Association of State Wetland Managers and the
International Institute for Wetland Science and Public Policy

MULTI-OBJECTIVE WETLAND RESTORATION IN WATERSHED CONTEXTS

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PREFACE

This report has been written for state, federal, local and nonprofit organizations that wish to carry out wetland restoration on a watershed or landscape basis. The paper describes a variety of restoration projects, examines selected issues with watershed approaches, and makes recommendations for avoiding problems and achieving successful projects.

Over the past two decades, federal, state, and local agencies, nonprofit organizations, and private landowners have carried out thousands of restoration projects for wetlands, floodplains, riparian areas and related ecosystems. A broad range of articles and books have been written about these projects, which have been carried out in both regulatory (mitigation) and nonregulatory contexts. Most of these projects were implemented on a site-by-site basis, with limited consideration of larger watershed and landscape contexts.

There has been growing interest in recent years in restoration planning and implementation in a watershed context. For example, a 2001 National Research Council Study, *Compensating for Wetland Losses Under the Clean Water Act*, recommended a watershed or landscape approach to restoration. Based in part on this report, federal agencies in December 2002 released the National Wetlands Mitigation Action Plan, which affirmed the goal of no net loss of U.S. wetlands and recommended compensatory mitigation in a watershed context. The Corps of Engineers, in *A Regulatory Guidance Letter* (No 02-2) adopted to implement this plan, also recommended a watershed approach to mitigation.

This shift from a site-by-site to watershed approach raises a number of important questions. What sorts of restoration projects are needed within a watershed context? What should “restoration” mean in a watershed context, and what sorts of goals should be set? Are different goals to be pursued in rural and urban areas? If “no net loss of function” is to occur on a watershed basis, what factors should be considered? What wetland assessment techniques are to be applied? How are socio-economic considerations to be reflected in planning and implementation?

The following paper discusses these and other selective issues with watershed approaches. It is intended to stimulate thinking and discussion. The paper includes a series of restoration cases studies and summaries on restoration needs and opportunities for various types of wetlands. A selected bibliography and list of Web sites conclude the paper.

The paper draws upon a review of restoration sites throughout the nation (more than 1000 total projects), carried out by the author and Mary Bender for the Association of State Wetland Managers (ASWM). The paper also draws on a series of earlier research projects carried out by author for ASWM, including the preparation of the reports: J. Kusler, 2004. Wetlands and Watershed Management: A Guide for Local Governments, ASWM. Berne, N.Y.; J. Kusler and M. Kentulla (eds). 1992. Wetland Restoration and Creation: Status of the Science, Island Press The paper reflects speaker presentations, conclusions and recommendations from wetland restoration national symposia and training workshops, which were conducted by ASWM in Vicksburg, Mississippi; St. Paul, Minnesota; Fairlee, Vermont; Albuquerque, New Mexico;

Plymouth, Massachusetts; Baton Rouge, Louisiana; and Annapolis, Maryland, and involved more than 1,600 participants.

Some of the lessons learned in the United States with regard to watershed-based restoration projects, such as the need for a combination of multi-objective and habitat projects, landscape analyses, getting the hydrology right, monitoring, mid-course correction, and the use of a broad range of implementation techniques, will be applicable in other countries. Multi-objective projects may be particularly important in countries with large populations and small financial and other resources. These countries may need to approach restoration in terms of "wise use" of land and water. For these reasons, this publication will be posted on the Internet. Comments or recommendations from international readers are most welcome.

The comments and suggestions of wetland restoration experts who have contributed case studies and reviewed a portion of these materials is also most appreciated.

Sincerely,

Jon Kusler

ACKNOWLEDGEMENTS AND DISCLAIMER

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Special appreciation is due Mary Bender, Bethann Stewart, and Sharon Weaver who collected background information and worked on this report.

EXECUTIVE SUMMARY

In 2001, a National Academy of Science's study on wetland mitigation (restoration, creation, enhancement) for regulatory purposes recommended that mitigation be carried out in a watershed context. In 2002, the Bush administration released a federal wetland Mitigation Action Plan, which also places strong emphasis upon restoration of wetland functions in a watershed context.

When approaching wetland restoration at a watershed or landscape scale, two types of projects are typically needed to address watershed problems, compensate for new development in the watershed, and restore wildlife and fisheries habitat. Both types of projects have been constructed in urban and rural watersheds, but usually not planned or implemented with a watershed perspective. These two, overlapping types of projects are:

(1) **Habitat-based restoration efforts.** These have been carried out primarily in rural areas. These projects are designed to re-establish waterfowl, fish, and wildlife habitat. Many of these projects have been located in the Prairie Pothole region and along rivers, streams, and the coasts. Most projects have been carried out on a site-by-site basis, with limited consideration of landscape or watershed context. Some have been part of broader waterfowl, fisheries, or other management planning efforts such as the North American Waterfowl Management Plan.

(2) **Multi-objective projects.** These have been primarily implemented in urban or intensively used rural areas. These projects have been designed to provide flood storage, flood conveyance, pollution and erosion control, source water protection, treatment of surface mine waters, or stormwater management, as well as habitat. Many of these restoration projects have been carried out for riverine wetlands and riparian areas adjacent to smaller streams, ponds, and estuaries, and for more isolated wetlands. Most of these projects have also been carried out on a site-by-site basis, although a fair number have also been part of broader flood loss reduction, pollution control, erosion control, stormwater, greenway and other watershed or regionally-based planning efforts.

Pros and cons: Both habitat-related and multi-objective projects are useful and important in watershed contexts that contain developed and rural areas. This is typical of mid-sized and larger watersheds. Each project type requires somewhat different assessment approaches, project designs, and measures for success. Each may be applicable in different regions of a watershed.

Rural, habitat-related projects have a number of important strengths. Construction in rural environments is less expensive, acre for acre, than urban multi-objective projects. Usually regional hydrology is less altered; there is less fragmentation of the resource; and there are often fewer threats to projects from changes in hydrology, water pollution, and exotic species.

Urban, multi-objective projects also have important strengths, although these projects often lack the habitat values of projects in more pristine rural areas. For example:

- Multi-objective projects in urban areas are implemented where the people are, and many water resource problems can be addressed through restoration, such as water pollution, flooding, erosion, and loss of recreation and educational opportunities.

- Multi-objective projects can tap sources of funds not available to habitat-related projects that have a single purpose.
- Multi-objective mitigation projects may help avoid legal problems in urban areas where destruction of wetlands will result in increased flood, erosion, pollution or other nuisances and potential legal liability for both landowners undertaking such activities and the governmental units which authorize them.
- Restoration can help implement land-use plans.
- Multi-objective restoration projects can involve neighborhood groups, restoring hope and encouraging people to plan for the future.
- Multi-objective restoration projects can interconnect economic development and resource function/value.

Multi-objective projects are also important in developed or semi-developed landscapes, where sustainable use is needed and there are few opportunities for outright protection or complete restoration of resources.

Unfortunately, the differing needs of rural, habitat-based projects and more urban, multi-objective projects have not been clearly articulated in guidance concerning wetland restoration. This has resulted in a bias against multi-objective projects. For example, wetland assessment techniques like HGM and IBI consider "functions," but not "goods and services" and "socioeconomic values" which are particularly important in urban settings. These techniques, with their emphasis on relative condition (measured against a standard of the least altered systems), are particularly useful in evaluating and restoring wetland habitat projects. However, they are only partly applicable to multi-objective projects where flood loss reduction, erosion control, water quality protection or recreation may be the major goals and the use of reference standards (defined in terms of natural conditions) is less applicable.

Clarification of the similarities and differences in the types of restoration appropriate in various watershed contexts is needed, along with explanations of the most appropriate assessment methods, measures for success, and implementation techniques for various types of restoration projects.

Watershed-based restoration involving both types of projects is subject to a wide range of data, funding, and other restraints. But watershed approaches hold the potential to improve habitat-based and multi-objective projects in order to achieve a broad range of watershed goals. Success will require:

- Clear definition of restoration planning goals and performance measures to include not only habitat but also water quality improvement, flood loss reduction, and erosion control.
- Recognition of the range of natural resource and socio-economic factors applicable to the identification of priority restoration sites on a watershed basis, including the establishment of mitigation ratios that reflect all factors.
- A clear understanding of the conflicts and compatibilities in goals.
- Use of a broad concept of "restoration" that includes return to natural conditions or improved conditions for multi-objective projects.

- More precise definition of wetland “functions” and “good and services” to apply the no net loss/net gain of function goal to production of services in a watershed context (e.g., flood control, erosion control, pollution control).
- The application of wetland and related aquatic resource assessment techniques to not only assess relative condition (e.g., HGM and IBI models) but also the ability of wetlands to performance specific “services.”
- The consideration of socio-economic factors, such as opportunity and social significance, as well as natural resource functions, in prioritizing wetland restoration sites and in restoration design. This may be assisted though the use of GIS systems or other systems.
- Planning of restoration projects for wetland areas in the context of broader aquatic ecosystems and related riparian and floodplain ecosystems.
- Integration of wetland protection and restoration projects into land and water management strategies and programs.

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PART 1: WATERSHED-BASED RESTORATION: TYPES OF PROJECTS

A WATERSHED/LANDSCAPE PERSPECTIVE

The National Research Council of the Academy of Sciences in a 2001 report, *Compensating for Wetland Losses Under the Clean Water Act*, provided a wide range of recommendations for restoring self-sustaining mitigation wetlands in watershed or landscape contexts. These recommendations are broadly applicable to wetlands. The National Research Council recommended, in part, that individuals proposing restoration projects:

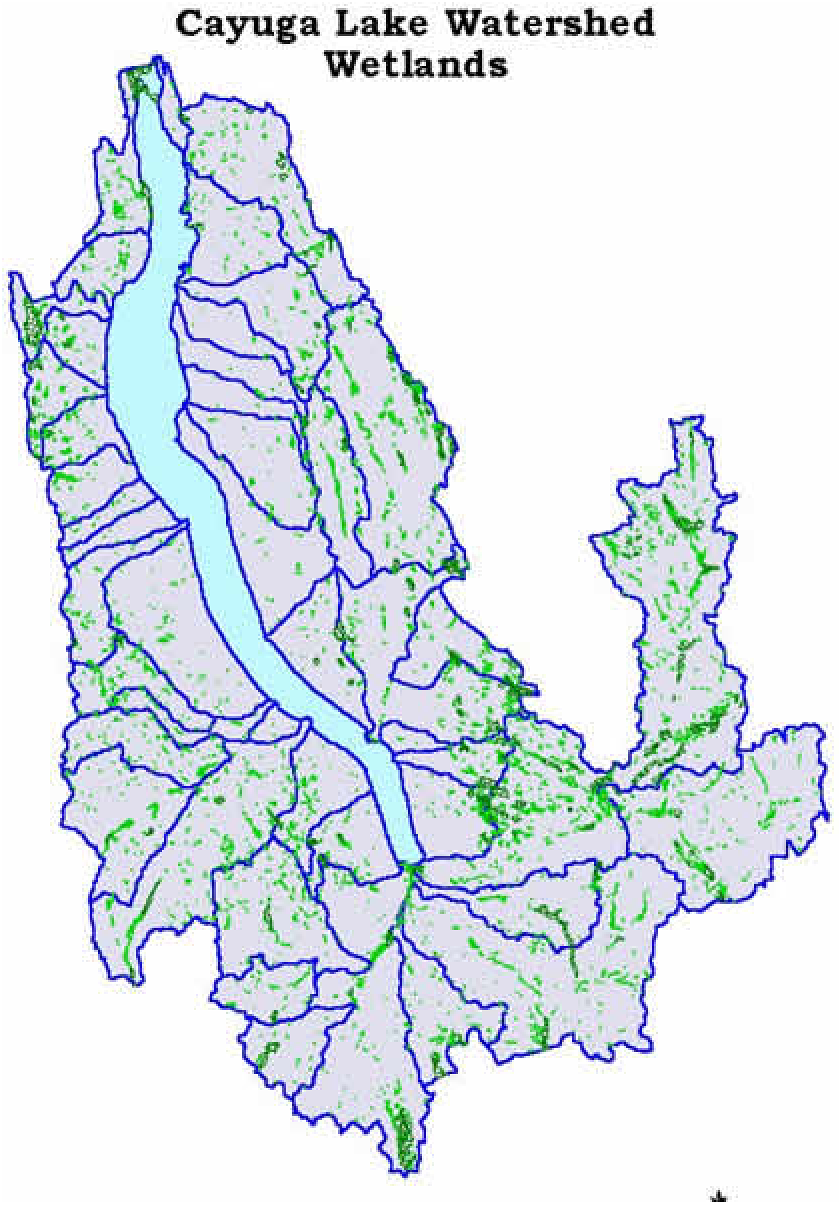
> **Adopt a landscape perspective.** Consider both current and future watershed hydrology and wetland location. Take into account surrounding land us and future plans for the landscape, such as preserving large buffers and connectivity to other wetlands. Build on existing wetland and upland systems. If possible, locate the mitigation site to take advantage of refuges, buffers, green spaces, and other preserved elements of the landscape. Design a system that utilizes natural processes and energies, such as the potential energy of streams as natural subsidies to the system.

The National Academy Report, the Bush administration's National Mitigation Action Plan, and the Regulatory Guidance Letter issued in 2002 by the Corps of Engineers in response to the National Academy Report, stress not only a landscape perspective, but also the achievement of the goal of "no net loss of the Nation's wetlands" (Mitigation Action Plan, 2002); more specifically, to "ensure effective restoration and protection of the functions and values of our Nation's wetlands" (Mitigation Action Plan, 2002). The achievement of no net loss and net gain of wetland functions and values is an important goal for restoration on a watershed or landscape basis.

The watershed concept is not new, nor is the recognition that many wetland "functions" or "services" depend on landscape or watershed concept (see Box 1 for examples). What is new is the acknowledgement that many wetland restoration projects fail when landscape and watershed perspectives are not reflected in the project's location and design. The growing body of digitally-based information enhances the analysis of wetlands in the watershed context. Data sources include: satellite imagery, digital aerial photography, flood maps, wetland maps, topographic maps, geologic maps, land cover information, and parcel ownership, among other types of information. What is also new is a commitment by federal agencies and many state and local agencies to analyze, manage, and restore wetlands in watershed or landscape contexts.

CHALLENGES

There are many challenges to wetlands restoration or management on a watershed basis. How is "restoration" defined? How large a watershed should be considered? How is watershed or landscape-based analysis to occur where there is limited hydrologic information available and little time or funds to generate such data? What are the watershed restoration goals, and who



Wetlands are increasingly inventoried as part of watershed studies. This is Cayuga Lake Watershed, New York. Source: http://www.gflrpc.org/Cayuga%20Lake/RPP/caywetland.htm defines them? What wetland assessment techniques are most appropriate? What restoration implementation techniques (breaching of levees, filling of drainage channels, etc.) are most appropriately in specific circumstances? How is watershed-scale implementation to take place for landowner incentive programs where much dependents on landowner initiatives (e.g., Wetland Reserve program), and the grant-in-aid, technical assistance, or regulatory agencies have limited control over the location and design of projects?

Further, if no net loss of function is to occur on a watershed basis, how is "function" to be defined? How are functions to be measured? Will "functional values" and socioeconomic values be considered? If so, how? If not, why not?

