Development of a Statewide Freshwater Wetland Restoration Strategy

Site Identification and Prioritization Methods

Nicholas A. Miller and Francis C. Golet

Department of Natural Resources Science
University of Rhode Island, Kingston
Kingston, RI 02881

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Executive Summary

In July of 1999 the University of Rhode Island's Department of Natural Resources Science and the Rhode Island Department of Environmental Management's (RIDEM's) Office of Water Resources initiated a project to develop a statewide, freshwater wetland restoration strategy to be applied on a watershed-by-watershed basis. This project is funded by the U.S. Environmental Protection Agency under a Section 104(b)(3) grant. The ultimate goal of this effort is to reinstate wetland functions (e.g., flood abatement, water quality improvement, fish and wildlife habitat, heritage) in areas where wetlands have been destroyed or degraded. The strategy is designed for proactive restoration, not regulatory use.

This report presents the results of Phase I of this project, which focused on the development of site identification and prioritization methods. Specifically, the report: (1) provides a foundation for developing a restoration strategy (see Tasks A through D, below); (2) lists techniques used to identify restoration opportunities (see Task E); and (3) describes the approach developed to prioritize potential restoration sites (see Task F). Site identification and prioritization methods were tested in a 3.5-x3.5-mile study area within the Woonasquatucket watershed. During Phase II of this project, these methods will be applied as we develop a restoration plan for the entire Woonasquatucket watershed.

Throughout Phase I, project personnel have actively sought input from stakeholders. A meeting was convened early in the project to inform them of the plan to develop a statewide freshwater wetland restoration strategy; attendees included representatives from State and Federal agencies, municipal governments, watershed associations, nongovernmental conservation organizations, and other interested parties. Results and conclusions from Phase I were presented at meetings of several groups, including the Rhode Island Habitat Restoration Team, the Woonasquatucket Watershed Council, and the Rhode Island Association of Wetland Scientists. Stakeholders have been given the opportunity to review and comment on this report.

Task A. Review of wetland restoration programs in other states.

The goal of Task A was to provide a context for the development of a statewide wetland restoration strategy. We accomplished this goal by investigating restoration programs in other states and regions of the country. Investigations were conducted by interviewing program personnel; a profiles of each program is provided in Appendix A. A total of 23 states or programs was investigated; of these, 18 restoration programs are being developed or have already been implemented. We paid special attention to programs that identify restoration opportunities in advance and to those that prioritize opportunities. Approaches and methods developed in other programs were considered during completion of Tasks E and F.

Task B. Freshwater wetland restoration activities in Rhode Island.

Task B was undertaken to determine the status of restoration efforts within Rhode Island. The original intent was to catalogue past and ongoing freshwater restorations in the State; however, very few proactive restorations have occurred. RIDEM's Office of Compliance and Inspection has ordered the restoration of many freshwater wetlands in response to illegal alterations.

Another goal of Task B was to determine the roles of State agencies, Federal agencies, and nongovernmental conservation organizations in freshwater wetland restoration in Rhode Island. This report contains a brief summary of the activities of each group, including specific projects they have completed or proposed and ranking strategies that may have been applied to select projects for implementation.

Task C. Generic review of the types of freshwater wetland restoration opportunities that exist in Rhode Island, both in terms of impacts that would have to be removed and the probability of restoration success for individual freshwater wetland types.

We conducted a literature review to ensure that our development of identification and prioritization methods was founded on good science; this review addressed fundamental issues involved in restoration. The text for this task is divided into three sections.

Section 1 identifies impacts to Rhode Island freshwater wetlands that might be removed through restoration projects. Nine categories of impacts were addressed: filling, sedimentation, stream channelization, draining, trash dumping, removal of wetland vegetation, removal of adjacent upland vegetation, impedance of surface flow, and invasive species. The influence of the removal of each impact type on flood abatement, water quality improvement, groundwater recharge, groundwater discharge, wildlife habitat, fish habitat, and heritage functions of wetlands are summarized in Table C1. Recommendations for the relative priority that each impact type should receive are presented in Table C2. Information in this section contributed heavily to the development of prioritization methods, which are presented under Task F.

Section 2 discusses the restorability and projected functions of restoration sites, based on wetland type. The discussion assumes that restoration involves a return to the wetland type prior to impact. Wetland types examined included ponds, vernal pools, marshes, wet meadows, forested swamps, shrub swamps, fens, bogs, and streams; we also addressed the vegetation of adjacent uplands. Wetland type factors heavily into restorability; for example, marshes may be relatively easy to restore, forested swamps may be restored but require decades to reach maturity, and bogs are difficult—if not impossible—to restore. The relative restorability of each of these types is summarized in Table C3.

Section 3 addresses additional factors that may influence wetland restorability. Those factors include urban vs. rural context, hydrogeomorphic setting, monitoring and maintenance requirements, time requirements, current land use, and the size of the restoration site.

Task D. Status of Rhode Island's freshwater wetland resources on a watershed basis.

The goal of Task D was to provide freshwater wetland area statistics for each Rhode Island watershed. Data were summarized from the Rhode Island Geographic Information System (RIGIS) wetlands coverage and all of the RIGIS open space coverages. Table D1 presents wetland acreage by ownership category (i.e., Federal, State, municipal, nongovernmental conservation organization, and private). Table D2 presents the total acreage of each wetland type within each watershed.

Task E. Development and testing of techniques for identifying specific restoration opportunities.

Many data sources and methods were considered for the identification of potential restoration sites. The most promising methods were tested in a 3.5-x3.5-mile study area within the Woonasquatucket watershed. Based on those tests, we recommend the following methods for future use in the Woonasquatucket and other Rhode Island watersheds. Each recommended method is described in detail within the body of the report. Step-by-step instructions for each method are provided in Appendix E2. A stakeholder site nomination form and guidelines are provided in Appendix E3.

To identify *destroyed* sites (i.e., wetland that has been converted to upland through filling or drainage), we recommend two techniques:

1. Comparison of 1939 aerial photography with 1988 aerial photography containing wetland delineations.
2. Inspection of 1981 soil survey data.

To identify *degraded* sites (i.e., existing wetland within which certain functions have been compromised), we recommend three techniques:

1. Interpretation of delineated 1988 aerial photography.
2. Interpretation of 1997 digital orthophotography.
3. Site nomination by stakeholders.

Identified sites should be entered into a GIS point coverage. The attributes table for that coverage should contain information about wetland type, impact type, land use, and other factors relevant to restoration (see Table E1). The approximate boundaries of destroyed sites should be delineated to create a GIS polygon coverage. The GIS coverages will facilitate the cataloging of potential restoration sites and the prioritization process.

Task F. Development and testing of approaches to prioritize restoration opportunities.

The goal in Task F was to identify those sites that have the greatest potential to provide the most benefits after restoration. We developed a filtering process to select such sites from among the hundreds that may exist within each Rhode Island watershed. An outline of the entire filtering process is provided in Figure F1.

We propose that restoration opportunities first be prioritized according to the general impact category; this is because the potential to re-create various wetland functions depends on the nature of the impact (see Task C, Section 1). Under our approach, destructive impacts (i.e., filling, draining) would be ranked highest. Restoration of destroyed wetlands has the potential to provide the most benefits; it involves re-creation of wetland functions where none currently exist. Degraded sites already perform certain functions; they would be given lower priority than destroyed sites because there is less to gain. Degrading impacts should be prioritized further, according to the specific impact type. In order of decreasing priority, those impacts include removal of adjacent upland vegetation, impedance of surface flow, dumping of trash, stream channelization, invasive species, and sedimentation (Figure F1). The reasoning behind this order is given in Section 1 of Task C.

We also recommend that individual sites be further ranked within each of the broad impact categories listed above (see Figure F1). Destroyed sites should be ranked according to their ability to perform each of five functions (i.e., flood abatement, water quality improvement, wildlife habitat, fish habitat, and heritage) and according to their ability to perform multiple functions. An assessment method was developed to accomplish this ranking (see Appendices F1, F2, and F3 for details and rationale). Each function has a list of criteria associated with it; those criteria are used to calculate the probability that the function would be performed, given restoration. Probability scores are increased if it is clear that restoration would result in social benefit. Scores are further adjusted to ensure that large sites receive high priority.

We recommend a unique ranking procedure for sites associated with each of the degrading impact types. For an overview of each recommended procedure, refer to Figure F1.

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Table of Contents

List of Tables

List of Figures

Task A. Review of wetland restoration programs in other states.

Introduction

We investigated wetland restoration programs in other states and regions of the country, with emphasis on techniques for the advance identification and prioritization of potential restoration opportunities. This survey provided a context for developing a freshwater wetland restoration strategy in Rhode Island and gave us a range of methodologies to consider. We had originally intended to investigate only freshwater wetland restoration programs in New England and other Northeastern states, under the assumption that these areas possess similar resource bases—both economic and ecological—to Rhode Island. However, some of the more notable programs are outside the Northeast or focus on coastal wetland restoration; therefore, we decided to expand our search to include these programs. A total of 23 states or programs was investigated; of these, 18 restoration programs are being developed or have already been implemented. This report is not intended to be a comprehensive survey of wetland restoration programs throughout the United States; however, it does provide a representative sample of the range of techniques employed, particularly in the more prominent programs. None of the restoration planning occurring in Rhode Island is included in this section; see Task B for information on those programs and activities.

Table A1 identifies the programs reviewed, gives their current status, and indicates whether advance identification or prioritization is involved in each case. Appendix A provides a detailed profile of each program. The programs are arranged first by current status (i.e., implementation, development, or no program), and then alphabetically.

Results and Conclusions

Date of Inception

Wetland restoration is a recent phenomenon, and this is reflected in the age of restoration programs. Most of these programs were initiated within the past 5 to 10 years. The Long Island Sound Study (LISS) began in 1985, and is the oldest of the programs investigated.

Table A1. Wetland restoration programs investigated for Task A.

Program	*Current status*	*Advance identification*	*Prioritization*	*Page number*
Illinois Conservation Reserve Enhancement Program	Implementation	No	No	75
Long Island Sound Study	Implementation	Yes	Yes	77
Maryland Department of the Environment	Implementation	Yes	Yes	80
Massachusetts Bays Program	Implementation	Yes	No	82
Massachusetts Wetland Restoration and Banking Program	Implementation	Yes	Yes	84
North Carolina Wetlands Restoration Program	Implementation	Yes	Yes	87
Oregon Wetlands Joint Venture	Implementation	Yes	No	89
Pennsylvania Wetland Replacement Project	Implementation	No	No	91
Puget Sound Wetlands Restoration Program	Implementation	Yes	Yes	93
Southern California Wetlands Recovery Project	Implementation	Yes	Yes	95
Southern New England/New York Bight Coastal Ecosystem Program	Implementation	Yes	Yes	97
Tennessee Wetlands Conservation Strategy	Implementation	Yes	Yes	99
Chesapeake Bay Program Wetlands Initiative	Development	Yes	No	101
Delaware	Development	Yes	Yes	103
Gulf of Maine Program	Development	Yes	No	105
Maine	Development	Yes	No	107
Maryland Department of Natural Resources	Development	Yes	Yes	109
Oregon Governor’s Watershed Enhancement Board	Development	Yes	Yes	111
Michigan	No Program	No	No	113
Minnesota	No Program	No	No	114
New Hampshire	No Program	No	No	116
New Jersey	No Program	No	No	117
Vermont	No Program	No	No	119

Habitats Addressed

The majority of programs do not discriminate between coastal and freshwater wetlands in regard to site identification or prioritization. Of the 18 restoration programs reviewed, 5 focus specifically on freshwater wetland ecosystems, 3 target coastal wetland ecosystems, and 10 address both coastal and freshwater wetlands. Sometimes, as in the case of Massachusetts' Wetland Restoration and Banking Program (WRBP), where both categories of wetland are addressed, coastal wetlands receive higher priority.

Program Context

Seven of the 18 restoration programs operate in a nonregulatory, proactive context. Four programs focus specifically on wetland restoration as mitigation to compensate for wetland loss. The final seven programs conduct wetland restorations in both regulatory and nonregulatory settings.

Pilot Studies

Seven of the 18 restoration programs have conducted pilot studies or are in the process of doing so. Pilot studies allow program personnel to test and modify various methods for site identification and prioritization.

Advance Identification of Restoration Opportunities

Massachusetts' WRBP categorizes restorations as either Type 1 ("reestablishing a wetland in a former wetland site that is presently non-wetland") or Type 2 ("returning a damaged, degraded, or otherwise functionally impaired wetland to its prior [pre-disturbance] condition or one similar to it"). This distinction is more than just conceptual; methods for the identification of former (i.e., destroyed) wetland are distinct from those used to identify degraded wetland.

Advance identification of potential restoration opportunities is central to most of the restoration programs. Of the 18 programs reviewed, 16 identify opportunities in advance. To accomplish this, many different methods have been used. Traditional aerial photo-interpretation and computer-intensive methods (e.g., GIS) are the most common techniques.

Seven of the programs use traditional aerial photo-interpretation. Time-lapse analyses are employed to locate *destroyed* wetlands. In this method, historic photos are compared to more recent photos; differences in the shape, size, or extent of wetlands indicate wetland loss. The LISS fuses this approach with a computer-intensive approach by digitizing delineations of historic and recent aerial photos and overlaying them in a GIS environment. To identify *degraded* wetlands, recent aerial photos are interpreted for any signs of impact.

Ten of the programs incorporate computer-intensive methods, such as GIS, into their identification strategy. The most common approach for the identification of destroyed wetland is to conduct an overlay of a wetlands dataset (most often National Wetland Inventory [NWI] digital maps) with a hydric soils coverage. Alternatively, a hydric soils coverage can be overlaid with a land use-land cover dataset to identify former wetland sites.

GIS analyses often serve as a screening process; large amounts of data are filtered to identify sites that may have been impacted. These sites must then be verified by checking aerial photos or conducting field visits. The extent to which these methods are used and the quality of the output are primarily a function of the quality of the initial datasets. Comprehensive, high-quality datasets are lacking in many states—particularly the larger states. Rhode Island is a small state with high-quality spatial datasets in the Rhode Island Geographic Information System (RIGIS). The RIGIS wetlands dataset is much more accurate than NWI maps. For this reason, GIS methods that have been used in other states could have even greater value in Rhode Island. RIGIS has additional statewide datasets (e.g., FEMA floodplains, roads coverage, land use-land cover) which could be used to infer wetland degradation or destruction; the use of these types of datasets appears to have been largely unexplored in other states.

There are other means of identifying restoration opportunities. Three programs identify sites by conducting field surveys or soliciting site nominations from the general public. Five of the programs hold meetings in which potential restoration opportunities are listed and discussed.

Prioritization of Sites

Of the 18 restoration programs, 11 prioritize or rank restoration opportunities. Prioritization can be a complex, and sometimes contentious, process. Because of this, there are a wide variety of approaches. Several of the programs avoid prioritizing sites at all because low-ranked projects may often be more economically and logistically feasible than high-ranked projects; however, it is difficult to get people interested in low-ranked projects. Four of the programs assign potential restoration sites to broad priority categories (e.g., high, medium, or low). Three of the programs provide multiple, ranked lists of sites—one list for each wetland function of interest. North Carolina's Wetland Restoration Program ranks sites according to the results of a cost-benefit analysis. Four of the programs conduct *ad hoc* ranking based on meetings and discussions. By providing a queriable database, the Gulf of Maine Program allows the user to select parameters of interest and create his or her own list of priority sites. Three of the programs rank watersheds or hydrologic units within watersheds; individual sites may or may not be ranked.

The criteria used to prioritize sites also are diverse. LISS divides criteria into three categories: ecological, logistical, and public/economic benefits criteria. The following examples of criteria have been taken from all of the programs reviewed; for convenience they have been assigned to the categories used by LISS. Ecological criteria may include site area, wetland type, potential to restore historic functions, benefits to rare species, habitat connectivity, or wetland juxtaposition. Logistical criteria may include probability of restoration success, stakeholder support, cost per acre, future maintenance requirements, site ownership, current land use, soil drainage class, or distance from roads. Public/economic benefits criteria may include accessibility, potential for outdoor education, provision of open space, environmental equity, cultural significance, potential for recreational use, research value, flood desynchronization, surface and groundwater improvement, or base flow maintenance. For comprehensive lists of prioritization criteria, see the profiles for the Puget Sound Wetlands Restoration Program and the LISS in Appendix A. Cost-benefit analyses, such as those conducted by North Carolina's Wetland Restoration Program, may also provide a basis for ranking sites. Costs can be both economic and ecological (e.g., loss of valuable upland habitat).

Four of the programs set goals and evaluate restoration needs on a watershed-by-watershed basis. Massachusetts' WRBP dubbed this technique a "functional deficit analysis." Watershed needs are evaluated by examining all sources of available data (e.g., total maximum daily loads, flooding reports, or water quality assessments). Goals are set by considering these deficits and consulting with experts and stakeholders. Functional deficit analyses allow for prioritization criteria and methods to be tailored to individual watersheds.

Task B. Freshwater wetland restoration activities in Rhode Island.

Introduction

Task B was undertaken to determine the status of freshwater wetland restoration efforts within Rhode Island. This chapter describes the framework within which we are developing the statewide freshwater wetland restoration strategy; it also reviews resources within the State that may support future restoration efforts. State agencies, Federal agencies, and nongovernmental conservation organizations that are involved in freshwater wetland restoration are identified. The following text describes the role that each agency and organization plays, specific projects they have completed or proposed, and ranking strategies that have been applied to select projects for implementation.

Although wetland creation and enhancement efforts within the State are briefly mentioned below, our principal focus was on proactive wetland restoration. For purposes of this project, *wetland restoration* is defined as the re-creation or rehabilitation of wetland ecosystems whose natural functions have been destroyed or impaired. Very few proactive restorations have occurred within the State. However, the Rhode Island Department of Environmental Management's (RIDEM's) Office of Compliance and Inspection has ordered the restoration of many freshwater wetlands in response to illegal alterations. Those enforcement cases will serve as a valuable source of information about the restorability of various wetlands within Rhode Island.

Agencies and Organizations Involved with Restoration

Federal Agencies

National Oceanic and Atmospheric Administration (NOAA). NOAA focuses primarily on coastal ecosystems; however, NOAA personnel have expressed an interest in restoring riverine wetlands to improve habitat for anadromous fish (J. Turek, pers. comm.). NOAA provides funding for wetland restoration projects.

U.S. Fish and Wildlife Service (USFWS). Through its Partners for Wildlife Program, USFWS has been cooperating with other agencies and organizations to restore and enhance both wetland and upland habitats. Approximately 25 projects have been undertaken in Rhode Island since the inception of the program in 1992; most of those projects have focused on upland or coastal wetland habitat (G. Mannesto, pers. comm.). Two of the projects involved maintenance of freshwater wetland enhancements via replacement of water control structures. The program has limited funds that may be available for future freshwater wetland restoration projects. Although there is no formalized ranking process, projects are funded based on their ability to provide certain benefits and meet certain criteria. Projects are qualitatively assessed for their potential to help endangered or threatened species, contribute to regional biological diversity, contribute to the goals of the North American Waterfowl Management Plan, reduce landscape fragmentation, restore natural communities listed by the Rhode Island Natural Heritage Program, control invasive species, benefit anadromous fish, and provide habitat with minimal or no maintenance requirements.

U.S. Department of Agriculture (USDA). The Natural Resources Conservation Service (NRCS) has been extensively involved with freshwater wetland creation and enhancement projects on private lands in Rhode Island through the USDA Wildlife Habitat Incentives Program (WHIP). The program also supports upland and coastal wetland projects. Past freshwater wetland projects have ranged from the creation of ponds to the installation of water control structures (B. Clarke, pers. comm.). Funds for FY2001 are targeted for specific areas (the Blackstone, Woonasquatucket, and South County watersheds), but are also available statewide. Projects are funded based on the results of a quantitative ranking process. Sites are assigned points according to specific criteria including habitat type and setting, benchmark conditions, anticipated post-project conditions, operation and maintenance requirements, societal benefits, likelihood of success, estimated cost per acre, and partnership contributions. Bonus points are added if the site supports (currently or historically) threatened or endangered species or if the site is adjacent to such an area. Bonus points are also added if the site contains habitat of special concern (e.g., a vernal pool, bog, fen, or marsh). NRCS also administers the Wetlands Reserve Program which, to date, has not been active in Rhode Island.

U.S. Army Corps of Engineers. The Corps of Engineers is undertaking one of the few proactive freshwater wetland restorations in Rhode Island. The project will remove fill at the former Lonsdale Drive-in movie theater, re-create floodplain forest, and create a vernal pool and marsh habitat (M. Penko, pers. comm.). The Corps also completed a Rhode Island Ecosystem Reconnaissance Study. The Study includes a draft Project Study Plan (PSP) that identifies approximately 15 potential restoration projects to advance to a feasibility phase; all of the projects are located within the Narragansett Bay watershed. The PSP includes cost estimates and preliminary designs for fish ladders along the Ten Mile River, a project that may be advanced through the feasibility phase. During the study, two brownfield sites along the Woonasquatucket River were identified as potential freshwater wetland restoration sites: Lincoln Lace and Riverside Mills.

State Agencies

Rhode Island Department of Environmental Management (RIDEM). Several Divisions within RIDEM have conducted proactive habitat restoration and enhancement projects for many years, including the Division of Fish and Wildlife, the Office of Planning and Development, and the Division of Parks and Recreation. In 1999, the RIDEM Director's Office created a Department-wide Habitat Restoration Team to promote a Statewide coordinated approach to all restoration. The Office of Water Resources, the Narragansett Bay Estuary Program, the Office of Compliance and Inspection, the Division of Agriculture, and the Office of Strategic Planning and Policy are also represented on the RIDEM Team. The Team's purposes are to coordinate and promote restoration efforts within RIDEM, to integrate restoration considerations into the activities of RIDEM Offices, and to advocate for restoration-oriented legislation. The RIDEM Habitat Restoration Team is presently working with others to develop a Corporate Wetlands Restoration Partnership. The Team maintains a broad focus on restoration of all habitat types including uplands, coastal wetlands, and freshwater wetlands. RIDEM Habitat Restoration Team members also are active members of the Rhode Island Habitat Restoration Team (see below).

Nongovernmental Conservation Organizations

Save the Bay (STB). This private conservation organization promotes environmental awareness through public outreach and education. It is involved in coastal wetland restoration planning efforts (focusing on salt marshes, seagrass beds, and anadromous fish runs) and environmental monitoring; it has also coordinated on-the-ground, volunteer-based salt marsh restorations (W. Ferguson, pers. comm.). STB has expressed an interest in expanding its efforts to freshwater wetland systems.

The Nature Conservancy (TNC). The Rhode Island Field Office of TNC primarily protects habitats by purchasing land titles or easements. Habitat restoration efforts have included the removal of trees to reestablish pine barrens in the Queens River watershed; however, TNC has not conducted any freshwater wetland restorations to date (V. Carpenter, pers. comm.).

Audubon Society of Rhode Island (ASRI). ASRI has conducted upland habitat restorations in partnership with USFWS, including the restoration of native grasses at sites in Tiverton and Warren (E. Marks, pers. comm.). They have also assisted TNC in restoring pine barrens habitat near the Queens River. To date, the Society has not conducted any wetland restorations in Rhode Island.

Ducks Unlimited (DU). DU has participated in coastal wetland restoration efforts in Rhode Island. It is likely that they would also be interested in contributing to restoration of freshwater systems (C. Ferris, pers. comm.).

Trout Unlimited (TU). TU is a national fish conservation organization that conducts stream and streambank restorations, advocates dam removal, and installs fish ladders to restore fish habitat. The Rhode Island Chapter of TU has conducted six stream restorations in the Arcadia Wildlife Management Area in cooperation with the RIDEM Division of Forest Environment, USFWS Partners for Wildlife, and NRCS (P. Kapsner, pers. comm.). All of these restorations consisted of streambank erosion control in response to impacts such as clear-cutting, road crossings, and horse-trail crossings. Techniques involved planting native vegetation and installation of coarse woody debris, pressure-treated lumber, and rip-rap. TU provided materials and volunteer labor, NRCS developed plans, and RIDEM planted vegetation and obtained wetlands permits. TU volunteers have casually monitored the sites and report increases in trout populations.

Rhode Island Habitat Restoration Team (RIHRT). Meetings of this group—which are jointly hosted by RIDEM, the Rhode Island Coastal Resources Management Council (RICRMC), and STB—are attended by personnel from State agencies, Federal agencies, municipal governments, nongovernmental conservation organizations, watershed associations, private environmental consulting firms, and concerned citizens. The group's purpose is to promote habitat restoration in Rhode Island. To accomplish this, they identify restoration priorities, link specific projects to funding sources, and advocate increased State restoration funding (T. Ardito, pers. comm.). Until recently, RIHRT focused specifically on coastal habitats (i.e., salt marshes, seagrass beds, and anadromous fish runs). They have recently broadened their focus to address all habitat restoration concerns in the State, including freshwater wetlands.

Task C. Generic review of the types of freshwater wetland restoration opportunities that exist in Rhode Island, both in terms of impacts that would have to be removed and the probability of restoration success for individual freshwater wetland types.

Section 1: Impacts to Rhode Island Freshwater Wetlands

We identified nine categories of impacts that might be removed during restoration of freshwater wetlands in Rhode Island. Those impacts, and the restoration activities that may remedy them, are discussed in the following paragraphs in relation to specific wetland functions. Although additional impact categories exist (e.g., nonpoint-source pollution and conversion to deepwater habitat), they are either considered to be beyond the scope of this project or there are other factors—ecological or social—which impede restoration in those cases. Information in this chapter contributed heavily to the development of prioritization methods, which are presented under Task F. A summary of the information presented in this chapter is provided in Table C1. Recommendations for the relative priority that each impact type should receive are presented in Table C2.

Filling

Impact description and restoration required. A wide variety of materials (e.g., sand, gravel, rock, tree stumps, and construction and demolition debris) have been dumped in wetlands throughout Rhode Island. Filling may destroy an entire wetland or a portion of one. Although the vast majority of wetland fill sites have been built upon, some areas remain undeveloped; these are often excellent candidates for restoration. Restoration activities would primarily involve removal of fill material and a return to original wetland elevations.

Effects of impact removal on wetland functions. Removal of fill material may be more effective than any other restoration activity at increasing the functional capacity of altered

Table C1. Probable effects of restoration activities on wetland functions. Symbols are defined as follows: "+" = positive effect on function, "-" = negative effect, "+/-" = positive and negative effects, "n/a" = no effect. Parentheses indicate uncertainty or minor effects.

	Restoration activity									
Long-term function	**Remove fill**	**Remove sediment**	**Recreate natural channel**	**Plug ditches**	**Remove trash**	**Reestablish wetland vegetation**	**Reestablish upland vegetation**	**Enhance surface flow**	**Remove invasives**	**Effective restoration activities**
Flood abatement	+	+	+	+	+	+	(+)	-	n/a	7
Water quality improvement	+	+	+	+	+	+	+	+/-	n/a	7+
Groundwater recharge	(+)	(+)	+	-	(+)	(-)	(-)	(+)	n/a	5
Groundwater discharge	+	+	(+)	+	n/a	(-)	(-)	-	n/a	4
Wildlife habitat	+	+	+	+	+	+	+	+/-	+	9
Fish habitat	+	+	+	+	+	+	+	+	n/a	8
Heritage	+	+	+	+	+	+	+	+/-	+	8+
Functions benefited	7	7	7	6	6	5	5	2+	2	

Table C2. Restoration priority of impacts to Rhode Island freshwater wetlands.

Type of impact	*Priority*[1]
Filling	High
Draining	High
Removal of adjacent upland vegetation	High
Impedance of surface flow	Moderate
Removal of wetland vegetation	Moderate
Trash dumping	Moderate/Low
Stream channelization	Moderate/Low
Invasive species	Low/Moderate
Sedimentation	Low

[1]See Task C, Section 1 text for rationale.

wetlands. This activity results in an increase in the abundance and size of wetlands, and therefore has the potential to positively influence each of seven wetland functions (Table C1). Removal of fill increases the total volume of floodwater that a wetland has the potential to store. By increasing the abundance or size of wetlands, surface water is "filtered" through a greater wetland area, resulting in increased nutrient transformation, sediment trapping, and pollutant removal capabilities. Groundwater discharge would be more likely to occur because fill removal lowers the ground surface to a point closer to the groundwater table. Groundwater recharge would be more likely to occur where fill removal restores basin wetlands that could collect and hold surface runoff or streamflow for extended periods. Wetland-dependent wildlife would benefit from an increase in the size or abundance of wetland habitat. Fish would directly benefit from an increase in open water or marsh habitat, and may indirectly benefit from restoration of other adjacent habitat types due to the potential for improved water quality. Aesthetics, educational opportunities, biodiversity, open space, and recreational potential all can be expected to increase with greater wetland area.

Recommendations. Because filling has resulted in extensive wetland loss in this State, and because removal of fill material has the potential to positively influence all seven of the wetland functions of interest, wetlands that have been filled should receive high priority during restoration planning.

Sedimentation

Impact description and restoration required. Sedimentation occurs most often where roads—which are sanded during winter—cross wetlands. Other sources of sediment may include unpaved road surfaces, cultivated fields, active construction sites, and gravel mining operations. The effects of sedimentation are similar to those of filling (see above). Portions of wetlands may be converted to upland, or wetland surface waters may become turbid or shallower due to sedimentation.

Effects of impact removal on wetland functions. As with fill removal, removal of sediment has the potential to enhance all seven wetland functions.

Recommendations. In most instances, sedimentation is an ongoing process; simple removal of sediments may not result in restoration of sustainable wetland functions and it may contribute to the establishment of invasive species. For these reasons, sediment removal should not be a primary focus of wetland restoration efforts.

Stream Channelization

Impact description & restoration required. In Rhode Island, many small streams have been channelized, often due to historic farming practices. Channelized streams are usually straighter, deeper, and wider than natural streams. As a result, the water table in the surrounding land is lowered and local flooding problems may be reduced. However, channelization can cause local wetland loss and greater flooding problems downstream. Channelization may be partly remedied through reconstruction of the stream channel, but full restoration often is not feasible due to development in adjacent areas and the increased threat of flooding.

Effects of impact removal on wetland functions. Where re-creation of a natural channel is possible, all seven of the functions of interest may be enhanced. Floodwaters are slowed by the meandering of a natural channel and by floodplain vegetation during overbank flow; these processes reduce flood levels and delay the flood crest downstream. The same processes cause greater sediment deposition and increased interactions among water, substrates, and vegetation, resulting in improved water quality downstream. Water that has topped the banks of a re-created stream channel may percolate down through the substrate of the bordering floodplain and recharge the local groundwater system. Stream channelization usually lowers the local groundwater table; re-creation of a natural channel could raise the local groundwater table to a point where more groundwater discharge occurs seasonally. A return to a natural stream bottom, decreased water velocities, and resulting increases in the abundance of in-stream vegetation would greatly improve fish habitat. Wildlife would also benefit from re-creation of natural stream channels due to increased microhabitat diversity and (for piscivorous species) increased prey abundance. Natural stream channels are more visually complex and aesthetically appealing than channelized streams; restoration would increase all of the heritage functions.

Recommendations. Although re-creation of natural channels has the potential to positively influence each of the seven functions, this impact type probably should not be emphasized during the restoration planning process. As already noted, the restoration process may increase the flooding threat to adjacent areas that were developed after channelization took place.

