this project. Write in the actual variables monitored in the first column (for example, you can write in DO, pH, and temperature under chemical). Place an x in the appropriate column to indicate when the monitoring was done (before, during, after). Please also note the sampling protocols used as well as the frequency and duration of the monitoring. Also note if the protocol was also performed at a reference site.

Monitoring Variables	Implementation			Protocols used	Sampling		Reference/Control		Data Trends			
(list actual variables)	Before	During	After	(simple details)	Frequency	Duration	Before	After	+	-	=	TS
a) Chemical					once, monthly, seasonally, annually, > 1 year, > 5 year	one shot deal, one year, 2-5 years, 6-10 years, >10 years						
b) Physical												
c) Biological												
d) Photo Monitoring e) Visual Observation												

Q31) Were there constraints that prevented you from collecting any additional data in order to evaluate the restoration project?

☐ yes ☐ no ☐ I don't know

If yes, *[Check all that apply]*

- o Lack of funding
- o Lack of people power or staff time
- o Lack of materials needed for data collection
- o Lack of technology for data analysis
- o Not hired to do data collection
- o Not part of organizational mission
- o Other

Q31a) What would you have monitored if constraints had not existed? *[Check all that apply]*

- o Physical
- o Chemical
- o Biological – non veg.
- o vegetation
- o Photo monitoring
- o Nothing
- o Other

Q32) Did you use previously collected monitoring information as baseline data for your evaluation?

☐ yes ☐ no ☐ I don't know

Q33) Was the monitoring a part of a regional monitoring effort?

☐ yes ☐ no ☐ I don't know

Q34) How did you choose your monitoring protocol(s)? *[check all that apply]*

- o Protocol for previously collected data
- o Federal protocol (EPA)
- o State protocol
- o Local/regional conservation group developed protocol
- o Book/manual/report/scientific literature
- o Expert advice
- o Mandate
- o Other
- o I don't know

Q35) Did you or someone else **analyze** the data?
Have the data that were collected been formally used to evaluate the project

☐ yes ☐ no ☐ I don't know

If yes,
Q35a) What sort of analysis was used to summarize the data?

- Statistical
- Comparative
- Modeling
- Descriptive/classification
- Visual (of photo-monitoring)
- Other
- I don't know

Q36) Were the results of your monitoring reported?
☐ yes ☐ no ☐ I don't know

Q36a) If yes, through what specific media? *[Check all that apply]*

- Website [text]
- Scientific journal [text]
- Popular press [text]
- Agency or funder report [text]
- Public report
- Meeting presentation [text]
- newsletter
- Other [text]

PART IV – EVALUATION

Q37) Has there been a major perturbation in this system since the project was constructed, such as flood, drought, sewage overflow, invasion of non-native species, fire, rupture of a sediment pond?

☐ yes ☐ no ☐ I don't know

Q37a) how did the project respond?

☐ No change or ☐ Change

AND

☐ Maintenance Needed or ☐ Maintenance Not Needed

optional [TEXT] for interesting stories

Q38) Were success criteria explicitly stated in the project design plan?
[define 'success criteria'as measurable project objectives]

☐ yes ☐ no ☐ I don't know

Q38a) If yes, what were they? [TEXT- REQUIRED]
NOTE, THIS IS ONE OF TWO QUESTIONS WERE TEXT IS REQUIRED (UNLESS NO TO Q38]

Q38b) Can you tell me BRIEFLY why these were selected? [TEXT-REQUIRED]
NOTE, THIS IS ONE OF TWO QUESTIONS WERE TEXT IS REQUIRED (UNLESS

NO TO Q38]

Q38c) Did this project accomplish its stated success criteria?

- No, not at all
- Partially
- Yes, completely
- Too soon to tell
- No information available

Q39) There are lots of different ways projects can be successful, for example a project might be a social success and an environmental success. Do you consider this project successful?

- No, not at all
- Partially
- Yes, completely
- Too soon to tell

Q39a) If partially or yes, what made this project successful? *[check all that apply]*

[If specific success criteria listed in 36 were accomplished, ask "Are there additional ways in which this project was successful?"]

- Overall positive effects on river morphology
- Overall positive effects on hydrology
- Overall positive effects on water quality
- Overall positive effects on fish, wildlife, plants
- Positive effects on human community
- Increased understanding of river systems
- Capacity building *[increase organization's ability to implement future project, improve interagency collaboration, etc.]*
- Ecological indicators point to yes
- Improving appearance
- Success criteria were met
- Other [TEXT]
- I don't know

Q39b) If partially or no to Q39, What prevented this project from being completely successful? *[check all that apply]*

- exotic weeds
- structural failure
- public disapproval
- human disturbance
- natural disturbance
- inadequate design *[inadequate consideration of environmental context]*
- inadequate funding
- ecosystem didn't respond as expected
- specific success criteria not met
- wasn't implemented correctly
- plants died
- other [TEXT]

Q40) **IF YES TO Q27** Were monitoring data used to evaluate project success?

☐ yes ☐ no ☐ I don't know

Q41) How [**OR IF YES TO Q27**, how else] did you assess whether the project was successful? *[check all that apply]*

- Past Experience – How many like projects have you done? ☐
- Observations (Photographic/Site Visits)
- Measurements
- Independent Review - describe
- Positive Public Opinion/Awareness
- Positive Participant Reactions
- Other [text]

Q42) Do you intend further assessment?

☐ yes ☐ no ☐ maybe/depends ☐ I don't know

Q42a) If yes, what types of assessment will be done? *[check all that apply]*

- o Observations (Photographic/Site Visits)
- o Measurements
- o Independent Review – describe [TEXT]
- o Positive Public Opinion/Awareness
- o Positive Participant Reactions
- o Other [text]

Q43) Were there additional benefits to this project? *[check all that apply]*

- o increased ability to do more restoration projects
- o increased adjacent property values
- o community awareness
- o developed new partnerships with other industry partners/community groups
- o learned new information that supports or refutes current scientific ideas or highlighted a key knowledge gap
- o learned more about the life history or process of the organism targeted for restoration
- o Other? [text]
- o None

Q44) Would you make changes to any of the following aspects of the project? I will read each item in turn.

- o Partners / Team / Personnel (questions about technical expertise, input from scientists here) [Yes/No] [Text]
- o Project management process (as opposed to the particular players, etc in the previous bullet) [Yes/No] [Text]
- o Funding Sources and their associated requirements [Yes/No] [Text]
- o Design Process [Yes/No] [Text]
- o Implementation process [Yes/No] [Text]
- o Permitting [Yes/No] [Text]
- o Monitoring [Yes/No] [Text]
- o Evaluation [Yes/No] [Text]
- o Public involvement [Yes/No] [Text]
- o Size of project [Yes/No] [Text]
- o Other? [text]

Q45) Was information about this project disseminated outside your organization?

☐ yes ☐ no ☐ I don't know

Q45a) If yes, through what specific media? *[check all that apply]*

- o Website [text]
- o Scientific journal [text]

- Popular press [text]
- Agency or funder report [text]
- Public report
- Meeting presentation [text]
- newsletter
- Other [text]

PART V. ADDITIONAL INPUT AND ADVICE

Q46) Are there any lessons learned, positive or negative, that you'd like to share with other practitioners? [Text]

Q47) Is there anything else that I haven't asked that you feel we should know about this project? [TEXT]

Q48) Where should we put the results of this study in order to make it easily accessible to you & your colleagues?

- Website / Journal (if so which one:____) / White Paper / Association Meetings / Conferences / Restoration handbook / Restoration training session or workshop
- Other? [text]

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