There are no simple answers to these questions. Implementation of watershed approaches to restoration will take time and commitment of financial resources. Management-oriented research is also needed to better establish the effectiveness of watershed restoration techniques and designs because much remains unknown about the effectiveness of various restoration and impact reduction approaches.

Nevertheless, restoration experience over the last two decades suggests that consideration of the broader hydrologic regime and landscape context can reduce restoration, creation, and enhancement failures; can help integrate wetland restoration with river and steam, lake, estuary, coastal water, floodplain and riparian area restoration; and can help integrate wetland protection and management with broader land and water management. See case studies cited below.

Box 1
Examples of Interrelationships Between
Watershed Contexts and Specific Functions/Values

Many wetland functions and values depend largely on a wetlands watershed and landscape context and only partly on the internal characteristics (within wetland boundaries). Examples include:

Flood Storage. Flood storage of a riverine wetland depends on the flood characteristics of the river or stream, and the size and the relationship of the entire wetland depression, including any berm or rim around the wetland, to adjacent waters. Protection of the wetland alone will not protect much of its flood storage unless the topographic contours of the entire depression are also protected.

Flood Conveyance. Flood conveyance of a riverine wetland similarly depends on the flood characteristics of the entire river or stream, the topographic contours of the wetland, the area on both sides of the river or stream capable of conveying flood flows, and the vegetation.

Pollution Prevention and Control. The pollution prevention and control capabilities of a wetland depend on the overall surface water runoff regime, including flows from upland areas to lakes, streams or estuaries, the position of a wetland in this regime, and a wetland's connections (or lack of connections) to these waters, soils, and vegetation.

Fisheries. Wetland fisheries depend not only on the characteristics of the wetland, but also whether it is connected to a larger water body where fish live, feed, and breed, and the fisheries habitat characteristics of this larger water body.

Waterfowl. Waterfowl breeding and feeding in wetlands depends on whether the wetland is adjacent to a lake, river or stream, and the wetland's location in relationship to other wetlands for feeding, nesting, or resting.

Song Bird Habitat. Bird habitat depends on the adjacent buffer and upland areas, since many bird species nest in upland areas and use wetlands for feeding.

Mammal Habitat. The use of wetlands by raccoons, bears, deer, moose, mountain lions, and other mammals that use wetlands for feeding and water depends on adjacent upland habitat and the adequacy of the connections between wetland and upland habitats and other wetlands and waters.

Reptile and Amphibian Habitat. The use of wetlands by reptiles and amphibians for breeding and as habitat depends on adjacent upland habitat and the adequacy of connections between the upland and wetland habitat, since many reptiles and amphibians spend only a portion of their life cycles in wetlands.

Recreational Uses. The recreational use of wetlands by boaters and paddlers depends on the proximity of the wetland to open water and the ability of the boaters or paddlers or to enter and exit the wetlands.

TYPES OF PROJECTS

What types of restoration projects are needed in watershed contexts?

In 1989, the National Wetland Policy Forum recommended dual national goals of achieving no net loss of wetland functions and values, and achieving a net gain of functions and values over time (Forum, 1989). President Bush, Sr. endorsed these goals in l989, as did President Clinton in 1995, and President Bush, Jr. in 2002.

Since 1989, tens of thousands of wetland and related ecosystem restoration projects have been undertaken. Much of this restoration has occurred in nonregulatory contexts. However, the 2001 National Academy of Sciences report referenced above (National Academy, 2001), found that between 1993 and 2000 the U.S. Army Corps of Engineers permitted, through the Section 404 program, approximately 24,000 acres of wetlands to be filled, with 42,000 acres required as compensatory mitigation on an annual basis. Restoration is also occurring at state and local levels in regulatory mitigation contexts.

Regulatory mitigation and nonregulatory restoration projects may be divided into two overlapping categories which differ somewhat in terms of goals, planning and design, maintenance and operation needs. A watershed or landscape perspective benefits both categories.

Rural, Habitat-Oriented Restoration Projects

In the last two decades, thousands of habitat-oriented restoration projects have been carried out, primarily in rural areas. The goal of most of these projects is to restore waterfowl and other wildlife habitat. Many projects involve restoration of drained agricultural lands, including thousands of Wetland Reserve (Farm Bill) projects. These efforts have often involved crushing drain tiles, filling drainage ditches and/or constructing small, water control structures.

Rural, habitat-oriented restoration projects include almost all of the more than 200 "mitigation banks." Such banks are intended to compensate for damage to wetlands in urban areas. Mitigation is often proposed at rural sites because it is much less expensive to restore wetlands at rural rather than urban sites. In addition, it is often possible to better restore habitat values where there are fewer threats from pollution, sedimentation and changing hydrologic regimes. The 2001 National Academy of Sciences report, *Compensating for Wetland Losses Under the Clean Water Act*, recommended that " (a)ll mitigation wetlands be self sustaining." The National Mitigation Action Plan of 2002 further supports this goal.

Most rural wetland restoration projects are habitat-oriented. *Source: Smithsonian Environmental Research Center. http://www.serc.si.edu/migratorybirds/breed_wetland_birds.htm*

Protection and restoration of plant species like this Purple Fringed Orchid is a goal of the Cache River, Illinois Restoration Project. NRCS is helping to protect and restore more than 9,000 acres in this project, primarily through the Wetland Reserve Program.
Source: www.nrcs.usda.gov/programs/wrp/states/usccess_il.html

Many rural restoration projects are also partially, multiobjective. Duffy's Marsh multiobjective wildlife habitat and flood reduction project, Wisconsin can hold 55 million cubic feet of water and well as meet habitat goals. Source: NRCS.
http://www.nrcs.usda.gov/programs/wrp/states/success_wi.html

Multi-objective Restoration Projects

A second type of project has also been undertaken — multi-objective restoration, creation and enhancement projects. As the name suggests, these projects are typically designed to serve a variety of objectives, which include, but are not limited to, habitat restoration. Other main objectives include: stormwater management, flood loss reduction, sediment and pollution control, improvement of water quality, recreation, education, and production of natural or man-made crops, such wild rice and timber. These projects are most common in urban and urbanizing areas. Some of these projects have also been undertaken for intensively-used rural landscapes (agriculture, forestry, mining).

Many multi-objective projects involve wetland creation or enhancement, as well as restoration. Active management of restored wetlands, such as control of water levels and control of exotic species, is quite common. Often, there is no attempt to return the restored wetland to a natural condition, but rather to an improved condition, defined in terms of project goals (e.g. construction of a small dam in drainage ditch to improve stormwater storage). These projects have often been carried out as part of larger stormwater and flood control projects, greenways and open space acquisition projects, park and recreation projects (including ecotourism) and rehabilitation of gravel pits and strip-mined areas. They also include many partially restored, partially constructed wetlands used for tertiary treatment of sewage.

Multi-objective projects are quite often designed to remedy or prevent specific problems**,** which may or may not have to do with habitat, such as flooding and water quality. For example, the Massachusetts Restoration and Banking Program in the Neponset River Watershed Wetlands Restoration Plan identified potential restoration sites by addressing three questions:

- What are the problems in the watershed related to flooding, water quality, fish and wildlife habitat that might be improved through wetlands restoration?
- What are the opportunities for restoration in each town?
- Which restorable wetland sites have the greatest potential to increase flood storage, improve water quality, and enhance fish and wildlife habitat?

As one would expect, multi-objective projects often do not compare favorably with rural-based habitat projects in regard to restoration of habitat for sensitive wildlife species. But, they do provide habitat for some species and may be important for urban flood control, water pollution control, erosion control, stormwater management, education, water supply, and recreation and other “services.”

Most wetland restoration projects in urban areas like this pond with a fringe in Portland, Oregon are multiobjective and are designed to meet water quality, birdwatching, flood and stormwater storage as well as habitat needs. Source: EPA and USGS *http://water.usgs.gov/nwsum/WSP2425/images/fig56.JPEG*

The acquisition and protection of these Charles River wetlands near Boston was to achieve multiobjective flood loss prevention as well as habitat protection.
Source: *http://www.nae.usace.army.mil/recreati/crn/crnpbm.htm*

THE NEED FOR BOTH TYPES OF PROJECTS

From a watershed perspective, both habitat-oriented and multi-objective restoration projects are needed to address specific issues. Neither type of project is intrinsically better or worse. However, each has different requirements, which must be recognized. Part 2 will provide more detailed examples of both types of projects. Parts 3, 4, 5, 6 will examine some of the differences and similarities in both types of projects.

Box 2
Examples of Problems or Issues
Prompting Multi-objective Restoration Efforts

Inadequate Water Supply

- Falling ground water levels
- Inadequate quantity of surface water for domestic, industrial and other uses
- Water disputes among landowners, governmental entities
- Fish kills, other loss of wildlife or habitat due to inadequate flows, low water levels in rivers, ponds, lakes, streams

Repeated and Serious Flood Damages

- Disaster or flood insurance payments
- Residences, commercial activities, other activities subject to frequent flooding
- Loss of life
- Loss of jobs or serious “down time” for economic activities
- Repeated damage to public works (roads, sewer and water)
- Threats to levees, dams, etc. due to increased flood heights cause by watershed activities
- Liability law suits

Erosion and Sedimentation

- Reservoirs, lakes quickly filling with sediment
- Erosion threatening bridges, infrastructure
- Streambed and bank erosion threatening residential, commercial, industrial, agricultural, other activities
- Breach of barrier islands, destruction of beaches
- Coastal land loss (e.g., Louisiana) due to sediment deprivation

Pollution

- Algae blooms in lakes, streams, and estuaries due to excessive nutrients in water
- Fish kills
- No fish or shellfish, or fish with high levels of contaminate
- High coliform levels, limiting swimming, water skiing, or other water sports, and domestic water supplies
- High level of toxics in waters threatening fish, wildlife, domestic water supplies
- Loss of waterfowl, other birds, amphibians, etc.
- Abandoned lands (e.g., Superfund sites, dumps)

Loss of Wildlife and Wildlife Habitat

- Loss of endangered and threatened species of all types
- Loss of biodiversity

Loss of Community Heritage, Cultural and Aesthetic Values

- Archaeological values
- Biodiversity
- Ecotourism
- Education, interpretation
- Recreational use
- Natural views, open spaces

PART 2: TYPES OF PROJECTS

HABITAT-BASED PROJECTS

A wide variety of habitat-based restoration projects have been constructed in the last two decades. Some examples include:

1. Wetland restoration projects in national, state, and local wildlife refuges with habitat protection and restoration as a primary goal.

Many National Wildlife Refuges contain large acreages of restored wetlands, such as Quivera Refuge in Kansas, Bosque del Apache Refuge in New Mexico, Montezuma Refuge in New York, and Horicon Refuge in Wisconsin. Waterfowl production is an important goal for many refuges but this goal has broadened over the last decade to emphasize multispecies management. Refuge wetland restoration projects are often intensively managed to control water levels, vegetation, exotic and dominant species (e.g., cattails).

2. Public land management in parks, national forests, and on other public lands.

Many wetland restoration projects have been undertaken as part of broader public land management (e.g., U.S. Forest Service, Bureau of Land Management, Bureau of Reclamation). A number of large wetland restoration projects have been underway to help protect or restore the ecosystems of national parks and monuments, for example, the massive restoration effort underway for Everglades National Park in Florida. Unlike restoration of the wildlife refuge wetlands, however, habitat protection and restoration of wetlands is often a component of broader public land management to serve a diverse range of goals.

3. Restoration as part of waterway maintenance projects.

The Corps of Engineers, Bureau of Reclamation, and their state counterparts have undertaken many habitat restoration projects as part of maintenance dredging, dredge spoil disposal, and dam, dike, levee, and channel maintenance projects. These are also, typically, multiobjective although habitat restoration is the major goal.

4. Restoration on lands owned or managed by environmental nonprofit organizations, such as the Nature Conservancy, Ducks Unlimited, Trust for Public Lands, duck clubs, and local land trusts.

Almost all of these wetland restoration projects by not for profit organizations are primarily habitat-related, although there are exceptions, such as Jackson Bottoms wetland restoration in Oregon, which serves multiple objectives.

5. Restoration of partially drained agricultural lands on private property

Most Wetland Reserve and Partners for Wildlife projects on private lands have been primarily designed to replace habitat, although some are also are designed to reduce water pollution, provide water-based recreation and ecotourism, among other goals. There are thousands of these projects.

6. Coastal wetland restoration

The primary objective for most of coastal and estuarine restoration projects is habitat restoration, although some, like the Louisiana coastal and estuarine projects, are designed to reduce land loss, flooding and erosion as well.

7. Mitigation banks

Most of the more than 200 mitigation banks have been constructed in rural areas, with habitat restoration as the major goal.

8. Some onsite mitigation projects

Many onsite mitigation projects in urban and rural areas are at least partially designed to replace lost habitat. Others have erosion control, flood loss reduction, stormwater management, or other multi-objective goals.

MULTI-OBJECTIVE PROJECTS

Of the many types of multi-objective projects that have been constructed in the last two decades, examples include:

1. Streambank and riverine wetland restoration projects to prevent/remedy flood and erosion losses, and enhance fisheries

Tens of thousands of restoration projects have been carried out for small and mid-sized streams to address bank erosion and meander, loss of fish habitat, and sedimentation problems, and to serve pollution control and water supply protection. The most common projects involve re-meandering stream reaches and bioengineering of stream banks. One example of a large-scale project is the Kissimmee River Restoration Project.

River and stream restoration projects involving both some "hard" and "soft" engineering including re-meandering and bioengineering are now common throughout the nation. This is stream restoration in Pennsylvania.

2. River/wetland restoration in a post-disaster context to reduce flood and erosion losses, provide habitat, meet other objectives

Many wetland and riparian restoration projects have been constructed after flood disasters to reduce future flood losses, as well as to provide habitat and improve water quality, among other objectives. Floods can cause serious damage to houses, bridges and other infrastructure, and erode stream banks and overtop levees. Restoration of stream, wetland and riparian areas is often possible as part of flood recovery. Landowners may wish to leave the floodplain at this time and disaster assistance funds can be used, in part, to undertake restoration. Major projects were initiated along the Mississippi and Missouri rivers after the Great Flood of 1993 (see Appendix B). Many stream restoration projects have been carried out after severe flooding in states like Vermont.

Louisa 8 (Horseshoe Bend) restoration project. This 2,606-acre tract on the Iowa River in Iowa was purchased by the and the Fish and Wildlife Service with funding support from NRCS after the Great Flood of 1993. Source: http://midwest.fws.gov/portlouisa/info/horseshoebend.htm

3. Delta restoration in a context of sea level rise and subsidence to prevent land and erosion loss, and to provide habitat

A variety of restoration projects are underway for delta wetlands to address sea level rise, subsidence, flooding, erosion and land loss. The largest and most extensive projects are being carried out for the Mississippi Delta. Other projects are underway for the Sacramento Delta and the deltas of many smaller rivers in southern California, Oregon, Washington state and New England. Restoration is particularly challenging where sediment deprivation is taking place due to upstream reservoirs. Some of these projects involve freshwater and sediment diversions (e.g., Carnarvan project in Louisiana) and diking coastal wetlands.

4. Dam removal to reduce threats to safety, increase fish passage, improve water quality and wetland habitat

The goal of most of these projects is to reduce threats to health and safety from collapse of dams during floods. Habitat improvement, by allowing the migration of fish and other species, and recreation benefits is another major goal. These projects may however also reduce the size of wetlands formed in and along the margins of reservoir pools.