Drainage

Impact description and restoration required. In the past, many wetlands of the Woonasquatucket watershed study area were drained—via ditching—and then converted to agricultural fields. Wetlands in other areas of Rhode Island also have been ditched for agriculture or mosquito control. Ditching may result in partial drainage (i.e., conversion to a drier wetland water regime) or complete drainage (i.e., conversion to upland). Many completely drained areas have been built upon, while others have naturally revegetated. In some areas, ditches have filled in naturally, promoting a return to wetland conditions. The potential for restoration exists where ditches continue to drain undeveloped areas. Restoration activities would include plugging or filling of the ditches. Former wetlands drained by open ditches may be among the easiest to restore; they already have hydric soils that contain a seedbank of hydrophytic species (Tiner 1995).

Effects of impact removal on wetland functions. In cases where wetland has been completely drained, restoration activities would cause an increase in wetland abundance, as with fill removal. Regardless of whether drainage has resulted in wetland loss or degradation, plugging or filling of ditches has the potential to restore six of the functions of interest (Table C1). After ditches have been plugged or filled, water may more readily disperse across the wetland surface; this will increase floodwater retention time. It will also promote increased interactions among water, substrates, and vegetation, resulting in nutrient uptake, adsorption, and transformation and improved water quality. Because drainage increases soil oxygen levels, former wetland organic soil horizons may decompose more rapidly and the surface may subside. After restoration, the groundwater table would be closer to the surface than prior to the ditching, and discharge would be more likely. At the same time, significant groundwater recharge would be less likely because the restored wetland would have a higher water table for longer periods of time. Ditch removal activities that increase wetland extent provide more habitat for wetland-dependent wildlife. If the plugging of ditches results in increased marsh or open water, fish would benefit. Restoration of ditched wetlands may create additional recreational opportunities, enhance regional biodiversity, and otherwise improve the heritage function.

Recommendations. Plugging ditches is a relatively inexpensive endeavor, when compared to fill removal. Although there are few of these opportunities in Rhode Island, unlike in states where agriculture has been a principal cause of wetland alteration, these opportunities should be ranked high during the restoration planning process.

Trash Dumping

Impact description and restoration required. Wetlands often serve as dumping grounds for broken appliances, junked cars, and other trash. When significant amounts of trash have been deposited, the impacted area may no longer perform certain functions and the wetland area has essentially been lost. Therefore, the issues associated with this type of impact—and its remedy, trash removal—are similar to those associated with filling. Certain types of dumped material (e.g., junked cars, oil drums) may leak oil and toxic chemicals.

Effects of impact removal on wetland functions. Trash could be considered a type of fill; see the section on fill removal for information about how trash removal might influence specific wetland functions, with the following exception. Trash removal probably has no effect on groundwater discharge; groundwater can continue to discharge in and around mounds of trash.

Recommendations. Wetlands that have been subjected to significant amounts of dumping should be targeted for restoration and ranked relatively high. Removal of minor amounts of trash and litter should be the focus of local volunteer efforts.

Removal of Wetland Vegetation

Impact description and restoration required. Freshwater wetland vegetation may be removed for a number of reasons, for example, to obtain fuelwood or to improve a viewshed. If limited to a single occurrence, removal of vegetation is a temporary form of wetland degradation. As long as there has not been an accompanying alteration of hydrology, most wetlands will revegetate naturally. Planting could enhance and expedite this process. However, certain plants such as Atlantic white cedar (*Chamaecyparis thyoides*) might be difficult to reestablish.

Effects of impact removal on wetland functions. Reestablishment of wetland vegetation has the potential to positively influence five of the seven functions of interest (Table C1). The presence of emergent vegetation (especially dense, persistent vegetation) plays a key role in reducing the velocity of floodflow in wetlands; this increases the probability that wetlands may reduce the severity of downstream flooding. Reduction of water velocity also causes sediments to drop out of suspension. Combined with the nutrient uptake capabilities of emergent plants, the reestablishment of wetland vegetation can therefore positively influence water quality. The groundwater discharge function of wetlands might be reduced by reestablishing vegetation because plants would take up and evapotranspire water that might otherwise be discharged. Reestablished vegetation could have a negative effect on recharge as well, by reducing the amount of water that might reach the groundwater table. Vegetation is a key component of wildlife habitat; reestablishment of vegetation that has been removed would do much to reinstate lost habitat values. Reestablishment of submergents, floating-leaved plants, or emergents could provide microhabitat for fish. Other wetland vegetation types could provide shade and water quality improvement functions that would also benefit fish. There is little doubt that a naturally vegetated wetland is more aesthetically pleasing than a denuded wetland. Revegetation would enhance heritage functions.

Recommendations. Although reestablishment of wetland vegetation may positively influence most of the functions, this impact type should probably not receive priority during the restoration planning process. If the disturbance that caused the vegetation removal is not ongoing, the wetland will most likely revegetate naturally from its seedbank and by seed dispersal from other wetlands. However, planting may grant more desirable species a competitive edge in areas where there is a threat of invasion by the common reed (*Phragmites australis)* or purple loosestrife (*Lythrum salicaria*).

Removal of Adjacent Upland Vegetation

Impact description and restoration required. Removal of adjacent upland vegetation was, by far, the most common type of impact observed in this study (see Task E chapter). In cases where parking lots or yards now occupy the denuded areas, restoration is unlikely. The best restoration opportunities exist where cleared areas remain free of development and are unused. The primary restoration activity for this type of impact would involve reestablishment of adjacent upland vegetation.

Effects of impact removal on wetland functions. Reestablishment of adjacent upland vegetation would have minimal influence on flood abatement in the wetland; however, dense vegetation in the adjacent upland may slow surface runoff into a wetland and promote infiltration in upland soils, thereby prolonging the period before floodwaters exceed the storage capacity of the wetland. The presence of dense, persistent, upland vegetation would positively influence the long-term ability of a wetland to improve water quality. Upland vegetation surrounding wetlands can remove sediments, nutrients, and other pollutants from surface water, decreasing the likelihood that a wetland will become saturated with these pollutants. Planting vegetation in uplands surrounding wetlands has no direct impact on wetland groundwater functions; however, theoretically, high transpiration rates in the adjacent upland might lower wetland groundwater levels and reduce the probability or duration of groundwater discharge. Similarly, slowing surface runoff into wetlands and increased infiltration in adjacent uplands might reduce total water available for groundwater recharge in the wetland. Vegetated uplands adjacent to wetlands screen out noise and filter water-borne pollution that would otherwise adversely influence wetland-dependent wildlife and fish. Vegetation in the adjacent upland may also satisfy key habitat requirements (e.g., nest sites, roosting sites, foraging areas) for wetland wildlife. Reestablishment of upland vegetation adjacent to wetlands can increase the effective size of natural areas and positively influence the heritage function, especially aesthetics.

Recommendations. Although reestablishment of adjacent upland vegetation might have major positive effects on only four of the seven functions of interest (Table C1), this restoration activity should receive high priority during restoration planning. Planting upland vegetation is non-invasive (i.e., there is minimal disturbance of existing wetland soils or wetland vegetation) and it is inexpensive relative to restoration efforts that require heavy machinery.

Impedance of Surface Flow

Impact description and restoration required. Culverts that have been blocked by sediments or other material and those that have been installed at inappropriately high elevations often cause surface water to impound. These impoundments can create wetter water regimes, and they may result in a change in wetland type. The restoration activities required to amend these impacts include removing obstructions to flow or installing new culverts at more appropriate elevations; these activities may both be categorized as enhancing surface water flow.

Effects of impact removal on wetland functions. Enhancing surface water flow positively influences at least three of the seven functions (Table C1). Flood abatement would be negatively impacted because restoration would remove constrictions to wetland outlets; constricted outlets enhance the floodwater storage capability of wetlands. Water would flow more quickly through the wetland after restoration and sediments would be less likely to drop out of suspension; in this regard, water quality would be negatively influenced. However, if flow enhancement replaced open water with dense, persistent emergent vegetation, nutrient uptake would be improved and sediments might be trapped by the dense vegetation; in this case, water quality would be positively influenced. Groundwater recharge might be enhanced if improved surface water flow resulted in a return to a temporarily or seasonally flooded water regime instead of longer periods of inundation. If water were allowed to move more quickly through a wetland, the local water table might drop farther below the surface and the probability of groundwater discharge would decline. Fish and wildlife that had inhabited the site prior to impoundment would benefit from a return to original habitat types, while species favoring the wetter conditions would decline. The heritage function would not necessarily be directly influenced, since restoration would simply result in a change in water regime or conversion from one wetland type to another. However, impoundment might threaten survival of highly regarded plant species or communities. On the other hand, water-based recreational opportunities might decline after flow enhancement.

Recommendations. Enhancement of surface flows may be accomplished relatively inexpensively if sediment removal is the only issue. These situations should receive moderate priority in the restoration planning process. In cases where the elevation (invert) of the culvert is too high, restoration would be more costly. Under both scenarios, restoration could result in temporary flooding problems downstream.

Invasive Species

Impact description and restoration required. Invasion of wetlands by *Phragmites* or purple loosestrife is a growing problem in Rhode Island. Both species have the potential to produce monotypic stands covering large expanses of wetland. In such extreme situations, control can only be achieved through intensive, continuous management (i.e., cutting and application of herbicides). Where *Phragmites* has only begun to colonize a wetland, hand removal and treatment with herbicides may check its advance; however, continual maintenance will probably be required. Results from recent experiments suggest that biological control of purple loosestrife may be achieved by introducing an exotic beetle to impacted wetlands.

Effects of impact removal on wetland functions. Regardless of the technique employed, removal of invasive species has the potential to positively influence only two of the seven functions. Wildlife habitat would be improved because many wetland-dependent species cannot make use of monotypic stands of *Phragmites* or purple loosestrife. These monotypic stands also threaten regional biodiversity. For this reason, removal of purple loosestrife or *Phragmites* would improve the heritage function of a wetland.

Recommendations. This restoration activity should receive low priority during the restoration planning process because removal of invasive plant species requires continual, intensive maintenance and the techniques used are not without risk (e.g., application of herbicides, introduction of exotic beetles). In addition, very few wetland functions are enhanced via this removal. Efforts should be restricted to particularly valuable wetlands where there is some hope of stemming the tide of invasives or where maintenance of high-quality wildlife habitat is a major objective.

Section 2: Restorability of Major Wetland Types

In Section 1, we showed that the nature of the impact to a wetland can determine which functions have the potential to be restored. The restorability and projected functions of a given site also depend on the wetland type that is targeted for restoration. Kusler and Kentula (1990) noted that the majority of "restoration" activities actually involve wetland enhancement (e.g., impoundment of existing wetland to enhance waterfowl habitat) and wetland creation (e.g., using dredged material to create marshes along rivers or in bays). Although literature related to such projects has been consulted, the following discussion hinges on our narrower definition of restoration: re-creation or rehabilitation of wetland ecosystems whose natural functions have been destroyed or impaired. In this instance, the goal is to re-create the type of wetland that existed before alteration, and its functions, insofar as possible.

Different wetland types are often quite distinct in structure and certain functions. Some wetland types are easier to rehabilitate or re-create than others. The National Research Council (1992) stated that "controversy exists as to whether or not certain wetland systems can be restored." Much of this controversy exists because, although there have been many attempts to restore wetlands, very few of those attempts have been critically evaluated (Kusler and Kentula 1990). The following paragraphs present information about the relative restorability of major wetland types, based on restoration projects that have been evaluated. A summary of this information is provided in Table C3.

Table C3. Restorability of Rhode Island freshwater wetland types, based on the scientific literature.

Wetland type	***Rating***[1]
Ponds	High
Marshes	High
Wet meadows	Moderate
Streams	Moderate
Vernal pools	Moderate
Shrub swamps	Moderate
Forested swamps	Low/Moderate
Fens	Low
Bogs	Low

[1]See Task C, Section 2 text for rationale.

Ponds

Ponds are among the easiest of wetland types to create. Tiner (1995) noted that "ponds have been successfully created by many cultures throughout the course of human history." In fact, open water bodies are restored and created disproportionately to the frequency with which they occur in nature (Kentula 1993). But this bias may not be due entirely to the ease of restoring ponds; pond creation often is unintentional. Galatowitsch and van der Valk (1996) found that, in recently restored prairie pothole wetlands, the water regime was often wetter than planned, resulting in more open water habitat than what occurred historically. This overabundance of open water was at the expense of other, less common wetland types such as sedge meadow. Organic substrates drained for agriculture subside due to enhanced decomposition rates; subsidence results in lower soil elevations and wetter water regimes after hydrologic restoration. Additional anthropogenic causes of pond formation include gravel mining, rock quarrying, crop irrigation or livestock watering, floodwater detention, and road construction (Hollands 1990). Filled sites that are restored as a result of enforcement orders are sometimes excavated to below the original wetland grade in an attempt to ensure wetland hydrology (S. Tyrell, RIDEM, pers. comm.). Ponds may also be disproportionately represented because of their aesthetic and recreational properties. Numerous ponds have been created in Rhode Island through the efforts of the Natural Resource Conservation Service—and other agencies and groups—to restore or enhance wildlife habitat or the heritage function. Although the total number and acreage of Rhode Island ponds has undoubtedly increased as a result of human activities, additional pond restorations are justifiable in an attempt to recreate natural habitats that have been destroyed or degraded.

The success of pond restoration will depend on the nature of the impact and, therefore, the restoration technique employed. Removal of fill material, sediment, or trash simply requires excavation to a depth sufficient to maintain the desired amount of water. Excavation to a certain water depth may also effectively control invasive plant species such as *Lythrum salicaria* (Weiher et al. 1996) and *Phragmites australis*. Water quality impacts are more difficult to rectify. Open water bodies act as sinks for nonpoint-source runoff of silt, nutrients, and pesticides (National Research Council 1992). Although revegetation of adjacent uplands may help to filter some of these pollutants (Fennessy and Cronk 1997), significant water quality improvement would require reduction of pollutants at the source—a task well beyond the scope of onsite wetland restoration projects. Aquatic bed plant communities of ponds (e.g., *Potamogeton* spp., *Nymphaea* *odorata*, *Nuphar luteum*) may be difficult to restore if water quality is poor. Successful aquatic bed restoration requires water that is clean, clear, permanent, and shallow (Tiner 1995). Turbidity can limit reestablishment of submersed species (Mitsch and Gosselink 1993). Galatowitsch and van der Valk (1994) found that submergent plant species readily recolonized prairie potholes of the Midwest that were drained for agriculture and subsequently restored. Pond drainage appears to be rare in Rhode Island; no drained ponds were detected in the Woonasquatucket study area.

Vernal Pools

Restoration of vernal pools has been largely overlooked. Some have been created inadvertently as a result of excavation for other purposes (e.g., borrow pits, fire protection). Restoration or creation techniques and issues for vernal pools are similar to those for permanent ponds (see above). However, the hydrology of vernal pools is much more dynamic than that of permanent ponds, and it would likely be much more difficult to replicate natural water regimes. Research over the last 10 years has demonstrated that pond hydroperiod is a key determinant of amphibian community composition, species richness, and reproductive success (Semlitsch 2000). A solid understanding of vernal pool hydrology—and the relationship between hydrology, surficial geology, and other site factors—is required for restoration efforts to succeed. Because of their small size, destruction of entire pools is likely; therefore, most restoration efforts would involve vernal pool creation. Schiller et al. (2000) reported success in restoring populations of an endangered plant species (*Pogogyne abramsii*) by creating vernal pools in California. Many vernal pool-breeding amphibians require extensive tracts of upland forest contiguous with their breeding pools. To successfully recreate habitat for these species, vernal pool restorations should occur in large forested areas not threatened by development.

Marshes

Reintroduction of proper hydrology is critical to restoration of a specific wetland plant community (Lowry 1990). Fortunately, most marsh plants can tolerate relatively large fluctuations in water level (Kusler and Kentula 1990) and, for that reason, marshes are “among the easiest wetlands to restore” (Tiner 1995). The simple structure and rapid maturation of marsh vegetation communities and the presence of native seed stocks also contribute to quick and relatively successful restorations (Kusler and Kentula 1990). However, in a paper discussing the trajectories and time requirements of wetland restorations, Zedler and Calloway (1999) warned that even simple communities like cattail marshes require 5 to 10 years for restoration of most functions. More diverse, complex communities have greater time requirements. Galatowitsch and van der Valk (1996) found that tile-drained prairie pothole marshes could be restored; emergent plant species quickly recolonized restoration sites (Galatowitsch and van der Valk 1994). Marshes are often disproportionately represented in restoration and creation efforts for the same reasons that ponds are over-represented (see above). In addition, other wetland types (e.g., forested wetland) are often converted to marsh for purposes of wildlife habitat “enhancement” (Golet 1986); this is at the expense of wildlife dependent on the former wetland type.

Marshes provide habitat for a diversity of wetland-dependent and wetland-associated wildlife species; they are often targeted for restoration to benefit migratory waterfowl. After 3 years of monitoring avian communities of New York marshes restored from drained agricultural sites, Brown and Smith (1998) concluded that, although restored wetlands provided adequate habitat for wetland birds, they did not function quite as well as natural reference marshes. They predicted, however, that further succession of the restored vegetative community might cause bird communities in restored and natural marshes to become more similar.

Former marshes that have been drained and cultivated are relatively easy to restore, particularly if they are small and drained by open ditches (Tiner 1995). Because natural seedbanks may be viable for centuries, planting is not required; restoration of such sites simply involves plugging the ditches. Tile-drained marshes may be more difficult and costly to restore. Fortunately, marshes that have been drained for agriculture in Rhode Island generally have been drained using open ditches, but such restoration opportunities are scarce here. Wetland basins with large watersheds are also more difficult to restore because they may require water- and erosion-control measures to prevent washouts (Tiner 1995). Tiner also recommended tilling sites before restoring hydrology to hasten recolonization by hydrophytes in the existing seed bank. However, Brown (1999) found that restored sites with disturbed substrates ended up as monotypic stands of cattail, providing less value for wetland birds.

Wet Meadows

In comparison to marshes, there is little published information on restoration of wet meadows. Tiner (1995) grouped wet meadows with marshes in regard to restoration difficulty, perhaps because, like marshes, they represent an early stage of hydrarch succession. Although the lack of vegetative structural complexity suggests that restoration should be relatively simple, the hydrologic regime required to maintain wet meadows—and to prevent rapid invasion by woody plants—is more difficult to re-create. Wet meadow vegetation requires prolonged soil saturation, often with temporary or seasonal flooding. Galatowitsch and van der Valk (1994) stated that sedge meadow zones were rarely established successfully following restoration of hydrology to drained prairie potholes in the Midwest. This probably can be attributed to two factors: restored water regimes were wetter than original water regimes (Galatowitsch and van der Valk 1996) and *Carex* species typical of wet meadow communities have poor seed set and low long-term seed viability (Budelsky and Galatowitsch 1999). The absence of certain breeding bird species in restored prairie potholes, when compared to natural potholes, has been attributed to the lack of a wet meadow zone in restored sites (Delphey and Dinsmore 1993, VanRees-Siewart and Dinsmore 1996).

Larson (1999) stated that attempts to create mature sedge-meadow communities in a short period of time will result in failure; he said that, instead, we should attempt to mimic the natural successional pathways of wetland communities. Larson has achieved this in restored Wisconsin sedge meadows by planting woolgrass (*Scirpus cyperinus*) at restoration sites. Woolgrass forms tussocks upon which other sedges can establish, and also inhibits invasion by exotics. Later-successional plants can be propagated in "waves," or succession can be allowed to occur naturally.

Tiner (1995) recommended placing fences around restored wet meadows to eliminate grazing problems. In many areas of the Northeast, however, wet meadows typically succeed to shrub swamp and, eventually, forested wetland in the absence of continued disturbance (Golet et al. 1993). Disturbance regimes such as grazing, cutting, or mowing may need to be applied to ensure continued dominance of wet meadow vegetation after restoration. However, this need for long-term maintenance could make the restoration of wet meadow habitat controversial. Many restoration scientists (e.g., Zedler 1988, Kentula 1993) assert that the probability of long-term success is significantly reduced if restored wetlands are not designed to be self-maintaining. If a "hands off" approach is taken, restored wet meadow can be expected to succeed to forested wetland. As Zedler (1988) pointed out, "it is hard to plan for a system that is naturally dynamic."

Forested Swamps

Although there have been numerous attempts to restore bottomland forests in the South (Tiner 1995), forested wetland restoration has rarely been attempted in the glaciated Northeast (Lowry 1990). In their assessment of the status of restoration science, Kusler and Kentula (1990) concluded that forested wetlands are much more difficult to restore than earlier-successional wetlands such as marshes. At that time, Clewell and Lea (1990) stated that it was too early to evaluate the success of forested wetland restorations conducted in the southeastern United States because forests are complex ecosystems that require long periods of time to fully develop. Clewell (1999) later reported success in creating forested wetland within 11 years on phosphate-mined land in Florida. After restoration this site contained over 200 species of trees, shrubs, vines, ferns, grasses, and forbs; the canopy had reached 85% coverage and some trees had attained a height of 12.5 meters. Tiner (1995) suggested that it may take 50 years before it is possible to assess success because trees require decades to reach maturity. Although some functions of forested wetlands (e.g., flood abatement, groundwater functions) may be effective despite the lack of a mature forest canopy, restoration sites presumably would not be suitable for forested wetland-dependent wildlife for several decades.

The lengthy time requirement for ecosystem maturation and for evaluation of success is not the only factor that makes restoration of forested wetlands difficult. The restoration of appropriate hydrologic conditions may be the most critical factor in forested wetland restoration (Clewell and Lea 1990, Tiner 1995). McLeod et al. (2000)

reported that slight differences in elevation, and therefore hydrology, can substantially influence the survival and health of trees planted in swamps. This sensitivity to hydrologic regimes is long-term (Kusler and Kentula 1990); even mature forest vegetation can be damaged by wide-ranging hydrologic conditions. In an attempt to create forested wetland in New Hampshire, Barry et al. (1996) contended with this hydrologic sensitivity of woody species by mimicking the mound and pool microtopography found in natural wetlands. The rationale was that mounds provide a wide variety of water regimes (see Golet et al. 1993) and therefore may increase the probability that planted trees can survive prolonged periods of excessive inundation; i.e., there is more room for error. However, this technique may only be appropriate for the creation of swamps on non-organic substrates. Barry et al. (1996) cited an attempt by Crispin and Randall (1990) to restore microrelief in former forested wetland of southeastern Massachusetts; the attempt was unsuccessful because heavy equipment became mired.

Shrub Swamps

Few restoration or creation attempts have targeted shrub swamp communities. In terms of restorability, shrub swamps are intermediate between forested wetlands and marshes. Shrubs reach maturity more quickly than trees. Tiner (1995) stated that many types of shrub wetlands may be as easy to establish as marshes because of similar hydrology. This may be true for swamps containing buttonbush (*Cephalanthus occidentalis*), which can tolerate prolonged flooding. However, many shrub species are less tolerant of inundation; in these cases, many of the difficulties cited for forested wetland restoration (see above) would also characterize shrub swamp restoration. Hollands (1990) reported that most of the shrub vegetation in a created shrub swamp in Massachusetts was killed off during one summer with unusually high water levels. Marsh vegetation at the same site survived the excessive inundation.

Fens

The lack of scientific literature available regarding fen restoration suggests that it has rarely been attempted. In 1990, Lowry questioned the feasibility of fen restoration and stated that it had not been attempted in the glaciated northeastern United States. Perhaps the unique hydrology and water chemistry of fens have precluded such attempts. Crosson et al. (1999) removed invasive alien shrub species from a Wisconsin fen and reported some success in planting native fen species. Continued success in this fen, however, may be dependent on prescribed burns. Some research has been conducted in the Netherlands to compare restoration methods for fens impacted by acidification and eutrophication (Beltman et al. 1996). In the fens that were studied, a surplus of acid rainwater had formed a lens over calcareous groundwater, promoting dominance by mosses (especially *Sphagnum* spp.). The authors reported that a combination of drainage and sod removal was successful in removing the symptoms of this impact. There are no studies that have addressed restoration of fens impacted by filling or draining, the impacts that are most likely to have occurred in fens of Rhode Island.

Zedler and Callaway (1999) stated that wetland systems with unique water-quality requirements (such as fens) are likely to take much longer to restore than other wetland types. Full functionality may not be achievable. Zedler (1988) presented a strong argument for preservation of such ecosystems by stating that restoration may not be a realistic option.

Bogs

Tiner (1995) considered bogs with ericaceous shrubs to be the most difficult wetland type to establish, due to their unique chemistry and deep organic soils. If restoration is even possible—and that has been questioned (Lowry 1990)—it would require an extremely long period of time (Tiner 1995). Kusler and Kentula (1990) asserted that isolated freshwater wetlands supplied by groundwater are the most difficult types to restore; Rhode Island bogs clearly fit this description. No bog restorations have been attempted in the glaciated northeastern United States (Lowry 1990). Bog restoration attempts in Europe have met with some success. Grosvernier et al. (1997) reported that Swiss bogs that have been drained “undergo a strong chemical disturbance, which, in turn, [negatively] affects the growth of *Sphagnum* mosses.” However, Buttler et al. (1996) claimed that cutover bogs of Switzerland can be rapidly and fully restored via natural development of secondary peat-forming vegetation. These Swiss bogs, however, are not kettle-hole bogs; they have formed via paludification and the same process restores them after peat harvest. Paludification does not occur under Rhode Island's climate; therefore, the results of these Swiss studies are not directly applicable to Rhode Island bogs. In addition, peat harvest has rarely occurred in Rhode Island bogs. Bogs of this region are more likely to be impacted by filling or by changes in nutrient and water inputs resulting from development of surrounding uplands.

Highly acidic, nutrient-poor wetlands, such as bogs, are relatively scarce when compared to other wetland types, and they often support rare and endangered plant species. Because they are uncommon, and also because they are difficult or, perhaps, impossible to restore, emphasis should be placed on preservation of these wetlands instead of restoration (Moore et al. 1989, Weiher et al. 1996).

Streams

The feasibility of stream restoration is a function of both the current land use surrounding the stream and the nature of the impact to the stream. Mitsch and Gosselink (1993) stated that "the restoration of entire rivers has been shown to be an elusive goal in many parts of the world." They attribute this failure to channelization, subsequent development in floodplains, and increases in sediment loads and other nonpoint pollutants. Channelization reduces flooding problems locally, and therefore encourages development of adjacent floodplains. Restoration of meanders and natural stream morphology within those floodplains is not feasible after the areas have been urbanized. Many smaller streams occurring in urbanized areas of Rhode Island have been filled and built upon; therefore, these streams have little chance of being restored. Where buried streams have not been built upon, and thus could be restored, vast improvements in fish and wildlife habitat, flood abatement, and water quality improvement functions might result. Whether channelized, buried, or unaltered, many streams have been impacted through removal of adjacent upland vegetation (i.e., riparian vegetation). The National Research Council (1992) stressed that vegetated riparian habitats are essential to the natural ecological functioning of streams and rivers. See the following section ("Vegetation of adjacent upland") for more details about upland riparian vegetation.

Restoration projects that have manipulated in-stream characteristics have met with mixed results. Fennessy & Cronk (1997) reported that restoration of natural channel morphology is an important means to safeguard water quality in agricultural landscapes. In Finland, Laasonen et al. (1998) compared channelized streams with "near-pristine" streams and streams that had been restored from 0 to 16 years previously using boulder dams, flow deflectors, excavations, and channel enlargements. They found that biotic and abiotic characteristics of restored streams were intermediate between characteristics of near-pristine and channelized streams. Although conditions had been improved through restoration, the authors concluded that there was no indication that communities would reach pristine conditions with a longer recovery period (i.e., there was no trajectory, after restoration, toward natural conditions). Measurements of macroinvertebrate species richness and abundance were used to reach these conclusions; success in stream restoration is often measured in terms of macroinvertebrate communities. Gortz (1998) measured trout and macroinvertebrate populations in a stream restored to improve trout habitat. Gravel, boulders, and stream concentrators were used in the restoration. Invertebrate populations were different from pre-restoration conditions, and five times as many spawning trout occurred in restored areas relative to non-restored areas. However, trout in the restored areas experienced low spawning success. The authors concluded that trout production was not enhanced. Perhaps this restoration actually created a sink habitat for trout, attracting the fish away from more productive areas. Powell (1997) stressed that stream restoration projects that have targeted fish habitat as a goal will fail if water quality is poor.

Vegetation of Adjacent Upland

Vegetated uplands bordering wetlands enhance the ability of a wetland to provide many functions. In the following discussion, vegetated upland riparian zones are included in this category. Hollands (1990) asserted that establishment of a vegetated upland buffer zone should be a part of all restoration projects. From a wildlife habitat perspective, adjacent upland vegetation can provide a barrier or screen for wetland wildlife from human activity and provide habitat for wetland-dependent species (e.g., salamanders) that use both wetlands and adjacent uplands during different stages of their life cycle

(Hollands 1990). Vegetation surrounding wetlands can also control nonpoint-source pollution (Fenessy and Cronk 1997, Lowrance 1998), increase the aesthetic appeal of wetlands (Holland 1990), maintain wetland water temperatures, filter sediments from surface runoff, and slow down surface runoff, thereby enhancing the wetland's flood abatement capacity.

Restoration of adjacent upland vegetation should be a simple process relative to wetland restoration. Difficulties in restoring hydrology are the most common cause of wetland restoration failure, but hydrology is not nearly as great an issue in the restoration of upland vegetation. Forested buffer zones are the most structurally complex and would probably be the most effective at protecting and enhancing wetland functions. However, as with forested wetlands, it may take decades for the forest ecosystem to reach maturity. Hawkins et al. (1997) compared the distribution of riparian vegetation at points along a California river before and after a large flood. They found that the amount of riparian vegetation destroyed by the flood ranged from 0 to 40%; this loss was negatively correlated with the total area of riparian vegetation and positively correlated with the amount of development nearby. The authors concluded that, in order to increase the probability of success, riparian revegetation should be pursued in areas that already have extensive riparian vegetation and that are distant from urban development. Unfortunately, re-establishment of riparian vegetation is often needed most in heavily developed areas.

Conclusions

In any restoration attempt, we should be realistic about what it is possible to accomplish (Ehrenfeld 2000). Even if certain wetland types are deemed "easy" to restore relative to other types, it should never be assumed that *any* type can be restored to completely natural conditions. Duplication of naturally occurring wetlands over short time frames is impossible; at best, we can attempt to approximate systems and restore individual wetland functions (Kusler and Kentula 1990). Berger (1990) stated that "…no restoration can ever be perfect; it is impossible to replicate the biogeochemical and climatological sequence of events over geological time that led to the creation and placement of even one particle of soil, much less to exactly reproduce an entire ecosystem. Therefore, all restorations are exercises in approximation and in the reconstruction of naturalistic rather than natural assemblages of plants and animals with their physical environments." Due to our inability to duplicate natural wetlands, and to the uncertainties involved, many authors have concluded that preservation of existing functional wetlands is a much better option than attempting to restore degraded or destroyed systems (Tiner 1995, Ehrenfeld 2000). This is clearly the case for rare or uncommon wetlands that are difficult, or perhaps impossible, to restore (e.g., fens, bogs, cedar swamps). Many of these arguments have been made within the context of wetland mitigation, where permitted wetland impacts are often erroneously assumed to be offset via wetland restoration. However, within the context of a proactive restoration program, attempts to restore wetland communities can strengthen the functional capacity of our watersheds and landscapes. In instances where rare wetland types have been destroyed or where restoration to the original type is not possible, proactive restoration attempts may require a shift in focus from restoration of a specific wetland type to re-creation of certain wetland functions. In such cases, there may be no choice but to substitute wetland types that can be created with a greater probability of success.

Section 3: Additional Factors That Influence Restorability

Galatowitsch and van der Valk (1994) stressed that restoration success depends on different factors for each individual wetland. Although the nature of the impact and the wetland type targeted both greatly influence the probability of restoration success, there are additional factors. The following paragraphs address those factors.

Urban vs. Rural Context

Much of the Rhode Island landscape has been urbanized. The highly developed northeastern and coastal portions of the State contrast sharply with the rural and extensively forested western area. Wetlands surrounded by urban development have properties that differ from those in less disturbed contexts (Erwin 1990). Urban wetlands often have altered hydrology, increased chemical and nutrient inputs, and increased sediment inputs, and are surrounded by destroyed or fragmented upland habitats. The fact that urban wetlands receive greater inputs of surface water runoff and pollutants—coupled with the fact that neighboring wetlands have also likely been degraded or destroyed—increases the importance of those wetland functions that directly impact human health and welfare. The water quality improvement capabilities, flood abatement, aesthetic properties, and open space value of wetlands have great social significance in urban areas. These facts argue for an emphasis on restoration of urban wetlands in restoration planning. However, urban areas are "highly stressed environments" where restoration failures often are a result of the degraded status of the landscape in which they occur (Zedler and Callaway 1999). Restoration efforts in such settings may be subject to modified hydrology, exotic species invasions, and the effects of feral animals (e.g., bird predation by domestic cats). The National Research Council (1992) predicted quicker and more successful restorations in landscapes that are still intact. Kusler and Kentula (1990) claimed that excessive sedimentation can be a serious problem for many restored wetlands in urban areas. In addition, natural plant recolonization may be less likely in urban areas where nearby wetlands have also been destroyed.

Urban impacts may affect the various functions of wetlands differently. Restored urban wetlands may contribute more to watershed flood abatement and water quality improvement than rural wetlands because they have greater opportunity to perform these functions. However, increased inputs of runoff and pollutants will negatively influence the ability of a restored wetland to provide fish and wildlife habitat. Tiner (1995) noted that it may be impossible to restore healthy, viable fish and wildlife populations in urban areas with poor water quality. Helfield and Diamond (1997) asserted that wetland restorations often cannot serve the dual purpose of water quality improvement and fish and wildlife habitat; they referred specifically to highly urbanized sites that receive metallic, organic, or other contaminants. Wetlands tend to collect and concentrate contaminants; bioconcentration and biomagnification of these contaminants could occur throughout the aquatic community. If habitat is constructed to benefit fish or wildlife, but other aspects of the habitat are deleterious, these areas may form habitat "sinks" in the landscape; i.e., places where wildlife reside but do not reproduce successfully. Some research has investigated whether restored wetlands function as well as reference wetlands in providing habitat (e.g., Delphey and Dinsmore 1993, Brown and Smith 1998). However, Brown (1999) pointed out that even reference wetlands are rarely free of impacts, and "while we can restore wetlands similar to those that now exist in this landscape, we may be recreating systems that are significantly less valuable as wildlife habitat than the pristine wetlands that once existed in this area." Wildlife that depends on both wetland and upland for habitat (e.g., certain frogs and salamanders) will not benefit from wetland habitat restoration in urban areas where upland habitat is either extremely fragmented or nonexistent.

Wetland restoration efforts may meet with public resistance in highly urbanized landscapes due to perceived threats to humans. Wetlands are often viewed as the source of mosquitoes and mosquito-borne diseases, such West Nile Virus and Eastern Equine Encephalitis. Hydrologic changes associated with certain wetland restoration activities (e.g., dam removal, re-creation of a natural stream channel) could damage property or otherwise inconvenience nearby residents.

Kentula (1993) stated that "…activities surrounding a wetland can disrupt the functions that cause the wetland to exist." In selecting appropriate restoration sites, she recommended considering not only the current condition of site contexts, but also the projected condition of the surrounding upland 20 years after restoration. Our ability to re-create *sustainable* wetlands may be influenced greatly by landscape context.

Hydrogeomorphic Setting

Many authors have suggested that restoration success is largely based on the ability to restore appropriate hydrology (Golet 1986, Lowry 1990, Mitsch and Gosselink 1993). Kusler and Kentula (1990) suggested that the hydrology of restoration sites located near lakes and rivers is easier to predict than that of isolated wetlands. In other words, the probability of restoration success may be a function of hydrogeomorphic setting. Kusler and Kentula ranked sites according to their restorability, based on hydrogeomorphic setting. Estuarine and coastal marshes were considered to be among the easiest to restore. Freshwater wetlands along lakes and streams were considered only slightly more difficult because it is relatively easy to obtain surface water elevations from adjacent water bodies. In addition, such water bodies may have long-term data available from gaging records. Forested wetlands along lakes and streams were considered much more difficult to restore because woody vegetation has a much narrower range of hydrologic tolerance than most nonwoody vegetation. They placed isolated wetlands supplied predominantly by surface water in the next category of difficulty, and claimed that it is very difficult to attain the correct hydrology unless water-control structures are used. Isolated freshwater wetlands supplied predominantly by groundwater were considered the most difficult to restore.

Surficial geology may also influence restoration success. Lowry (1990) stated that there is a lack of knowledge regarding the relationship between restoration success and hydrogeologic setting. He pondered whether the potential for success was greater in stratified sand and gravel, where the local water table could be intersected, or on low-permeability till deposits, where surface water would be the major input. Tiner (1995) listed important considerations for site selection; they included local topography, hydrology, soil properties, degree of exposure to wave action, slope, site elevations, and proximity to other wetlands.

Monitoring and Maintenance Requirements

Monitoring, although it rarely occurs, is necessary to determine the success of restoration (Kusler and Kentula 1990). Monitoring of restored wetlands also allows researchers to determine which techniques have been most useful or cost-effective; such information can improve the feasibility and success of future restoration attempts. But monitoring can also contribute to the success of ongoing restoration efforts. Tiner (1995) stated that most problems with wetland restorations arise within the first 2 years of completion; monitoring is therefore imperative for at least 2 years. Simpler restorations (e.g., marshes, wet meadows, and shrub swamps) should be monitored for up to 5 years following restoration; forested wetlands and bogs should be monitored for at least a decade. During these monitoring efforts, problems with vegetation, hydrology, or other aspects of the restoration can be detected and rectified. Odum (1988) argued for long-term monitoring; he claimed that restoration success is often determined within 2 years of completion, but that “dramatic, unanticipated changes may occur over the ensuing years.” Clewell (1999) attributed the successful creation of forested wetland in Florida to—among other things—continual maintenance, mid-course corrections, and follow-up work. These activities are often referred to as “adaptive management.” Monitoring enables early detection of problems and development of site-specific solutions such as stabilizing eroding soils, replacing non-surviving trees, and removal of exotics and nuisance vegetation. Successful restoration of wetland communities requires effort and resources well beyond the construction and revegetation stages.

The spread of invasive plant species may be one of the strongest justifications for restoration monitoring and adaptive management. Certain plants (e.g., *Phragmites australis*, *Lythrum salicaria, Typha* spp.) have the potential to invade and eventually dominate freshwater wetlands (Odum 1988, Levine and Willard 1990, Weiher et al. 1996). These species are especially likely to invade degraded wetlands, particularly if bare substrates have been exposed. Unfortunately, most restoration efforts create ideal conditions for invasion by these species. Dominance by invasive plants often results in lower plant species diversity (Weiher et al. 1996) and reductions in wetland functions such as wildlife habitat, nutrient processing, and aesthetics (Odum 1988).

Once invasive species become established, the need for continual control is likely. Spurr and Niering (2000) reported the need to manually remove *Lythrum salicaria* from a recently created marsh; despite these efforts, the species continued to spread. Odum (1988) painted a bleak picture, saying "in many freshwater wetland sites it may be an expensive waste of time to plant species which are of high value to wildlife…. It may be wiser to simply accept the establishment of disturbance species as a cheaper although somewhat less attractive solution." Research has been conducted to establish techniques for the prevention or removal of invasive species. Weiher et al. (1996) found that it is possible to inhibit *Lythrum salicaria* establishment by flooding substrates to a depth of 5 or more centimeters. Gabor et al. (1996) found that treating *Lythrum salicaria* with herbicides can give native plants a competitive edge; herbicide treatment combined with biological control (i.e., introduction of exotic *Lythrum*-eating beetles) may be particularly effective. Although biological control has been proposed, its application is controversial, particularly for native species such as *Phragmites australis* (for more details, refer to the opposing viewpoints presented by Blossey and McCauley [2000] and Rooth and Windham [2000]).

Long-term commitments may be required, in particular, for restorations that rely on artificially maintained hydrology (i.e., water-control structures such as levees, irrigation pipes, pumps, dams, or weirs). Because the long-term maintenance of such technological fixes is never fully assured, Zedler (1988) concluded that they are "destined to malfunction." She therefore contended that the probability of long-term restoration success is significantly reduced if wetlands are not designed to be self-maintaining. Kentula (1993) echoed this sentiment, stating that "a system dependent on significant input from man is likely to fail."

Time Requirement

Most natural wetlands originated thousands of years ago. During these millennia, they have evolved into highly complex ecosystems (Berger 1990). It may not be realistic to expect that restoration attempts can provide an expeditious return to such a complex state. Recent research supports this assertion. Kentula (1993) stated that functional replacement in wetlands has not been demonstrated, mainly because the vast majority of restoration sites are ecologically young (i.e., it is too early to determine success). VanRees-Siewart and Dinsmore (1996) studied wetlands that had been restored up to 4 years previously and concluded that more time was needed to regain overall bird diversity. Street (1998) investigated whether functional replacement had occurred at 3-year-old Maryland mitigation sites and determined that it was too soon to tell. In at least some cases, success may not improve with time. According to Zedler and Callaway (1999), ecosystems do not necessarily follow a trajectory back to natural conditions after restoration takes place. A study of macroinvertebrate populations in restored Finnish streams—ranging in age from 0 to 16 years—supported this claim. Laasonen et al. (1998) found that, although macroinvertebrate populations were improved in restored streams relative to channelized streams, there was no indication that macroinvertebrate communities would approximate those in natural streams given a longer recovery period. Despite this, many restorations have been deemed successes. For example, Clewell (1999) reported successful restoration of a diverse forested wetland community in only 11 years. However, Kusler and Kentula (1990) maintained that even after a restoration has been deemed successful, it may be subjected to unanticipated threats (e.g., drought, flood, pollution, erosion) that could destroy the restoration site. Success is not only an elusive goal, but also an elusive concept; its very definition is often at issue. Success is usually measured by assessing the establishment of vegetation. However, Lowry (1990) questioned the validity of these measures, and asked “is there a direct correlation between vegetative composition and structure and the presence or degree of other wetland functions?”

Current Land Use

Many wetlands have been drained for agriculture. In some cases where the resulting cropland or pasture is “marginal,” wetland restoration may be both popular and successful. Entire state and Federal programs have been built around such activities (e.g., see the program profile of Illinois’ Conservation Reserve Enhancement Program in the Task A section of this report). Where drained wetlands have been converted to productive croplands, there is less incentive for restoration. Filled wetlands were usually built upon for construction purposes; consequently, such areas usually are not available for restoration. The greatest opportunities for wetland restoration occur where filled or drained areas are currently unused.

Degraded—but not destroyed—wetlands still may perform valuable functions. Kentula (1993) considered restoration of degraded wetlands to be risky. She suggested that, before attempting such restorations, we ask ourselves “can we afford to lose this system?” To illustrate this issue, Kentula stated that some highly degraded wetlands of California provide important habitat for endangered species. Any actions taken to restore this habitat could produce results harmful to the endangered species; their habitat could be destroyed inadvertently.

Size of the Restoration Site

It is intuitive that the size of a wetland influences the magnitude of that wetland’s functions. Large wetlands have the capacity to store a greater volume of floodwater than smaller wetlands. It has also been shown that larger patches of habitat often support a greater diversity of wildlife, and may provide the only habitat for certain area-sensitive species. Martine (1999) investigated the influence of size, classification, age, average depth, shoreline sinuosity, vegetative diversity, and percentage of surrounding cover on total bird species richness, breeding-bird species richness, waterfowl presence, and waterfowl diversity in 13 restored wetlands. He concluded that the size of the restoration site was the most important factor influencing each of the bird community characteristics. Restoration of large areas of wetland is likely to be more beneficial than restoration of small areas.

Task D. Status of Rhode Island's freshwater wetland resources on a watershed basis.

Introduction

The following tables provide freshwater wetland area statistics for Rhode Island watersheds; statewide data are provided at the end of each table. See Figure D1 for watershed locations. Table D1 presents wetland acreage by ownership category. Ownership may influence the feasibility of wetland restoration; this information might be of use in the development of prioritization methods. Table D2 presents the total acreage of each wetland type within each watershed. These data provide valuable information about the State's current wetland resource base and may also be useful in the prioritization process.

The Results and Discussion section below provides a summary of each table. Special attention is paid to the two watersheds selected for testing of site identification and prioritization methodologies (see Tasks E and F), the Woonasquatucket River Basin and the Queens River Sub-basin of the Pawcatuck River Basin.

Methods

The values in both tables were calculated using ARC/INFO, ArcView, and RIGIS datasets. We conducted "unions" of RIGIS Open Space coverages to determine ownership for Table D1. These coverages included Audubon Lands, Private Land Trust Holdings, Open Space Lands, Protected Public Lands, and Wildlife Management Areas. To ensure that we incorporated the most recent data available, updates to the first three coverages were obtained from The Nature Conservancy of Rhode Island and included in the analysis. The resulting coverage was "clipped" with the RIGIS wetlands dataset so that only wetland polygons were considered for further analysis. Polygons were coded according to ownership (i.e., Federal, State, municipal, nongovernmental conservation organization, or private [unprotected]). We summarized freshwater wetland ownership within each watershed by conducting a final "union" with a modified version of the RIGIS Rhode Island Basins coverage. The Basins coverage was modified to include the Rhode Island portions of watersheds that drain outside of the State's boundaries (e.g., the Moosup River Basin and Coastal Basin).

Figure D1. Rhode Island watersheds.

The total area of each wetland type within each watershed was determined by conducting a "union" of the RIGIS wetlands coverage with the modified RIGIS Rhode Island Basins coverage. Wetland types were categorized in Table D2 as follows:

EMA	Emergent Wetland: Marsh/Wet Meadow
EMB	Emergent Wetland: Emergent Fen or Bog
SSA	Scrub-shrub Wetland: Shrub Swamp
SSB	Scrub-shrub Wetland: Shrub Fen or Bog
FOA	Forested Wetland: Coniferous
FOB	Forested Wetland: Deciduous
FOD	Forested Wetland: Dead
LOW	Lacustrine Open Water (Lake)
POW	Palustrine Open Water (Pond)
ROW	Riverine Nontidal Open Water
RTW	Riverine Tidal Open Water

Results and Discussion

The following paragraphs describe freshwater wetland resources at the river basin scale; only freshwater wetlands that fall within the boundaries of Rhode Island are included.

Table D1: Wetland Ownership

The vast majority of freshwater wetlands within the State are privately owned. Only 16.2% are protected by Federal, State, or municipal governments, or by nongovernmental conservation organizations such as land trusts, The Nature Conservancy, and the Audubon Society of Rhode Island. The Federal government owns only 239.4 acres of the State's freshwater wetlands (less than 1%). These wetlands are concentrated in coastal watersheds (i.e., the Coastal Basin, Narragansett Bay Basin, and Point Judith Sub-basin of the Saugatucket River Basin). The State owns 60% of all protected wetlands (10,890.4 acres); each of Rhode Island's watersheds contains State-owned freshwater wetlands. Freshwater wetlands owned by municipal governments and nongovernmental organizations also are found in each of the watersheds. Municipal governments own 4,528.3 acres of freshwater wetland; nongovernmental organizations own 2,423.0 acres.

Table D1. Area of Rhode Island's freshwater wetlands, categorized by watershed and ownership class.[1]

	Ownership							
Watershed	**Federal**	**State**	**Municipal**	**NGO**	**Total protected**	**Private**	**Total wetland**	**Percent protected**
Blackstone River Basin		**810.4**	**505.9**	**94.3**	**1,410.6**	**11,514.8**	**12,925.4**	**10.9**
Blackstone River Sub-basin		253.2	409.1	45.9	708.3	5,353.4	6,061.7	11.7
Branch River Sub-basin		169.0		38.0	207.0	1,721.7	1,928.7	10.7
Chepachet River Sub-basin		20.4	86.0	10.3	116.7	1,781.9	1,898.6	6.1
Clear River Sub-basin		367.8	10.8		378.6	2,657.9	3,036.5	12.5
Coastal Basin	**124.2**	**69.1**	**84.8**	**269.2**	**547.3**	**5,138.6**	**5,685.9**	**9.6**
Block Island Sub-basin		9.7	7.1	4.2	21.0	507.6	528.6	4.0
Little Compton Sub-basin			1.1	106.9	108.0	2,407.5	2,515.5	4.3
Narragansett Shore Sub-basin	52.5	4.0	45.6		102.1	400.2	502.3	20.3
Newport Sub-basin		3.7	28.2	0.8	32.7	350.3	383.0	8.5
South Shore Sub-basin	71.6	51.6	2.9	157.3	283.4	1,473.0	1,756.4	16.1
Hunt River Basin		**23.5**	**75.5**	**51.1**	**150.2**	**2,521.6**	**2,671.7**	**5.6**
Hunt River Sub-basin		23.5	75.5	51.1	150.2	2,521.6	2,671.7	5.6
Moosup River Basin		**1,067.8**	**34.9**	**71.6**	**1,174.4**	**5,151.0**	**6,325.4**	**18.6**
Moosup River Sub-basin		1,067.8	34.9	71.6	1,174.4	5,151.0	6,325.4	18.6
Moshassuck River Basin		**126.5**	**30.4**	**15.5**	**172.4**	**1,420.9**	**1,593.3**	**10.8**
Moshassuck River Sub-basin		126.5	30.4	15.5	172.4	1,420.9	1,593.3	10.8
Narragansett Bay Basin	**39.6**	**599.4**	**1,430.7**	**289.7**	**2,359.4**	**12,895.2**	**15,254.6**	**15.5**
Annaquatucket River Basin		34.5	118.3	13.0	165.8	915.8	1,081.6	15.3
Greenwich Bay Sub-basin		15.7	24.2	2.7	42.6	539.5	582.1	7.3
Kickamuit River Sub-basin			39.1	12.4	51.6	276.1	327.7	15.7
Maskerchugg River Sub-basin		7.9			7.9	515.8	523.7	1.5
Mount Hope Bay Sub-basin			7.5	9.2	16.7	391.2	407.9	4.1
Narragansett Bay Sub-basin		507.1	518.2	178.5	1,203.8	3,809.0	5,012.8	24.0
Pettaquamscutt River Sub-basin	39.4	3.4	101.8	6.0	150.6	1,597.1	1,747.7	8.6
Providence River Sub-basin		12.6	126.6	18.8	158.0	780.5	938.5	16.8
Sakonnet River Sub-basin	0.3	18.2	490.5	49.1	558.0	4,054.3	4,612.3	12.1
Seekonk River Sub-basin			4.4		4.4	15.9	20.3	21.7

Table D1. Continued.

Watershed	Federal	State	Municipal	NGO	Total protected	Private	Total wetland	Percent protected
	Ownership							
Pawcatuck River Basin		**6,467.2**	**39.3**	**1,239.1**	**7,745.5**	**22,903.6**	**30,649.1**	**25.3**
Chickasheen River Sub-basin		357.2		0.6	357.8	791.8	1,149.6	31.1
Chipuxet River Sub-basin		1,525.3	21.5	125.8	1,672.6	3,340.9	5,013.6	33.4
Pawcatuck River Sub-basin		2,169.3	15.9	176.7	2,361.9	11,267.1	13,629.1	17.3
Queens River Sub-basin		92.1	1.3	834.4	927.8	2,927.4	3,855.2	24.1
Wood River Sub-basin		2,323.3	0.5	101.6	2,425.3	4,576.4	7,001.7	34.6
Pawtuxet River Basin		**1,597.4**	**1,687.8**	**169.9**	**3,455.1**	**21,441.7**	**24,896.8**	**13.9**
Barden Reservoir Sub-basin		15.7	47.2	16.4	79.3	2,502.2	2,581.4	3.1
Big River Sub-basin		1,293.3	33.5		1,326.8	1,476.7	2,803.5	47.3
Flat River Reservoir Sub-basin		31.1	4.6	74.1	109.8	2,878.6	2,988.3	3.7
Moswansicut Reservoir Sub-basin			45.8		45.8	558.0	603.9	7.6
North Branch Pawtuxet River Sub-basin		53.9	171.7	42.2	267.8	1,268.2	1,536.0	17.4
Pawtuxet River Sub-basin		56.5	92.8	12.3	161.7	2,178.4	2,340.1	6.9
Pocassett River Sub-basin		136.0	190.5		326.5	1,496.5	1,823.0	17.9
Ponagansett Reservoir Sub-basin						323.0	323.0	0.0
Regulating Reservoir Sub-basin			156.1	10.2	166.3	1,640.6	1,806.9	9.2
Scituate Reservoir Sub-basin		0.4	897.2	5.2	902.7	4,726.8	5,629.6	16.0
South Branch Pawtuxet River Sub-basin		10.5	17.2	9.5	37.2	2,057.1	2,094.3	1.8
Westconnaug Reservoir Sub-basin			31.2		31.2	335.6	366.7	8.5
Saugatucket River Basin	**75.6**	**27.0**	**153.9**	**109.8**	**366.3**	**2,931.5**	**3,297.8**	**11.1**
Point Judith Pond Sub-basin	75.6	13.3	57.3	57.7	204.0	698.4	902.4	22.6
Saugatucket River Sub-basin		13.7	96.6	52.0	162.3	2,233.2	2,395.5	6.8
Taunton River Basin		**0.4**	**20.9**		**21.3**	**1,212.9**	**1,234.2**	**1.7**
Taunton River Sub-basin		0.4	20.9		21.3	1,212.9	1,234.2	1.7
Ten Mile River Basin		**36.2**	**284.2**	**37.6**	**358.1**	**210.3**	**568.3**	**63.0**
Ten Mile River Sub-basin		36.2	284.2	37.6	358.1	210.3	568.3	63.0

Table D1. Continued.

Watershed	*Ownership*							
	Federal	**State**	**Municipal**	**NGO**	**Total protected**	**Private**	**Total wetland**	**Percent protected**
Warren River Basin		**4.1**	**80.5**	**17.0**	**101.6**	**756.9**	**858.5**	**11.8**
Barrington River Sub-basin			74.0	2.1	76.1	142.4	218.5	34.8
Palmer River Sub-basin				8.7	8.7	214.8	223.5	3.9
Runnins River Sub-basin			6.5		6.5	242.1	248.6	2.6
Warren River Sub-basin		4.1		6.0	10.1	157.6	167.8	6.0
Westport River Basin		**0.1**	**31.5**	**2.1**	**33.8**	**1,016.2**	**1,050.0**	**3.2**
Adamsville Brook Sub-basin		0.1	31.5	2.1	33.8	1,016.2	1,050.0	3.2
Woonasquatucket River Basin		**61.2**	**68.0**	**56.1**	**185.4**	**4,631.9**	**4,817.2**	**3.8**
Woonasquatucket River Sub-basin		61.2	68.0	56.1	185.4	4,631.9	4,817.2	3.8
Statewide	**239.4**	**10,890.4**	**4,528.3**	**2,423.0**	**18,081.1**	**93,747.1**	**111,828.2**	**16.2**

[1]Data are based on interpretation of 1988 1:24,000-scale panchromatic aerial photographs and stored in the Rhode Island Geographic Information System (RIGIS); minimum map unit = 1/4 acre. Values include wetlands and deepwater habitats as defined by Cowardin et al. (1979).

The percentage of wetlands protected ranges from a low of 1.7% in the Taunton River Basin to a high of 63.0% in the Ten Mile River Basin. The amount of protected wetland varies widely between our test watersheds; only 3.8% of the total wetland area in the Woonasquatucket River Basin is currently protected , while 24.1% is protected in the Queens River Sub-basin. Undoubtedly, there are more opportunities for wetland restoration on private lands; however, landowner cooperation, and therefore restoration feasibility, will likely be greater in protected areas.

Table D2: Wetland Types

Deciduous forested wetlands (FOB), also known as forested swamps, are, by far, the most abundant freshwater wetland type; they account for over 50% of the State's freshwater wetland area. Forested swamps and shrub swamps (SSA) together account for over 70%. Lakes (LOW) are also abundant and add nearly 16% to the total. At the other extreme, riverine wetlands (ROW, RTW) and fens and bogs (EMB, SSB) are rare; combined, they account for less than 4% of the State's total freshwater wetland area. Marshes (EMA) and ponds (POW) fall in the middle; they each account for approximately 4% of the total area.

This pattern in the statewide data is generally maintained when the data are broken down by river basin. Swamps and lakes are often the most abundant wetlands; bogs, fens, and riverine wetlands remain the most scarce. In the Woonasquatucket River Basin, forested swamps and shrub swamps comprise over 68% of the freshwater wetlands, lakes comprise almost 18%, ponds account for 6%, marshes account for 4%, riverine wetlands make up less than 2%, and fens and bogs comprise less than 2%. In the Queens River Sub-basin, swamps account for more than 90% of the freshwater wetlands, ponds comprise less than 4%, marshes account for less than 2%, lakes make up less than 2%, fens and bogs comprise less than 2%, and riverine wetlands account for less than 1%.

Table D2. Area of Rhode Island's freshwater wetland types, by watershed.[1]

Watershed	*Wetland type*[2]											
	EMA	EMB	SSA	SSB	FOA	FOB	FOD	LOW	POW	ROW	RTW	Total
Blackstone River Basin	**590.0**	**55.1**	**806.0**	**301.3**	**1,240.5**	**6,178.6**	**1.9**	**2,660.7**	**628.5**	**462.7**		**12,925.3**
Blackstone River Sub-basin	402.2	31.5	404.3	116.6	385.0	2,919.4	1.4	1,163.3	286.0	351.9		6,061.6
Branch River Sub-basin	90.0	0.3	126.2	11.6	132.0	1,092.3		251.6	140.7	83.9		1,928.7
Chepachet River Sub-basin	29.5	4.7	95.1	71.3	311.8	858.9		440.0	75.9	11.3		1,898.6
Clear River Sub-basin	68.3	18.5	180.5	101.8	411.6	1,307.9	0.5	805.9	125.8	15.6		3,036.5
Coastal Basin	**567.5**	**0.4**	**1,249.4**	**59.2**	**157.7**	**3,046.3**	**7.9**	**177.9**	**418.8**	**0.8**		**5,685.9**
Block Island Sub-basin	146.8		189.2					26.0	166.6			528.6
Little Compton Sub-basin	194.7		451.8	1.3	51.5	1,725.6	7.9	23.2	58.7	0.8		2,515.5
Narragansett Shore Sub-basin	36.8		111.5			330.5			23.6			502.3
Newport Sub-basin	132.1		183.9			59.0			7.9			383.0
South Shore Sub-basin	57.1	0.4	313.0	57.9	106.1	931.3		128.7	162.0			1,756.5
Hunt River Basin	**57.8**	**2.6**	**159.8**	**14.8**	**176.7**	**2,126.3**	**5.2**		**110.2**	**18.4**		**2,671.7**
Hunt River Sub-basin	57.8	2.6	159.8	14.8	176.7	2,126.3	5.2		110.2	18.4		2,671.7
Moosup River Basin	**245.3**	**39.4**	**735.8**	**305.5**	**1,267.9**	**2,352.0**	**59.7**	**925.6**	**325.1**	**69.2**		**6,325.4**
Moosup River Sub-basin	245.3	39.4	735.8	305.5	1,267.9	2,352.0	59.7	925.6	325.1	69.2		6,325.4
Moshassuck River Basin	**100.4**		**112.2**	**1.5**	**25.4**	**971.2**		**248.4**	**121.6**	**12.6**		**1,593.3**
Moshassuck River Sub-basin	100.4		112.2	1.5	25.4	971.2		248.4	121.6	12.6		1,593.3
Narragansett Bay Basin	**1,107.2**	**5.9**	**2,046.4**	**69.1**	**392.6**	**9,637.3**	**11.4**	**1,440.3**	**529.0**	**15.2**	**0.1**	**15,254.6**
Annaquatucket River Basin	65.1	0.6	126.2		17.4	647.7	7.3	174.3	43.1			1,081.6
Greenwich Bay Sub-basin	14.3		49.5		0.6	422.2		51.9	42.4	1.1		582.1
Kickamuit River Sub-basin	45.0		41.4			204.6		31.0	5.7			327.6
Maskerchugg River Sub-basin	16.3		19.9		1.0	455.0	0.9		30.5			523.7
Mount Hope Bay Sub-basin	32.4		67.5		31.2	253.9		0.7	18.7	3.6		407.9
Narragansett Bay Sub-basin	334.5	1.7	743.5	31.5	96.5	3,233.5	2.6	398.8	169.2	1.0		5,012.8
Pettaquamscutt River Sub-basin	21.0	3.6	86.8	37.6	47.9	1,421.4		57.5	66.4	5.5		1,747.7
Providence River Sub-basin	35.5		87.4		5.0	601.3		127.7	78.1	3.3	0.1	938.5
Sakonnet River Sub-basin	540.7		823.5		193.0	2,385.9	0.6	598.3	70.3			4,612.4
Seekonk River Sub-basin	2.5		0.8			11.9			4.5	0.6		20.3

Table D2. Continued.