5. Restoration of bottomland hardwoods and other forested wetlands to provide sustainable forestry, enhance habitat and improve water quality

Some restoration projects are underway for forestry and agricultural landscapes along the lower Mississippi to enhance timber production, restore habitat values, reduce pollution, provide water supply and provide ecotourism opportunities. These include restoration projects like the Savannah River Restoration project and many projects in Louisiana.

6. Restoration of partially drained agricultural lands on private lands to address water quality, other problems

Many restoration projects are being constructed on agricultural lands in the mid-West to intercept and reduce agricultural runoff. These projects are often multi-objective and serve wildlife as well as pollution prevention goals.

7. Retrofitting of stormwater management facilities

Hundreds of stormwater detention facilities have been retrofitted as wetlands to provide flood storage and treat water quality, as well as to meet some habitat goals.

8. Restoration or a combination of retoration/creation to treat municipal, domestic or industrial wastes

Municipalities have constructed hundreds of restoration/creation projects to provide tertiary treatment of sewage and to create habitat. Examples include Lakeland, Florida and Jackson Bottoms near Portland, Oregon. In the West, cities like Phoenix are using stormwater and treated effluents to restore wetlands and riparian systems. However, some of these projects are controversial because of their poor water quality. Wildlife may be attracted to these wetlands and then threatened by water contaminants.

9. Restoration to restore gravel pits or treat mine wastes

Many wetland restoration projects have been constructed to help restore gravel pits and strip-mined areas and to treat mine wastes, in addition to restoration of habitat. An example is the Des Plaines River wetland restoration project near Chicago (old gravel pits).

10. Onsite mitigation projects to address stormwater issues, reduce pollution, reduce flood and erosion hazards, and provide habitat

Thousands of small wetlands are being constructed as part of residential subdivisions and commercial developments to temporarily store and treat stormwaters. These wetlands can reduce flood and erosion losses, and provide some wildlife habitat.

11. Wetland restoration and ecotourism

Wetland restoration to enhance ecotourism and bird watching, as well as provide habitat, has taken place in some locations such as the Everglades, Corkscrew Swamp, and Saco, New Brunswick.

12. Wetland restoration/creation for educational and research purposes

Many universities and high schools have restored or created wetlands for education and research, such as the Virginia Institute for Marine Sciences restoration wetland and the Ohio State University Olentangy wetland restoration project. Some zoos, such as Brookfield Zoo in Chicago and the National Zoo in Washington, have also created and restored wetlands for educational purposes.

Olentangy Multiobject Education Site, The Ohio State University
Source: http://swamp.ag.ohio-state.edu/images/orwbirview97.jpg

PART 3: SOME STRENGTHS AND WEAKNESSES OF HABITAT-BASED AND MULTI-OBJECTIVE PROJECTS

Some strengths and weaknesses of **rural, habitat-based projects** include:

Strengths:

- They provide more effective restoration of sensitive habitats than multiobjective projects.. More specific reasons for this are described below.

- They are often less expensive per acre than multi-objective urban projects because land values in rural areas are lower and restoration often involves low cost measures, such as blocking drainage ditches.

- They have often fewer conflicts in goals.

- They are subject to fewer threats from adjacent land uses.

- Rural hydrology is often less impacted by impervious surfaces, roads, ditches and intensive land uses.

- Some habitat-based projects require less interdisciplinary expertise because they are simpler than multi-objective projects.

- They may be more effectively evaluated in terms of relative condition (e.g., HGM and IBI assessment models) with the use of an unaltered wetland reference standard.

On the other hand, **rural, habitat-based projects** are also often subject to a number of limitations in meeting watershed restoration needs, such as:

- Destruction of a wetland at an urban site with replacement of a "habitat" wetland many miles away has quite different public interest and legal implications than replacement at the original site. For example, a public or private landowner who drains a wetland and increases flooding on another landowner may be legally liable to the damaged landowner. See, for example: Hendrickson v. Wagners, Inc. 598 N.W.2d 507 (S.D., 1999) (Injunction granted by the court to require landowner who drained wetlands with resulting flooding of servient estate to fill in drainage ditches); Boren v. City of Olympia, 112 Wash. App. 359, 53 P.3d 1020 (Wash. 2002) (City was possibly negligent for increasing discharge of water to a wetland which damaged a landowner); Snohomish County v. Postema, 978 P.2d 1101 (Wash. 1998) (Lower landowner had potential trespass action against upper landowner who cleared and drained wetland); Lang et al v. Wonnenberg et al, 455 N.W.2d 832 (N.D., 1990) (Court upheld award of damages when one landowner drained a wetland resulting in periodic flooding of neighboring property).

In some instances, the government agency permitting an activity that damages other property may also be liable. For example, in Hurst v. United States, 739 F. Supp. 1377 (D.S.D. 1990) the U.S. Army Corps of Engineers was successfully sued by private landowners for flood and erosion damage that resulted from the Corps' issuance of a Section 10 and 404 permit for construction of jetties in a river. The court held that the Corps had negligently supervised the project and failed to issue a prohibitory order to prevent the activities causing the flood and erosion damage. See also Annot., "Liability of Government Entity for Issuance of Permit for Construction Which Caused or Accelerated Flooding," 62 A.L.R.3d 514 (1975) and many cases cited therein. See, for example, Cootey v. Sun Inv., Inc., 690 P.2d 1324 (Haw.App. 1984) in which a Hawaii court held that a county may be liable for approving a subdivision with inadequate drainage: "(I)n controlling the actions of a subdivider of land, a municipality has a duty not to require or approve installation of drainage facilities which create an unreasonable risk of foreseeable harm to a neighboring landowner, and where a breach of that duty is established, a municipality may be held liable for consequential damages." Id. at 1332. See also City of Columbus v. Smith, 316 S.E.2d 761 (Ga.App. 1984) (City may be held liable for approving construction project resulting in flooding); Pickle v. Board of County Comm'rs of Platte, 764 P.2d 262 (Wyo. 1988) (County had duty of exercising reasonable care in reviewing subdivision plan).

- Habitat-based projects may benefit rural ecosystems, but this benefit may be at the expense of urban ecosystems if restoration is undertaken in a rural area to compensate for permitted damage or destruction in an urban context.
- Habitat-based projects in rural areas are often less accessible to the public for recreation, bird watching, nature study, research and other public uses than multi-objective projects in urban areas.

Destruction of wetlands which store flood waters at one site and restoration at a separate, distance site will often result in flooding of adjacent lands at the original site and potential legal liability. Source: http://sjr.state.fl.us/programs/outreach/pubs/streamln/02fall/images/flooding.jp

MULTI-OBJECTIVE PROJECTS

Some of the strengths and weaknesses of **multi-objective projects** include:

Strengths:

- Multiobjective projects are often constructed where the most serious watershed problems exist. It is in the urban and intensively-used rural areas that much of the water pollution occurs due to septic tanks, industrial and commercial pollution, and stormwater runoff. This is where the most serious flood problems occur due to increased runoff from impervious surfaces, many fills and other constrictions in flood conveyance areas, destruction of flood storage, and the location of many buildings in flood hazard areas. Serious erosion is often a problem at construction sites and along erodible stream banks. The people who live in the urban areas also seek nearby outdoor recreation, bird watching, education and other opportunities that wetlands provide.

- Multiobjective projects can often become a cost effective part of urban public works engineering. It is often less expensive for communities to bioengineer eroding stream banks than to repair them with concrete or riprap. It is often less expensive to retrofit or design stormwater facilities as wetlands than to treat polluted stormwaters. It may be less expensive to restore or create wetlands and to provide tertiary treatment of domestic wastes than to use traditional sewage treatment measures.

- Multi-objective projects can tap sources of funds not available to habitat-related projects with a single purpose. For example, some traditional stormwater management detention areas constructed with stormwater funding have been retrofitted as wetlands to improve water quality using infrastructure funding. In some instances, restoration of rivers and riverine wetlands has involved the removal of damage prone development from the floodways, like that which occurred along the Mississippi River and its tributaries after the Great Flood of 1993 when more than 30,000 structures were acquired and moved out of the floodplain with post disaster funds.

- Multiobjective projects can help urban planners achieve not only flood loss reduction and erosion control goals, but also to create greenway, recreational opportunities and open space.

- Restoration has a social dimension. The possibility of restoration projects for wetlands and streams in urban, low-income areas has encouraged people to think about other ways to improve their lives. There have been hundreds of stream restoration efforts implemented in poor neighborhoods such as Berkeley, California and San Antonio, Texas.

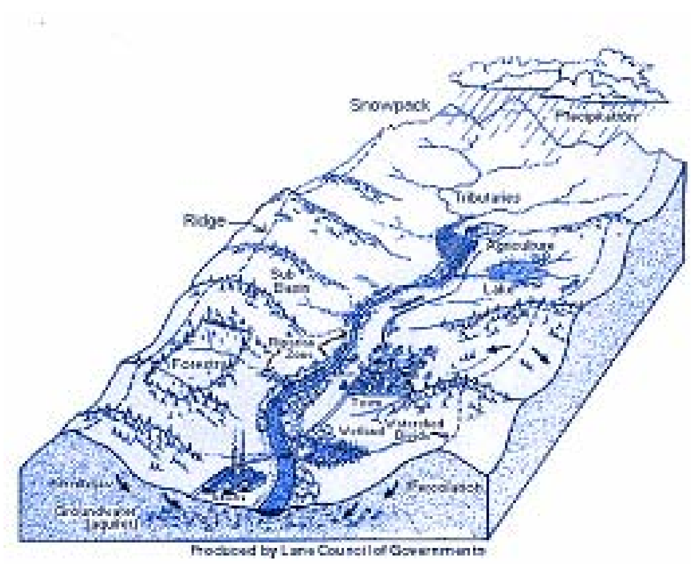
- Multi-objective restoration projects can mesh economic development and resource function/value. For example, Indigenous Peoples can grow and harvest wild rice for domestic consumption and sale while, at the same time, achieve waterfowl and other habitat objectives. This is consistent with “sustainable use” concepts.

- Multiobjective projects are particularly useful in helping to protect and restore urban stream, river and drainage corridors. Such protection can often serve a broad range of goals (see Box 3).

Box 3
Benefits of Protecting and Restoring River, Stream, Drainage Corridors

Protection of rivers, stream and drainage corridors, including adjacent wetlands, floodplains, and riparian areas can:

- **Protect flood conveyance along rivers and streams**
- **Reduce damage from stream bank and coastal erosion**
- **Store and slowly release flood and stormwaters**
- **Reduce development in flood-prone areas**
- **Reduce the amount of nonpoint source pollution (sediment, nutrients, chemicals, debris) reaching rivers, lakes and streams from upland sources**
- **Provide wildlife habitat and corridors**
- **Provide shade to reduce the temperature of water in rivers and streams**
- **Provide outdoor recreation opportunities**
- **Link neighborhoods and protect the beauty and quality of life of communities**



Riverine wetlands and corridors in a watershed context
Source: Lane Council of Governments
http//www.epa.gov/owow/watershed/whatis.html

Weaknesses: Multi-objective projects are also subject to a number of limitations, for example:

- They usually do not restore wetlands to a natural condition and are no substitute for wetland protection or habitat-oriented restoration projects. They often need to be combined with rural habitat restoration projects to compensate for wetland habitat and other losses in urban areas.

- Project goals may be conflicting. For example, a habitat restoration project designed as a stormwater detention pond may become toxic to wildlife due to the concentration of pollutants.

- Control of exotic weeds, removal of silt, replanting, and other management activities may be needed on a long-term basis. Unfortunately, developers often do not wish to provide long- term management for mitigation projects.

- Hydrologic changes, due to changes in watershed vegetation and development, results in some restored wetlands becoming too wet or too dry over time and the failure to achieve project goals.

- Invasive and exotic species take over a wetland. Some multi-objective restoration projects have been quickly overgrown by species such as Phragmetes or Melaleuca.

The Role of Watershed Planning/Management

Watershed data gathering, analysis, and planning approaches can help identify and prioritize both potential rural habitat and urban multi-objective restoration projects throughout a watershed context. Suggested elements of such an approach are set forth in Box 4. Selected elements will be discussed in greater depth in Part 4.

Box 4
Suggested Elements of a Watershed-Based Approach to Wetland Restoration

Watershed-based restoration efforts involving both habitat and multiobjective projects may best involve the following elements:

- **Define watershed boundaries.** Use USGS Maps, topographic maps, air photos.

- **Identify present wetlands in the watershed.** Use National Wetland Inventory maps, state wetland maps, air photos.

- **Identify historical wetlands in the watershed.** Use soil maps, time series air photos (if available), NWI maps, USGS planimetric and topographic maps, other historical information.

- **Identify present and anticipated land and water uses in the watershed.** Use air photos, zoning maps, state or local GIS (if available).

- **Identify habitat problems in the watershed that might be addressed through restoration.**
  - Loss of particular types of habitats throughout the watershed
  - Pollution, encroachments, other threats to endangered and other species
  - Fragmentation of wetlands
  - Loss of buffers

  Use existing sources of information, public hearings, field surveys:

- **Identify non-habitat problems in the watershed that might be addressed through restoration, such as:**
  - Flooding
  - Habitat loss
  - Water pollution
  - Source water
  - Recreation loss

- **Determine overall watershed hydrology and likely changes in hydrology.** Where is the water coming from? Where is it going? How will hydrologic regimes change? Accurate information is usually not available and may be very expensive to develop. Nevertheless, even approximate information based on overall rainfall, slope, soils and vegetation may be helpful.

- **Identify potential habitat and multiobjective wetland restoration sites on a preliminary basis.** Combine information from above steps. In addition, use soils maps, flood maps, topographic maps, air photos, and other sources of applicable information.

- **Evaluate and prioritize potential restoration sites in terms of potential for addressing habitat losses and achieving other watershed goals.** Relevant factors may include:
  - Severity of problems addressed
  - Ease of restoration
  - Cost of restoration
  - Land ownership and willingness of landowners to undertake restoration
  - Presence or absence of buffers
  - Number of people who might benefit and how
  - Connectivity or fragmentation
  - Condition
  - Existing and likely adjacent uses

- **Once priorities have been identified, develop more refined profiles and plans on potential sites**

- **Find funding**

- **Implement plans through the application of a variety of techniques (e.g., regulatory programs, tax incentives, easement programs, etc.)**

PART 4: SELECTED ELEMENTS OF A WATERSHED APPROACH

Part 4 examines in greater depth selected issues or elements of a watershed approach involving both habitat-based and multi-objective projects.

CONSIDER HYDROLOGY

Knowledge of watershed hydrology is critical to the selection of restoration sites and the design and implementation of both habitat and multi-objective projects. Too often wetland restoration efforts have not considered the watershed context, resulting in project failures and failure to achieve pollution control, flood loss reduction, and habitat objectives. Some critical questions that need to be addressed on each potential restoration site include: Where is the water coming from? Where is it going? How much or little water will there be at a site over time? What fluctuations occur in water levels and velocities? What changes in hydrologic regime are likely due to urbanization or other factors? What is the quality of the water? How much sediment does it contain? What role will erosion and sedimentation play?

The feasibility of considering regional hydrology in siting restoration projects and in project design and implementation varies. Watersheds range in size, shape, topography, hydrology, soils and geology, climate, remaining and destroyed wetlands, degree of urbanization, and many other features relevant to restoration. The Nation Research Council refers to a watershed as “the land areas that drains into a stream or other water body” (National Academy 2001). Watersheds vary in size from a few acres or less, which may be quite easily analyzed, to the huge Mississippi River watershed, which is not only large, but also characterized by extremely complex hydrology.

Getting the hydrology “right” is essential to all restoration efforts.
Source: Desplaines River Restoration site.
http://water.usgs.gov/nwsum/WSP2425/images/fig56.JPEG

Hydrologic analyses may take place "upfront," on a site-specific basis, or through a combination of approaches which include:

- **Upfront watershed inventories and plans**

  Up front identification of potential restoration sites can be based on stream flow records, precipitation records, ground water records, tide records, lake level records, soils, vegetation, and other sources of information (see discussion below). Such inventories can also help guide the location and design of restoration projects throughout a watershed. Upfront inventories offer advantages in providing a larger context for analysis and more predictability to landowners and agencies. However, they are expensive, time-consuming and of little value if the relevant hydrologic and other types of information are not available. In addition, upfront inventories must often be tailored to land ownership and political boundary needs, as well as hydrologic system requirements. Some measure of supplemental, case-by-case watershed analysis is usually needed for project design, even when data gathering and planning has taken place, because there are practical limits to the detail of upfront surveys.

- **Case-by-case analyses for individual projects**

  A second watershed approach to restoration considers site-specific and broader context hydrology as individual projects are proposed. A project proponent, a reviewing regulatory agency, or a technical assistance/granting agency analyzes each project, taking into account the watershed considerations discusses earlier. However, investigating both site specific and regional hydrology is often difficult with the budget, time and other restraints of a case-by-case approach. This is particularly true for projects in regulatory contexts. Despite limitations, even case-by-case hydrologic analysis can improve the design and success of projects.

Watershed analyses may occur at a variety of scales and in a variety of contexts (see Box 5 for examples).

Box 5
Applying Watershed Analyses

The scales and foci of watershed analysis are typically determined by scientific and institutional considerations, such as land ownership and community boundaries. Scientifically, watershed analysis should be applied on a watershed basis. However, practical considerations often require that some combination of watershed-scale analysis and landowner- or government unit-scale analysis.

- **Parcel focus.** The land parcel is the typical assessment and planning unit for a private or public landowner. Detailed analysis of the quantity and quality of water falling on the parcel, and entering and running off a parcel is needed for stormwater planning and management, soil and water conservation planning, wetland assessment, and wetland restoration. Parcel-level analysis also needs to take place within an overall hydrologic and ecological framework because the parcel typically does not coincide with the entire runoff area.

- **Specific water body/wetland focus.** A second common focus for analysis is a specific water body (wetland, river, stream, lake, pond.) and its watershed area. The watershed for a specific water body or wetland includes all of the lands providing runoff or groundwater flow. It may include hundreds of acres to hundreds or thousands of square miles. Determination of the quantity and quality of water entering and running off a watershed is undertaken in community stormwater management, floodplain management, lake protection and restoration, estuarine protection and restoration, source water planning, and nonpoint and point pollution control efforts. These studies may be of considerable value in wetland restoration as well.
- **Community-wide focus.** Community-wide watershed analysis is also quite common. Assessing the quantity and quality of water entering and running off of community lands typically requires analysis of a number of subwatersheds. The scale of watershed and subwatershed analysis depends on the application and situation, but generalized analysis are usually undertaken because of limitations on funds and staff. More detailed analysis may take place for specific areas within a community that have special problems or special resources (e.g., a pristine lake).
- **Regional, state, basin wide focus.** Large-scale hydrologic analyses have also been undertaken on a regional or state basis for some areas. For example, all states have inventoried their waters from pollution and source water perspectives. The quantity and quality of water entering and running off of a state or region also requires analysis of subwatersheds. The scale of analysis also depends on the application. Typically, only general analysis is possible on a region, state, or basin focus. However, more detailed analysis may take place for particular problems or special resource areas.

CONSIDER OTHER LANDSCAPE/WATERSHED VARIABLES

As noted above, consideration of hydrology is absolutely critical to both habitat-based and multi-objective and projects. But, other factors related to landscape context need to be considered as well. As suggested by Box 1, wetland functions and values depend on the broader ecosystem, adjacent land uses, presence of absence of buffers, the topography and soils of adjacent lands, adjacent vegetation, and whether barriers such as dikes, levees and roads exist between the wetlands and adjacent lands. These factors need to be reflected in the selection and prioritization of wetland restoration sites and the design of projects (see discussion below).

APPLY A BROAD CONCEPT OF RESTORATION

A broad definition of restoration is needed if watershed approaches are to incorporate both habitat-based and multi-objective projects. For example, if the concept of restoration only involves returning to a historical, self-sustaining condition, then priority restoration sites will almost always be located in more pristine rural areas with near historical conditions. In contrast, if broad goals are adopted and a broader concept of restoration is used, then more projects will be located in urban and urbanizing areas as well.

The National Academy of Sciences Committee on Restoration of Aquatic Ecosystems (National Academy, 1992) suggested a definition for restoration that fits rural, habitat-driven restoration projects when the goal is a return to historical or near historical conditions:

> "Restoration is the return of a former or degraded ecosystem to a close approximation of its condition prior to disturbance. In restoration, both the structure and functions of the ecosystem are recreated, and ecological damage to the resource is repaired. The goal is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs."

In contrast, the goal of many urban restoration projects is to rehabilitate wetlands and related ecosystems to a **functioning, but not natural condition.** Such projects often cannot hope to return wetlands to a historically undisturbed condition due to the highly modified hydrology at urban sites, many sources of disturbance, and broad scale fragmentation of aquatic ecosystems. Instead, restoration can aim to restore as many functions to near historical levels as possible, and to partially restore others. In some instances, functions like flood storage or conveyance may be enhanced to exceed natural levels (e.g., the Charles River Valley Storage Project), but often at the expense of other functions and values. From a wildlife perspective, the challenge is to restore as much habitat as possible while preventing possible negative impacts, such as attraction of migratory birds to stormwater wetlands with toxic water quality.

ESTABLISH MULTI-OBJECTIVE RESTORATION GOALS

It is, of course, possible to undertake watershed-based restoration using a single wetland restoration goal, such as improving wildlife habitat, improving fisheries, improving water quality, or reducing flood losses. However, watershed management efforts typically need to be undertaken to serve multi-objective goals—reduce water pollution, provide water supply, reduce flood damages, provide outdoor recreation opportunities, etc. (Kusler, 2004). Wetland restoration also needs to be carried out to achieve these goals.

APPLY MULTIPLE CRITERIA FOR "NO NET LOSS/NET GAIN"

The "no net loss/net gain" goal is broadly applied in wetland protection and restoration efforts. It has been widely incorporated into federal and state administrative regulations. This goal has been endorsed by Presidents George Bush, Sr., Bill Clinton, and George W. Bush. It has been incorporated in a number of Congressional Acts and is a useful goal for watershed-based wetland restoration.

However, the no net loss/net gain goal is subject to a variety of interpretations (e.g., no net loss/net gain of acreage, function, functional value, socio economic value, biodiversity, ecosystem health, sustainability, etc.). There has been little consistency and agreement in the definition.

The specific definition and the performance measures chosen for "no net loss loss/net gain" make a great deal of difference in wetland program activities, and the benefits and costs to the public. Most programs, such as the Section 404 program, require that activities seeking a regulatory permit result in no net loss of wetland "function and value" or "function and "acreage." The specific criteria to be applied in terms of measuring no net loss/ net gain are, therefore, of great importance. If function is defined to include habitat processes, without considering hydrologic functions, then a regulatory agency may permit a habitat-based mitigation project that has limited impact on wildlife but destroys flood storage. If function is defined primarily with regard to hydrologic processes and habitat is ignored, the converse will be true.

Socio-economic factors can also play a significant role. For example, if a regulatory agency defines function to only include natural processes and a broad no net loss standard is applied, a proposed project may be approved if the project proponent agrees to provide compensatory mitigation to "replace" the lost functions anywhere in the watershed or state, without considering the impacts on people. Consideration of socio-economic values may produce a different result because wetlands provide functions in a particular location in relation to particular individuals.

Watershed-based approaches involving both habitat and multiobjective restoration projects should apply a broad concept of function in applying the no net loss/net gain goal. They should consider not only wetland natural processes (functions), but also socioeconomic values – the relationship of these functions to people. The goal should be to maximize services (see Box 6), and not simply functions. This is discussed in greater depth below.

Box 6
Examples of Wetland "Services" or "Functional Values"
(Derived From Reports, Statutes, Regulations)
Which May Be Restored

Restoration of wetland and related water and floodplain/riparian areas can provide the following goods and services. They are sometimes referred to as functions, values, functional values or by other terms. The magnitude of these functions/values depends on a specific context.

Provide flood storage. Some wetlands and floodplains temporarily store floodwaters and reduce flood heights and velocities that affect downstream lands.

Provide flood conveyance. Some wetlands convey floodwaters, thereby reducing flood heights and velocities at upstream, adjacent and downstream lands.

Reduce wave damage. Some wetlands and floodplains reduce the force of waves and thereby reduce wave and erosion damage to back lying properties and structures.

Provide erosion control. Many wetlands and floodplains help reduce erosion by reducing water velocities and binding the soil.

Reduce sediment loadings in lakes, reservoirs, streams, estuaries and coastal systems. Many wetlands and floodplains reduce the sediment flowing into lakes, streams and estuaries by intercepting and trapping sediment.

Prevent and treat pollution:

- **Prevent pollution from entering a water body.** Virtually all wetlands and floodplains may intercept sediment, nutrients, debris, chemicals, etc. from upland sources before they reach down-gradient bodies of water.
- **Treat (remove) pollution in a water body.** Wetlands may remove pollutants from these waters.

Produce crops and timbers. Many wetlands and floodplains produce cranberry, blueberry, saltmarsh hay, aquaculture, wild rice, timber and other crops.

Provide groundwater recharge. Some wetlands provide groundwater recharge, although most are discharge areas much of the year.

Provide groundwater discharge. Some wetlands and floodplains help maintain the base flow of streams and help reduce ground water levels, which would otherwise flood basements and cause other problems, by providing groundwater discharge.

Provide habitat for fish, produce fish. Wetlands can provide food chain support, spawning and rearing areas and shelter for fish.

Provide habitat for shellfish, produce shellfish. Wetlands may provide shellfish habitat.

Provide habitat for mammals, reptiles, amphibians and birds. All wetlands and floodplains/riparian areas may provide important wildlife habitat.

Provide habitat for endangered and threatened species. Virtually all wetlands, floodplain and riparian areas may provide food chain support, feeding, nesting and substrate for endangered and threatened animals and plants.

Provide scenic beauty. Many wetlands and floodplains have aesthetic value. Scenic beauty may enhance real estate values and enhance ecotourism.

Provide recreational opportunities. Many wetlands and floodplains provide paddling, boating, birding, hiking, wildlife viewing and other recreational opportunities.

Provide historical, archaeological and heritage value. Some wetlands and floodplains, such as the Concord Marshes or the Everglades, have historical value. Many others have archaeological value (shell mounds, burial sites).

Provide educational and research opportunities. Many wetlands provide a site for education and research opportunities for schools and government agencies.

Provide atmospheric gas exchange potentially important to moderation of global warming. Wetlands and floodplains produce oxygen due to photosynthesis. Some wetlands are carbon or methane sinks.

Provide micro-climate modification. Wetlands and floodplains, particularly those near cities and large devegetated areas, may reduce temperatures and pollution levels.

CONSIDER CAPACITY, OPPORTUNITY, AND SOCIAL SIGNIFICANCE

One of the major benefits of watershed-based restoration is that it can take into account a broader range of socio-economic factors than is possible with case-by-case siting of projects. Watershed approaches can help identify wetland restoration sites where restoration projects have the greatest likelihood of success from a scientific perspective, and where they can best serve the needs of people. For example, a restoration project in an urbanizing water supply watershed may have greater community benefits than one in a rural, agricultural area.

The Wetland Evaluation Technique (WET), developed by the U.S. Army Corps of Engineers in the early 1980s to evaluate wetland functions and values, had severe limitations as an operational procedure. However, it used three sets of factors to assess functions and values, which continue to make sense in terms of identifying functions and values, and potential restoration sites on a watershed basis. These factors are capacity, opportunity and social significance (see Box 7). Only capacity is evaluated by the HGM and IBI wetland assessment models.

Box 7
Capacity, Opportunity and Social Significance

Capacity refers to the ability of a wetland, related water and land resources to produce various goods and services of use to society. For example, a wetland may store 1,000 acre-feet of flood water in a 100-year storm. Capacity depends on natural hydrologic, biological and chemical processes (functions), as well as on other characteristics, such as soils, topography and size.

Opportunity describes a wetland ability to deliver certain goods or services to the public or, conversely, for the public to enjoy such goods and services. For example, a wetland capable of storing 1,000-acre-feet of water may have considerable opportunity to reduce flood losses if it is located upstream from a residential subdivision. In contrast, a wetland in a wilderness setting may have a capacity to provide flood storage or remove pollutants, but there may be no downstream flood damage reduction potential at the site because no downstream structures exist. Opportunity is not as easy to evaluate, however, because wetlands that lack present opportunity to provide flood loss reduction or pollution control may have a future opportunity if development, pollution or other changes occur in the area.

Social significance refers to the importance of wetlands to people. Assessing social significance requires simultaneous consideration of capacity, opportunity and the impacts on people who may benefit or suffer costs from the change in a wetland. To evaluate social significance, an agency needs to determine (at least in a generalized manner) who benefits and suffers costs from changes in the flood storage, pollution control and recreation opportunities. And, the agency needs to know what this means to affected groups.

Capacity, opportunity and social significance are best considered through upfront watershed scale inventories and planning approaches, including the use of GIS systems, which reflect land uses, population densities, access roads to wetlands, watershed problems (e.g., flooding, erosion, pollution). However, these factors can also (although less satisfactorily) be considered through case-by-case analyses.

Opportunity and social significance as well as functions should be considered in siting and design of restoration projects. Restoration projects are increasingly designed to provide public access to the restored wetland for education, research, bird watching, and ecotourism purposes.

AVOID BIASED APPOACHES

Bias should be avoided in watershed-based assessment methods. As discussed above, both habitat and multi-objective projects have strengths and weaknesses and can fill specific needs. Unfortunately, a variety of factors often now create a bias in favor of rural restoration projects.

- It often cheaper and easier to restore wetlands in rural settings. There is also greater probability of success in restoring habitat functions. This creates a bias in favor of rural, habitat restoration among some scientists and wildlife agencies, as well as developers. Low cost or ease of success does not mean, however, that restoration in rural areas will best address urban needs. Landowner proposals to destroy urban wetlands and restore or recreate them in rural settings will worsen urban pollution and flooding problems.

- The National Academy has recommended that mitigation wetlands be self-sustaining systems. This is a laudable goal, but not one that can be easily achieved. It is particularly difficult to design multi-objective restoration projects in urban areas as totally self-sustaining systems. The self-sustaining goal may therefore, in selection of restoration sites, create a bias in favor of identification of rural restoration sites, unless there is some flexibility and realism in its application.