Watershed	*Wetland type*[2]											
	EMA	**EMB**	**SSA**	**SSB**	**FOA**	**FOB**	**FOD**	**LOW**	**POW**	**ROW**	**RTW**	**Total**
Pawcatuck River Basin	**572.4**	**71.5**	**2,375.9**	**765.5**	**4,860.1**	**16,984.5**	**85.4**	**3,448.0**	**887.2**	**598.6**		**30,649.1**
Chickasheen River Sub-basin	20.5		76.4	7.7	91.3	776.5		162.9	13.4	1.0		1,149.6
Chipuxet River Sub-basin	35.6	5.3	270.6	76.6	576.7	2,596.1	17.8	1,314.7	105.8	14.4		5,013.6
Pawcatuck River Sub-basin	340.1	41.0	1,191.6	384.8	2,035.7	7,983.8	31.6	930.8	327.3	362.3		13,629.1
Queens River Sub-basin	63.5	1.4	157.8	58.8	621.8	2,734.5	3.0	51.5	138.6	24.3		3,855.2
Wood River Sub-basin	112.7	23.8	679.6	237.6	1,534.6	2,893.6	32.9	988.0	302.1	196.7		7,001.7
Pawtuxet River Basin	**672.0**	**52.7**	**1,389.4**	**457.2**	**2,308.9**	**12,035.9**	**25.1**	**6,566.3**	**910.5**	**478.9**		**24,896.8**
Barden Reservoir Sub-basin	46.1	5.3	254.3	48.3	331.7	1,498.5	16.8	274.7	96.0	9.6		2,581.4
Big River Sub-basin	57.2	41.2	120.7	207.1	636.9	1,468.1	2.4	143.5	102.2	24.2		2,803.5
Flat River Reservoir Sub-basin	53.7		148.5	45.8	325.8	1,274.0	0.5	1,045.0	92.7	2.3		2,988.3
Moswansicut Reservoir Sub-basin	17.5		26.1		7.8	249.1		298.4	5.1			603.9
North Branch Pawtuxet River Sub-basin	45.1		85.8	25.1	48.2	1,072.8	4.1	51.5	104.9	98.5		1,536.0
Pawtuxet River Sub-basin	160.8		243.4		6.8	1,387.6		195.6	195.0	150.9		2,340.1
Pocassett River Sub-basin	119.0		138.8	3.0	18.0	1,137.3	0.3	303.2	83.8	19.6		1,823.0
Ponagansett Reservoir Sub-basin	1.9	0.5	2.9	3.0	12.5	60.2		240.3	1.7			323.0
Regulating Reservoir Sub-basin	39.6	0.4	105.5	20.7	56.4	1,245.6		257.4	79.6	1.7		1,806.9
Scituate Reservoir Sub-basin	67.6	3.8	145.5	31.1	177.5	1,849.9		3,307.1	46.9	0.3		5,629.6
South Branch Pawtuxet River Sub-basin	60.5	0.8	111.4	71.8	649.1	655.4	1.0	281.2	91.6	171.7		2,094.3
Westconnaug Reservoir Sub-basin	2.9	0.9	6.4	1.2	38.3	137.5		168.4	11.1			366.7
Saugatucket River Basin	**46.5**		**187.1**	**12.7**	**43.6**	**2,381.1**	**3.5**	**432.6**	**178.6**	**12.0**		**3,297.9**
Point Judith Pond Sub-basin	19.5		113.2	4.9	12.1	572.0		67.5	113.2			902.4
Saugatucket River Sub-basin	27.1		73.9	7.8	31.5	1,809.1	3.5	365.1	65.4	12.0		2,395.5
Taunton River Basin	**25.7**		**58.7**	**0.9**	**116.5**	**538.1**	**1.0**	**489.4**	**3.9**			**1,234.1**
Taunton River Sub-basin	25.7		58.7	0.9	116.5	538.1	1.0	489.4	3.9			1,234.1
Ten Mile River Basin	**25.8**		**40.6**			**165.2**		**272.9**	**20.6**	**43.2**		**568.3**
Ten Mile River Sub-basin	25.8		40.6			165.2		272.9	20.6	43.2		568.3

Table D2. Continued.

Watershed	Wetland type[2]											Total
	EMA	EMB	SSA	SSB	FOA	FOB	FOD	LOW	POW	ROW	RTW	
Warren River Basin	**89.0**		**146.3**			**597.6**			**23.1**	**2.5**		**858.6**
Barrington River Sub-basin	8.3		18.9			179.9			11.7			218.7
Palmer River Sub-basin	22.7		40.7			156.8			3.2			223.5
Runnins River Sub-basin	38.5		38.5			163.8			5.3	2.5		248.6
Warren River Sub-basin	19.5		48.2			97.1			2.9			167.8
Westport River Basin	**37.5**		**45.8**		**15.9**	**905.2**	**24.0**		**20.9**	**0.5**		**1,050.0**
Adamsville Brook Sub-basin	37.5		45.8		15.9	905.2	24.0		20.9	0.5		1,050.0
Woonasquatucket River Basin	**202.6**	**1.5**	**248.6**	**72.6**	**293.6**	**2,764.9**		**855.7**	**281.8**	**88.5**	**7.3**	**4,817.2**
Woonasquatucket River Sub-basin	202.6	1.5	248.6	72.6	293.6	2,764.9		855.7	281.8	88.5	7.3	4,817.2
Statewide	**4,339.9**	**229.2**	**9,602.0**	**2,060.3**	**10,899.5**	**60,684.2**	**225.1**	**17,517.8**	**4,459.9**	**1,803.0**	**7.4**	**111,828.2**

[1]Data are based on interpretation of 1988 1:24,000-scale panchromatic aerial photographs and stored in the Rhode Island Geographic Information System (RIGIS); minimum map unit = 1/4 acre.
[2]Wetland type codes are defined in the Task D Methods section.

Task E. Development and testing of techniques for identifying specific restoration opportunities.

Overview

We considered many data sources for identifying restoration opportunities and developed site identification methods based on those sources. Techniques developed in other states and regions (see Task A) were reviewed during this process. For each method that we considered, we first assessed the pros, cons, time requirements, and relative value, and then designated the method as high, medium, or low priority (Appendix E1).

We tested the high-priority site identification methods in a 3.5-x3.5-mile study area within the Woonasquatucket watershed (Figure E1). This area included both heavily urbanized and somewhat rural landscapes, a wide variety of wetland types and impact types, and a diversity of land use settings. Site identification efforts in the Queens watershed were de-emphasized. After preliminary investigations, we concluded that there were far fewer impacts in the Queens, and that the Woonasquatucket study area provided an adequate range of conditions for testing.

The techniques that we finally adopted—and that we recommend for future use in Rhode Island watersheds—are highlighted in Appendix E1; they are discussed in detail below. Step-by-step instructions for the application of these methods in Rhode Island watersheds are provided in Appendix E2.

Wetland Impact Types

There are two major categories of wetland impacts: those that destroy wetlands, and those that degrade them. Destroyed wetlands have been converted to upland; degraded wetlands are still wetlands, but certain functions within them have been compromised. The data sources and methods used to identify restoration opportunities within the two categories are distinctly different. We focused our identification efforts on several types of impacts within the two categories:

Destructive impacts

Filling
Drainage

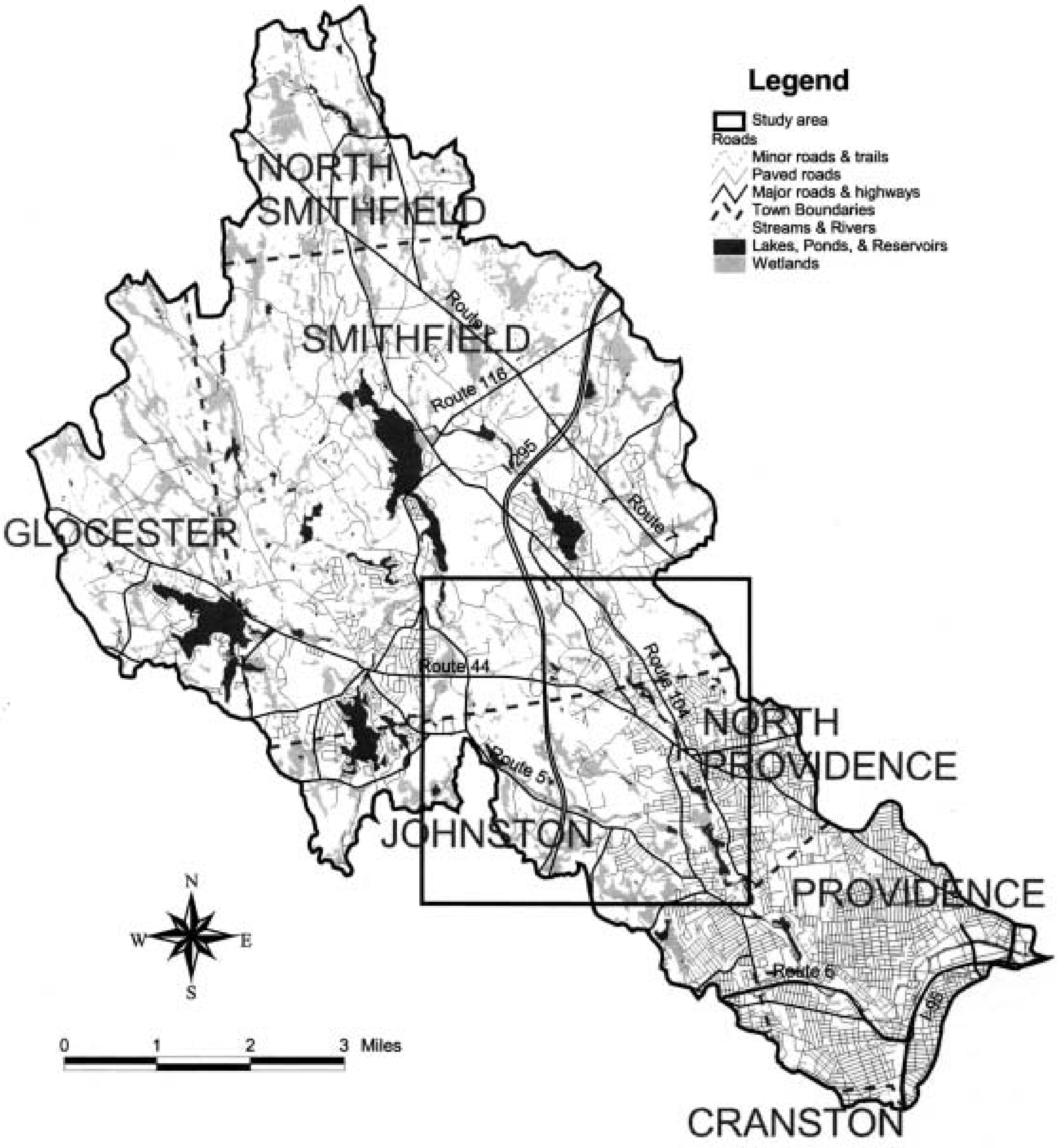

Figure E1. Woonasquatucket watershed and study area.

Degrading impacts

Stream channelization
Impedance of surface flow
Removal of wetland vegetation
Removal of adjacent upland vegetation
Trash dumping
Invasive species
Sedimentation

Site Identification Methods

Destroyed Wetland

We chose the following methods and data sources for identifying potentially restorable areas of destroyed wetland in the Woonasquatucket study area. Restorability is, in large part, based on current land use; for that reason, we did not inventory areas of destroyed wetland that had been built upon, except where structures appeared to have been abandoned.

Comparison of 1939 aerial photography with delineated 1988 aerial photography

We employed a time-lapse approach to identify wetland lost during the 49-year period from 1939 to 1988. The 1939 aerial photographs are the State's oldest historic data source, and the 1988 aerial photographs, which bear the original RIGIS wetland delineations, are our best and most current wetland data source. We thoroughly examined the same areas on both sets of photos to locate wetlands that had changed in size or shape or that had been lost entirely. Where possible, the photographs were viewed under a Topcon mirror stereoscope to enhance the interpretation process. Despite minor difficulties posed by differences in scale, this approach was quick and efficient because wetlands on the 1988 photos had already been accurately delineated. The 1939 photos were also useful for identifying streams channelized prior to 1939.

Analysis of 1981 soil survey data

Wetlands that had been filled were also located by searching in the RIGIS soils coverage for UD (Udorthents-Urban land complex) polygons or Ur (Urban land) polygons. There is a high probability of wetland filling where those soil types—which indicate filling or excavation to at least 2 feet—are adjacent to hydric soils. Alternatively, hard-copy soil maps of the Rhode Island Soil Survey (Rector 1981) could be used for the same purpose. This method complemented the time-lapse analysis; it confirmed sites identified with that method and enabled identification of possible wetland filling that occurred prior to 1939. Although this method may be substituted for the previous method in cases where high-quality, historic, aerial photographs are not available, there are certain limitations. The minimum mapping unit for UD and Ur polygons is 5 acres, so small fill sites will be overlooked. In addition, designation as UD or Ur may indicate excavation instead of filling.

Degraded Wetland

Interpretation of delineated 1988 aerial photography

The best way to search for degraded wetlands is to examine recent aerial photography using a high-powered stereoscope. We used the 1988 aerial photographs that bear the RIGIS wetland delineations for this purpose. Although more recent photos are available (e.g., 1995, 1999), the prior delineations on the 1988 "RIGIS" photos greatly enhanced the speed and reliability of the identification process.

Interpretation of 1995 digital orthophotography

We also detected degraded wetlands by simultaneously viewing 1995 digital orthophotography and wetland boundaries from the RIGIS wetlands coverage in ArcView. These orthophotos are somewhat "grainy" (minimum pixel size = 1 meter) and they cannot be viewed in stereo; however, this technique provides a means of detecting wetland impacts that have occurred since 1988. Digital orthophotos taken in 1997 became available after our testing was completed; they should be used in place of the 1995 orthophotos in future work. In addition to providing more recent data, the 1997 orthophotos have superior resolution (i.e., 2-foot pixel size).

Site nominations

Certain impact types (e.g., invasive species, trash dumping, sedimentation) are difficult or impossible to identify remotely. Identification of such impacts generally requires personal knowledge of the watershed or extensive field surveys. We developed a site nomination form (Appendix E3) and distributed it to stakeholders in the Woonasquatucket study area. The form includes guidelines for identifying restoration opportunities in the field. It also helped us to educate stakeholders about wetland restoration, to develop a rapport with them, and to actively involve them in the project. This should be useful in the future as restoration strategies are developed in individual watersheds. We do not believe it is practical for project personnel to conduct field surveys to identify the impact types listed above; however, we do recommend that they record instances of such impacts when they are observed in the course of other field work.

Geographic Information System Coverages and Databases

We created a GIS point coverage so that we could record information about individual restoration opportunities. The coverage contains a point for each degraded or destroyed wetland identified using the methods described above. The attributes table for the coverage (Table E1) contains location information for each point, as well as information on land use setting, impact type, impact extent, prior wetland type, and other features. Information included in this database was used in the development of prioritization methods; it will also be useful during future feasibility studies. Additional site-specific information was collected and incorporated into the GIS database as part of the site prioritization process (see Task F). In order to locate and evaluate destroyed sites in the field, we needed to know the extent of the filling or drainage. This information was also needed in the prioritization process (see Task F). Therefore, we delineated the approximate boundaries of destroyed sites to create a GIS polygon coverage. Wetlands, or parts of wetlands, that were destroyed after 1939 were delineated on mylar overlying the 1939 aerial photography. The mylar was then fixed to a computer screen so that the delineations could be viewed simultaneously with the 1995 orthophotos and the 1988

Table E1. Information collected during the site identification process and recorded in the GIS database of restoration opportunities.[1]

1. Site ID #
2. Associated wetland unit ID #
3. Location of the site (x,y coordinates)
4. Area (acres) of the potential restoration site (for destroyed sites only)
5. Area (acres) of the associated wetland unit
6. Impact type (e.g., filling, draining, removal of adjacent upland vegetation)
7. Prior wetland type (if able to determine from 1939 aerials)
8. Current wetland type (for degraded sites)
9. Current land use (for destroyed sites)
10. Adjacent land use
11. Land use status (whether the land is currently used or abandoned)
12. Identification source (method used to identify the site)
13. Lab comments
14. Field comments

[1]The database contains additional information used to rank potential restoration sites.

RIGIS wetland boundaries. After adjusting the orientation of the mylar delineations and the scale of the orthophotos to obtain a good alignment, we identified those areas of wetland that had been converted to upland. Those areas were then heads-up digitized to create a GIS polygon coverage. Sites filled prior to 1939 could not be delineated using this technique. Although this method was simply developed to determine the approximate extent of wetland filling or drainage, it served other purposes. The method helped us to verify or refute the occurrence of filling at smaller, more questionable sites; this was particularly valuable where ground-truthing was not possible. In several cases, areas originally identified as a single instance of wetland destruction were found to contain multiple fill sites. Although the resulting polygons were only approximations of the extent of wetland loss—and they would not be accurate enough for use during feasibility analyses—this technique provides a basic foundation for the development of watershed restoration plans.

Results and Conclusions

In total, 228 potential restoration sites were identified in the Woonasquatucket study area (Appendix E4). The most frequently identified impact types, by far, were the removal of adjacent upland vegetation and filling (Table E2). The size of fill sites ranged from less than 0.03 acres to greater than 6 acres. Field observations are critical to determine whether or not remotely identified impacts represent genuine restoration opportunities; they also assist in updating land use information, which may have changed since aerial photos were taken. Approximately half of the 228 potential restoration sites were visited in the field; the remainder were inaccessible. Most of the ground-truthed sites had been accurately identified and described in the lab using aerial photos and orthophotos. The majority of the sedimentation and invasive species impacts were identified in the field during checks of other impacts. In the entire Woonasquatucket watershed, six restoration opportunities were nominated by stakeholders; of those, only one—a major dumping site—was within the study area. With increased stakeholder participation, it should be possible to identify more of the impacts that are difficult to identify remotely (i.e., invasive species, sedimentation, and trash dumping).

The methods that were developed and tested in the Woonasquatucket study area were effective and reliable. However, we recommend maintaining flexibility in the site identification process. New and more accurate datasets should be incorporated into the identification process as they become available. Maintaining a flexible approach will promote efficiency and accuracy as restoration strategies are developed for individual watersheds.

We recommend that the identification methods be streamlined in the future, so that only potentially restorable sites are identified. For example, the restorability of sites where adjacent upland vegetation has been removed is largely dependent on the surrounding land use; for this reason, we recommend limiting the inventory of such impacts to sites that are not actively used or productive (e.g., abandoned parking lots, abandoned fields, and other unused areas). Channelized streams in heavily urbanized areas should also be excluded; their restoration could create serious flooding problems.

Table E2. Potential restoration sites identified in the Woonasquatucket study area, by impact type.

Impact	*Count*
Destructive impacts	
Filling	73
Complete drainage	5
Degrading impacts	
Removal of adjacent upland vegetation	85
Invasive species	20
Sedimentation	19
Stream channelization	13
Partial drainage	4
Impedance of surface flow	4
Removal of wetland vegetation	3
Trash dumping	2
Total	228

Task F. Development and testing of approaches to prioritize restoration opportunities.

Introduction

Over 200 potential restoration sites were identified in the Woonasquatucket study area (see Task E). It is likely that many more sites will be identified when the proposed identification techniques are applied at a watershed scale. Because the number of restoration opportunities may be overwhelming to agencies, organizations, or others interested in restoration, it is necessary to prioritize individual opportunities. In the following paragraphs we describe a filtering process; an outline of the process is provided in Figure F1. We developed this approach to rank individual restoration opportunities (i.e., instances of human impacts identified in Task E), not to rank entire wetland units. During development of the approach, our goal was to highlight the sites that have the greatest potential to provide the most benefits after restoration.

All of the methods that we have devised were put to three tests: (1) they had to be based on good science, (2) they had to be intuitive, and (3) they had to be relatively easy to apply. To ensure that our methods passed all of those tests, we took a number of steps. First, we consulted the scientific literature (see Task C). This review focused on the restorability of specific wetland functions based on the nature of the impact; it served as the foundation for the overall prioritization process and for making finer-scale decisions within that process. Second, we considered prioritization strategies that had been developed in other states and regions (see Task A). Special attention was paid to methods developed by the Massachusetts Wetland Restoration and Banking Program. Finally, we solicited stakeholder reviews and comments regarding our proposed approach.

Prioritizing Opportunities Based on Impact Type

We believe that restoration opportunities should first be prioritized according to the type of impact. In Figure F1, capital letters and numbers in parentheses indicate the relative priority that we assigned to each of the impact types. Sites with destructive impacts (i.e., filling and draining) were ranked higher than degrading impacts. Restoration of destroyed wetlands has the potential to provide the most benefits; it involves re-creation of wetland functions where none currently exist. Degraded sites

(A) *Destructive impacts* (filling or draining)

Individual functions

1. Obtain landowner permission to access sites.
2. Conduct field- and lab-based functional assessments.
3. Calculate probability scores, based on opportunity and effectiveness.
4. Add bonus points for social significance, if appropriate.
5. Disregard sites with scores < 0.6.
6. Multiply scores by a size factor.
7. For each function, rank sites by sorting the scores from highest to lowest.

Combined functions

1. Begin with scores from step #4 (left).
2. For each site, count the number of functions with scores ≥ 0.6.
3. Multiply the number of functions by a size factor.
4. Rank sites by sorting the scores from highest to lowest.

(B) *Degrading impacts*

(1) *Adjacent upland vegetation removal*

1. Determine if site is vulnerable to human impact (y or n).
2. Determine if site contains an especially sensitive wetland type (y or n).
3. If "y" to both questions, then high priority.
4. If "y" to only one question, then medium priority.
5. If "n" to both questions, then low priority.
6. Within these priority groups, rank sites further by the total length of wetland border that is unvegetated.

(2) *Impedance of surface flow*

1. Rank by the ease with which the problem can be resolved:
   a. High priority: sediment removal from culvert.
   b. Lower priority: change of culvert invert or installation of new culvert.
2. Within these priority groups, rank wetlands further by the size of the affected upstream area.

(3) *Trash dumping*

Rank sites by the area of wetland that has been impacted.

(4) *Stream channelization*

1. Rank sites first by context:
   a. Rural sites are ranked as high priority.
   b. Restoration of streams in urban areas is generally not feasible.
2. Within these priority groups, rank wetlands further by the length of the stream that has been affected.

(5) *Invasive species*

(6) *Sedimentation*

Sites within these impact types are not ranked.

Figure F1. Freshwater wetland restoration prioritization process. Capital letters and numbers in parentheses indicate relative priority levels.

already perform certain functions; they were given lower priority than destroyed sites because there is less to gain. In addition, restoration of degraded sites will likely entail alterations that may compromise existing wetland functions. For example, exposure of the soil surface after removing sediment from existing wetlands may create conditions favorable for invasive species. Degraded sites were further prioritized according to the specific impact type. In order of decreasing priority, those impacts include removal of adjacent upland vegetation, impedance of surface flow, dumping of trash, stream channelization, invasive species, and sedimentation (Figure F1). We established this order after a literature review and extensive discussions. Our reasoning is given in Section 1 of Task C.

Ranking Individual Sites Within Impact Categories

We recommend that individual sites be further ranked within the broad impact categories listed above. We have developed a ranking procedure that is unique to each impact type. The procedures are described below; a general overview of each is presented in Figure F1.

Ranking Sites Where Wetland Has Been Destroyed

Destroyed sites were ranked within the Woonasquatucket study area after conducting assessments to estimate the probability that, if restored, they could perform each of five wetland functions (see Appendix F1). The five functions were flood abatement, water quality improvement, wildlife habitat, fish habitat, and heritage. Because the functional assessment method that we developed relies heavily on field data, only sites that were accessible in the field (i.e., sites where landowners had granted permission) could be assessed and ranked. Sites were ranked by their ability to perform each individual function, and also by their ability to perform multiple functions. Therefore, six ranked lists of destroyed sites were generated: one list for each function and one list for combined functions. Ranking sites by their ability to perform individual functions allows users with special interests to target specific functions; for example, fish conservation organizations may wish to target restoration sites that could improve fish habitat. The ranked list that is based on multiple functions allows users with broader goals to target wetlands that have the greatest potential to provide the most functions. The ranking procedures that we developed are described in detail below; a step-by-step overview and an example are provided in Appendix F2.

Functional assessments

Appendix F1 contains a form that was used to generate scores for ranking destroyed wetland sites within the study area. Each of the five functions on the form has a list of criteria associated with it. These criteria were generated from the experience of the authors and a review of wetland functional assessment methods developed by Adamus et al. (1987) and the U.S. Army Corps of Engineers (1995). Rationale for these criteria, and methods for assessing them in the lab or in the field, are provided in Appendix F3. Data were collected in the field and in the lab to determine which criteria were met for each function at each site. Each criterion was designated as an "opportunity," "effectiveness," or "social significance" criterion; these terms were borrowed from Adamus et al. (1987). *Opportunity* criteria indicate whether a wetland has the chance to perform a certain function. For example, wetlands surrounded by impervious surfaces receive large quantities of surface runoff during storms; those wetlands have the opportunity to abate downstream flooding problems. *Effectiveness* criteria assess the capacity of a wetland to perform a specified function, based on the wetland's characteristics. For example, wetlands that occur in basins are more effective at temporarily storing floodwaters than wetlands that occur on slopes. *Social significance* criteria indicate whether performance of a certain function at a particular site would have clear benefits to society. For example, the flood abatement function of a wetland has social significance if the wetland lies upstream of developed, flood-prone areas.

Calculation of functional probability scores

We used opportunity and effectiveness criteria to calculate the probability that a wetland, if restored, could perform a certain function. For example, there are eight "O" and "E" criteria for the heritage function. If, after assessments have been conducted in the field and in the lab, it is determined that six of the eight criteria have been met for a given wetland, then the probability that the wetland could perform the heritage function would be 0.75. Scores were increased by 0.1 for sites where at least one of the social significance criteria was met. Wildlife habitat and fish habitat functions do not have social significance criteria; site scores for those functions were automatically increased by 0.1. For each function, all sites that had an O-E-S score of 0.6 or greater were included in the remainder of the ranking process; all other sites were removed from the ranking process for that function. Therefore, only sites with a high probability of performing a given function were considered further.

Ranking sites by individual functions

For all sites with O-E-S scores of 0.6 or greater, we multiplied the score by a size factor. Scores for sites smaller than 0.5 acres were multiplied by 1.0; scores for sites between 0.5 and 2.0 acres were multiplied by 1.5; scores for sites larger than 2.0 acres were multiplied by 2.0. Size factors were based on the acreage of the impact areas, rather than the acreage of the wetland units of which the impact areas are a part. Sites were then ranked for each function according to their final score, which ranged from 0.6 to 2.2. Where ties existed among sites with the same scores, sites were further ranked by absolute size.

Ranking sites by the total number of functions performed

For each site, we determined the number of functions that had a high probability of being performed (i.e., those functions that had an O-E-S score of 0.6 or higher). The number of functions was then multiplied by the appropriate size factor (see values above). Because size factors ranged from 1.0 to 2.0 and the possible number of functions ranged from 0 to 5, final scores could range from 0 to 10. Sites were ranked by sorting the scores from highest to lowest. Where ties existed, sites were further ranked by absolute size.

Ranking results for destroyed sites

The results of ranking for the destroyed wetland sites are presented in Appendix F4. Study area sites were ranked by their potential to perform individual functions, and also by their potential to perform multiple functions.

Ranking Sites That Have Been Degraded

We recommend unique ranking procedures for sites associated with each of the degrading impact types (Figure F1); the impact types are addressed below in descending order of priority. We did not test these ranking procedures.

Removal of adjacent upland vegetation

We propose that sites within this impact type be ranked based on the answers to two questions: (1) is the site vulnerable to human impacts, based on context, and (2) is the wetland type either especially valuable or especially sensitive to human impacts? Sites that are near roads, industry, commercial centers, high-density residential development, or other land uses that might contribute to further wetland degradation would be considered vulnerable. Especially valuable or sensitive wetland types include bogs, fens, marshes, standing water bodies, and Atlantic white cedar (*Chamaecyparis thyoides*) swamps. If the answer to both of the questions is "yes," then the site would be considered high priority. If the answer to one question is "yes," and the other "no," then the site would be considered medium priority. All other sites would be considered low priority. Within these priority groups, sites would be further ranked by the total length of wetland border that is unvegetated.

Impedance of surface flow

Sites that have been unintentionally impounded (primarily as a result of road construction) would be ranked according to the ease with which the problem might be resolved. The highest priority sites would be those that could be restored by removing sediments from blocked culverts. Lower priority sites would be those that require a change of culvert invert or installation of a new culvert. Within these priority groups, wetlands would be further ranked by the size of the affected upstream area.

Trash dumping

We recommend ranking dumping sites by the area of wetland that has been impacted. Although larger sites may require more resources, their cleanup would likely provide greater benefits. Where trash dumping has been so extensive that wetland functions are no longer evident, we propose that the site be considered filled (destroyed) and ranked accordingly.

Stream channelization

We suggest that streams that have been channelized (i.e., straightened, deepened, and widened) first be ranked according to their context. Rural sites would be ranked as high priority. All other sites would be ranked as lower priority. Channelized streams in urban environments generally have been developed right up to the streambank. The lack of space to restore natural stream meanders and the increased likelihood of localized flooding resulting from such efforts generally render restoration of streams in urban areas unfeasible. Classification of a stream as “urban” or “rural” is somewhat subjective; decisions would have to be made on a case-by-case basis. Within the context-based priority groups, streams might be further ranked by the length of channel that has been altered.

Invasive species

Sites within this impact type would not be ranked further. In general, we recommend that stakeholders focus their efforts on restorations that (1) have a high probability of restoration success, (2) have the opportunity to positively influence several wetland functions, and (3) involve low ecological risk. Invasive species control does not meet these criteria. On the other hand, revegetation of uplands bordering wetlands has the potential to provide great benefits while incurring little risk. For more discussion on this topic, please refer to Task C, Section 1. It is not practical to rank invasive species sites according to the size of the area impacted because, generally, it would be far more difficult to eradicate invasive species from areas where they are well established than from areas they had just colonized.

Sedimentation

We do not recommend further ranking of sites within this impact type either. Ranking by the size of the affected area often is not possible; the size of an obvious pile of sediment may not reflect the magnitude of the sedimentation problem. During field reconnaissance of this impact type we found that, while some sediment may accumulate near the source, it is often spread diffusely throughout wetlands by surface water flow. In such cases the impact cannot be effectively removed, or even measured. Field observations also indicated that sedimentation was an ongoing problem in all of the identified cases. This would argue for shifting the focus to road maintenance (e.g., installation and maintenance of sediment traps), rather than sediment removal from wetlands. As noted earlier, removing sediments from wetlands also produces bare substrates which, in turn, encourage the establishment of invasive species.

Further Ranking During Phase II

The prioritization methods that we have proposed thus far are based largely on ecological considerations. We have intentionally omitted certain logistical criteria that could be used to prioritize sites. These additional considerations will be addressed in Phase II of this project. After identifying and prioritizing sites for the entire Woonasquatucket watershed, we propose to select sites for feasibility analyses based on criteria such as projected restoration costs, local need for specific wetland functions, proximity to other wetlands, proximity to other proposed restoration sites, stakeholder priorities, landowner cooperation, permitting hurdles, and physical accessibility. Additional criteria that will be used to select sites for restoration include proximity to other recommended sites and proximity to sites nominated by other restoration projects in the watershed (e.g., the RIDEM Office of Strategic Planning's Woonasquatucket Riparian Reforestation project and NRCS's Wildlife Habitat Incentives Program).

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Appendix A. Profiles of restoration programs reviewed.

1. Program: Illinois Conservation Reserve Enhancement Program

2. Overview:

Illinois' State-run Conservation Reserve Enhancement Program pays landowners 20% above market value to retire marginal farmland from production. Among other conservation activities, wetland restoration is targeted by this program to improve soil and water quality. This is a voluntary program, and sites are not identified or prioritized in advance.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1998

5. Parent Organization(s): IL Department of Natural Resources (DNR), Office of Resource Conservation and USDA Natural Resource Conservation Service

6. Habitats Addressed: Coastal_____ Freshwater__X__

7. Geographic Extent: Statewide_____ Regional__X__ (Illinois River Basin)

8. Context: Regulatory_____ Nonregulatory__X__

9. Advance Identification: Yes_____ No__X__

10. Identification Strategy:

11. Prioritization of Sites: Yes_____ No__X__

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes__X__ No_____

15. Funding Sources: NRCS CREP

16. Additional Information:

The IL DNR and IL Environmental Protection Agency are also working in four small pilot watersheds, in an effort to establish watershed groups and provide them with opportunities. Stakeholder groups are organized, and agency personnel inform them of ecological problems within their watersheds, possible solutions to those problems (including wetland restorations), and potential funding sources or programs.