- The use of mitigation banks to compensate for wetland losses in regulatory and management programs will likely reduce multi-objective projects in urban areas. Most mitigation banks are now located in rural areas. This means that landowners proposing to destroy wetlands in urban or intensively utilized rural areas may be increasingly permitted to compensate for such losses by purchasing credits in a rural bank at some distance from the original loss. This makes sense, in some instances, from a habitat perspective. However, allowing destruction of a wetland in an urban area with compensation in a rural area will not address urban flood problems, pollution problems, loss of habitat, loss of recreation opportunities and loss of open space.

- The Hydrogeomorphic Wetland Assessment method and a number of other methods compare the relative condition of a wetland against other wetlands of that type on a continuum from unaltered to highly altered. Condition is assumed to be a measure of the services that a wetland may provide. The relative condition is then used to establish mitigation ratios for restoring or creating replacement wetlands. There appears to be good correlation between condition and habitat. But, there is less correlation between condition and other wetland services, such as flood storage, flood conveyance, and erosion control. This could result in an inherent bias against multi-objective projects to serve these broader objectives. (Part 5 discusses HGM and other assessment methods in greater depth.)

APPROACH RESTORATION FOR MITIGATION PURPOSES WITH SPECIAL CARE

Watershed-based restoration projects can meet both regulatory (mitigation) and nonregulatory restoration needs. However, regulatory and nonregulatory projects need to be approached somewhat differently.

With regulatory (mitigation) projects, the project proponents are usually proposing to destroy or damage a wetland. The mitigation project is typically designed to compensate for such destruction or damage. A net loss of wetland acreage, functions and values will occur in the watershed if the mitigation wetland is not constructed or fails to meet design goals. Those who propose to destroy or damage wetlands usually want to minimize costs and do not want long-term maintenance responsibilities. They want to construct and leave. Or, they want to buy credits in a mitigation bank and leave. This means that mitigation wetlands whether onsite, offsite, or through a mitigation bank must, to the extent possible, be self-sustaining. Developers also often want to minimize costs through low cost designs and by locating restoration projects in rural areas. They often wish to combine wetland restoration requirements with other requirements, such as open space or stormwater requirements. For example, it is common for developers to propose to compensate for some wetland damage or loss by constructing onsite "stormwater" wetlands. This may result in no net loss of wetland acreage, but it may result in loss of wetland function.

In contrast, restoration in nonregulatory contexts is usually not proposed in exchange for damaging or destroying an existing wetland. Most nonregulatory wetland restoration will result in a net gain of wetland acreage in a rural or urban context. There will be a net gain in acreage and functions even if such nonregulatory projects partially fail. The project sponsor for a nonregulatory project (a landowner, nonprofit organization, environmental agency) is often more motivated to insure a successful project design, and may be more willing to undertake midcourse corrections and provide long term maintenance of the restored wetland. There is less risk of failure.

This all means that agencies need to approach mitigation wetlands with particular care. For example, requirements that wetlands be self-sustaining systems may be particularly needed for mitigation wetlands. Relatively large mitigation ratios may be justified because of these risks of failure and because of other factors (see Box 8). In many instances, developers should be encouraged or required to provide some measure of both onsite (e.g., multi-objective stormwater wetlands) and offsite mitigation (e.g. rural habitat-oriented projects) to compensate for specific types of losses.

Box 8
Factors Relevant to the Establishment of
Mitigation (Compensation) Ratios

Some key factors relevant to the establishment of mitigation (compensation) rations include:

- **The overall ecological condition (persistence, biodiversity, ecosystem integrity) of the original wetland versus the probable ecological condition of the replacement (restoration/creation) wetland.** Larger ratios are justified where a replacement wetland will be less persistent, diverse, or have less ecosystem integrity than the original wetland.

- **The opportunity that society has to make use of the original wetland versus the opportunity that society probably has to make use of the replacement (restoration/creation) wetland/related resource.** Larger ratios are justified where a replacement wetland will be less available for public use; smaller ratios are justified where a replacement wetland will be more accessible to a larger number of people.

- **The range and magnitude of functions/values of the original wetland/related resource versus the probable range of functions/values of the replacement (restoration/creation) wetland.** Larger ratios are justified where a replacement wetland will have a smaller number of functions/values with lesser magnitude than the original wetland.

- **The wetland/resource type and probable project success or failure for this type.** Larger ratios are justified for the wetland types that have proved most difficult to restore or create with resulting greater possibilities of project failure. Difficulty is determined by the complexity of restoring or creating original or comparable hydrology. In general, difficulty increases in the following order: (a) estuarine (shallow and deep marsh); (b) coastal (shallow and deep marsh); (c) lake fringe and stream fringe (shallow and deep marsh); (d) depressional (shallow and deep marsh); and (e) flat and slope (shallow and deep marsh, shrub).

- **Whether restoration or creation are involved.** Larger ratios are needed for the difficult efforts to create functions/values and with the lowest probability of success such as restoration or creation of endangered or threatened species habitat. Smaller ratios are justified for less difficult efforts to restore or create functions such as flood conveyance or storage which also have a greater probability of success.

- **The expertise of the agency/consultant proposing to carry out the project.** Larger ratios are justified for less expert and less experienced project proponents.

- **The length of time it will take for the restoration to become fully functioning.** Larger ratios are justified where it will take many years for a project to be fully functioning.

- **Threats to the restoration site (if any).** Larger ratios are justified where there are threats to compensation sites (changes in hydrology, sedimentation, water pollution, etc.); smaller ratios where there are none.

- **Whether the site will be susceptible to mid-course corrections.** Larger ratios are justified where the site has little mid-course correction capability; smaller ratios are justified where there is more correction capability.

- **Whether there will be monitoring to provide the basis for mid-course corrections over time.** Larger ratios are justified where there will be little or no monitoring; smaller ratios where there will be monitoring and mid-course corrections.

- **Whether active management will take place over time.** Larger ratios are justified where there will be no active management; smaller ratios are justified where active management (e.g., fencing, exotic weed control, controlled burns) will be undertaken.

- **The relative costs and equities between onsite restoration/creation versus offsite restoration/creation.** Larger ratios may be justified where the costs of offsite restoration/creation are less than the costs of onsite restoration/creation. Project proponents allowed to use offsite restoration/creation should not gain huge financial advantages over those required to carry out onsite restoration/creation.

PART 5: WETLAND ASSESSMENT IN A WATERSHED CONTEXT

Wetland assessments (data gathering and analyses) are needed in watershed contexts to meet a variety of regulatory (mitigation) and nonregulatory needs. Assessments are needed for both habitat-based and multi-objective projects.

Assessments are needed to:

- Identify and prioritize potential habitat-based and multi-objective wetland restoration sites for use in nonregulatory or regulatory contexts.
- Determine the functions and values of original wetlands and proposed replacement wetlands (mitigation contexts).
- Provide the factual information needed for project designs (e.g., hydrologic or ecological information).
- Provide the monitoring information needed during project construction to allow midcourse corrections.
- Determine the success of restoration projects and provide the basis for remedial actions where failures occur.

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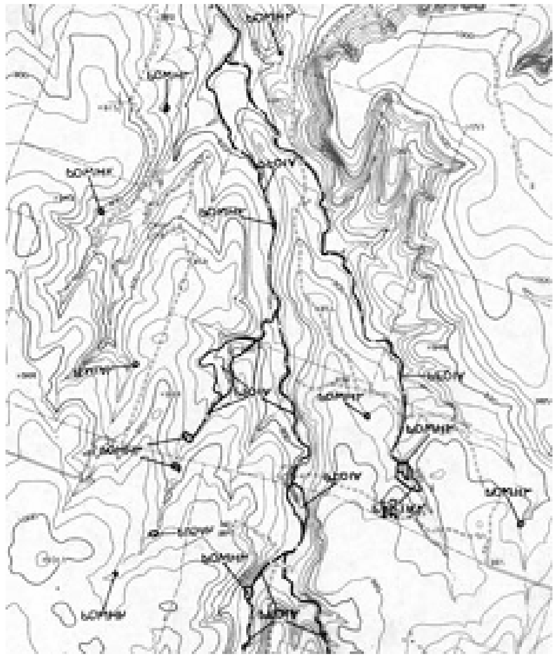
In mitigation contexts assessments are more specially needed to:

- Gauge the functions, values and acreages of the wetlands that have been proposed to be damaged.
- Gauge the functions, values, and acreage of proposed mitigation wetlands offered as compensation for damage or destruction of wetlands.
- Establish mitigation ratios.

In depth discussion of wetland assessment techniques is beyond the scope of this report. However, a brief discussion of selected assessment issues and techniques will be provided because of the importance assessment to the location and design of projects.

Unfortunately, there is little agreement among agencies at any level of government about the use of specific wetland assessment techniques for restoration planning in watershed or case-by-case project contexts. Some efforts have been made to use “rapid” assessment techniques, such as the WET approach, to analyze wetlands in federal/state advanced identification efforts (i.e., Anchorage, Alaska). The Hydrogeomorphic Assessment Method and Indices of Biological Integrity Method have also been used in some watershed contexts to establish the relative condition of wetlands, including restoration needs. A broad range of GIS assessment models are being used to identify, prioritize, and assist the design of wetland restoration projects on a regional basis in California, Louisiana, South Carolina, North Carolina, and in the Great Lakes region.



Assessment must begin with wetland mapping. This is a National Wetland Inventory Map.

RELEVANT FACTORS

The following types of information are often needed to identify and prioritize potential restoration sites and to help design projects. These are the types of information that have been used in regional and watershed assessment of potential restoration sites and design of projects in Louisiana, the Chesapeake, the Great Lakes, Massachusetts, North Carolina, southern California and other locations (note, not all types of information have been gathering in all instances):

Physical features:

- **Historical location and extent of wetlands in the landscape** (use soil maps, old aerial photos, site surveys).
- **The location, extent and types of existing wetlands in the watershed, and the relative scarcity of certain types of wetlands** (use NWI maps, other wetland maps, soils maps, aerial photos).
- The **functions** and potential functions of restored wetlands in watershed **problem solving, and problem prevention and ecosystem contexts** (see discussion of assessment methods below).
- **Potential roles of restored wetlands in meeting ecosystem** needs, such as restoring habitat for rare and endangered species, providing biodiversity in the landscape, and linking natural communities.

- The **types of alterations that have damaged the wetlands in the landscape (e.g., fills, drainage, pollution) and their susceptibility to remediation** (use aerial photos, existing pollution and flood inventories, additional field surveys).
- The **condition (hydrologic, biological, chemical) of potential restoration sites and related ecosystems** (use air photos, inventories of endangered species, fish and wildlife surveys, site surveys, HGM and IBI models).
- Existing **hydrologic and anticipated future hydrologic regimes** for various potential restoration sites (use water supply papers, hydrologic analyses available for floodplain delineation, water resource studies, HEC, other models).
- The **extent to which damaged wetlands will "self-repair" if left alone or the extent to which active management** (e.g., breaching of levees) **will be needed** to restore wetlands (use air photos, common sense).
- **Existing land uses at and adjacent to potential restoration sites,** including possible buffers, existing public lands, greenways, etc. (use aerial photos, land use inventories, zoning maps, site visits).
- **Fragmentation and connectivity between potential wetland restoration sites and other wetland and related aquatic ecosystem, riparian, floodplain and upland systems,** (use air photos, topographic maps, drainage surveys and plan, NWI maps, carry out site visits).
- **Threats to potential restoration sites from changes in hydrologic regimes, water pollution, grazing, natural predation and erosive floodwaters, etc.** (use aerial photos, water pollution surveys, records of flooding, hydrologic information such as flood studies or develop new hydrologic information).

Socio-economic features:

- **Land ownership** (use land ownership, tax maps, local GIS and LIS systems).
- **Size of parcels** (use land ownership maps, tax maps).
- **Land values** (use tax maps, other land ownership maps).
- **Landowner attitudes** (use Wetland Reserve sign-up lists, environmental organization acquisition sign-up lists, hold hearings).
- **Numbers and types of people who might use restored wetlands** (use demographic data, GIS information).
- **Accessibility of potential restoration sites to public use** (use air photos, road maps, trail maps, topographic maps, public recreation inventories and plans).
- **Potential for restoration sites to solve or prevent watershed problems, including the magnitude of these benefits** (use flood maps, pollution inventories, source water inventories, local land and water use plans, watershed plans).
- **Potential costs of projects and available funding levels** (use information from other projects, projections of labor, land and equipment, agency and other budgets).
- **Legal rights and duties, and possible legal problems due to projects (e.g. suits by oyster fisherman due to changed salinity in waters)** (examine changes that may result from projects and impacts of various groups, consult with lawyers)

Riparian and stream restoration as well as wetland restoration is taking place for the Lake Champlain watershed and ecosystem. Source: U.S. Fish and Wildlife Service. http://www.fws.gov/r5lcfwro/wetland.htm

ASSESSMENT CHOICES ARE IMPORTANT

The wetland assessment technique or combination of techniques chosen for wetland/watershed analysis is of great importance. This choice will often determine what becomes a priority restoration site, what gets constructed, and what does not. It will determine restoration mitigation ratios in regulatory contexts, and project designs and monitoring requirements.

For example, use of a wetland assessment technique that emphasizes flood control may identify deeper wetland basins, which are dry or nearly dry between flood events, as priority sites. These sites may have high flood storage value but limited wildlife value. Similarly, if a technique is used that emphasizes wildlife, priorities may favor restoration sites that have mixed open water and vegetation, but more limited flood storage value.

Over the last decade, scientists have developed more than 90 rapid wetland assessment techniques to assess wetland functions or functions and values (Kusler, 2003, 2004; Bartoldus, 1999). Most operate on a case-by-case basis and are not designed for use on a watershed or landscape scale. They vary greatly in terms of the primary factors considered in the analyses, the degree of field data gathering required, cost, and degree of expertise required, among other factors.

Unfortunately, most wetland assessment techniques develop only a small portion of the information relevant to the selection of wetland restoration sites, establishment of mitigation ratios, or development of project designs discussed above. And, the techniques are often time-consuming and difficult to use.

Furthermore, there has been no agreement on the use of a specific assessment technique for even a single objective—assessing natural functions or processes for regulatory mitigation purposes. Federal agencies, in a 1996 Federal Register Notice, declared the intention of developing the Hydrogeomorphic Assessment Method to be used on 80% of the section 404 permits by 2000. As will be discussed shortly, a variety of HGM models have been developed, but they have been little used in regulatory contexts.

ASSESSING FUNCTIONS

Recent guidance on wetland mitigation from the Corps of Engineers for the Section 404 program emphasizes the assessment and replacement of wetland functions in a watershed context. Also, a number of wetland assessment models developed in recent years focus on wetland functions.

However, the term "function" is not defined in the regulations. What is to be included in an analysis of functions? Is the term to be applied to natural processes alone, such as denitrification? If so, of the many thousands of natural processes that occur in each wetland, which ones are to be examined? Is biodiversity to be considered? Is the sustainability of the system over time a consideration? How are these natural processes to be related to wetland "functional values" (i.e., goods and services provided to landowners and the public)?