17. Contact Information:

Ryan Taylor
Illinois Department of Natural Resources
Office of Resource Conservation
600 North Grand Avenue West
Springfield, IL 62706
Phone: (217)785-8287
Email: rtaylor@dnrmail.state.il.us

1. Program: Long Island Sound Study (Connecticut and New York State)

2. Overview:

The Long Island Sound Study works in close cooperation with towns and organizations to identify priority projects, secure funding, and provide technical assistance for restorations. In Connecticut, restorations are conducted by the Connecticut Wetland Restoration Team of the Department of Environmental Protection (DEP); New York does not conduct restorations in-house. Freshwater wetland activities are mostly limited to anadromous fish run restorations. Some upland restorations are also targeted (e.g., coastal grasslands, wetland buffers, riparian zones).

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1985

5. Parent Organization(s): CT DEP and NY State Department of Environmental Conservation

6. Habitats Addressed: Coastal__X__ Freshwater__X__

7. Geographic Extent: Statewide_____ Regional__X__ (Long Island Sound)

8. Context: Regulatory__X__ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

Several methods were used to identify over 400 potential wetland restoration sites. In Connecticut, historic aerial photography was delineated, digitized, and compared to 1995 aerial photography within a GIS environment. Additional GIS coverages were used to identify tidal restrictions and other sources of impact. In both states, sites were added to the list based on conclusions from well-attended public meetings and consultation with experts in government agencies and non-governmental organizations. In addition, any interested parties may submit forms to nominate sites.

11. Prioritization of Sites: Yes__X__ No_____

12. Prioritization Criteria:

Ecological Criteria: area (weighted by wetland type), protected species benefits, potential to obtain historic ecological functions, potential to restore full species use (connectivity, adjacent habitat quality, etc.)
Logistical Criteria: technical probability of success, community support, cost/acre, implementation readiness, future maintenance requirements
Public/Economic Benefits Criteria: accessibility/provision of open space, environmental equity, economic benefits, recreational use, education potential, surface and groundwater improvements

13. Prioritization Process:

Within each of the three broad criteria categories (above), individual criteria are assigned a value of 1, 2, or 3 (i.e., low, medium, or high). Values are averaged within each category; resulting values for all three categories are then averaged to produce a final rank of low, medium, or high for each wetland. Ecological criteria are weighted more heavily than logistical criteria or public/economic benefits criteria. Sites ranked as medium or low are sometimes restored before higher-ranked sites if they are of local importance, and have a strong local support base.

14. Pilot Studies: Yes_____ No __X__

15. Funding Sources:

Federal: Section 319 grants, Federal Highway Administration T21 (Transportation Enhancement Act of the 21st Century), USFWS, USACE, NOAA National Marine Fisheries Service, National Fish and Wildlife Foundation's Five-Star Restoration Challenge Grant
State (CT): Bond allocations (specifically for wetland wildlife habitat restoration), Long Island Sound License Plate Program
State (NY): New York's Clean Air/Clean Water Bond Act (a portion of which is administered through NY's Long Island Sound Study)
Other: Ducks Unlimited

16. Additional Information:

Much of the success of this program has been attributed to the manner in which it was developed. A steering committee was formed, consisting of state and Federal agencies. This consensus-driven approach allowed for development of a common set of goals and methods and fostered further cooperation among agencies.

Additional freshwater wetland restorations occur in New York State under USFWS North American Waterfowl Management Plan and the NRCS Wetland Reserve Program. Neither of these programs prioritizes sites or identifies them in advance. New York attributes a net gain of wetlands to these programs.

17. Contact Information:

CT: Chris Rilling
Connecticut Dept. of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127
Phone: (860) 424-3034 x2770
Email: chris.rilling@po.state.ct.us

NY: Lisa Holst
New York State Dept. of Environmental Conservation
205 North Belle Mead Road
East Setauket, NY 11733
Phone: (516) 444-0469

1. Program: Maryland Department of the Environment

2. Overview:

MD Department of the Environment (MDE) oversees compensatory mitigation restorations. This agency authored "A guide on site searches for mitigation projects" within its Nontidal Wetlands and Waterways Division.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1998

5. Parent Organization(s): MDE

6. Habitats Addressed: Coastal_____ Freshwater__X__

7. Geographic Extent: Statewide__X__ Regional_____

8. Context: Regulatory__X__ Nonregulatory_____

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

In the MDE publication "A guide on site searches for mitigation projects," potential restoration and creation sites are identified using one or all of four approaches. These approaches include 1) GIS software and coverages; 2) hard copies of soil surveys, NWI maps, and other "office information;" 3) field survey criteria; or 4) a registry of sites pre-approved by MDE. These guidelines suggest general approaches for identifying sites, but do not provide a step-by-step procedure.

11. Prioritization of Sites: Yes__X__ No_____

12. Prioritization Criteria:

In the identification of potential mitigation sites, MDE attempts to consider many factors, including site ownership, wetland juxtaposition, soil drainage class, current land use, and distance from roads. They stress that criteria should vary, depending on mitigation goals (i.e., the function(s) to be restored).

13. Prioritization Process:

The MDE guidelines suggest an informal, qualitative assessment of the factors mentioned above.

14. Pilot Studies: Yes_____ No__X__

15. Funding Sources:

This program is regulatory; therefore, developers pay for wetland restorations and creations.

16. Additional Information:

17. Contact Information:

Denise Clearwater
Nontidal Wetlands and Waterways Division
Maryland Department of the Environment
2500 Broening Highway
Baltimore, MD 21224
Phone: (410) 631-8094

1. Program: Massachusetts Bays Program

2. Overview:

The Bays Program inventories and restores tidally restricted coastal wetlands of Massachusetts.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1990

5. Parent Organization(s): Massachusetts Executive Office of Environmental Affairs

6. Habitats Addressed: Coastal__X__ Freshwater_____

7. Geographic Extent: Statewide_____ Regional__X__ (MA coastal areas, except the Cape and islands)

8. Context: Regulatory_____ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

Although the Bays Program has identified sites through comprehensive field surveys, they primarily use MA Wetlands Restoration and Banking Program (WRBP) methods (i.e., aerial photo-interpretation and ground-truthing).

11. Prioritization of Sites: Yes_____ No__X__

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes_____ No__X__

15. Funding Sources:

USFWS, State highway money, WRBP (State bonds)

16. Additional Information:

The Bays Program limits its activities to restoration of tidally restricted wetlands. Although potential restoration sites are not prioritized, the ranking of sites has been considered for the future. The geographic area covered may be expanded soon to include Cape Cod.

The Bays Program is also developing an index of wetland ecological integrity—incorporating scientifically based rapid assessment procedures for the ecological health of wetland study sites.

17. Contact Information:

Jan Peter Smith
Massachusetts Bays Program
Executive Office of Environmental Affairs
100 Cambridge Street
Boston, MA 02202
Phone: (617) 727-9530 x1231
Fax: (617) 723-5408
Email: jan.smith@state.ma.us

1. Program: Massachusetts Wetlands Restoration and Banking Program

2. Overview:

The Wetlands Restoration and Banking Program (WRBP) was assisted by the USACE and Natural Resources Assessment Group of the University of Massachusetts in developing and applying the following methodology. Methods were initially tested in the Neponset River Watershed; slightly modified methods are now being applied in the Neponset and five other Massachusetts watersheds. Plans for additional watersheds are currently being developed. WRBP works closely with watershed groups to establish goals, identify opportunities, and obtain funding.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1994

5. Parent Organization(s): MA Executive Office of Environmental Affairs

6. Habitats Addressed: Coastal__X__ Freshwater__X__

7. Geographic Extent: Statewide__X__ Regional_____

8. Context: Regulatory__X__ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

Potential restoration sites are identified on a watershed basis. The WRBP distinguishes between former wetlands (Type 1 restorations) and wetlands with functions that have been impaired or degraded (Type 2). Degraded wetlands are identified primarily through interpretation of aerial photographs. Former wetlands are identified using soils and land use coverages in a GIS; the co-occurrence of hydric soils and disturbed land uses indicates a former wetland. Sites proposed by watershed stakeholders may also be considered. All sites are ground-truthed.

11. Prioritization of Sites: Yes__X__ No_____

12. Prioritization Criteria:

Wetland restoration goals for individual watersheds are determined after assessing watershed functional deficits, and by collaborating with watershed stakeholders. Seven goals were set for the pilot Neponset River Watershed, including water quality improvement, salt marsh restoration, wildlife habitat improvement, flood storage improvement, invasive species control, cold water fisheries habitat improvement, and groundwater recharge and stream baseflow improvement.

13. Prioritization Process:

Multiple site lists are created for each watershed. Nine lists of potential restoration sites were generated for the Neponset River Watershed: one for each of the seven watershed goals listed above, one consisting of sites identified as important by the watershed community, and one consisting of sites owned by the Metropolitan District Commission. Sites are organized by their ability to meet watershed goals; they are then ranked by size. A "Priority Wetland Restoration Sites" list was also created for the Neponset to highlight the most significant potential restoration sites overall. These were also ranked by size.

14. Pilot Studies: Yes __X__ No _____

15. Funding Sources:

The WRBP provides the following list of potential funding sources to those interested in wetland restoration:

Federal: USFWS (National Coastal Wetlands Conservation Grant Program, North American Wetlands Conservation Grant Program, Partners for Fish and Wildlife, Challenge Grant Program, Challenge Cost Share Program); National Fish & Wildlife Foundation grants; Gulf of Maine Council (Coastal and Marine Environment grants); NRCS (WRP, WHIP, Section 566 River Basins); USACE (Section 22, Section 1135, Section 206, Floodplain Management Services); USGS (State/Federal Cooperative Program); USEPA (Five-Star Restoration Program); NMFS (Community-based Restoration)

State: WRBP (GROWetlands Grant Program); MA Department of Environmental Protection (104(b)(3) water quality and wetlands grants, Section 604(b) Water Quality and Management Planning Program, Section 319 Nonpoint Source Program, Research and Demonstration Program); Massachusetts Environmental Trust (Implementation Program)

16. Additional Information:

Although one goal of the WRBP is to determine whether wetlands mitigation banking can improve mitigation success, the above methods were developed to address restoration in a nonregulatory context.

17. Contact Information:

Christy Foote-Smith, Director
Wetlands Restoration and Banking Program
Executive Office of Environmental Affairs
One Winter Street
Boston, MA 02108
Phone: (617) 292-5991
Fax: (617) 292-5850
Email: christy.foote-smith@state.ma.us

1. Program: North Carolina Wetlands Restoration Program

2. Overview:

The North Carolina Wetlands Restoration Program (NCWRP) develops "Basinwide Wetlands and Riparian Restoration Plans" for each of the State's major river basins. These plans are developed in two phases: 1) prioritization of watersheds within river basins, and 2) selection of sites within priority watersheds. NCWRP also administers restoration funds; on-the-ground restorations are conducted by private contractors.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1996

5. Parent Organization(s): NC Department of Environment and Natural Resources, Division of Water Quality

6. Habitats Addressed: Coastal__X__ Freshwater__X__

7. Geographic Extent: Statewide__X__ Regional_____

8. Context: Regulatory__X__ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

NWI digital datasets are used to locate altered wetlands that have been classified with special modifiers. Forested wetlands that have been cleared are identified through an overlay of the NWI coverage with more recent satellite-generated land cover data. Where digital soils data are available, information on hydric soils can assist in the identification of former wetland sites that have been filled. Cleared riparian areas are identified by overlaying a buffered hydrography data set with a land cover data set. Other groups (i.e., state and Federal agencies, local governments, and non-profit organizations) are also consulted during the identification process.

11. Prioritization of Sites: Yes__X__ No_____

12. Prioritization Criteria:

Sites must be located in priority watersheds to be considered for restoration. Ecological needs of river basins are determined (e.g., floodwater storage, water quality, wildlife habitat); priority watersheds are those sub-basins or hydrologic units having the potential to contribute to basin-wide goals. This is, in effect, a functional deficit analysis.

13. Prioritization Process:

Restoration sites are prioritized using a four-step process:

1) Restoration opportunity is determined using a landscape-level GIS analysis.
2) Field visits are conducted to verify results of Step 1, and to determine restorability through assessment of current and potential functions.
3) Ecological and economic costs of restoration are assessed.
4) A cost-benefit analysis is conducted.

High-priority sites are those that occur in priority watersheds, and are designated as high-benefit and low-cost. Among these, sites that are located in close proximity to other such sites are considered the highest priority.

14. Pilot Studies: Yes_____ No __X__

15. Funding Sources:

Funds have been appropriated by the North Carolina State Legislature ($9 million). In addition, the North Carolina Department of Transportation pays the program $2.5 million annually for mitigation siting. In-lieu fee payments (authorized by a Memorandum of Understanding with the ACOE) are also used to restore sites.

16. Additional Information:

17. Contact Information:

Laura P. Jones
Planning Coordinator
Wetlands Restoration Program
Division of Water Quality
NC Department of Environment and Natural Resources
P.O. Box 29535
Raleigh, NC 27626-0535
Phone: (919) 733-5311
Fax: (919) 733-5321
Email: laura_jones@h2o.enr.state.nc.us

1. Program: Oregon Wetlands Joint Venture

2. Overview:

The Oregon Wetlands Joint Venture is a coalition of private conservation, waterfowl, fisheries, and agriculture organizations working with government agencies to restore, enhance, and protect important wetland habitats of Oregon. It coordinates state-level activities for the Pacific Coast Joint Venture and the Intermountain West Joint Venture, two regional partnerships under the USFWS North American Waterfowl Management Plan.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1991

5. Parent Organization(s): USFWS

6. Habitats Addressed: Coastal__X__ Freshwater__X__

7. Geographic Extent: Statewide__X__ Regional_____

8. Context: Regulatory_____ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

Potential restoration and enhancement sites are identified by consulting local experts and by examining existing planning documents.

11. Prioritization of Sites: Yes_____ No__X__

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes_____ No__X__

15. Funding Sources:

Funding is sought from various Federal, State, and private sources after identifying specific restoration opportunities.

16. Additional Information:

Focus Area Plans are being developed for ten areas throughout the State. These plans document the status of existing wetland resources, including past and present impacts, current and former fish and wildlife resources, and existing habitat protection. Objectives are established for each area (in terms of wildlife population levels and habitat acreage), and specific actions are recommended to meet these objectives. Although planning for each area continues, specific restoration projects have already been implemented through this program.

The Joint Venture has avoided prioritizing sites because in the short term, lower-ranked projects may be more feasible than those that would be ranked higher, and because it is difficult to get local people interested in lower-ranked projects.

17. Contact Person:

Bruce Taylor, Executive Director
Oregon Wetlands Joint Venture
Phone: (503) 697-3889
Email: Btaylorwet@aol.com

1. Program: Pennsylvania Wetland Replacement Project

2. Overview:

This project gives developers the option of contributing "in-lieu" fees to offset impacts to wetlands, rather than conducting individual mitigation projects. Fees are collected and applied to wetland restoration and creation projects conducted by Pennsylvania Department of Environmental Protection (DEP) staff. The project was developed after a study in Pennsylvania reported a 50% rate of failure for mitigation sites under ½ acre. The DEP views this as a means of enhancing the success of small mitigation restorations.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1996

5. Parent Organization(s): Pennsylvania DEP; Division of Waterways, Wetlands and Erosion Control; Bureau of Water Quality Protection

6. Habitats Addressed: Coastal_____ Freshwater__X__

7. Geographic Extent: Statewide__X__ Regional_____

8. Context: Regulatory__X__ Nonregulatory_____

9. Advance Identification: Yes_____ No__X__

10. Identification Strategy:

Wetland restoration and creation sites are volunteered by agencies and private landowners. Wetland replacement must occur on site or in the same basin as the impact.

11. Prioritization of Sites: Yes_____ No__X__

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes_____ No__X__

15. Funding Sources:

Developers may provide in-lieu fee payments as an alternative to conducting individual compensatory mitigation projects. Contribution rates vary according to the areal extent of wetland impacts. Payments are pooled and applied to the project's wetland restoration efforts.

16. Additional Information:

Pennsylvania has proposed a statewide Wetlands Net Gain Strategy, and claims to be meeting these goals through the NRCS Wetland Reserve Program, USFWS Partners for Wildlife, and larger mitigation projects requiring greater than one-to-one compensation. As part of this strategy Pennsylvania will "develop a statewide watershed-based targeting system to identify critical areas where restoration efforts can provide immediate short-term and long-term benefits."

17. Contact Information:

Kelly Heffner
Bureau of Water Quality Protection
Division of Waterways, Wetlands and Erosion Control
Pennsylvania Department of Environmental Protection
P.O. Box 8775
Harrisburg, PA 17105-8775
Phone: (717) 787-6827
Fax: (717) 772-5986

1. Program: Puget Sound Wetlands Restoration Program (Washington State)

2. Overview:

Identification and prioritization methods have been published as the document, "Restoring Wetlands at a River Basin Scale: A Guide for Washington's Puget Sound." The methods are fairly complex and provide a logical and detailed framework for site identification and prioritization. Methods were tested in the Stillaguamish River Basin; slightly revised techniques are now being applied in the Nooksack River Basin. The Program cooperates with agencies and organizations that conduct wetland restorations by providing technical support and identifying and prioritizing potential wetland restoration sites. Partnerships are developed with river basin residents, tribes, and organizations, but the Program itself does not conduct restorations.

3. Current Status: No Program_____ Development _____ Implementation __X__

4. Date of Inception: 1994

5. Parent Organization(s): Washington State Department of Ecology

6. Habitats Addressed: Coastal __X__ Freshwater __X__

7. Geographic Extent: Statewide_____ Regional __X__ (Puget Sound)

8. Context: Regulatory_____ Nonregulatory __X__

9. Advance Identification: Yes __X__ No _____

10. Identification Strategy:

In the Stillaguamish River Basin, identification of potential restoration sites relied primarily on a GIS overlay of a hydric soils coverage with a wetlands coverage. The results delimited the maximum potential extent of wetlands. Sites with at least 90% of their maximum potential area intact were considered preservation sites; all others were considered potential restoration sites.

In the Nooksack River Basin, the identification of restoration sites is relying primarily on photo-interpretation. Efforts are confined to areas of the Nooksack where restoration success is more likely and where there is greater opportunity.

11. Prioritization of Sites: Yes __X__ No _____

12. Prioritization Criteria:

Criteria vary among river basins according to analyses of functional deficits (e.g., compromised water quality, flooding problems) and the results of surveys of agency personnel, experts, and the general public. Aspects of wetlands that provide salmon habitat and bolster salmon populations, either directly or indirectly, have been given particular attention. Functions that are assessed for each potential restoration site include water temperature maintenance; fecal coliform control; sediment retention/transformation; nutrient removal/transformation; groundwater nutrient retention; flood flow storage and desynchronization; base flow maintenance; groundwater recharge; shoreline stabilization; anadromous and resident fish diversity and abundance; migratory water bird diversity and abundance; aquatic diversity and abundance; rare, threatened, and endangered species diversity and abundance; food chain support; active and passive recreation; outdoor education; and cultural significance/unique qualities.

13. Prioritization Process:

Multiple ranked site lists are generated—one for each function identified. Each potential restoration site capable of performing a given function is ranked according to its area. The ability of each site to perform functions is determined using hydrogeomorphic (HGM) classification and "function characterization models." These models are developed using GIS, and are based on wetlands literature and the input of local experts. Sites located in watersheds, drainages, or other subunits of the major river basin that have been identified as higher priority, in terms of water quality and quantity issues, are ranked higher than sites occurring in lower priority hydrologic units.

14. Pilot Studies: Yes __X__ No _____

15. Funding Sources:

The Puget Sound Water Quality Action Team of the State's Governor's Office funds the site identification and prioritization process. The Program does not conduct on-the-ground restorations, and thus does not seek additional restoration funding.

16. Additional Information:

17. Contact Information:

Richard Gersib
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
Phone: (360) 407-7259
Email: rger461@ecy.wa.gov

1. Program: Southern California Wetlands Recovery Project

2. Overview:

The Southern California Wetlands Recovery Project is a partnership of five Federal agencies and 11 State agencies focusing on coastal wetland restoration.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1996

5. Parent Organization(s): CA Resources Agency, CA Coastal Conservancy

6. Habitats Addressed: Coastal__X__ Freshwater_____

7. Geographic Extent: Statewide_____ Regional__X__ (southern California)

8. Context: Regulatory__X__ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

A private consulting firm was hired to write comprehensive reports on each of the 41 coastal wetlands of southern California. A science advisory panel was formed to identify sites of ecological importance in need of protection (through acquisition) or restoration.

11. Prioritization of Sites: Yes__X__ No_____

12. Prioritization Criteria:

Science Criteria
- Restoration potential/functional gain
- Self-sustainability
- Connection to transitional/upland areas
- Connection to marine environment
- Regional linkage

Policy Criteria
- Threat of future degradation/loss
- Research value

12. Prioritization Criteria (Continued):

Feasibility Criteria
Site availability
Cost/benefit effectiveness
Funding
Near-term potential
Restoration/enhancement plan
Technical practicability
Appropriate future owner/manager

13. Prioritization Process:

The above criteria were qualitatively assessed by a technical advisory committee to prioritize coastal wetlands for restoration or acquisition. Although an emphasis was placed on ecological criteria during the prioritization process, restoration projects have been undertaken mainly on the bases of opportunity and logistics.

14. Pilot Studies: Yes_____ No __X__

15. Funding Sources:

The project was initially funded through an interagency grant from California's Department of Fish and Game to the Coastal Conservancy. The State's 1998-99 budget included $6.75 million for Wetlands Project activities. The Project has developed a draft strategy to secure $200 million from Federal, State, local, and private sources to fund its projects over the next 10 years.

16. Additional Information:

The California Coastal Conservancy has also initiated a USEPA-funded project to create an internet-based analysis tool for coastal watersheds of southern California. This project is being piloted in 3 watersheds, and will provide internet users the ability to remotely view GIS coverages and query tabular data sets. Watershed profiles, photographs of key resources, and links to other sites will also be provided.

17. Contact Information:

Trish Chapman
California Coastal Conservancy
1330 Broadway, 11th Floor
Oakland, California 94612
Phone: (510) 286-0749
Fax: (510) 286-0470
Email: tchapman@igc.org

1. Program: Southern New England/New York Bight Coastal Ecosystem Program (Massachusetts, Rhode Island, Connecticut, New York, and New Jersey)

2. Overview:

This is part of The Coastal Program, a larger national program of the USFWS that covers 11 high-priority coastal ecosystems (Albemarle/Pamlico Sounds, Chesapeake Bay, Delaware Bay, Galveston Bay/Texas Coast, Gulf of Maine, Puget Sound, San Francisco Bay, Southern California/San Diego Bay, South Carolina Coast, South Florida/Everglades, Southern New England/New York Bight). Currently, the Southern New England/New York Bight Coastal Program focuses its efforts on 4 areas in Connecticut, New York, and New Jersey: Long Island Sound, the south shore of Long Island, the Peconic Bays, and the New York/New Jersey Harbor. Although no on-the-ground restorations are conducted, this program facilitates the restoration and conservation planning process and assists states and agencies in competing for grants.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1990 (began restoration planning activities in 1993)

5. Parent Organization(s): USFWS

6. Habitats Addressed: Coastal__X__ Freshwater__X__

7. Geographic Extent: Statewide_____ Regional__X__ (Cape Cod to southern New Jersey)

8. Context: Regulatory_____ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

Most of the identification process takes place in meetings, in which groups of watershed stakeholders and local experts discuss potential restoration and preservation sites. In some cases, interpretation of aerial photography has supplemented this process.

11. Prioritization of Sites: Yes__X__ No_____

12. Prioritization Criteria:

Criteria vary, depending on the focus area within the Bight. See the Long Island Sound Study's (LISS) profile for one example.

13. Prioritization Process:

Ranking of sites usually occurs *ad hoc*, via meetings with stakeholders and experts. See the LISS profile for an example of more systematic ranking within this program.

14. Pilot Studies: Yes_____ No __X__

15. Funding Sources:

The program assists partners in obtaining funding from the National Coastal Wetlands Conservation Grant Program, the North American Wetlands Conservation Grant Program, and the National Fish and Wildlife Foundation.

16. Additional Information:

A web-enabled ArcView/Access database of restoration sites is currently being developed.

17. Contact Information:

Andrew Milliken, Senior Biologist
U.S. Fish and Wildlife Service
Southern New England/New York Bight Coastal Ecosystems Program
Shoreline Plaza, Route 1A
P.O. Box 307
Charlestown, RI 02813
Phone: (401) 364-9124
Fax: (401) 364-0170
Email: R5ES_SNE-NYBCEP@fws.gov

1. Program: Tennessee Wetlands Conservation Strategy

2. Overview:

Tennessee adopted their Wetlands Conservation Strategy in 1994. One objective of this strategy was to identify priority wetland restoration sites in each major river corridor. A USEPA grant was used to meet this objective. Priority restoration sites are now used as wetland impact mitigation sites.

3. Current Status: No Program_____ Development_____ Implementation__X__

4. Date of Inception: 1997

5. Parent Organization(s): Tennessee Department of Environment and Conservation, Division of Natural Heritage

6. Habitats Addressed: Coastal_____ Freshwater__X__

7. Geographic Extent: Statewide__X__ Regional_____

8. Context: Regulatory__X__ Nonregulatory_____

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

Potential restoration sites were selected from a detailed database of wetlands throughout the State. This database was the result of an effort to centralize all wetland datasets and miscellaneous information from all State agencies, organizations, and concerned private citizens. Fifty-nine potential restoration sites—designated as high priority—were chosen based on the criteria listed below (see #12). NWI maps, satellite-derived land use maps, and the State's Biological and Conservation Data System Database (BCD) were used to populate the database fields and to determine whether each site met the criteria. When siting mitigation projects, regulators select the priority site closest to the impact.

11. Prioritization of Sites: Yes__X__ No_____

12. Prioritization Criteria:

1) Proximity to a major river (i.e., within 0.3 miles)
2) Known prior-converted or marginally productive wetland (i.e., current land use classification of "cropland" or "pasture")
3) Proximity to other wetland sites (i.e., within 0.3 miles)
4) Proximity to known protected areas (i.e., within 4.0 miles)
5) Presence of rare species

13. Prioritization Process:

High priority sites were those that met *all* of the above criteria, based on existing information in the database. There was no further ranking.

14. Pilot Studies: Yes_____ No __X__

15. Funding Sources:

Because this is a regulatory program, all restoration money comes from the developers.

16. Additional Information:

Restoration efforts target bottomland hardwood forest; this is a relatively scarce community in Tennessee due to historic impacts.

17. Contact Information:

Mike Williams, Biologist
Division of Natural Heritage
Department of Environment and Conservation
14 Floor L&C Tower
401 Church Street
Nashville, TN 37243-0447
Phone: (615) 741-9205
Email: mwilliams7@mail.state.tn.us

1. Program: Chesapeake Bay Program, Wetlands Initiative (Maryland, Pennsylvania, Virginia)

2. Overview:

This initiative associates various functions with wetlands, based on wetland type and setting. Information is made available to local governments and watershed associations for incorporation into planning activities (e.g., wetland protection, restoration, enhancement, or development planning). The process is divided into three phases:

Phase 1: NWI data and GIS datasets are used to assess wetlands' opportunities to perform functions.
Phase 2: Locally available data are used to refine Phase 1.
Phase 3: Field identification and assessment are used to update Phases 1 and 2.

After these phases have been completed, local development plans are used to project how changes may affect wetland functions.

3. Current Status: No Program_____ Development__X__ Implementation_____

4. Date of Inception: Program: 1987; Initiative: 1997

5. Parent Organization(s): USEPA

6. Habitats Addressed: Coastal__X__ Freshwater__X__

7. Geographic Extent: Statewide_____ Regional__X__ (Chesapeake Bay, including MD, PA, and VA)

8. Context: Regulatory__X__ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

NWI data and GIS are used to assess the potential for *all* wetlands within a watershed to perform certain functions. Using local planning data, projected functional capacity of wetlands is compared to current conditions, and plans for restoration, enhancement, or protection can be formed. There is no formal methodology for these activities.

11. Prioritization of Sites: Yes_____ No__X__

12. Prioritization Criteria:

Prioritization has been a topic of discussion, but there is concern regarding potential misapplication of ranking systems—particularly for low-ranked sites.

13. Prioritization Process:

14. Pilot Studies: Yes _X__ No _____

15. Funding Sources:

16. Additional Information:

17. Contact Information:

Kate Schmidt
Chesapeake Bay Program
410 Severn Avenue, Suite 109
Annapolis, MD 21403
Phone: (800) 968-7229

1. Program: Delaware

2. Overview:

Although Delaware does not have an official wetlands restoration program, progress has been made toward developing one within the Delaware Department of Natural Resources and Environmental Control (DNREC). USEPA 104(b)(3) grants funded 1) a study entitled "An evaluation of three remote sensing/geographical information system methodologies for siting non-tidal wetlands restoration," tested in the Inland Bays watershed, and 2) development of a watershed-based approach to coastal and freshwater wetlands restoration, piloted in the Silver Lake watershed. Both projects were produced by the DNREC Division of Water Resources and focus primarily on restoration of farmed wetlands in the context of compensatory impact mitigation.

3. Current Status: No Program_____ Development__X__ Implementation_____

4. Date of Inception: 1993

5. Parent Organization(s): DE DNREC

6. Habitats Addressed: Coastal __X__ Freshwater__X__

7. Geographic Extent: Statewide_____ Regional__X__ (pilot projects in two watersheds; plans to apply statewide)

8. Context: Regulatory__X__ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

Three methods for identifying potential wetland restoration sites in agricultural land were evaluated and contrasted. These methods involved 1) analysis of satellite (SPOT) imagery, 2) using ARC/INFO to "clip" agricultural land designated as hydric with a digitized NWI dataset, and 3) aerial photo-interpretation of wetlands in agricultural production.

11. Prioritization of Sites: Yes__X__ No_____

12. Prioritization Criteria:

In the Inland Bays Watershed project, agricultural sites with hydric soils were prioritized for restoration based on soil type and drainage class. Sites were not prioritized in the subsequent Silver Lake Watershed project.

13. Prioritization Process:

Identified sites were classified as “most suitable,” “suitable,” or “somewhat suitable,” depending on soil classification, soil drainage class, and relative organic and mineral content.

14. Pilot Studies: Yes __X__ No _____

15. Funding Sources:

Most of the restorations are compensatory mitigations resulting from impacts and, therefore, are funded by the applicant. Other funding sources include NRCS (Wetlands Restoration Program), USFWS (Partners for Wildlife), CWA Section 319, and penalty fund money from the State. In the Silver Lake Watershed, the State paid farmers to retire marginal land (via 5-year easements) in a program structured similarly to NRCS’s WRP.

16. Additional Information:

In 1993, the DNREC launched the Delaware Whole Basin Planning Initiative, which attempts to plan and manage resources at a watershed scale.

Approximately 90% of wetland restorations in Delaware are in freshwater settings.

17. Contact Information:

Mark Biddle
Watershed Assessment Section
Division of Water Resources
Dept. of Natural Resources and Environmental Control
Silver Lake Plaza, Suite 220
820 Silver Lake Boulevard
Dover, DE 19904-2464
Phone: (302) 739-4590
Fax: (302) 739-6140
Email: mbiddle@dnrec.state.de.us

1. Program: Gulf of Maine Program (Maine, New Hampshire, Massachusetts, Canada)

2. Overview:

The Gulf of Maine Program is a coalition of stakeholders, including Federal and state agencies, nongovernmental organizations, academicians, and citizens. Its goal is to inventory potential restoration sites, and to standardize monitoring protocols for coastal wetland restorations.

3. Current Status: No Program_____ Development__X__ Implementation_____

4. Date of Inception: 1998

5. Parent Organization(s): Commission on Environmental Cooperation (NAFTA)

6. Habitats Addressed: Coastal__X__ Freshwater_____

7. Geographic Extent: Statewide_____ Regional__X__(Gulf of Maine: Canada to Massachusetts)

8. Context: Regulatory__X__ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

The identification strategy is still under development. The Program will incorporate potential restoration sites that have already been identified by states and provinces.

11. Prioritization of Sites: Yes_____ No__X__

12. Prioritization Criteria:

13. Prioritization Process:

Rather than prioritizing sites, the Program will provide a queriable database to parties interested in restoring sites. This will allow database users to develop their own list of priority sites. The database will include the following information: location, associated waterbody, adjacent land use, vegetation types, ownership, historic condition, nature of alteration, impacts, acreage, restoration action, estimated cost, and status.

14. Pilot Studies: Yes_____ No__X__

15. Funding Sources:

The Program was initiated using seed money from NAFTA, and is in the process of attracting larger funders (e.g., NOAA).

16. Additional Information:

The Program does not conduct restorations, but supplies information to those that do. Therefore, the database may be used for siting mitigation restorations or for proactive purposes.

17. Contact Information:

Hilary Neckles
U.S. Geological Survey
26 Ganneston Drive
Augusta, ME 04330
Phone: (207)622-8205 x119
Email: hilary_neckles@brd.usgs.gov

1. Program: Maine

2. Overview:

Maine does not have a wetlands restoration program. However, methods are being developed in cooperation with USFWS NWI for the advance identification of valuable wetlands for Section 404 of the Clean Water Act. Due to the regulatory nature of the project, sites are not being prioritized. Although it is not yet intended for the advance identification of potential wetland restoration sites, it may be applied for these purposes in the future. The Casco Bay Watershed serves as a pilot study area for the program, which may eventually be applied to other watersheds of Maine.

3. Current Status: No Program_____ Development__X__ Implementation_____

4. Date of Inception: 1997

5. Parent Organization(s): Maine State Planning Office and USFWS NWI

6. Habitats Addressed: Coastal__X__ Freshwater__X__

7. Geographic Extent: Statewide_____ Regional__X__(Casco Bay Watershed)

8. Context: Regulatory__X__ Nonregulatory_____

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

A GIS database was developed from existing NWI digital data; it was then edited to include hydrogeomorphic-type (HGM) characteristics such as landscape position, landform, and water flow path. Several functions of each existing wetland site in the watershed were determined by querying this database. These functions were sediment retention, flood flow alteration, plant and animal habitat, freshwater fish habitat, and shellfish habitat. In addition, a "cultural function" (i.e., value to humans) was assessed. Valuable wetlands were those deemed particularly successful at providing any single function, or those that provide multiple functions.

11. Prioritization of Sites: Yes_____ No__X__

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes__X__ No_____

15. Funding Sources:

16. Additional Information:

See the Gulf of Maine Project profile for more information about restoration planning in this State.

NWI developed this methodology in Maine and intends to offer it in other areas as a new product entitled “Watershed-based Wetland Characterization Study and Preliminary Assessment of Wetland Functions.”

17. Contact Information:

Elizabeth Brown
Maine State Planning Office
38 State House Station
Augusta, ME 04333
Phone: (207) 287-3261
Email: elizabeth.brown@state.me.us

1. Program: Maryland Department of Natural Resources

2. Overview:

Plans to develop a State Wetland Conservation Plan are underway, but there is currently no separate wetlands restoration program in Maryland. In 1997, the governor announced an initiative to restore, create, or enhance 60,000 acres of wetlands (15,000 acres by 2010) to offset wetland acreage lost since the 1940's. The MD Department of Natural Resources (DNR) assists the proactive wetland restoration efforts of groups or individuals by providing technical assistance. They are also developing techniques for the advance identification of potential restoration sites and for prioritizing watersheds for wetland restoration.

3. Current Status: No Program_____ Development__X__ Implementation _____

4. Date of Inception: 1998

5. Parent Organization(s): MD DNR

6. Habitats Addressed: Coastal _____ Freshwater__X__

7. Geographic Extent: Statewide__X__ Regional_____

8. Context: Regulatory_____ Nonregulatory__X__

9. Advance Identification: Yes__X__ No _____

10. Identification Strategy:

Due to a lack of accurate statewide GIS data, MD DNR does not attempt to identify specific restoration sites in advance; however, they do identify important areas and watersheds for wetland restoration (see #12 and #13). Individual sites are predominately identified by landowners who volunteer them. New, more accurate, statewide spatial datasets are currently being generated (e.g., SSURGO soils data), and this may facilitate identification of specific restoration sites in the near future.

11. Prioritization of Sites: Yes__X__ No _____

12. Prioritization Criteria:

Watersheds and wetlands are prioritized very generally, according to the function of interest (i.e., wildlife habitat, water quality improvement, flood storage).

13. Prioritization Process:

Wetlands are prioritized for the restoration of habitat functions by applying techniques developed for the “Green Infrastructure Land Network” (see #16). Wetlands located in large, contiguous blocks of natural habitat (hubs) or wetlands that help connect these hubs (serving as corridors) are ranked higher than wetlands in different settings. Other wetland functions (e.g., water quality improvement, flood storage) are prioritized on a watershed basis. Wetlands within watersheds that have experienced the greatest estimated amount of wetland loss receive higher priority. This loss is estimated in a GIS by clipping a soils dataset with an NWI dataset; remaining polygons represent an approximation of wetland loss.

14. Pilot Studies: Yes_____ No __X__

15. Funding Sources:

MD DNR’s program is still being developed. Their role in wetland restoration is to provide technical assistance, rather than funding.

16. Additional Information:

The MD DNR is currently developing “The Green Infrastructure Network,” a statewide approach to preserving and restoring Maryland’s remaining ecologically valuable uplands and wetlands. GIS software and spatial datasets are used to determine where critical habitats are located and how to manage them. The proposed network would link large, contiguous blocks of natural resource lands (hubs) with corridors that are also of ecological significance. Underlying assumptions derived from wildlife management and landscape ecology theories are used to identify and rank individual landscape units. Ranking criteria include patch shape and size, corridor length and connectivity, surrounding land use, and risk of development. The network will be expanded and refined as more spatial datasets become available, and as existing datasets are improved.

17. Contact Information:

David F. Bleil
Maryland Department of Natural Resources
580 Taylor Avenue
Tawes State Office Building
Annapolis, MD 21401
Phone: (410) 260-8784
Email: dbleil@dnr.state.md.us

1. Program: Oregon Governor's Watershed Enhancement Board

2. Overview:

The Governor's Watershed Enhancement Board (GWEB) promotes the restoration and enhancement of Oregon watersheds by providing technical assistance to interested parties, administering a grant program, and fostering public awareness and education. Wetland restoration is just one of many "watershed enhancement" activities undertaken by this program. The Board has focused primarily on management of salmon and trout habitat in the past, but it has expanded its scope; it is currently adopting methods proposed in the recent publication "Recommendations for a nonregulatory wetland restoration program for Oregon" (Good and Sawyer 1998).

3. Current Status: No Program_____ Development__X__ Implementation_____

4. Date of Inception: 1987

5. Parent Organization(s): Governor's Natural Resources and Watershed Enhancement Office

6. Habitats Addressed: Coastal__X__ Freshwater__X__

7. Geographic Extent: Statewide__X__ Regional_____

8. Context: Regulatory_____ Nonregulatory__X__

9. Advance Identification: Yes__X__ No_____

10. Identification Strategy:

The methods for identifying potential restoration sites are in a formative stage. The document "Recommendations for a nonregulatory wetland restoration program for Oregon" (Good and Sawyer 1998) proposes identification methods that borrow heavily from watershed-based restoration programs in the Puget Sound and Massachusetts. GIS analyses, photo-interpretation, and hydrogeomorphic (HGM) classifications will be used in the identification process.

11. Prioritization of Sites: Yes__X__ No_____

12. Prioritization Criteria:

Methods for prioritizing sites are still being developed. Oregon is a large state with a variety of distinct ecoregions; therefore, criteria will first be determined at the ecoregional scale, and then at the scale of watersheds within those ecoregions.

13. Prioritization Process:

Prioritization methods will resemble those developed in the Puget Sound and in Massachusetts (e.g., watershed functional deficits will be assessed, and goals will be set for each watershed based on these assessments).

14. Pilot Studies: Yes __X__ (planned) No _____

15. Funding Sources:

The State of Oregon has budgeted $30 million per biennium to be used for restoration. This funding—assured for the next 15 years—is administered by the GWEB, and is available through grants for a wide variety of watershed enhancement and restoration activities. Another $18 million is available from Federal sources.

16. Additional Information:

The document "Recommendations for a nonregulatory wetland restoration program for Oregon" also recommends the development of a statewide database of completed, ongoing, and potential restoration sites. This database would use ArcView software and be accessible through the internet.

17. Contact Information:

Kenneth F. Bierly, Program Manager
Governor's Watershed Enhancement Board
Public Services Building
255 Capitol St. NE, 3rd Floor
Salem, OR 97310-0203
Phone: (503) 378-3589 Ext. 831
Fax: (503) 378-3225
Email: ken.bierly@state.or.us

1. Program: Michigan

2. Overview:

Michigan's DEQ will be starting a project to develop methods for the identification of potential wetland restoration sites sometime in late 1999. DEQ, USFWS, and NRCS are currently restoring wetlands in Michigan waterfowl flyways under the North American Waterfowl Management Plan (NAWMP); however, no formal framework for the identification or prioritization of sites is being employed.

3. Current Status: No Program__X__ Development_____ Implementation_____

4. Date of Inception:

5. Parent Organization(s):

6. Habitats Addressed: Coastal_____ Freshwater_____

7. Geographic Extent: Statewide_____ Regional_____

8. Context: Regulatory_____ Nonregulatory_____

9. Advance Identification: Yes_____ No _____

10. Identification Strategy:

11. Prioritization of Sites: Yes_____ No _____

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes_____ No _____

15. Funding Sources:

16. Additional Information:

17. Contact Information:

Rob Zbiciak
Phone: (517) 373-0789
Email: zbiciakr@state.mi.us

1. Program: Minnesota

2. Overview:

Although several agencies (e.g., USFWS, MN DOT, MN DNR) are currently restoring wetlands in Minnesota, there is no formal wetlands restoration program or advance identification or ranking of sites. Minnesota uses mitigation banks for mitigating permitted impacts to wetlands.

3. Current Status: No Program__X__ Development_____ Implementation_____

4. Date of Inception:

5. Parent Organization(s):

6. Habitats Addressed: Coastal_____ Freshwater_____

7. Geographic Extent: Statewide_____ Regional_____

8. Context: Regulatory_____ Nonregulatory_____

9. Advance Identification: Yes_____ No _____

10. Identification Strategy:

11. Prioritization of Sites: Yes_____ No _____

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes_____ No _____

15. Funding Sources:

16. Additional Information:

The MN Board of Water and Soil Resources prepared a document entitled "Minnesota Wetland Restoration Guide" in 1992. This document provides guidelines for the entire restoration process, but only briefly discusses locating and prioritizing sites—on a project-by-project basis.

The MN Department of Natural Resources, Division of Waters, published a report in 1997 entitled "A Digital Method to Inventory Converted Wetlands." In this study, artificially drained wetlands were identified in a GIS using a soils coverage, digital NWI

16. Additional Information (Continued):

data, and an artificial drainage coverage. Each identified site was assigned to one of 5 categories, according to the probability that it really was a converted wetland.

17. Contact Information:

Erv Berglund, Wetland Hydrologist
Minnesota Department of Natural Resources
Division of Waters
500 Lafayette Road
St. Paul, MN 55155-4032
Phone: (651) 297-4601
Fax: (651) 296-0445
Email: erv.berglund@dnr.state.mn.us

1. Program: New Hampshire

2. Overview:

Almost all freshwater wetland restoration activities in New Hampshire are related to impact mitigation. See the Gulf of Maine Program profile for information regarding coastal wetland restoration.

3. Current Status: No Program__X__ Development_____ Implementation_____

4. Date of Inception:

5. Parent Organization(s):

6. Habitats Addressed: Coastal_____ Freshwater_____

7. Geographic Extent: Statewide_____ Regional_____

8. Context: Regulatory_____ Nonregulatory_____

9. Advance Identification: Yes_____ No _____

10. Identification Strategy:

11. Prioritization of Sites: Yes_____ No _____

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes_____ No _____

15. Funding Sources:

16. Additional Information:

17. Contact Information:

Ted Diers
New Hampshire Coastal Program
Concord, NH
(603) 271-2155

1. Program: New Jersey

2. Overview:

New Jersey does not have a program for wetland restoration. Impact mitigation money is often used to acquire and protect existing wetlands. For information regarding coastal wetland restoration planning activities in New Jersey see the profile for the Southern New England/New York Bight Coastal Ecosystem Program.

3. Current Status: No Program__X__ Development_____ Implementation_____

4. Date of Inception:

5. Parent Organization(s):

6. Habitats Addressed: Coastal_____ Freshwater_____

7. Geographic Extent: Statewide_____ Regional_____

8. Context: Regulatory_____ Nonregulatory_____

9. Advance Identification: Yes_____ No _____

10. Identification Strategy:

11. Prioritization of Sites: Yes_____ No _____

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes_____ No _____

15. Funding Sources:

16. Additional Information:

The Land Use Regulation Program of the NJ Department of Environmental Protection produced a report in 1999 that presented methods for identifying and prioritizing important wetland complexes of the Passaic River Basin for acquisition and protection—but not for restoration. All wetland complexes greater than 50 acres were identified as potential acquisition sites, and prioritized on the basis of: 1) USEPA Priority Wetland Area designation, 2) potential use as a water supply source, 3) water quality, 4) presence of threatened and endangered species, 5) fishery conditions, 6) degree of threat (from development, water quality degradation, etc.), and 7) flood storage potential. Wetland complexes were assigned a score, ranging from zero to three, for each attribute; these

16. Additional Information (Continued):

scores were summed for each wetland complex. Sites with the highest score became acquisition priorities. This ranking scheme was designed to be flexible and to accommodate varying objectives. For instance, sites with poor water quality were assigned low scores, thereby decreasing their priority level. However, if acquisition objectives changed, these same sites could be assigned higher scores. In this manner, sites at greater risk would attain higher prioritization levels than sites in a more pristine state. Acquisition and protection funds are obtained from the New Jersey State Green Acres Bond Fund, the Federal Land and Water Conservation Fund, and mitigation money.

17. Contact Information:

Larry Baier
New Jersey Department of Environmental Protection
Phone: (609) 292-8838

1. Program: Vermont

2. Overview:

Wetland restoration in Vermont is limited to compensatory mitigation activities. Mitigation sites are identified on a site-by-site basis.

3. Current Status: No Program__X__ Development_____ Implementation_____

4. Date of Inception:

5. Parent Organization(s):

6. Habitats Addressed: Coastal_____ Freshwater_____

7. Geographic Extent: Statewide_____ Regional_____

8. Context: Regulatory_____ Nonregulatory_____

9. Advance Identification: Yes_____ No_____

10. Identification Strategy:

11. Prioritization of Sites: Yes_____ No_____

12. Prioritization Criteria:

13. Prioritization Process:

14. Pilot Studies: Yes_____ No_____

15. Funding Sources:

16. Additional Information:

17. Contact Information:

Carl Pagel
Vermont Department of Environmental Conservation
Phone: (802) 241-3770
Email: carlp@waterq.anr.state.vt.us

Appendix E1. Comparison of methods for identifying potential restoration sites.[1]

	Method category[2]	Data source	Wetland status[3]	Overview of method	Pros	Cons	Time input	Relative value	Comments	Priority[4]
1	Field ID	**Stakeholder Surveys**	Degraded & Destroyed	Survey watershed stakeholders for restoration recommendations.	Familiarity with local wetlands; building of stakeholder support.	Biased toward accessible sites.	Med	Med	Supplemental to other methods; results may overlap other techniques.	High
2	PI	**1939 photos**	Destroyed	Visually compare with delineated 1988 photos, look for discrepancies (time-lapse analysis).	Excellent photos; most accurate historic data.	Differing scales; must digitize ID'd sites, manually assess entire watershed.	Med	High	1890's topos could provide similar data, over a greater time-span, but with much less accuracy.	High
3	PI	**Recent photos (1999?)**	Degraded	Compile a list of impacts; visually assess each wetland for signatures of those impacts.	Recent data; stereo view is a great advantage.	Wetlands not delineated on photos.	High	High	Orthos could provide similar data--no stereo, but easier to add to database.	Med
4	PI	**1988 photos**	Degraded	Use stereoscope to identify degrading impacts.	Wetlands already delineated; stereo view; access to photos.	Not the most recent dataset; small scale.	Med	High	Prior delineation of wetlands provides a distinct advantage over more recent photos.	High
5	PI/GIS	**1995 Orthophotos**	Degraded	View in GIS w/ outline of RIGIS wetlands; visually assess impacts.	Hybrid of PI and GIS; data already in GIS format; no scale differences.	No stereo view will limit ability to detect some impacts; grainy resolution.	Med	Med to High	1:12,000-scale; 1-meter pixel resolution.	High
6	PI/GIS	**1997 Orthophotos**	Degraded	View in GIS w/ outline of RIGIS wetlands; visually assess impacts.	Hybrid of PI and GIS; data already in GIS format; no scale differences; better resolution than ‘95 orthos.	No stereo view will limit ability to detect some impacts; not yet available!	Med	High	1:5,000-scale; 2-foot pixel resolution.	High
7	GIS	**RIGIS Land Use/Land Cover (LULC)**	Destroyed	Query for all polys coded as wetland in '88 but not in '95.	Can accurately ID changes in wetland extent btwn '88 and '95.	Is this more of a regulatory, enforcement issue?	Very Low	High	May detect permitted changes.	High

Appendix E1. Continued.

	Method category	Data source	Wetland status	Overview of method	Pros	Cons	Time input	Relative value	Comments	Priority
8	GIS	**RIGIS FEMA**	Destroyed	In GIS, overlay FEMA with LULC. Query for developed areas in floodplain.	Most accurate way to do this; floodplain bounds not easily ID'd in photos.	FEMA map probably only covers major rivers/streams; positional inaccuracies.	Low	High	Will reveal current violations, in addition to historic impacts. There may be a lot of them!	High
9	GIS	**1981 Soil Survey**	Destroyed	UD and Ur polygons next to hydric soils are potential fill sites.	Very quick way to ID major fill sites.	UD/Ur polys may denote excavation; min. map unit = 5 acres.	Low	High	Despite some limitations, this method is quick with useful results.	High
10	GIS	**RIGIS Roads dataset**	Degraded & Destroyed	Do an "intersect" of roads and wetlands in GIS.	Best way to ID road impacts; quick, and easy to add to database.	All sites must be field-verified to confirm degradation.	Low	High	Although these impacts could be identified using traditional aerial PI, this is much faster & easier.	High
11	GIS	**1890's topos**	Destroyed	Georeference in GIS; heads-up digitize around wetland symbols.	Oldest dataset available, detects 40-50 more years of wetland loss than '39 photos.	Wetland extent underestimated; wetland bounds are fuzzy.	Med to Low	Med	Perhaps do this to supplement info from 1939 photos (as time allows).	Med
12	GIS	**RIGIS Land Use/Land Cover**	Degraded	Convert to line cover, query for wetlands adjacent to nonvegetated upland.	Quickly and easily ID all wetlands lacking upland buffer.	Relying on accuracy of LULC data -- need to field-verify.	Low	High	Although redundant to PI methods, this method is quick & could verify the PI.	Med
13	GIS	**RIGIS Rivers & Streams**	Degraded	Do an overlay "identity" with LULC; query for lines that are adjacent to non-vegetated land uses.	Easy way to ID potential impacts to watercourses.	Same as above.	Low to Med	High	Although redundant to PI methods, this method is quick & could verify the PI.	Med
14	GIS	**RIGIS Lakes & Ponds**	Degraded	Same as above.	Same as above.	Same as above.	Low to Med	High	Same as above.	Med
15	GIS	**1939 photos**	Destroyed	Digitize photos or delineations into GIS; overlay with RIGIS wetlands; query for differences.	Fast analysis; can determine wetland loss (acreage); dataset is available for other analyses.	Greater set-up time; must verify each ID'd polygon (some polys represent error, not wetland loss).	High	High	This method could be very effective, but it duplicates the method with PI of 1939 aerial photos.	Low

Appendix E1. Concluded.

	Method category	Data source	Wetland status	Overview of method	Pros	Cons	Time input	Relative value	Comments	Priority
16	GIS	**1930's - 40's Soil Surveys**	Destroyed	Scan & georegister; heads-up digitize hydric soils; overlay with RIGIS wetlands; query for differences.	An old dataset; good historic info; could estimate wetland loss.	Archaic soil classifications; error from differing scales; extensive setup time.	High	Med	This provides results similar to other techniques (e.g., 39 photos), but has more drawbacks.	Low
17	GIS	**RIGIS Wells & Wellheads**	Degraded	Overlay with RIGIS wetlands; query for wetlands in wellhead protection areas.	The only way to identify this type of impact.	Impact to wetland is not certain, but potential.	Very Low	Low	These areas are currently being used. There's little chance for restoration.	Low

[1]Recommended methods have been highlighted.

[2]Field ID = identification of sites in the field; PI = aerial photo-interpretation; GIS = Geographic Information System analyses.

[3]Destroyed wetlands have been converted to upland habitat; degraded wetlands are existing wetlands with functions that have been compromised.

[4]Priority levels for each option are based on all of the preceding information.

Appendix E2. Steps to remotely identify and record restoration opportunities.

A. Compare 1939 aerial photography with delineated 1988 aerial photography to identify destroyed sites.

1. Obtain full set of 1939 photos and gain access to the delineated 1988 photos from the URI Department of Natural Resources Science (URI/NRS) for the watershed or area of interest.

   Note: If 18" x 18" photos are not available, the original 9" x 9" copies of the 1939 photos may be viewed at the Rhode Island Office of Statewide Planning

2. Compare the two sets of photos to identify:
   a. wetlands that have changed in size or shape.
   b. wetlands that have been entirely destroyed (i.e., filled or drained).
   c. streams that have been channelized.

B. Locate wetland fill sites using 1981 Soil Survey maps.

1. Obtain a copy of the Soil Survey of Rhode Island (Rector 1981) or view the RIGIS soils coverage in ArcView.
2. Search for UD or Ur polygons (i.e., potential fill sites) adjacent to hydric soil polygons.

C. Search for degrading impacts using delineated 1988 aerial photography.

1. Gain access from URI/NRS to delineated 1988 aerial photography for the watershed or area of interest.
2. Using a stereoscope, carefully examine each wetland and identify degrading impacts.

D. Search for degrading impacts using 1995 digital orthophotography.

1. Simultaneously view orthophotos and the outlines of RIGIS wetlands in ArcView.
2. Search for degrading impacts that may have occurred since 1988.

E. Create a GIS point coverage to record identified impacts.

1. Add a point for each destructive or degrading impact identified.
2. For each point, enter data for each of the applicable items in the attributes table (see Table E1).

F. Create a GIS polygon coverage to determine the extent of wetland loss.

1. For each wetland that has been filled or drained, delineate the 1939 wetland boundaries on mylar.

   Note: If filling occurred before 1939 it will not be possible to remotely determine the previous extent or type of wetland.

2. View the digital orthophotos and 1988 RIGIS wetland boundaries in ArcView, and adjust the scale to that of the mylar delineations.
3. Align and fix the mylar delineations over the orthophoto image.
4. Heads-up digitize the portions of wetland that have been converted to upland.

Appendix E3. Stakeholder site nomination form and guidelines.

Field Identification of Potential Freshwater Wetland Restoration Sites

The University of Rhode Island and the Rhode Island Department of Environmental Management are collaborating on a project funded by the Environmental Protection Agency to develop a freshwater wetland restoration strategy for the State. The ultimate goal is to restore natural functions of wetlands that have been destroyed or degraded as a result of human activities. As part of a preliminary effort, we are attempting to identify potential restoration sites in two watersheds—the Woonasquatucket and the Queens. We are using several methods in this identification process, including aerial photo-interpretation, GIS computer applications, and field surveys. Your help in locating potential restoration sites in the field would be greatly appreciated.

We are interested in restoration of all types of freshwater wetlands, including marshes, peat bogs, wet meadows, shrub swamps, forested swamps, ponds, and streams, as well as upland vegetation bordering these wetlands. Human land use may degrade these wetlands or even destroy them. Some of the potential restoration sites that you encounter may still look like wetlands, and will therefore fall into the *degraded* category; *destroyed* wetlands might be difficult to identify in the field because these wetlands may have been converted to residential, industrial, commercial, agricultural, or other land uses. However, if you are aware of former wetland sites that might be restorable, please report these also. The attached sheets describe various types of impacts and how to recognize them in the field.

Note: The majority of wetlands in Rhode Island are privately owned, and permission should be obtained from landowners before venturing onto their property. If you do speak with private landowners, please keep in mind that our project is proactive, not regulatory, in nature. We would seek to restore wetlands on private lands only with full cooperation of the landowners. Do not assume that wetland alterations you encounter are necessarily illegal.

If you locate a site where wetlands have been degraded or destroyed, please complete the attached form. This will help us to re-locate and assess the site further. If you have any questions, contact Nick Miller by phone at (401) 874-7058 or by email at nick@uri.edu. Nomination forms must be received by May 31st to be considered in this phase of the project; forms received after that date will still be considered for future restoration planning. Completed forms may be submitted to:

Nick Miller
Department of Natural Resources Science
210B Woodward Hall
University of Rhode Island
Kingston, RI 02881

Thank you very much for your valuable assistance, and for your interest in the restoration of Rhode Island's freshwater wetlands.

UNIVERSITY OF RHODE ISLAND   RI DEM   EPA

Field Identification of Potential Freshwater Wetland Restoration Sites: Guidelines

DEGRADATION OF WETLANDS

1. Partial Drainage (Still wetland)

Wetlands have often been ditched to lower water levels for mosquito control, farming, forestry, or other land uses. Partial drainage of wetlands reduces the depth and duration of flooding and soil saturation, which leads to changes in the structure and species of vegetation present, habitat quality, and other wetland functions.

What to look for: Look for ditches within, or exiting, wetlands.

2. Excessive Sedimentation

Excessive sedimentation is often the result of certain human land uses directly abutting wetlands, and it can therefore be a symptom of inadequate upland buffering (see #9). Wetlands that are adjacent to gravel and sand mining operations, plowed agricultural lands, unpaved roads, or paved roads that are "sanded" in the winter are at high risk. Sedimentation affects water depth and the duration of flooding in wetlands, vegetation composition, and wildlife habitat quality.

What to look for: The best way to verify this impact is to locate wetland edges directly adjacent to one of the land uses listed above, and then to dig a small hole. Look for sand, gravel, or silt deposits overlying organic-rich (black or dark brown) wetland soils. If sediments are entering the wetland from a single point, they will often form a fan-shaped deposit. Invasive species and plants more typical of uplands may grow on these deposits. Streams or ponds that receive excessive sedimentation will appear turbid, or muddy.

3. Dumping

Old tires, abandoned vehicles, tree stumps, demolition debris, discarded appliances, and other debris have often been dumped into wetlands. In addition to being an eyesore, these waste products may leach contaminants into the wetlands. We will be focusing on removal of trash at sites where repeated dumping has occurred.

What to look for: Look for discarded debris in wetlands.

4. Impoundment

The duration and depth of flooding of some wetlands has been increased through the blockage or constriction of surface water flow from the wetlands. Such a change in water regime can cause dramatic changes in wetland vegetation, wildlife species, and functions such as water quality improvement. The most common causes of impoundment are dam construction, undersized culverts under roads constructed across wetlands, accumulation of sediment in culverts, and dumping of fill in waterways.

What to look for: Look for instances, especially along highways, where wetlands on the upstream side of the road are noticeably wetter than on the downstream side, and especially where flow through culverts is obstructed due to sediment accumulation.

5. Invasive Species

Invasive plant species often form dense stands, spread rapidly, and outcompete native vegetation. This reduces wetland plant diversity and the quality of habitat for wildlife. *Lythrum salicaria*, or purple loosestrife, is an aggressively spreading weed of Eurasian origin that is now well established in many areas of the northeastern United States. *Phragmites australis*, the common reed, often becomes established where the soil has been exposed by grading or filling. Both of these species can spread quickly; even small stands may cause problems and should be reported.

What to look for: See the attached drawings to help identify these species in the field. Purple loosestrife can grow up to 6-7 feet tall and produces purplish-pink flowers in July and August. It persists and appears brown throughout the winter. *Phragmites* can grow up to 15 feet tall, and also persists through the winter.

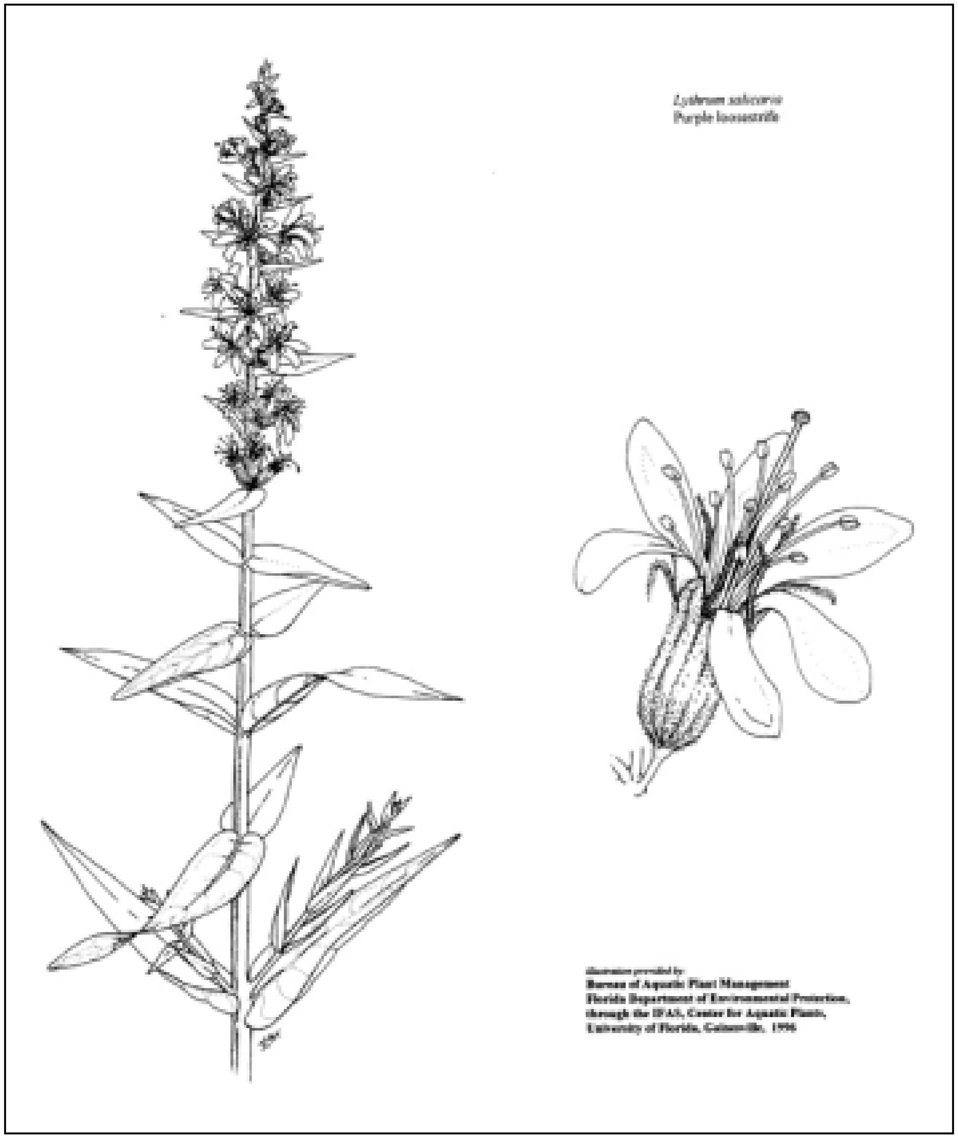
6. Removal of Wetland Vegetation

Trees may have been removed from some forested wetlands for timber or fuelwood. In a few cases, wetlands may have been cleared for "aesthetic" purposes, primarily to enhance visibility. If no other alterations have been made (e.g., to hydrology), these wetlands may be relatively easy to restore.