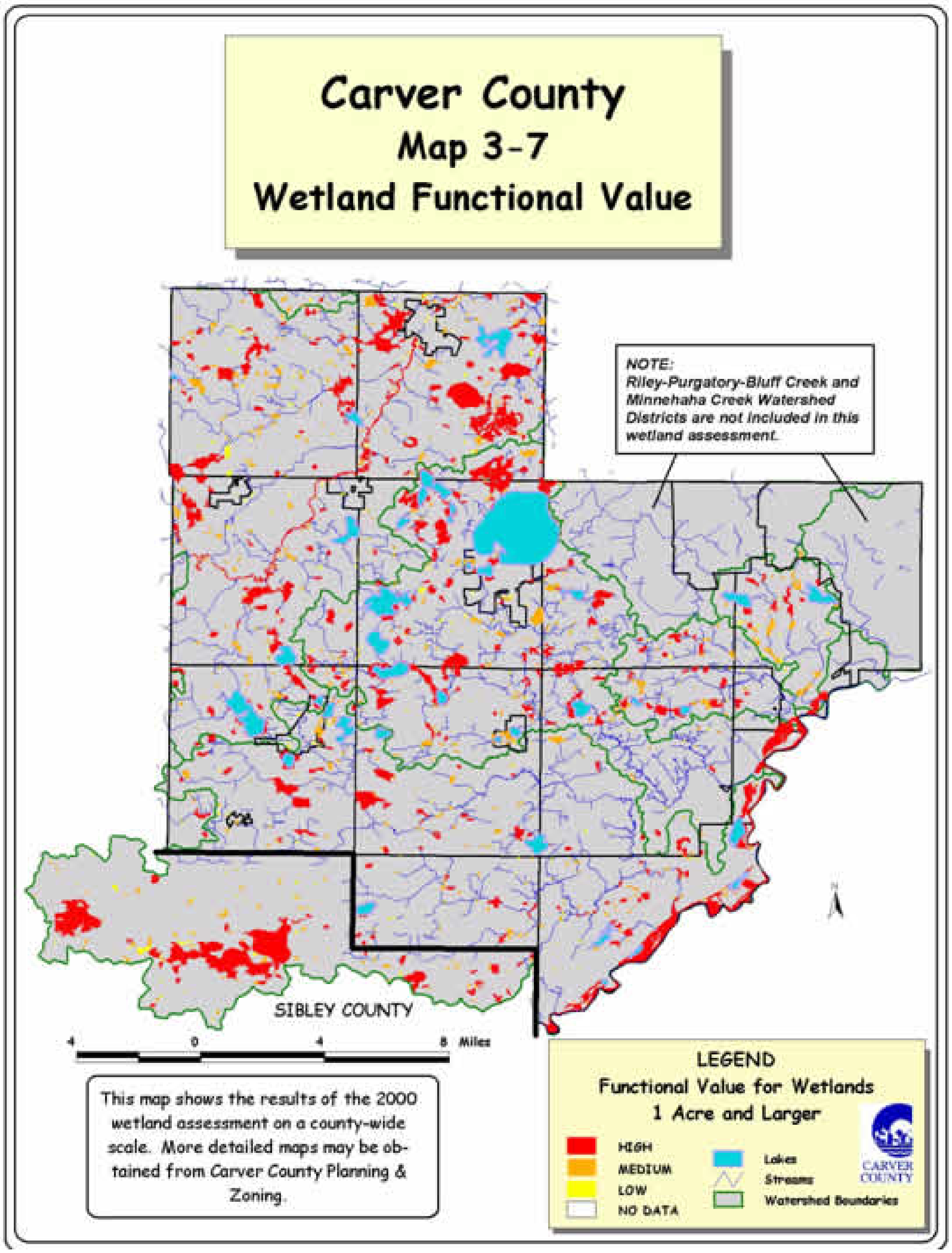
This is more than a semantic issue because regulations typically require that a mitigation wetland replace lost functions when a wetland is damaged or destroyed. What is to be replaced?

Some of the wetland assessment models developed in recent years, such as HGM and IBI models, use the term "function" to refer to natural processes alone. These models attempt to measure wetland condition of various "functions" against a suite of reference wetlands of a particular type. With such approaches, least altered wetlands are rated highest.

But, as indicated by field studies by the Washington Department of Ecology, the least altered wetlands may rate the highest from the perspective of endangered species, biodiversity, and "ecosystem health," but they do not necessarily rate highest in terms of some of the hydrologic "functional values," such as flood storage and conveyance, erosion control, or pollution control (Hubry, 2001).

Other assessment techniques, such as WET, use the term "function" more broadly. This is consistent with the National Wetland Forum use of "function" in 1989, where the no net loss/net gain goal was coined (see table in that report).

The factors to be considered in the Section 404 public interest regulatory review and in most state wetland programs are stated in regulations in terms of wetland end-products services, not just basic processes. Many natural processes may be relevant to safety, water quality, general environmental concerns, shore erosion, flood hazards, and other public interest review factors but measuring natural processes alone with not determine the "public interest".



Carver, County, Minnesota has carried out a generalized wetland assessment for all wetlands. See generally http://www.gis.smumn.edu/Pages/GradProjects/BSands.pdf for a description of some of the assessment procedures applied in Carver County.

Watershed-based inventories should either apply a broad concept of function (i.e., relate function to functional values) or take into account opportunity and social significance, as well as function, in other ways as suggested above. Biodiversity and sustainability should also be considered. Assessment of functions should be directly related to the services pursued (e.g., pollution control).

USE OF ASSESSMENT METHODS IN A WATERSHED CONTEXT

It is clear is that many types of information are needed to identify and prioritize potential wetland restoration sites, and to design and implement projects. Wetland assessment techniques that focus on function alone can, at best, provide only a small (albeit important) part of this information. Efforts to gather all of the needed information have typically involved some combination of existing information, remote sensing, and field surveys. A number of approaches can be used to meet data gathering and analysis needs in a watershed context. Examples include:

(1) Compilation of existing data

Efforts to identify potential restoration sites have usually begun by gathering available information on a watershed basis, such as:

- NWI and other wetland maps
- Soils maps
- Topographic maps
- Land and water use maps
- Zoning maps
- Air photos and satellite imagery
- Land ownership information
- Existing surveys of endangered species

In some instances, much of this information has been available in state or local GIS systems, or has been assembled in a GIS format.

(2) Acquisition of new aerial photography combined with photo interpretation

Often new IR photography has also been obtained. Aerial photography or satellite digital images can be used as base maps (orthophotos preferred); they can be used to identify existing wetlands and land uses; and they can be used to help develop a profile on regional and site hydrology.

(3) Conduct of field surveys

Air photo interpretation, combined with field observations and surveys, are used to fill many of the gaps in existing information. Field surveys may involve many types of information gathering, depending on the priority needs in a particular context. Examples include the:

- Identification of wetland soils
- Identification of rare or endangered species, or representative ecosystems
- Determination of wetland condition

- Determination of wetland depths, soils, vegetation for wetlands to be used as reference wetlands
- Determination of land uses
- Determination of the public/private ownership boundaries (e.g., high water mark)

Some field surveys may involve named formal assessment techniques, such as wetland delineation using the 1987 U.S. Army Corps of Engineers manual for the Delineation of Jurisdictional Wetlands. Transects and sampling procedures may be used. More often, field surveys simply involve visual observations, with note taking and photographs.

(4) Use of wetland assessment models

As discussed above, efforts to identify and prioritize restoration sites and to guide the design of restoration projects have not, in general, utilized formal wetland assessment methods. Little agreement on the meaning of "function" has been one limitation. Funding has been another. There are thousands of separate biological, chemical, hydrologic and other processes going on in each wetland. Which are to be measured with limited funds, time, and staff expertise?

More use of models can be expected in the future. Examples of methods include the following.

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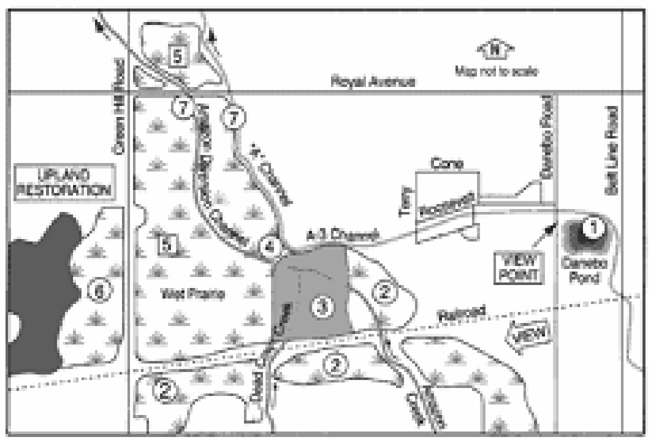


A variety of wetland assessment approaches were used to evaluate wetlands and develop wetland management plans in West Eugene, Oregon Wetland.
From http://www.ci.eugene.or.us/wewetlands/Self_Guided_Tour/sgtsit 1e.htm

WETLAND EVALUATION TECHNIQUE (WET)

The Corps of Engineers developed WET in the early 1980s. This procedure was limited in its ability to assess wetland functions and values with enough specificity to enable the prioritization of restoration sites and the calculation of compensation ratios in mitigation contexts. Nevertheless, WET considers three sets of factors in assessing functions and values that continue to make sense in identifying and designing restoration sites. These conceptually sound factors – capacity, opportunity and social significance – are relevant to any assessment of socio-economic value. These three features are briefly described in Box 9. Only capacity is evaluated by the HGM and IBI models, and it is only partially considered.

It is unlikely that WET will be used in the future due to its complexity and other problems. However, elements of WET have been incorporated into most GIS models used to identify potential restoration sites.

HGM

The HGM wetland assessment method was proposed in 1995 by the Corps and other federal agencies for use on individual Section 404 regulatory permits (see work plan published in the Federal Register, August 16, 1996). So far, the Corps has published an action plan, a number of support documents, and a variety models that describe this method in detail. The approach was first described in Smith, D., A. Ammann, C. Bartoldus, and M. Brinson. 1995. An Approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices, U.S. Army Corps of Engineers, Waterways Experiment Station, Wetlands Research Program Technical Report WRP-DE-9.

HGM was originally designed to help regulators assess overall wetland ecological condition for specified processes and to establish compensation ratios on individual projects. HGM had a number of significant new and interesting features, in comparison with earlier rapid assessment approaches. Several features are particularly attractive for improving assessment of wetland functions/values, and the functions/values of related aquatic and floodplain/riparian ecosystems in a watershed context:

- the classification system
- the utilization of reference sites
- the focus on wetland functions

Regional subclass guidebooks will also be useful to agencies in evaluating the capacity of wetlands and the impact of activities on capacity. However, HGM has received limited use in regulatory contexts, and questions remain concerning its application for several reasons, such as:

- The formula HGM incorporates for calculating compensation ratios (condition x acreage) is too simplistic and fails to take into account many relevant factors (see Box 8).
- HGM is complicated and time consuming to use.
- Most functional assessment models have not been extensively field tested.
- HGM does not consider opportunity and social significance.

HGM compares the functions of wetlands within a class or subclass based on relative degree of disturbance in calculating compensation ratios. This method establishes compensation ratios by multiplying the relative condition of wetland processes by the acreage. A proposed restoration wetland in a rural setting would almost always receive a higher relative condition score than a wetland in an urban setting, if a combination of urban and rural wetlands were used for reference purposes. In other words, a developer might propose to destroy two acres of urban wetland and replace it with one acre of rural wetland, if broader factors were not considered in setting compensation ratios.

Several states (e.g., Washington, Oregon, Alaska) have developed HGM-based assessment models, and others (e.g., Ohio) are using IBI models with numeric outputs, although many of these numeric models have not been tested.

ANNIMAL SPECIES AND BIOLOGICAL COMMUNITY EVALUATION MODELS

Many efforts are underway to develop models for measuring the biological integrity and relative biological condition of wetlands and related aquatic and riparian ecosystems. These efforts involve information gathering for particular types of plant and animal species for a broad range of similar sites, with various levels of anthropogenic impacts. Information gathering typically pertains not only to plants and animals, but also to hydrogeomorphic setting, hydrology, and other features. These approaches have been used extensively to gauge the biological integrity of rivers and streams, set restoration goals, and measure success in meeting those goals.

For examples of these models, see: HEP (Habitat Evaluation Procedures), U.S. Fish and Wildlife Service. (1980). Habitat Evaluation Procedures (HEP) Manual (102ESM). U.S. Fish and Wildlife Service; Washington, D.C.; Cable, T.T., V. Brack, Jr., and V.R. Holmes. (1989). "Simplified Method for Wetland Assessment." *Environmental Management* 13; pp. 207-213; Whitlock, A.L, N. Jarman, J.A. Medina, and J. Larson. (1995). WETHINGS. The Environmental Institute, University of Massachusetts; Amherst; Adamus, P.R. and K. Brandt. (1990). Impacts on Quality of Inland Wetlands of the United States: A Survey of Indicators, Techniques, and Applications of Community-level Biomonitoring Data. EPA/600/3-90. Office of Research and Development, U.S. Environmental Protection Agency; Washington, D.C.; Davis, W.S., and T.P. Simon, eds. (1995). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers; Boca Raton, FL.

Wetland managers may use a combination of field observations and various inferential models to determine the capacity of wetlands to serve as wildlife and fish habitat. They can use these models to determine functions and to establish water quality standards for wetlands, to enforce such standards and assist monitoring efforts.

With IBI models, reference sites are identified with no or little disturbance; a suite of similar sites representing various levels of disturbance are also identified. Plants, insects, amphibians, birds and other forms of life are compared at the various sites. Indicator species are identified which can be used to compare the relative condition or sites. Quantitative indices are also typically developed, which allows the comparison of sites.

These biological surveys and indices have a number of important uses on a watershed or site-specific basis. First, the biological information gathered at a site of a proposed activity can be used to determine whether there are endangered species at the site and the impact of a proposed activity on fish and wildlife. Biological information is also somewhat useful as a surrogate for the types and magnitudes of other wetland functions (e.g., food chain support, pollution control). Indices can be used to establish water quality standards for wetlands. For example, such standards can specify that water quality and other features (e.g. depth, vegetation) cannot be degraded to the point that there will be a loss of specific indicator species in a wetland, lake, or stretch of stream. Alternatively, standards can specify that water quality and other features must be restored to the point that the water body will again support specific indicator species. Emergence of indicator species will indicate success.

Despite the promise of biological indices, development of such indices is proving difficult, time consuming, and expensive. It is also difficult to develop accurate indices to characterize whole wetlands because there are often many ecological zones within a single wetland and these zones shift by season and over a period of years as rainfall varies. Finally, the correspondence between biological integrity and many other wetland functions/values, such as flood storage, flood conveyance, erosion control, and natural crop production has yet to be fully demonstrated.

HYDROLOGIC AND HYDRAULIC MODELS

Regulatory agencies, landowners and consultants have used hydrologic and hydraulic models in some instances to investigate flood conveyance, flood storage, erosion control and wave attenuation to help select and design restoration sites. These models can also be used to determine natural hazards at sites and the impact of a proposed activity on these hazards. For example, the Rational Formula and computerized models that incorporate variations on this model can be used to calculate the quantity of runoff from a watershed based on rainfall, slope, area and other factors. Hydrologic and hydraulic models can also be used to project future conditions by assuming various degrees of urbanization, impermeable surface and density of development. (See, for example, NRCS (SCS) TR-20 computer program for Project Formulation Hydrology and TR-55 Urban Hydrology for Small Watersheds). Engineers use the Computer Program HEC-2, "Water Surface Profiles," in hydrologic studies to determine floodplains, floodways and the effects of fills, culverts, bridges and other obstructions on water surface elevations. (See U.S. Army Corps of Engineers, Hydrologic Engineering Center. (1988). Floodway Determination Using Computer Program HEC-2. U.S. Army Corps of Engineers, Hydrologic Engineering Center. (1992). Computing Water Surface Profiles With HEC-2 on a Personal Computer. Training Document No. 26).

Hydrologic and hydraulic models typically use information gathered from stream gauging and rainfall records and estimates, combined with topographical, soils, vegetative cover and land use information. These models provide quantified outputs for analysis of project impacts and evaluation of the adequacy of impact reduction and compensation. They do not evaluate social significance, but can be used to determine the impact of various activities, such as land use changes, on specific downstream flood heights. Hydrologic and hydraulic models are increasingly combined with GIS models to predict future changes in hydrology.

The information generated by these models can be useful in evaluating wetland functional values since all functional values depend on water regime. This information can be used to determine flood conveyance and flood storage potential for a wetland, wave retardation and erosion control potential, as well as flood and erosion threats at a site and the impact of proposed wetland activities upon those threats. In addition, these models can be used to evaluate the adequacy of project impact reduction and compensation measures. However, the data gathering needed to apply these models is often expensive.

STREAM HYDROLOGIC/GEOMORPHIC APPROACHES

Wetland managers have, on occasion, used several models to evaluate the morphology and condition of streams and related riverine wetlands in order to determine functions/values and restoration and management needs. The models evaluate the condition of streams in terms of stream slope and form. These approaches are increasingly used to determine possible erosion, flooding and other problems, the impact of activities on these problems, and the adequacy of compensation measures. They are also used for planning and implementing restoration. See Rosgen, Dave. (1997). Applied River Morphology. Wildland Hydrology; Pagosa Springs, CO. Leopold, L.B. (1994). A View of the River, Harvard University Press; Cambridge, MA.

AREA-WIDE ASSESSMENT THROUGH THE SYNOPTIC APPROACH

The U.S. Environmental Protection Agency has proposed a "synoptic" approach to landscape level wetland assessment. This approach looks at wetland position in the landscape and overall landscape features to help evaluate wetland functions/values. (See Abbruzzese, B., S.G. Leibowitz and R. Sumner. 1990. Application of the Synoptic Approach to Wetland Designation: A Case Study Approach, EPA/600/3-90/072, U.S. EPA Environmental Research Lab, Corvallis, OR). It does not attempt to evaluate the functions/values of individual wetlands. The Synoptic Approach is broad brush, but has strengths in evaluating wetlands in broader hydrologic, ecological, and policy contexts, including the opportunity and social significance of wetlands.

GIS

A variety of other area wide approaches that use GIS systems to provide landscape-level analyses have been developed in Michigan, Missouri, North Carolina, and Maryland. These, like the Synoptic Approach, consider soils, topography, location, and other factors. GIS models have been used in regulatory permitting in North Carolina and Maryland, but not as a complete substitute for case-by-case, on the ground analysis.

TECHNIQUES FOR CONSIDERING SOCIO-ECONOMIC FACTORS

There have been relatively few efforts to assess socio-economic values in wetland restoration programs, although a modest bibliography exists pertaining to economic assessment of wetlands. (See, e.g., http://www.on.ec.gc.ca/wildlife/factsheets/fs_wetlands-e.html). However, wetland management agencies have incorporated a number of measures in their programs to determine who may be affected by changes and how, and the reactions of people to proposed projects through the distribution of plans, public hearings and other techniques which will be briefly outlined below. This feedback, although qualitative, is useful.

(1) Assessing opportunity

The "opportunity" a restored wetland has now, or will have in the future, to deliver goods and services to segments of population depends on the relationship between potential goods and services and actual user groups. Watershed-level approaches to restoration, including the use of GIS systems, allow for the evaluation of opportunity. Examples of approaches for qualitatively evaluating opportunity for restored wetlands include:

- Carry out studies, such as HEC flood studies, to determine the importance of a wetland in storing or conveying flood waters and the possible impact on upstream or downstream levees, houses and floodplain activities of this storage and conveyance.
- Distribute notices to groups (e.g., bird watching and fishing clubs), publish notices in newspapers and hold public hearings to solicit comments from existing and potential users concerning existing and proposed future uses of particular wetlands.
- Examine land and water use inventories to evaluate the opportunity restored wetlands will have to prevent or ameliorate water or land use problems, such as water pollution or flooding. This can be done manually or through GIS systems. GIS has particular promise for this sort of analysis.
- Determine, through public hearings, distribution of plans for comments, or contacting local sporting organizations, which groups of people may use restored wetlands.
- Examine demographic data to suggest the relationship of restored wetlands to existing and potential users. GIS systems may be useful with this as well.

(2) Assessing social significance

Having examined capacity and opportunity, a wetland manager may then consider the possible social significance of restoration projects. Concern over the social impacts of positive or negative changes in wetlands is needed by Corps regulators to determine whether the “public interest” will be served by issuance of a Section 404 permit with specific types of mitigation. State and local regulators need similar information in applying comparable criteria in state and local regulations. Federal agencies also need this information to make environmental equity determinations required by the Environmental Equity Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (1994).

If a proposed activity may have substantial negative impact on society, even limited impact on the resource may be unacceptable. For example, proposed damage to a wetland that helps protect the water supply of several million people may be unacceptable, even if limited damages are proposed.

A wetland manager can begin to qualitatively analyze the social significance of proposed restoration projects by answering the following questions:

1. **Who will be affected by the restoration?** This can help determine whether a wetland restoration may be of statewide or national significance. It can also help identify the legal right involved, such as private landowner riparian rights or public trust rights. The question is relevant to social equity and social justice. For example, an urban wetland may be more important to minorities than a rural wetland.

2. **How many people will be impacted?** An evaluation of the number of individuals that may enjoy benefits or suffer impacts from watershed restoration projects is also relevant to the public interest. For example, a wetland that helps protect or restore the New York City water supply may benefit more than eight million people, while many fewer people may benefit from protection of another wetland.

3. **In what ways will people be impacted?** For example, protection or restoration of a wetland that stores flood waters, thereby reducing downstream flash flooding, may have important health and safety implications. Similarly, protection or restoration of a wetland that serves as a water supply reservoir may have important health and safety implications. Protection of other wetlands may not.

Having determined who may be affected and how, a wetland agency may then gain feedback concerning public needs and interests by applying a variety of techniques outlined in Box 9.

Box 9
Some Options for Assessing
Social Significance of Restoration Projects

Provide notices of proposed plans, permit applications, other actions to other regulatory agencies and the public; examine feedback. Providing notices is the technique that wetland managers use most broadly to assess public opinion on regulatory permits. This approach can also be used to review proactive restoration plans. Responses give the agency some idea of the types, numbers, and seriousness of interests and concerns.

Conduct hearings. Agencies also broadly use public hearings to gather information and gauge public opinion, particularly on controversial projects.

Consult with local groups and organizations to determine priorities for protection and restoration. For example, the Lane County Regional Planning Agency undertook a wetland assessment process and prepared a detailed wetland plan for West Eugene, Oregon. This process used many techniques, including one-on-one consultations, questionnaires and public workshops, to gain feedback from various groups and individuals concerning community wetlands. The plan was ultimately submitted to the electorate for approval and is now used as the basis for regulatory permitting, acquisition, restoration, and use of a mitigation bank.

Undertake economic analyses for wetlands at specific sites. Economic valuation is relatively rare because it is typically time consuming and expensive. But, analyses have been used, particularly by agencies like the Corps, in preparing cost/benefit ratios for proposed water projects, including restoration projects.

Pose the question of benefits or preferences to local elected officials, executive commissions. A wetland agency may submit a proposed plan for restoration to local governments, soil and water conservation boards, commissions or planning agencies for reaction and comment.

Undertake public opinion surveys. These are relatively rare but have been carried out on some wetland projects (e.g., West Eugene).

These techniques provide qualitative information about opportunity and social significance. This information may, nonetheless, be important in assessing the public interest and public attitudes toward alternative projects and strategies.

Social-economic context is important. This is a group with Bill Mitch at the Olentangy research/restoration site at the Ohio State University which is widely used by students for research. Source: http://swamp.ag.ohio-state.edu/images/orwbirview97.jpg

SUMMARY: NEED TO UTILIZE A VARIETY OF ASSESSMENT TECHNIQUES AT VARIOUS SCALES

The bottom line for use of assessment methods in a watershed context is that no single approach presently being used is the silver bullet. None adequately reflect the full range of information relevant to the identification and prioritization of potential restoration sites.

A variety of manual and GIS-based information gathering and analysis approaches may be appropriately combined to help identify restoration sites, analyze these sites, and guide design, implementation and monitoring in a specific context. Overview analyses need to be combined with more specific studies on a case-by-case basis. While habitat assessment techniques, like Indices of Biological Integrity, HEP, or instream flow models, may be appropriate for rural, habitat-oriented restoration projects, other assessment methods are needed for multi-objective projects. For example, if one of the project goals is flood storage, a hydrologic model (e.g., HEC) can be used to evaluate flood storage for various design sizes, depths, overall topography and vegetation for particular floods. Results would then be reflected in the actual design, including grading and filling plans and plans for water control structures (if any). The operation and maintenance of the final project would reflect assessment results (e.g., the Charles River wetland project).

PART 6: KEYS TO SUCCESS; PROBLEMS TO BE AVOIDED

Much has been learned in the last two decades about the "do's" and "don'ts" of both habitat-based and multi-objective projects; Part 6 considers some of the common denominator "do's," for both types of projects and then describes some of the "do's" unique to habitat and multi-objective projects.

"DO'S": KEYS TO SUCCESS FOR BOTH HABITAT-BASED AND MULTI-OBJECTIVE PROJECTS

- **Clearly define project goals.** This is important for all types of projects, but particularly important for the multi-objective project, to guide project site selection, design, monitoring and maintenance/operation.

- **Use self-sustaining designs to the extent practical, with the recognition, however, that many "walk-away" projects are not achievable and may not be desirable in some contexts.** It may not be possible for a multi-objective project to achieve the goal of a self-sustaining ecosystem in urban and intensively used rural landscapes, and may not be appropriate. Active management is often needed for a number of reasons: to remove sediment from stormwater wetlands; to control exotic species for an urban wetland subject to encroachment by exotic species; and to control water levels where hydrology, including runoff, is changing due to urbanization. Slavish adherence to a self-sustaining goal would fail to consider these requirements. However, a self-sustaining system is a laudable goal, and it is imperative that adequate management mechanisms be provided for multi-objective wetlands if long-term management is needed.

- **Develop projects with multidisciplinary partnerships.** Most larger restoration projects have been partnership efforts. Typically, federal or state agencies provide technical assistance and funding to other units of government or private landowners. Often agencies help to carry out the project, even if it is on private lands. Partnerships are required to provide the multidisciplinary expertise needed for project designs, and to garner the necessary political and financial support.

- **Adequately supervise project construction.** One of the major causes of project failure has been that bulldozer operators and other construction crews have not achieved design grade elevations. Careful supervision of construction staff is needed.

- **Place a conservation agency or environmental organization in the lead for long-term management of projects.** One major problem is that many private project proponents, particularly those in favor of mitigation projects, do not want long-term maintenance responsibilities and fail to carry them out satisfactorily. The California Coastal Conservancy addressed this issue by facilitating the formation of "cooperative" projects with state, local or federal wildlife management agencies or not-for-profit organizations, such as the Nature Conservancy, acting as one partner. Such a partner has the expertise and motivation to undertake long-term maintenance and operation, and assumes control of the project once it is completed.

- **Incorporate mid-course correction and long-term management capability into projects.** Both large and smaller-scale projects often need to be designed with mid-course correction capability so that modifications can be made as needed, and the projects can be actively managed. In addition, long term management may be needed such as control of exotic species, and control of water levels through structural measures. Ongoing management is needed for many large-scale restoration projects to manipulate water supply, deal with exotic species and maximize the project's usefulness for flood control, water quality protection, ecotourism and other purposes.

- **Monitor projects over time.** Monitoring is needed to guide management and mid-course corrections, and to help advance the science of restoration by suggesting what works and what does not.

- **Provide buffers and other types of protection from incompatible upland and aquatic ecosystem activities.** Buffers are particularly needed for many projects because of incompatible adjacent uses, such as commercial or industrial activities and threats from water pollution and sedimentation. Fencing may be needed where cattle, dogs, cats or other domestic animals are a threat. Buffers may also be needed to help meet the upland needs of wetland species for feeding, nesting and resting since there is often limited open upland adjacent to such wetlands in urban and rural intensive use areas.

- **Design projects to provide habitat linkages and reduce fragmentation.** Even when multi-objective projects do not have high habitat value by themselves, they may be designed to provide important linkages between other wetlands and waters. For example, a river bank bioengineering and riparian zone restoration project may be designed to facilitate passage of fish to more suitable habitat areas, and to act as a corridor for wildlife, even if the site does not have large intrinsic value. Similarly, a small stream and wetland restoration project may have limited flood storage potential by itself, but may help create substantial flood storage when designed to link upstream and downstream floodplain and wetland open space areas.

- **Carry out regional watershed inventories to determine the most appropriate restoration sites.** Multi-objective restoration projects can be best targeted through regional analysis of possible sites, including studies of overall hydrology and ecosystem contexts. Other relevant factors include tailoring the restoration to the types of activities that caused the original damage to the wetland (e.g., fills versus drainage), land ownership, cost of land, and whether the project sponsor can provide long-term maintenance. Statewide inventories of sites are being conducted throughout the United States. More regionalized inventories are being conducted in the Gulf of Maine, the Gulf of Mexico and the Upper Mississippi.

ADDITIONAL KEYS TO SUCCESS FOR HABITAT-BASED PROJECTS

- **Use reference wetlands.** Wetland managers have found that reference wetlands can be very useful in establishing the elevations, vegetation types, and other features of restored wetlands, particularly for habitat-based projects. A suite of reference sites that represent a range of types and degrees of disturbance can also suggest restoration potential. The use of natural reference sites is somewhat less critical, although it can be useful for "engineered" wetlands used for stormwater management, flood control, flood conveyance, erosion control and outdoor recreation. A concept of "reference standard" linked to the capabilities of watershed to support various of restoration is also needed.

- **Include buffers, other protective measures.** Buffers are particularly important for habitat-oriented wetlands to provide habitat for amphibians, birds, reptiles and mammals that live in upland areas but use wetlands some of the time. Buffers are also important for habitat-oriented projects to protect them from incompatible adjacent land uses, water pollution, and sedimentation.

- **Control exotic species.** Control of exotic species is particularly needed for habitat projects because exotic species may destroy or greatly reduce achievement of the desired habitat goals.

- **Link projects; reduce fragmentation.** The linking of restoration wetlands with adjacent wetlands and water bodies is particularly needed for fish and wildlife habitat projects, where the fish and wildlife must move between the wetlands and the adjacent uplands.