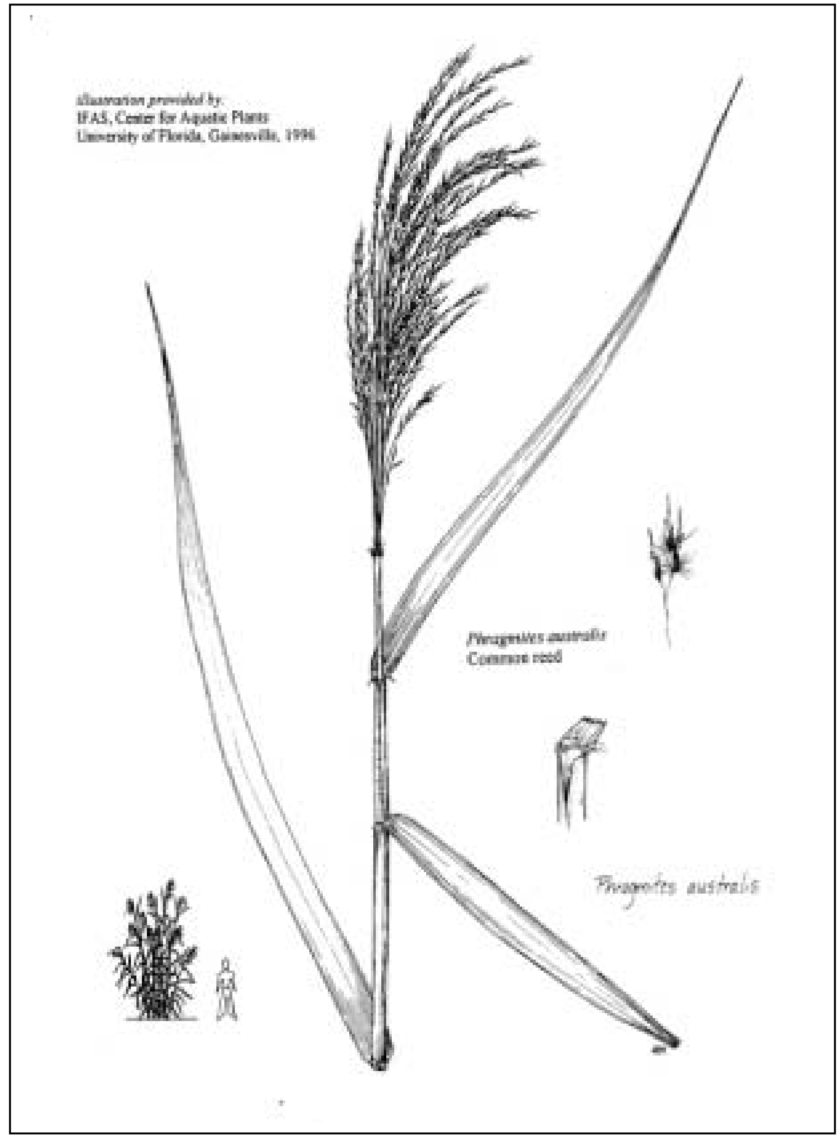
What to look for: Look for wetlands where vegetation has been cut (i.e., where tree stumps or other remains of plants are evident).

Invasive Species

Lythrum salicaria (Purple Loosestrife)



Phragmites australis (Common Reed)



7. Removal of Soil or Peat Deposits

In many areas of the world organic, peaty soils are harvested for horticultural use or for fuel. This is not a common occurrence in Rhode Island, but it has occurred in isolated areas.

What to look for: Look for cut banks or other signs of excavation in wetlands with peaty soils.

8. Stream Channelization

Streams may have been channelized to reduce local flooding problems. Unfortunately, these modifications destroy habitat and result in increased flooding problems downstream. The hydrology of wetlands adjacent to streams may also be altered as a result of channelization.

What to look for: Look for stream channels that have been straightened, deepened, or widened, and that have banks or bottoms consisting of artificial materials (e.g., rip-rap, concrete). In some cases, however, rip-rap or stone may be necessary near bridges that span rivers in order to curb erosion.

9. Removal of Adjacent Upland Vegetation

Naturally vegetated areas located between wetlands and more intensive human land uses help protect wetlands from polluted runoff and sedimentation, provide important wildlife habitat, reduce human harassment of wetland wildlife, and contribute to the scenic or aesthetic value of wetlands. Naturally vegetated areas also protect the shores of streams and ponds; without these areas, erosion may occur. By restoring areas where such vegetation has been removed, we can better maintain wildlife habitat, water quality, and scenic amenities within wetlands.

What to look for: Look for wetlands where natural vegetation has been removed from the adjacent upland and where any of a variety of human land uses (e.g., sand and gravel mining, urban development) continues right down to the wetland edge. Erosion of streambanks or pondshores may also indicate insufficient natural vegetation.

DESTRUCTION OF WETLANDS

Wetland that has been destroyed may be very difficult to identify in the field. Historic data (e.g., old topographic maps, aerial photographs, and soil surveys) provide the best clues as to where these wetlands formerly occurred. The knowledge and memories of local watershed residents may also help to determine what the landscape looked like prior to development.

1. Filling

Some wetlands have been filled to establish substrates suitable for construction. Filling may also result from disposal of dredged material. Wetlands may be partially or completely destroyed by filling.

What to look for: Wetlands **completely** destroyed by filling will be difficult to identify in the field because they will not exhibit any characteristics typical of wetlands. Knowledge of what the landscape looked like prior to development may help. Wetlands that have been **partially** filled may have steep slopes or banks at the edges of the fill deposits, while natural wetland edges are more likely to slope gradually into upland.

2. Complete Drainage

Ditching may alter local hydrology sufficiently to completely destroy wetlands. Afterward, these areas may have been developed or used for agriculture. After moisture has been removed from the soils, organic material tends to decompose, causing the soil surface to subside.

What to look for: Look at ditch-banks for soils that appear to have been wet in the past. Black layers (indicating high organic matter content) which overlie bright gray mineral layers are typical of many wetland soils—even those that have been drained.

Wetland Restoration

Site Nomination Form

Please fill out this form as completely as possible—one form for each site. If you need more room, please attach additional sheets. Proposed sites will be considered for addition to our list of potential restoration sites in your watershed. If you would like to discuss any sites in further detail, or if you need more forms, please contact Nick Miller by phone at (401) 874-7058 or by email at nick@uri.edu. Thank you very much for your valuable time and assistance.

1. Your name and contact information:

   Name: ________________________

   Address: ____

   ____

   ____

   Phone: ________________________

   Email: ________________________

2. Type of wetland (e.g., forested swamp, shrub swamp, marsh, bog, wet meadow, pond, stream) or upland adjacent to wetland:

   ____

3. Name of wetland (if available): ____

4. Location of wetland (This information is vital; please provide a detailed description and mark the location of the site on the attached map.):

   ____

   ____

   ____

   ____

5. Wetland ownership (check one, if known):

Federal_____ State_____ Municipal_____ Conservation organization_____

Private_____

6. If privately owned, please provide any known contact information:

Landowner:________________________

Address: ____
____
____

Phone number: ________________________

7. Types of impacts present (see attached guidelines):

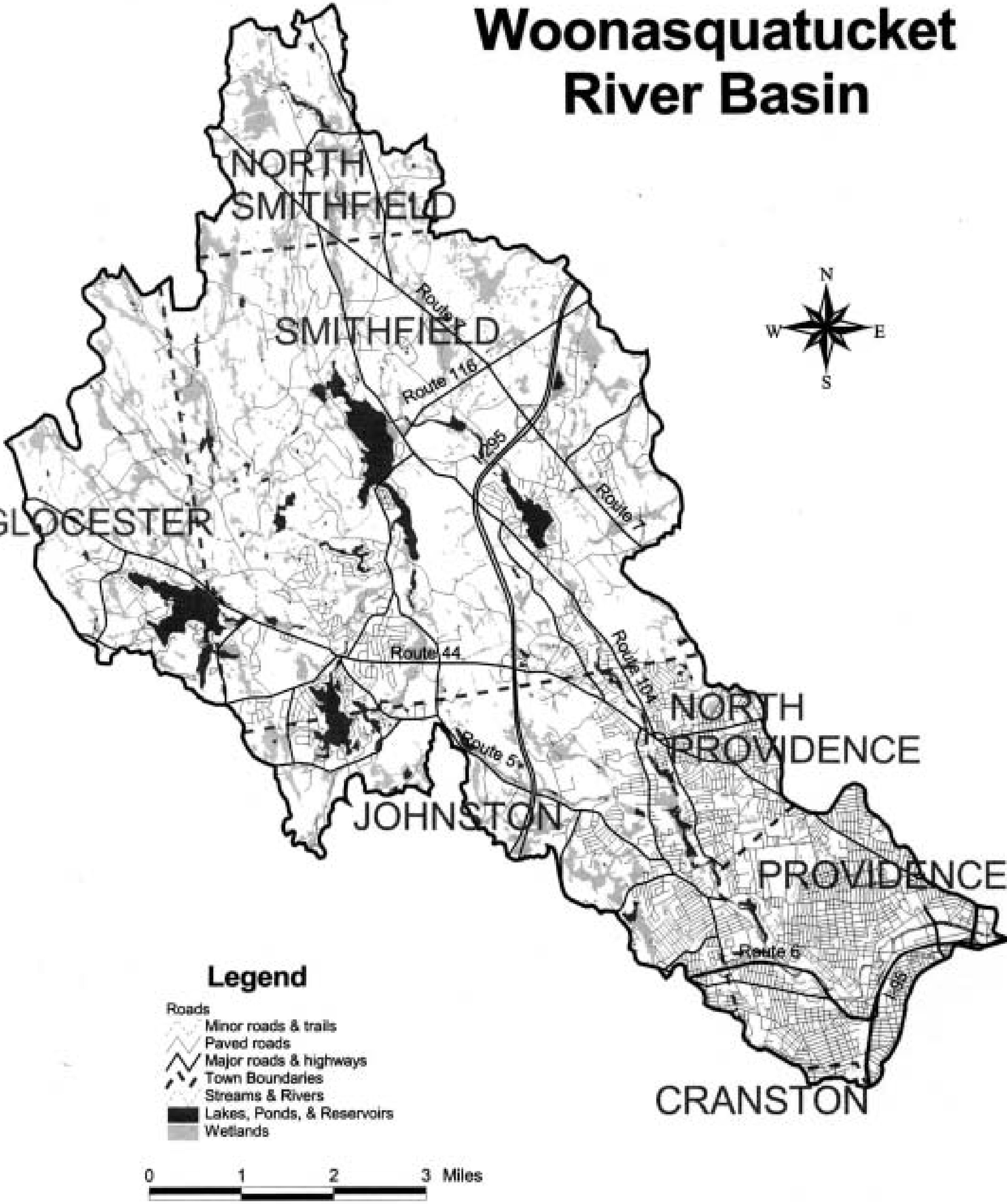
____
____
____
____

8. Approximate age of impact (if known): __________________

Completed forms should be submitted by May 31st to:

Nick Miller
Department of Natural Resources Science
210B Woodward Hall
University of Rhode Island
Kingston, RI 02881

UNIVERSITY OF RHODE ISLAND   RI DEM   EPA


Woonasquatucket
River Basin
NORTH SMITHFIELD
SMITHFIELD
GLOCESTER
JOHNSTON
NORTH PROVIDENCE
PROVIDENCE
CRANSTON
Route 116
Route 7
Route 44
Route 104
Route 5
Route 6
I-295
I-95
N
S
E
W
Legend
Roads
Minor roads & trails
Paved roads
Major roads & highways
Town Boundaries
Streams & Rivers
Lakes, Ponds, & Reservoirs
Wetlands
0
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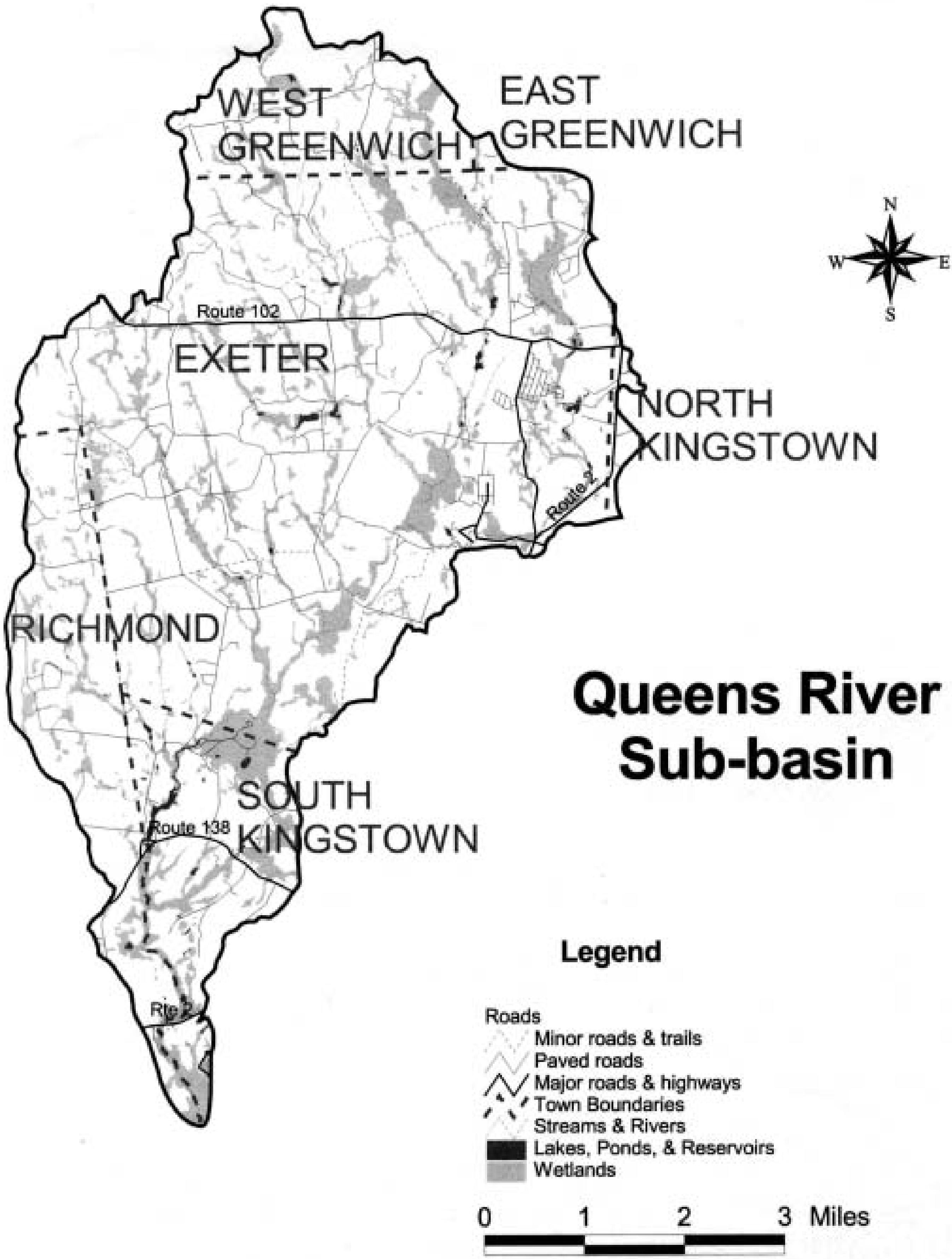

WEST GREENWICH
EAST GREENWICH
EXETER
NORTH KINGSTOWN
RICHMOND
SOUTH KINGSTOWN
Route 102
Route 2
Route 138
Rte 2
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S
E
W
Queens River Sub-basin
Legend
Roads
Minor roads & trails
Paved roads
Major roads & highways
Town Boundaries
Streams & Rivers
Lakes, Ponds, & Reservoirs
Wetlands
0
1
2
3
Miles

Appendix F1. Functional assessment form for potential wetland restoration sites.

Site ID #: __________ **Date:** ___________

Function	*	**Criteria** (highlighted criteria are necessary to the function)	**O,E,S†**	**Source‡**	**Notes**
Flood Abatement		Impervious surfaces cover > 20% of land within 500 feet	O	L	
		Slopes within 500 feet of wetland are > 15%	O	L	
		Point-source inflow	O	L,F	
		Bordering or containing a lower perennial stream	O	L,F	
		Basin wetland	E	F	
		Dominant vegetation is dense and persistent (EM, SS, or FO)	E	L,F	1,2
		Constricted outlet	E	L,F	
		Developed flood-prone areas downstream within 5 miles or to nearest dam (connection by stream or floodway required)	S	L	
Water Quality Improvement		Point-source discharge upstream or directly into wetland	O	L,F	
		Agricultural land or impervious surfaces comprise > 20% of land within 500 feet	O	L	
		Unsewered development within 200 feet	O	L	
		Dominant vegetation is dense and persistent (EM, SS, or FO)	E	L,F	1,2
		Basin wetland	E	F	
		Constricted (or no) outlet	E	L,F	
		Surface water drinking supply within 2 miles downstream	S	L	
		W/i wellhead protection area or major gw recharge area	S	L	
Wildlife Habitat		Local abundance of wetlands: Wetland and deepwater habitats comprise > 10% of land within 1 mile	E	L	
		Contiguous with > 500 acres of moderate/high quality habitat (forest, shrubland, abandoned field, or agricultural land)	E	L	
		Wetland unit plus contiguous lake or river > 5 acres	E	L	
		Wetland-dependent wildlife species present	E	F	
		WQ class of contiguous water body, if present, is B or better	E	L	3
		No invasive plant species present in contiguous wetland	E	F	
		Forest, shrubland, abandoned fields, or agricultural land comprise > 70% of land within 500 feet	E	L	

Site ID #: __________

Function	*	Criteria (highlighted criteria are necessary to the function)	O.E.S	Source	Notes
Fish Habitat		Perennial surface water is present in wetland unit or in contiguous area	O	F	4
		Water depth in WU, or in contiguous or connected open water body, is sufficient for overwintering	O	F	4
		Site is accessible to anadromous fish	O	L	
		WQ class of contiguous water body, if present, is B or better	E	L	
		Open water is bordered by a vegetated zone for > 75% of its length	E	L	5
		Forest, shrubland, abandoned fields, or agricultural land comprise > 70% of land within 500 feet	E	L	

Function	*	Criteria	O.E.S	Source	Notes
Heritage		Site is physically or visually accessible	O	F	
Aesthetics		Site is part of a public recreation area	O	L,F	
Recreation		Water-based recreation opportunities	O	F	
Education		Diversity of wetland types (3 or more types present)	E	L,F	1
Research		No evidence of pollution (noise, trash, degraded water quality) in wetland	E	F	1
Open space		Open or uncommon wetland type (open water, bog, fen, marsh, wet meadow, cedar swamp) present	E	L,F	1
Biodiversity		Large or conspicuous wildlife (e.g., waterfowl, waders, shorebirds, ospreys, terns) inhabit the wetland	E	F	1
		Native plants of high visual quality are present in wetland	E	F	1
		Upland forest, shrubland, abandoned field, or agricultural land comprises < 20% of land within 1 mile	S	L	
		Local scarcity of wetlands: Wetland and deepwater habitats comprise < 10% of land within 1 mile	S	L	
		Located within 1 mile of a school or college	S	L	

*Mark each box as Y, N, D, or NA (i.e., yes, no, don't know, or not applicable)
[†]O = opportunity; E = effectiveness; S = social significance
[‡]L = lab data; F = field data
[1]Not applicable if entire wetland unit has been destroyed.
[2]Not applicable if the wetland types of the existing unit and the destroyed portion are different.
[3]Not applicable for vernal pools
[4]Not applicable if wetland unit is isolated and has been completely destroyed.
[5]Not applicable if wetland unit lacks open water.

Appendix F2. Ranking sites for restoration: Destroyed wetlands.

Each site that has been filled or drained is ranked as follows:

Ranking sites by individual functions:

1. Field and lab assessments are conducted (see Appendix F1) to calculate functional probability scores, based on opportunity and effectiveness criteria (after Adamus et al. 1987). Opportunity criteria indicate the chance that a wetland has to perform a function; effectiveness criteria are related to the ability of a wetland to perform a function, based on its characteristics. To generate probability scores, the number of "O" and "E" criteria that have been met are divided by the total possible number of "O" and "E" criteria for each function.

   Example: *Site #347 has been filled. Four of the seven "O" and "E" criteria for the water quality improvement function have been met, so the probability that the site will be able to perform this function after restoration equals 0.57.*

2. Scores are increased by 0.1 for sites where performance of the function is socially significant (i.e., sites for which at least one of the social significance ["S"] criteria was met). Wildlife habitat and fish habitat functions do not have social significance criteria; site scores for these functions are automatically increased by 0.1.

   Example: *Restoration at Site #347 would be socially significant because it is directly upstream from a drinking water reservoir. Therefore, the water quality improvement score for the site would be increased from 0.57 to 0.67.*

3. Within each function, all sites that have an O-E-S score of 0.6 or greater are included in the remainder of the ranking process. Sites with O-E-S scores below 0.6 are removed from the ranking process for that function.

   Example: *Site #347 will be included in the remainder of the ranking process for the water quality improvement function because, after adjusting for social significance, the score for that function is greater than 0.6.*

4. O-E-S scores for the remaining sites are multiplied by a factor based on size:

Size (acres)	Factor
< 0.50	1.0
0.50 - 2.00	1.5
> 2.00	2.0

   Example: *Site #347 is 3.5 acres; therefore, the final water quality improvement score is 1.34 (i.e., 0.67 x 2.0 = 1.34).*

5. Sites are then ranked for each function according to their final scores, which may range from 0.6 to 2.2. Where ties exist among sites with the same scores, sites are further ranked by absolute size.

Ranking sites by the total number of functions performed:

1. Field and lab assessments are conducted to calculate functional probability scores (ranging from 0.0 to 1.0), as above.

2. The scores are then modified for social significance, as above, if appropriate.

3. For each site, the number of functions with an O-E-S score of at least 0.6 are multiplied by a size factor:

Size (acres)	Factor
< 0.50	1.0
0.50 - 2.00	1.5
> 2.00	2.0

Example: Four of the five functions at Site #347 have O-E-S scores that exceed 0.6. Therefore, the number of functions (i.e., 4) is multiplied by the size factor (i.e., 2.0) to obtain a final score of 8.0.

4. Sites are then ranked according to their final scores, which may range from 0 to 10. Where ties exist among sites with the same final scores, sites are further ranked by absolute size.

Appendix F3. Restoration assessment criteria: Rationale and data collection methods.

Introduction

This appendix provides the rationale for each of the criteria listed in Appendix F1; it also describes the procedures used for assessing restoration opportunities at destroyed sites. Guidelines are provided for field and lab assessments of individual criteria. In each case, field and lab techniques have been designated as the primary, supplementary, or sole source of information. Determinations made with the primary sources should generally override determinations made with supplementary sources; however, personal judgement should prevail when the sources provide contradictory results. Certain criteria are designated as "necessary to the function" (see below, and see Appendix F1). If one of these criteria is not satisfied at a potential restoration site, then the function cannot be provided at that site and assessment should be discontinued. All criteria address characteristics of the entire wetland unit (i.e., "wetunit") within which the impact occurred, rather than characteristics of the impact area itself.

Function: FLOOD ABATEMENT

Impervious surfaces cover > 20% of land within 500 feet

Rationale: Wetlands surrounded by impervious surfaces (e.g., roads, sidewalks, paved parking lots, buildings) are likely to receive significant amounts of runoff during storm events. As a result, these wetlands have a great opportunity to desynchronize floodwaters.

Lab assessment (primary source): Orthophotos are used to assess this criterion. A visual estimate of the percent cover of impervious surfaces is made for the area within 500 feet of each wetunit that contains restoration opportunities. The boundaries of this area are determined by buffering impacted wetunits in GIS.

Field assessment (supplementary source): Field notes should indicate the presence or absence of impervious surfaces in the vicinity of the wetland. Particular attention is paid to impervious surfaces that may have been constructed since 1995 (the date of the lab assessment data).

Slopes within 500 feet of the wetland are > 15%

Rationale: Wetlands surrounded by steep slopes are likely to receive significant amounts of surface runoff during storm events. These wetlands have a greater opportunity to desynchronize floodwaters.

Lab assessment (primary source): The RIGIS soils coverage, wetunits, a 500-foot buffer, and orthophotos are viewed simultaneously in ArcView. Soil map units coded as “D” (i.e., soils with slopes > 15 %) that occur within 500 feet of impacted wetlands are identified. Where the aspect of the slope is unclear, collateral data sources should be consulted (e.g., topographic maps or stereopairs of aerial photos).

Field assessment (supplementary source): Field notes should describe the slope of land surrounding the wetunit. Where slopes assigned in the Soil Survey are questionable, slope measurements may be made with a clinometer.

Point source inflow

Rationale: Runoff that has been channeled into a wetland (e.g., from roads or parking lots) increases the opportunity for that wetland to desynchronize floodwaters.

Field assessment (primary source): Field observations provide the most reliable source of information for this criterion.

Lab assessment (supplementary source): 1988 aerial photos are interpreted to determine where channels have been constructed between roads or parking lots and wetlands.

Bordering or containing a lower perennial stream

Rationale: Wetlands that contain, or are adjacent to, lower perennial streams have an opportunity to receive floodwaters via overbank flow.

Field assessment (primary source): Field observations provide the most reliable source of information for this criterion.

Lab assessment (supplementary source): Aerial photos may be viewed in stereo to determine the presence of lower perennial streams in, or adjacent to, impacted wetland units.

Basin wetland

Rationale: Wetlands occurring in basins can be effective at temporarily storing floodwater; slope wetlands cannot. This criterion is considered “necessary to the function.”

Field assessment (primary source): Field observations are made to determine whether wetunits occur in basins or on slopes. Field observations should always override conclusions from aerial photo-interpretation.

Lab assessment (supplementary source): 1988 aerial photos may be interpreted to determine whether wetunits occur in basins or on slopes.

Dominant vegetation is dense and persistent (EM, SS, or FO)

Rationale: Dense wetland vegetation can reduce downstream flood levels and delay flood crests by reducing floodwater velocity. Persistent vegetation (e.g., woody plants, robust persistent emergents) can perform this function even outside of the growing season.

Field assessment (primary source): The presence of dense, persistent vegetation is noted in the field. Where conflicts exist, field observations always override lab assessments.

Lab assessment (supplementary source): Wetland type is determined from the RIGIS wetlands database.

Constricted outlet

Rationale: Wetlands with constricted outlets are more effective in downstream flood abatement than wetlands with unrestricted flow. The wetland must have an outlet for this criterion to be applicable.

Lab assessment (primary source): Aerial photos are interpreted to determine whether or not wetunits that contain restoration opportunities have constricted (or no) outlets. Orthophotos also may be useful.

Field assessment (supplementary source): The presence and relative size of outlets should be noted in the field, where feasible.

Developed flood-prone areas downstream within 5 miles or to nearest dam (connection by stream or floodway required)

Rationale: Restoration of wetlands for flood abatement is socially significant if there are developed flood-prone areas downstream. For purposes of this assessment, restorable wetlands must be connected to developed flood-prone areas by surface water at the time of flooding.

Lab assessment (sole source): Orthophotos, FEMA maps, and restoration sites are viewed in ArcView to determine the presence of developed flood-prone areas and to measure the distance between those areas and the wetlands in question.

Field assessment: This criterion need not be assessed in the field.

Function: WATER QUALITY IMPROVEMENT

Point-source discharge upstream or directly into wetland

Rationale: Wetlands downstream of pollution sources have greater opportunity to improve water quality than wetlands not receiving such inputs.

Lab assessment (primary source): Impacted wetlands that are downstream from, or adjacent to, point-source discharges are identified by viewing orthophotos, restoration sites, and the RIGIS coverage of point-source discharges.

Field assessment (primary source): The presence or absence—and magnitude—of point-source discharges should be noted at all sites visited in the field.

Agricultural land or impervious surfaces comprise > 20% of land within 500 feet

Rationale: Agricultural land and impervious surfaces have the potential to add nutrients, sediments, and other pollutants to surface water and groundwater. Wetlands receiving these inputs therefore have the opportunity to improve water quality.

Lab assessment (primary source): Orthophotos are used to assess this criterion. A visual estimate of the percent cover of agricultural land and impervious surfaces is made for the area within 500 feet of each wetunit that contains restoration opportunities. The boundaries of this area are determined by buffering impacted wetunits in GIS.

Field assessment (supplementary source): The relative amount of agricultural land and impervious surfaces can be estimated in the field; these observations help to verify lab assessments.

Unsewered development within 200 feet

Rationale: Wetlands receiving groundwater inflow from unsewered developed areas have a greater opportunity to improve water quality than wetlands not receiving such inflow.

Lab assessment (sole source): In ARC/INFO, the impacted wetland units are buffered by 200 feet and the RIGIS sewer line coverage is buffered by 500 feet. The buffer coverages are viewed over orthophotos in ArcView. Unsewered development within 200 feet of impacted wetlands includes those areas that have been developed (as seen in the orthophotos) and are within the wetland buffer, but fall outside of the sewer line buffer.

Field assessment: This criterion need not be assessed in the field.

Dominant vegetation is dense and persistent (EM, SS, or FO)

Rationale: Dense wetland vegetation can serve as a filter for pollutants and can also impede the flow of water, causing sediments and associated pollutants to drop out of suspension. Persistent vegetation (e.g., woody plants, robust persistent emergent species) can perform this function even outside of the growing season.

Field assessment (primary source): The presence of dense, persistent vegetation is noted in the field. Where conflicts exist, field observations always override lab assessments.

Lab assessment (supplementary source): Wetland type is determined from the RIGIS wetlands database.

Basin wetland

Rationale: Basin wetlands retain water for longer periods of time than slope wetlands. Greater retention time permits increased interaction between plants or soil and pollutants, as well as settling of suspended solids.

Field assessment (primary source): Field observations are made to determine whether wetunits occur in basins or on slopes. Field observations should always override conclusions from aerial photo-interpretation.

Lab assessment (supplementary source): 1988 aerial photos may be interpreted to determine whether wetunits occur in basins or on slopes.

Constricted (or no) outlet

Rationale: Wetlands that lack outlets and wetlands with constricted outlets have the potential to retain polluted water for extended periods of time. Long retention times allow for increased interaction between plants or soil and pollutants, as well as settling of suspended solids.

Lab assessment (primary source): Aerial photos are interpreted to determine whether or not wetunits that contain restoration opportunities have constricted (or no) outlets. Orthophotos also may be useful.

Field assessment (supplementary source): The presence and relative size of outlets should be noted in the field, but lab assessments should take precedence over field observations.

Surface water drinking supply within 2 miles downstream

Rationale: Wetlands upstream of surface water drinking supplies are in a position to improve the quality of water entering the reservoirs. Therefore, there is social significance to restoration of such wetlands.

Lab assessment (sole source): Impacted wetland units, orthophotos, and surface water drinking supplies (a RIGIS coverage) are viewed in ArcView and distances are measured.

Field assessment: This criterion is not measured in the field.

Within wellhead protection area or major groundwater recharge area

Rationale: Wetlands within wellhead protection areas or major groundwater recharge areas are in a position to improve the quality of groundwater used for drinking. Therefore, there is social significance to restoration of such wetlands.

Lab assessment (sole source): Methods used depend on the number of sites to be assessed. If there is a large number of sites, this criterion is assessed in ARC/INFO by conducting an overlay of RIGIS wellhead and groundwater recharge coverages with the coverage of restoration opportunities. If there are relatively few sites, this criterion can be coded manually using the same coverages in ArcView.

Field assessment: This criterion is not measured in the field.

Function: WILDLIFE HABITAT

Local abundance of wetlands: Wetland and deepwater habitats comprise > 10% of land within 1 mile

Rationale: Potential restoration sites that are in close proximity to other wetlands, or that are part of larger wetland complexes, are more effective than isolated wetlands at providing habitat for wetland wildlife. Where wetlands are abundant, many species of wildlife are able to move among them to satisfy all of their habitat requirements.

Lab assessment (sole source): The RIGIS wetland coverage is converted to a grid with 10-x10-meter cells. An .aml is run in ArcGrid to determine the number of cells within 1 mile of each point that are designated as wetland. Values are then converted to percentages.

Field assessment: This criterion is not assessed in the field.

Contiguous with > 500 acres of moderate to high quality habitat (forest, shrubland, abandoned field, or agricultural land)

Rationale: Some wetland wildlife species can breed successfully in small patches of habitat. However, certain "interior" species are only successful in wetlands surrounded by extensive natural habitat; other species (e.g., deer, otter) have large home ranges and also require extensive natural areas. Contiguity of natural habitats also enables wildlife dispersal among wetlands; successful dispersal, in turn, ensures genetic diversity and lessens the chance of localized extirpations. To provide habitat for interior species and species with large home ranges, restoration efforts should focus on wetlands that are contiguous with extensive moderate to high quality habitat.

Lab assessment (sole source): Potential restoration sites and associated wetunits are viewed over orthophotos in ArcView. Contiguity with moderate to high quality habitat is assessed visually and measured by heads-up digitizing polygons. Major roads (as coded in the RIGIS roads coverage) are considered habitat edges.

Field assessment: This criterion is not assessed in the field.

Wetland unit plus contiguous lake or river > 5 acres

Rationale: Large wetlands are capable of supporting larger—and, therefore, more viable—wetland-dependent wildlife populations. Large wetlands can also supply habitat for wetland-dependent species with large home ranges.

Lab assessment (sole source): The attributes table of the wetland unit coverage is queried to determine wetland unit size.

Field assessment: This criterion is not assessed in the field.

Wetland-dependent wildlife species present

Rationale: Observation of wetland-dependent wildlife indicates that the assessed wetland is, to some degree, providing habitat.

Field assessment (sole source): Field personnel search for signs of wetland-dependent wildlife as other criteria are assessed.

Lab assessment: This criterion cannot be assessed in the lab.

Water quality class of contiguous water body, if present, is B or better

Rationale: To remain healthy and viable, wildlife populations require clean water. Restoration success for the wildlife habitat function is likely to be greater if water quality is good.

Lab assessment (sole source): RIGIS hydrologic coverages contain hydrologic units that are coded for water quality. Those coverages are viewed along with impacted wetland units in ArcView.

Field assessment: This criterion is not assessed in the field.

No invasive plant species present in contiguous wetland

Rationale: Wetlands dominated by invasive plant species, such as *Phragmites australis* and *Lythrum salicaria,* are often limited in their ability to provide foraging, roosting, or nesting habitat for native wildlife species. Where invasive species are already established in contiguous wetland, they are highly likely to colonize newly restored wetlands.

Field assessment (primary source): Stands of invasive species are sought out and catalogued in the field.

Lab assessment (supplementary source): The presence of invasives may be discovered during photo-interpretation, but this determination is best made in the field. The presence of invasives constitutes a separate restoration opportunity; after all opportunities have been entered into the database, this criterion can be assessed by querying the restoration opportunities database.

Forest, shrubland, abandoned fields, or agricultural land comprise > 70% of land within 500 feet

Rationale: This criterion considers the immediate context of the restoration site. Sites surrounded by the medium to high quality habitats listed above are more likely to support healthy wildlife populations. Such areas are less prone to pollution or disturbance of wildlife due to human activity. Natural surroundings also may provide important foraging, nesting, or roosting habitat for wetland wildlife such as waterfowl, turtles, wading birds, and certain birds of prey.

Lab assessment (primary source): Orthophotos are used to assess this criterion. A visual estimate of the percent cover of each land use category is made for each wetunit containing restoration opportunities. The boundaries of the assessment area are determined by buffering impacted wetunits in GIS.

Field assessment (supplementary source): Field notes should indicate the presence or absence of these land uses in the vicinity of the wetunit. Particular attention should be paid to changes in land use that may have occurred since 1995 (the date of the lab assessment data).

Function: FISH HABITAT

Perennial surface water is present in the wetland unit or in the contiguous area

Rationale: This criterion is necessary to the fish habitat function. Wetlands that contain perennial surface water have the opportunity to provide habitat for fish. Wetlands adjacent to perennial surface water also may influence habitat conditions for fish populations.

Field assessment (primary source): Field observations are made to determine if surface water is present, and if it appears to be perennial.

Lab assessment (supplementary source): Although it is possible to identify surface water from aerial photos, it is more reliable to determine in the field whether or not those areas are perennial.

Water depth in wetland unit, or in contiguous or connected open water body, is sufficient for overwintering

Rationale: This criterion is also necessary to the fish habitat function. If surface water freezes completely in winter, and fish cannot migrate to areas where overwintering is possible, then the area should not be considered viable fish habitat.

Field assessment (sole source): Sites that contain, or are connected or adjacent to, water sufficiently deep for overwintering (i.e., 3-4 feet) are noted.

Lab assessment: This criterion is not assessed in the lab.

Site is accessible to anadromous fish

Rationale: Anadromous fish runs have been heavily impacted within Rhode Island due to damming of rivers; anadromous fish populations have dwindled due to those impacts. Priority should be given to sites that are accessible to anadromous fish.

Lab assessment (sole source): Project personnel consult with fish experts at the RIDEM Division of Fish and Wildlife to determine which potential restoration sites are accessible to anadromous fish.

Field assessment: This criterion need not be assessed in the field.

Water quality class of contiguous water body, if present, is B or better

Rationale: To remain healthy and viable, fish populations require clean water. Restoration success for the fish habitat function is likely to be greater if water quality is good.

Lab assessment (sole source): RIGIS hydrologic coverages contain units that are coded for water quality. Those coverages are viewed along with impacted wetland units in ArcView.

Field assessment: This criterion is not assessed in the field.

Open water is bordered by a vegetated zone for > 75% of its length

Rationale: Vegetation bordering water can provide shade and help to maintain cooler water temperatures. Such vegetation may also contribute organic detritus that supports invertebrate prey items.

Lab assessment (primary source): Orthophotos are used to make a visual assessment of the percentage of open water edge that is vegetated.

Field assessment (supplementary source): Changes that may have occurred since the date of the orthophotos are noted in the field.

Forest, shrubland, abandoned fields, or agricultural land comprise > 70% of land within 500 feet

Rationale: This criterion considers the context of the restoration opportunities. Opportunities surrounded by the medium to high quality habitats listed above are more likely to support healthy fish populations. Such surroundings can filter sediments and pollutants.

Lab assessment (primary source): Orthophotos are used to assess this criterion. A visual estimate of the percent cover of each land use category is made for each wetunit containing restoration opportunities. The boundaries of the assessment area are determined by buffering impacted wetunits in GIS.

Field assessment (supplementary source): Field notes should indicate the presence or absence of these land uses in the vicinity of the wetunit. Particular attention should be paid to changes in land use that may have occurred since 1995 (the date of the lab assessment data).

Function: HERITAGE

Site is physically or visually accessible

Rationale: The heritage function considers the potential for wetland restoration to provide certain benefits to society (see Appendix F1). Society cannot benefit if the wetlands to be restored are visually and physically inaccessible; therefore, this criterion is considered necessary to the function.

Field assessment (sole source): Field observations indicate whether the site is accessible.

Lab assessment: This criterion is not assessed in the lab.

Site is part of a public recreation area

Rationale: Sites located within public recreation areas (e.g., town parks, wildlife management areas) are readily accessible to the general public. It is more likely that such sites will be visited for recreation, nature study, or research purposes than sites on private land.

Lab assessment (primary source): Sites are viewed along with RIGIS open space coverages in ArcView to determine which fall within public recreation areas.

Field assessment (supplementary source): Field notes should also be especially useful for identifying recreation areas that have been established since the RIGIS coverages were created.

Water-based recreation opportunities

Rationale: Sites containing open water may support swimming, fishing, waterfowl hunting, canoeing, or other popular water sports.

Field assessment (primary source): Field personnel determine the potential for water-based recreation.

Lab assessment (supplementary source): Open water bodies can be detected on aerial photos, but the potential for the site to provide specific recreation opportunities is best assessed in the field. Swimmability and fishability can be determined, in some instances, using the water quality coding of the RIGIS hydrography coverages.

Diversity of wetland types (3 or more types present)

Rationale: Within a wetland unit, diversity in wetland types may contribute to increased aesthetic value, heightened educational and research opportunities, and greater biodiversity.

Field assessment (primary source): The number of wetland types is determined onsite.

Lab assessment (supplementary source): This criterion can be assessed in the lab simply by viewing the RIGIS wetlands coverage. However, field visits should be made to confirm wetland types.

No evidence of pollution (noise, trash, degraded water quality) in wetland

Rationale: Restoration of the heritage function should take place in wetlands that will not continue to be degraded after restoration efforts are completed. All of the heritage values listed in Appendix F1 would be impaired by excessive noise, trash, and other pollutants.

Field assessment (sole source): Field personnel take note of trash, noise, and other pollutants in and surrounding the wetland unit.

Lab assessment: This criterion is not assessed in the lab.

Open or uncommon wetland type (open water, bog, fen, marsh, wet meadow, cedar swamp) present

Rationale: Open wetlands (i.e., open water, bog, fen, marsh, wet meadow) provide structural and visual diversity in the otherwise forested and urbanized landscapes of Rhode Island; therefore, they contribute heavily to aesthetic and biodiversity values. Uncommon wetland types (i.e., bog, fen, wet meadow, cedar swamp) are especially important for biodiversity, research, and education.

Field assessment (primary source): The presence of open or uncommon wetland types is determined on site.

Lab assessment (supplementary source): This criterion can be assessed in the lab simply by viewing the RIGIS wetlands coverage. However, field visits should be made to confirm wetland types.

Large or conspicuous wildlife (e.g., waterfowl, waders, shorebirds, ospreys, terns) inhabit the wetland

Rationale: The presence of large or conspicuous wildlife in a wetland can be aesthetically pleasing, can promote recreation (e.g., through hunting, birdwatching), and can provide a key focus for educational field trips.

Field assessment (sole source): During site visits, field personnel note the presence of large or conspicuous wildlife.

Lab assessment: This criterion cannot be assessed in the lab.

Native plants of high visual quality are present in the wetland

Rationale: Wetlands that contain attractive or visually interesting plants (e.g., pickerelweed, pitcher plant, sundew) contribute greatly to the aesthetic value of wetlands. Red maple (*Acer rubrum*) foliage is particularly striking in the fall. Note that, although *Lythrum salicaria* can be aesthetically pleasing during the late summer, it is an exotic species; therefore, it is ignored in the assessment of this criterion.

Field assessment (sole source): Field personnel note plant species of high visual quality.

Lab assessment: This criterion cannot be assessed in the lab.

Upland forest, shrubland, abandoned field, or agricultural land comprises < 20% of land within 1 mile

Rationale: This criterion assesses the abundance of open space in areas surrounding potential restoration sites. The open space value of restored wetlands will be greater in areas of the landscape where open space is scarce.

Lab assessment (sole source): The RIGIS land use coverage is converted to a grid with 10-x10-meter cells. An .aml is then run in ArcGrid to determine the number of cells within 1 mile of each point that are designated as upland forest, shrubland, abandoned field, or agricultural land. Values are converted to percentages.

Field assessment: This criterion is not assessed in the field.

Local scarcity of wetlands: Wetland and deepwater habitats comprise < 10% of land within 1 mile

Rationale: Wetland restorations that are accomplished in areas of the landscape where wetlands are scarce will have a positive effect on heritage functions (aesthetics, recreation, education, research, open space, and biodiversity).

Lab assessment (sole source): The RIGIS wetland coverage is converted to a grid with 10-x10-meter cells. An .aml is then run in ArcGrid to determine the number of cells within 1 mile of each point that are designated as wetland. Values are converted to percentages.

Field assessment: This criterion is not assessed in the field.

Located within 1 mile of a school or college

Rationale: Sites that are close to schools or colleges are more likely to be used for education and research purposes.

Lab assessment (sole source): This criterion is assessed by using the ARC/INFO pointdistance command on the restoration opportunities coverage and the RIGIS schools coverage.

Field assessment: This criterion is not assessed in the field.

Appendix F4. Potential wetland restoration sites in the Woonasquatucket study area, ranked by projected ability to perform selected functions. Only destroyed (not degraded) wetlands are included.

Flood Abatement		
Site#	Acres*	Score
67	0.750	1.65
22	3.408	1.53
37	0.708	1.44
11	0.373	1.10
195	0.117	1.10
38	0.092	1.10
24	0.433	0.96
204	0.368	0.96
216	0.000	0.96
188	0.428	0.93
36	0.338	0.93
189	0.260	0.93
25	0.401	0.81
130	0.000	0.81
8	0.126	0.67
58	0.041	0.67
42	0.299	0.60

Water Quality Improvement		
Site#	Acres*	Score
1	5.577	1.71
22	3.408	1.60
67	0.750	1.50
37	0.708	1.44
43	2.082	1.20
24	0.433	1.00
38	0.092	1.00
58	0.041	0.86
47	0.000	0.86
130	0.000	0.86
203	0.000	0.86
216	0.000	0.86
11	0.373	0.80
195	0.117	0.80
204	0.368	0.71
8	0.126	0.71
188	0.428	0.70
36	0.338	0.70
189	0.260	0.70
42	0.299	0.60
129	0.239	0.60

Wildlife Habitat		
Site#	Acres*	Score
22	3.408	1.34
1	5.577	1.20
67	0.750	0.90
41	0.524	0.90
188	0.428	0.81
36	0.338	0.81
189	0.260	0.81
25	0.401	0.77
204	0.368	0.77
216	0.000	0.77
24	0.433	0.60
38	0.092	0.60
58	0.041	0.60

Fish Habitat		
Site#	Acres*	Score
43	2.082	1.20
37	0.708	0.90
24	0.433	0.85
25	0.401	0.85
204	0.368	0.85
38	0.092	0.85
188	0.428	0.70
36	0.338	0.70
189	0.260	0.70
8	0.126	0.70
216	0.000	0.60

Heritage		
Site#	Acres*	Score
22	3.408	1.45
43	2.082	1.20
37	0.708	0.90
24	0.433	0.85
188	0.428	0.85
11	0.373	0.85
36	0.338	0.85
189	0.260	0.85
195	0.117	0.85
130	0.000	0.73
25	0.401	0.60
129	0.239	0.60
38	0.092	0.60

Multiple Functions			
Site#	#Functions	Acres*	Score
22	4	3.408	8.0
43	3	2.082	6.0
37	4	0.708	6.0
24	5	0.433	5.0
188	5	0.428	5.0
36	5	0.338	5.0
189	5	0.260	5.0
38	5	0.092	5.0
67	3	0.750	4.5
1	2	5.577	4.0
25	4	0.401	4.0
204	4	0.368	4.0
216	4	0.000	4.0
11	3	0.373	3.0
8	3	0.126	3.0
195	3	0.117	3.0
58	3	0.041	3.0
130	3	0.000	3.0
42	2	0.299	2.0
129	2	0.239	2.0
41	1	0.524	1.5
47	1	0.000	1.0
203	1	0.000	1.0

*A value of zero was assigned to sites that were difficult or impossible to delineate (i.e., sites that were very small and sites where fill was evident but the extent of fill in wetland was unknown).

Appendix G. Stakeholder questions and comments.

Throughout Phase I, project personnel actively sought input from stakeholders. A meeting was convened early in the project to inform stakeholders of the plan to develop a statewide freshwater wetland restoration strategy; attendees included representatives from State and Federal agencies, municipal governments, watershed associations, nongovernmental conservation organizations, and other interested parties. Results and conclusions from Phase I were presented at meetings of several groups, including the Rhode Island Habitat Restoration Team, the Woonasquatucket Watershed Council, and the Rhode Island Association of Wetland Scientists. In addition, an earlier draft of this report was circulated among stakeholders and DEM personnel; they were given the opportunity to review and comment on the report. The questions and issues that arose from those reviews and presentations are addressed below.

General Issues

Question: *Given limited funding for restoration activities, would it be better to restore several degraded sites rather than one destroyed site?*

Response: Restoration of destroyed (e.g., filled) wetland re-creates wetland functions and values where none currently exist. For that reason, the benefits gained per acre generally will be greater than for rehabilitation of degraded wetland (e.g., revegetation of adjacent upland), where existing wetland functions and values are enhanced. Re-creation of destroyed wetland usually will be more expensive than rehabilitation of degraded wetland, but given the greater benefits, it should be the first priority whenever funds are available. Both forms of restoration are important and both should be pursued aggressively. The balance between the two will ultimately be dictated by local restoration goals and availability of funds.

Question: *Preservation of existing wetlands should receive higher priority than restoration of destroyed or degraded wetlands. In addition to identifying restoration opportunities, could project personnel provide information about wetland complexes that should be highlighted for preservation?*

Response: Preservation of existing wetlands should be the cornerstone of any wetland management program, but identification of especially valuable, existing wetland complexes was not one of the objectives of this project. The functional assessment method designed for destroyed wetlands considers the characteristics of the destroyed wetland site and any contiguous (existing) wetland. Generally, the restoration sites that rank the highest for one or more functions will be those sites that are associated with the most valuable existing wetlands. So these results could be used to indirectly identify at least some of the most important wetlands in a watershed.

Question: *Did field work confirm remotely identified sites?*

Response: Roughly one-half of the sites identified via photo-interpretation were also visited in the field. The great majority of those sites were verified as actual wetland impacts. Therefore, we concluded that the methods presented in Task E provide a reliable means for identifying potential restoration sites.

Question: *Should alterations that have occurred since the Freshwater Wetlands Act be targeted, in the hope that landowners would be more cooperative?*

Response: All wetlands that have been impacted since 1939 will be considered potential restoration sites. One stakeholder suggested that an amnesty program could be developed for outstanding violations.

Question: *How would ongoing wetland violations be addressed?*

Response: In Phase II, the locations of potential restoration sites will be cross-referenced with the DEM wetland enforcement database to confirm the enforcement history and status. On a case-by-case basis, it will be determined whether a potential restoration site with an enforcement history should be considered in a proactive context. It is anticipated that active enforcement files will not be considered proactive restoration opportunities.

Comment: *Many wetland violations that occurred in the 1970's were never followed up on; these could have great potential for restoration.*

Response: See response immediately above. If an outstanding wetland enforcement action is resolved, that site would become eligible for proactive restoration.

Comment: *Sedimentation removal/restoration should be coordinated with nonpoint-source control demonstration projects.*

Response: We agree; however, water quality impacts stemming from nonpoint-source pollution were not targeted in this study.

Comment: *Sediment removal might be wise in ponds and vernal pools.*

Response: This is true; however, sediment removal could have major adverse impacts on habitat values if vegetation also needs to be removed. Soil disturbance and vegetation removal also may create ideal conditions for establishment of invasive plants. Generally, sediment removal should be limited to those sites where future sediment inputs can be controlled and invasive species managed.

Comment: *Urban wetlands that have been degraded should be protected on the bases of their educational and social values. Too often, these sites are regarded as unsalvageable or of limited value; therefore, permits often allow further degradation.*

Response: Urban wetlands should be given strong consideration for proactive restoration, as long as the potential to perform one or more key functions is evident. Stakeholders also should have the opportunity to recommend that low-ranked sites be restored, based on their local significance.

Question: *How will land ownership issues be addressed? When and how will this fit into the process?*

Response: In Phase II land ownership will be researched after potential restoration areas are identified. Landowners will be contacted by letter to inform them of the project, to describe the potential restoration opportunity that may exist on their property and to request permission to visit the property to confirm the restoration potential.

Comment: *Landowners may be very concerned about the potential for re-created wetlands to increase problems with West Nile Virus and EEE. We should be prepared to respond to this issue, or to address it up front.*

Response: RIDEM will prepare a response in the event someone raises this question.

Comment: *Identification of destroyed sites involves use of the 1939 aerial photographs of which there are only two known sets. Future application of this identification method in other watersheds is dependent upon the availability of these photographs through the University or the Department of Administration.*

Response: The 1939 aerial photographs are an excellent data source for determining prior wetland conditions and identifying areas where wetlands have been destroyed. Rhode Island is fortunate to have this dataset for restoration planning. It is true that application of this method in other watersheds will be dependent on availability of photos from URI or DOA. It may also be possible to locate the original negatives of these photographs and purchase additional sets.

Comment: *I didn't see anything about long-term monitoring of restored wetland sites being proposed for Rhode Island.*

Response: The Phase I objective was to develop a methodology to identify and prioritize restoration opportunities; we were not asked to address monitoring of restoration opportunities.

Comment: *The RIGIS wetland dataset should be used with caution because errors exist.*

Response: The project team is aware of the limitations of the RIGIS wetlands dataset. However, it provides an excellent baseline of wetland information. The RIGIS wetlands dataset was always used in conjunction with other datasets (e.g., 1988 aerial photographs, digital orthophotography, and soils data) to determine the location and extent of wetland impacts. Wherever possible, identified sites were verified in the field.

Comment: *Deer are not a wetland-dependent wildlife species.*

Response: The statement in the report does not mean to suggest that they are wetland dependent.

Prioritization Process

Question: *Was the likelihood of restoration success factored into the prioritization process?*

Response: Yes. Factors that influence restoration success are presented under Task C; they include the targeted wetland type, the targeted wetland functions, the impact type, the surrounding upland context, and others. Most of these factors were considered while developing the prioritization process. In our minds, success means ability to perform typical wetland functions. Because re-creation of a specific wetland type cannot be guaranteed, we did not incorporate the former wetland type into the prioritization process for destroyed sites.

Question: *The economic end of the [prioritization] assessment is critical. How can we assure that limited funding can provide the most functional gain?*

Response: The goal of the prioritization process presented under Task F was to identify those restoration opportunities that have the potential to provide the greatest functional gain. For that reason, this process was based on established concepts and principles of wetland ecology. During Phase II we will conduct feasibility studies – which will include cost analyses – at the highest-ranked sites in the Woonasquatucket watershed. Therefore, we will ultimately propose for restoration those sites that have the greatest potential to provide the most functional gain for the lowest cost.

Question: *Would a destroyed or degraded site that is in an area with few functioning wetlands receive higher priority than one that is in an area where other wetlands are functioning effectively?*

Response: For destroyed sites, the answer to this question depends on the wetland function of interest. For example, sites are ranked higher for the heritage function where wetlands are scarce (see Appendix F1). However, wildlife populations tend to be more viable where nearby wetlands are available for dispersal and recruitment. Therefore, sites are ranked higher for the wildlife habitat function where wetlands are more plentiful. The methods described under Task F produce lists of sites ranked for individual functions in addition to a list ranked for multiple functions. Groups interested in restoring sites can choose to use any of those lists, and can also select any sites from within the lists according to their particular goals. Proximity to other wetlands was not factored into the prioritization process for degraded sites.

Comment: *Restoration opportunities in urban settings are often quite small, and yet very important to surrounding communities. Because the proposed prioritization process emphasizes the size of restoration sites to such a great degree, small urban restoration opportunities may not receive adequate attention.*

Response: In the Phase I test area we found that the majority of potentially restorable wetlands in urban settings are the result of wetland degradation, especially the "removal of adjacent upland vegetation." The size of a restoration site factors heavily into the ranking of destructive impacts, but plays a minor role in the ranking of most degrading impacts. Therefore, we feel that existing small urban wetlands will receive adequate attention during the prioritization process. In addition, groups interested in wetland restoration can select any sites from within prioritized lists according to their particular goals (e.g., restoring wetlands in urban areas).

Comment: *In an urban environment, scenic, open space, and green space values should be given equal weight to other functions [in the prioritization process for destroyed sites].*

Response: Our prioritization process ranks potential restoration sites for individual functions, including heritage values, as well as for multiple functions. If desired, heritage values could be given top priority in site selection in certain geographic areas.

Question: *On what basis are sites prioritized by impact type?*

Response: For the rationale behind ranking of destroyed sites above degraded sites, see the section entitled, "Prioritizing Opportunities Based on Impact Type," under task F. For the rationale behind further prioritization of specific degrading impact types, see Section 1 under Task C.

Question: *Is the functional assessment only for destroyed wetlands?*

Response: Yes. The assessment method assumes re-creation of wetland functions where none currently exists.

Question: *Would the same methods for ranking [that were developed in the Woonasquatucket watershed] apply to all watersheds of Rhode Island?*

Response: Yes. The methods presented in this report were intended for application in any watershed. For that reason, we developed a flexible prioritization process that accommodates varying stakeholder goals, watershed conditions, and data sources.

Question: *Were data and information about soils considered for the water quality improvement criteria [for the prioritization of destroyed sites]?*

Response: Yes. However, we decided not to incorporate that information into the prioritization process. Although denitrification hot spots occur in certain soils, research has not conclusively demonstrated that general information, such as soil type or drainage class, would allow us to determine the potential for a site to improve water quality (A. Gold, URI Dept. Natural Resources Sciences, pers. comm. 2000). In addition, restoration attempts cannot guarantee a return to a specific soil type.

Question: *Is water quality sampling conducted during the functional assessments?*

Response: No. The goal of the functional assessments is to quickly filter out the more beneficial restoration opportunities from among the hundreds that may exist within each watershed. To assess the potential for water quality improvement and other functions, we often rely on coarse data associated with existing GIS coverages (e.g., surrounding land use). More detailed, site-specific, analyses will be conducted as we perform feasibility studies at a smaller number of selected sites.

Question: *How would prioritization occur at wetlands where there is more than one impact?*

Response: Our prioritization process creates ranked lists of impacts, not ranked lists of entire wetlands. For example, if filling occurred at two distinct points within one wetland, we would record and rank two potential restoration sites. During Phase II, we will conduct further analyses based on, among other factors, the proximity to other restoration opportunities.

Question: *Grant opportunities may be available for restoration projects if they could be related to rare, threatened, or endangered (RTE) species. Could the presence of, or the potential for, RTE species be incorporated into the prioritization process?*

Response: If a RTE species is already present at a site, it seems inadvisable to change conditions that are suitable to support the species in question. For example, removal of fill, sediments, or invasive plants from a wetland already supporting an endangered wildlife species could stress that species or alter its environment in such a way that the habitat would no longer be suitable. Furthermore, while it might seem reasonable to try to re-create former conditions at a site in hopes of attracting or re-establishing RTE species that may have used the site historically, previous attempts have often been unsuccessful (see Zedler and Callaway 1999).

Most RTE species have very specific habitat requirements that may be impossible satisfy through restoration. There is one exception to the above statements. One of the criteria for prioritizing sites where adjacent upland vegetation has been removed is that the wetland type is rare or especially sensitive to human impact. Such wetlands are more likely to support populations of RTE species than more common wetland types. Attempts to restore RTE species habitat may be more feasible for this impact type, because restoration activities would only occur around the perimeter of the wetland rather than in the wetland habitat itself.

Comment: *The prioritization of destroyed sites is dependent upon landowner permission to access properties. As proposed, if permission to access properties is not gained, a destroyed site cannot be prioritized. Is there a secondary way to prioritize those restoration sites where permission is not granted possibly based on remotely sensed data alone?*

Response: In Phase II we will attempt to do as much remotely as possible. We hope to be able to conduct the functional assessment of destroyed sites with little or no field checking required.

Comment: *Please provide a response to two ecologists who do not support ecological assessment methods that assign or result in scores or rankings. Please describe why you developed and recommend the functional assessment to prioritize wetland sites.*

Response: We were contracted to develop a method for prioritizing all of the freshwater wetland restoration opportunities in a watershed. By its very nature, prioritization involves ranking, i.e., listing sites in order of their ability to meet certain criteria. Wetlands are valuable to society because of the functions that they perform. The purpose of wetland restoration is to re-create or enhance those functions that have been destroyed or degraded. For these reasons, we decided that the most reasonable way to prioritize restoration opportunities from a scientific perspective was (1) to determine the probability that a given wetland, once restored, could perform each of several key functions; (2) to consider the size of the site and the social significance of each of those functions performed at that site; and (3) to order the sites accordingly.

We chose a numerical approach for assessing functions and for ranking sites simply because it was the most objective, least biased approach that we could think of. Probability is a numerical phenomenon and we were attempting to determine how likely it was (or how probable it was) that a restored wetland would be able to perform a certain function or functions. [Note that we did not propose to estimate the magnitude of the function performed (e.g., amount of floodwater stored) or to compare wetlands on that basis.] We believe that this approach is based on good science and that that is where the prioritization should begin. We envisioned that functional assessment rankings would only be the first step in prioritization of restoration sites. Our intention always has been that these objective results would be combined with information on landowner cooperation, stakeholder inputs, accessibility of sites, projected costs, and other factors to produce a final prioritization of sites.

Restoration Funding

Question: *Is it possible to obtain funding from the development community?*

Response: Although funding from any source is welcome, the goal of this project is to proactively restore wetlands outside of a regulatory context. Therefore, in-lieu fee payments will not be collected from developers to support wetland restoration.

Comment: *Corporations should be solicited to contribute funds for restoration activities.*

Response: A Corporate Wetland Restoration Partnership has been developed in Rhode Island similar to partnerships developed in other states. Local companies might also become interested in supporting restoration projects within their communities.

Comment: *In addition to the technical and planning efforts included in this report, concurrent efforts should be made to appropriate State-legislated funding for freshwater wetland restoration.*

Response: This will be taken into consideration.

Comment: *Ranked lists of sites are an important end-product; they can be used to leverage funds for restoration projects.*

Response: We agree.

Comment: *To obtain the cooperation of landowners, there will probably be a need for financial compensation (e.g., municipal tax abatement or a mechanism for easements).*

Response: This will be considered in future restoration planning, perhaps in conjunction with the RI Habitat Restoration Team.