ADDITIONAL KEYS TO SUCCESS FOR MULTI-OBJECTIVE PROJECTS

- **Consider conflicts and compatibilities in goals.** Multi-objective restoration projects cannot be all things. A clear understanding of conflicts and compatibilities can provide the basis for informed debate on what is, and is not, realistic. This understanding can also guide design. For example, retrofitting of a stormwater detention pond may or may not be compatible with habitat improvement.

- **Define habitat areas or zones within larger projects.** Larger multi-objective wetland restoration projects can sometimes be designed with inner habitat restoration zones, even when the overall project is primarily designed to serve non-habitat needs. For example, an urban flood storage wetland may be designed to store floodwaters in the entire wetland. However, a smaller, more central protected area may be designed for protected, habitat use.

- **Integrate wetland protection and restoration projects into land and water management strategies and programs.** Integration is needed because multi-objective projects are often funded as part of broader land and water management activities. The political acceptability of restoration increases in such contexts, and costs are reduced.

- **Use wetland and related ecosystem assessment models suitable for analysis of goals and to guide design in a specific context.** While habitat assessment techniques, such as Indices of Biological Integrity, HEP, or instream flow models, may be appropriate for rural, habitat-oriented restoration projects, other assessment methods are also needed for multi-objective projects. For example, if one of the goals is flood storage, a hydrologic model (e.g., HEC) can be used to evaluate flood storage for various design sizes, depths, overall topography and vegetation for particular floods. Results would then be reflected in the actual design, including grading and filling plans and plans for water control structures, if any. The operation and maintenance of the final project would also reflect assessment results (e.g., the Charles River wetland project).

- **Anticipate changes in hydrology.** For restoration projects in urban areas or areas with intensive land uses, an analysis should be made of likely future, as well as existing, hydrology. Otherwise, the restored wetland may become a lake or a dry meadow over time, where runoff is increasing or decreasing due to watershed land uses. Anticipating future hydrology is not easy, but it is possible to qualitatively predict changes and reflect these in project designs that target different water levels. For example, a wetland in an urbanizing area that experiences increasing runoff can be designed with different target water levels in various areas of the wetland. Lower sections might fill with water immediately, with wet meadows formed in areas of higher elevation. These wet meadows could become marshes as the amount of runoff increases.

PART 7: APPLYING RESTORATION TECHNIQUES

A wide variety of wetland restoration techniques may be appropriate within specific watershed contexts. Some techniques are more appropriate for certain types of wetlands and functions. For example, habitat-based restoration projects in rural areas often best involve the blockage of artificial drainage channels, the installation of wiers and small dams, the crushing of subsurface drainage tiles, the breaching of levees, and the removal of exotic and nuisance plant and animal species.

Multi-objective projects may use the same techniques. Additional techniques include removal of fill, grading, rediversion of water and sediments, removal of dams, use of dredge spoil to create or restore wetlands, and active management of water levels over time.

Box 10
Common Restoration Techniques

- **Block drainage channels, install wiers or small dams**
- **Crush subsurface drainage tiles in agricultural lands with a bulldozer or backhoe**
- **Remove fill from wetlands (rare but done)**
- **Reconfigure stream channels**
- **Bioengineer stream banks**
- **Relocate to other areas residential, commercial, industrial construction in wetlands, floodplains and riparian areas**
- **Use dredge spoil to create wetlands in rivers, harbors**
- **Redivert water and sediment to wetlands (e.g., Mississippi Delta diversion)**
- **Operate dams to provide minimum flows; remove dams**
- **Reduce pollution and sedimentation in streams and lakes through wetland restoration and establishment of stream buffers**
- **Replant denuded wetlands, floodplains**
- **Remove exotic and invasive plant and animal species**

RESTORATION TECHNIQUES BY TYPE OF WETLAND

Appropriate restoration techniques differ somewhat for different types of wetlands (see Appendix B). Examples include:

- Coastal and Estuarine Fringe Wetlands: Breaching dikes, filling artificial drainage channels, removing fill (rare), regarding, replanting, using dredge spoil from maintenance dredging to restore/create wetlands, grading, and controlling exotic species.

- Lake Fringe Wetlands: Filling artificial drainage channels, constructing dikes with water control structures to flood previously drainage wetland areas (e.g., Great Lakes), using dredge spoil from maintenance dredging to create/restore wetlands, and controlling exotic species.

- Riverine Fringe Wetlands: Constructing setback levees, breaching levees and dams, regulating water releases from dams to simulate natural flooding, augmenting depleted natural flows (e.g., the West) through use of stormwater and tertiary treated effluent, bioengineering stream banks, reconfiguring stream channels and floodplains, filling drainage ditches, fencing, using dredge spoil from maintenance dredging to create/restore wetlands, and controlling exotic species.

- Slope Wetlands: Filling drainage channels, fencing and controlling exotic species.

- Depressional Wetlands: Filling drainage ditches, installing water control structures, removal of fill (some), controlling exotic species.

- Mineral and Organic Flat Wetlands: Filling drainage channels, constructing water control structures, controlling exotic species.

Bioengineering techniques are commonly used in stream restoration. Often they are combined with some measure of "hard engineering". Here poles have been set into bank. Below the poles rocks have been used to stabilize the bank.

Replanting. Source: Stream Restoration, Inc.
http://www.streamrestorationinc.org/education/wetlands.html

Control and removal of exotic species is often needed for all types of wetlands although exotics are a particular problem for some types like these riparian wetlands at Bosque del Apache in New Mexico. Source: http://bhg.fws.gov/images/BDArio1.jpg

RESTORATION TECHNIQUES BY TYPE OF FUNCTION/VALUE

Applicable restoration techniques also vary somewhat by function, or functional/value (service).

- **Restoring flood storage.** Remove fill; block artificial drainage channels, construct water control structures, remove or breach levees. Re-establishing wetland vegetation may also slow the release of floodwaters. Various hydrologic models may be used to calculate storage based on alternative topographic configurations.

- **Restoring flood conveyance.** Restore natural topography; thin dense vegetation. This means removing fills, dikes and other obstructions to flood flows. Various hydrologic models, such as HEC models, may be used to calculate conveyance needs.

- **Restoring wave attenuation functions.** Re-establish natural topography and vegetation (trees, shrubs). This may require grading and reseeding or replanting of wetland plants and trees (e.g., mangroves).

- **Restoring erosion control functions.** Bioengineer stream banks and replant denuded coastal, estuarine, or freshwater wetlands.

- **Restoring pollution control functions.** Restore natural topography, revegetate denuded wetlands, create buffers.

- **Restoring natural crop and timber production functions.** Restore natural topography and vegetation by blocking drainage channels and breaching dams and levees to generate conditions favorable for bottomland hardwoods and other timber production, and production of natural crops. Undertake active management, including plantings and control of exotic species.

- **Restoring habitat for fish, producing fish.** Restore natural water quality, topography and connections to lakes, streams, and estuaries. Remove dams, remeander streams, bioengineer stream banks, block artificial ditches and drainage channels, breach levees, remove fills, construct instream pools and other structures to restore fish spawning, feeding and resting habitat.

- **Restoring habitat for mammals, reptiles, amphibians and birds.** Restore natural water quality, topography, vegetation, soils and connections between wetlands and waters by removing fills and breaching dams and levees. Restoring adjacent buffer areas.

- **Restoring scenic beauty.** Restore wetland water quality by controlling sources of pollution; restore topography; restore the diversity of wetland visual elements (open water, shrubs, trees).

- **Restoring recreational opportunities (paddling, birding, hiking, wildlife viewing).** Restore wetland water quality by controlling sources of pollution; restore topographic contours by removing fills; restore vegetation; restoration connections to lakes, rivers and estuaries.

- **Providing educational and research opportunities (schools, research institutions, nonprofits, government agencies).** Restore wetland water quality, topography, vegetation, soils, connections to other wetlands. Provide access to areas, construct trails and boardwalks.

PART 8: LOOKING TO THE FUTURE

As suggested by the discussion above, a watershed approach to restoration will not be simple or easy, yet it is much needed to guide the selection of restoration sites, restoration design, and long term management.

Productive future directions for both habitat and multiobjective efforts may include:

- **Combine habitat and multi-objective projects in a watershed context.** As discussed through this paper, a combination of habitat and multi-objective projects designed and implemented from a watershed perspective is needed. The differences and similarities between these types of projects should be recognized in assessment methods, prioritization of restoration sites, project design and project monitoring. Over the next several years, the Army Corps of Engineers, EPA, NOAA, NRCS, and other agencies will be preparing guidance for wetland restoration mitigation projects (Mitigation Action Plan, 2002). Hopefully, they will address both types of projects and recognize their differences and similarities.

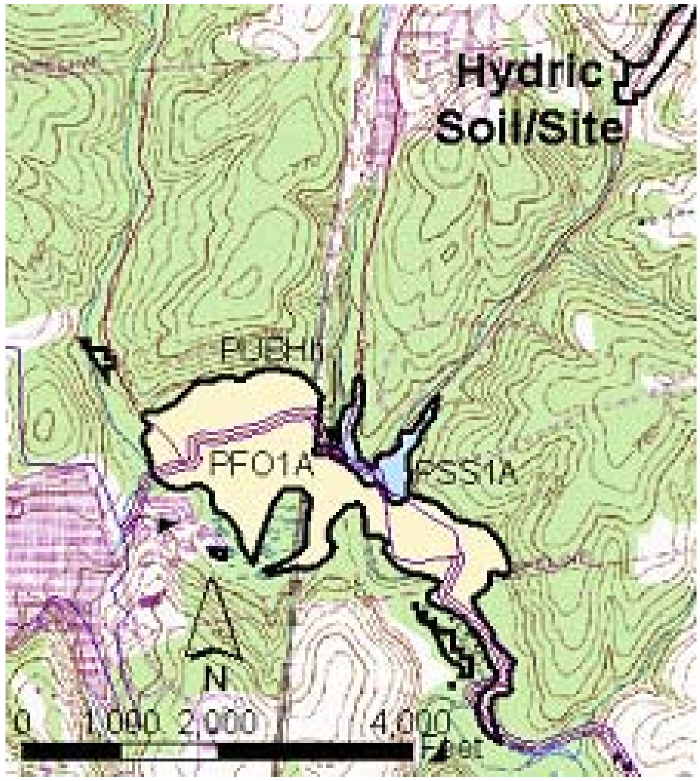
As discussed above, multi-objective projects will often not fully compensate for habitat losses, nor will they be fully self-sustaining. However, they will often more fully meet pollution control, flood storage and other needs than habitat-related projects. In contrast, habitat-related projects can more completely address wildlife and ecosystem needs, but such projects will not often achieve broader goals.

- **Develop guidance and provide training for both types of projects.** Guidebooks, training manuals, training videos, training workshops and other educational materials and activities are needed for both habitat and multi-objective projects. Such materials and training should address the similarities and differences between these two types of projects in the definition of restoration, restoration goals, assessment techniques, project design, monitoring and other aspects of project implementation.

- **Identify and prioritize potential habitat and multi-objective restoration sites on a watershed basis.** Inventories of potential project sites should be prepared on a watershed basis taking into account capacity, opportunity and social significance. GIS-based approaches hold particular promise. Corridor-oriented approaches also have the potential to meet multi-objective goals.

- **Incorporate restoration inventories and implementation initiatives into broader land and water use planning and implementation programs.** Improved funding and political and ecological success in restoration will require integration of efforts to identify restoration sites and to design and carry out implementation within broader, ongoing wetland management efforts, including fee and easement acquisition programs, such as the Wetland Reserve and state bond acquisition efforts.

- **Increasingly utilize GIS and other watershed-scale approaches to consider capacity, opportunity and social significance.** Such approaches hold promise for improving contextual analyses, as discussed above.



As discussed above, use of GIS-based assessment approaches are increasingly common to target potential restoration sites. This map is from a GIS-based effort in North Carolina. NWI Mapping and hydric soils. Source: http://gis.esri.com/library/userconf/proc02/pap0994/p0994.htm

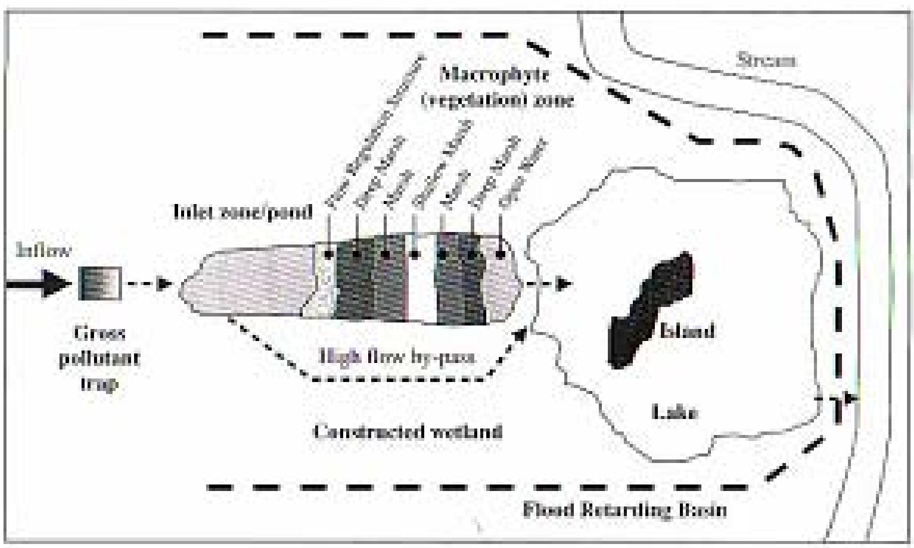
- **Undertake restoration on an "opportunistic" basis as funds and political support become available** (see Box 11). Advance planning is needed for when a flood disaster occurs, erosion occurs, a gravel pit is shut down, a stormwater management pond is cleaned, or other land grading or filling events occur. The plans may then be opportunistically applied.

Box 11
Opportunistic Restoration

Wetland restoration, creation and enhancement projects may be undertaken as funding becomes available and the political will to carry out projects solidifies. Such projects may include:

- **Greenway and trail systems** (e.g., Portland, OR; King County, WA).
- **Retrofitting stormwater facilities** (e.g., many towns in Maryland).
- **Water resource mitigation projects.** Wetlands are often restored in mitigating the impacts of levees, groins, dams and other flood control measures (e.g., setback levees along the Missouri River after the Great Flood of 1993. Horseshoe Bend District).
- **Buyouts and relocation projects.** Wetlands are sometimes restored in buyouts, relocating houses and creating open spaces in post-flood disaster contexts (e.g., Missouri after the Great Flood of 1993).
- **Stream and river restoration** (e.g., Berkeley, CA).
- **Nonstructural floodplain management** (e.g., Tulsa).
- **Control of nonpoint sources of pollution.** Wetlands are sometimes restored through efforts to control pollution from agricultural runoff, urban runoff and other pollution sources (e.g., Jackson Bottoms near Portland).
- **Flood hazard reduction.** Wetlands are sometimes restored through efforts to reduce the flood damage potential of rivers (e.g., the Charles River Project).
- **Park enhancement** (e.g., the Kissimmee, the Everglades, restoration of wetlands and riparian zones in Bosque del Apache National Wildlife Refuge).
- **Forest management** (e.g., Pen Branch Project in South Carolina, many units of the National Park Service, Bureau of Reclamation).
- **Resizing sanitary sewers** (e.g., proposed for Portland, OR).
- **Tertiary treatment of effluent.** Wetlands are often restored or created through the disposal of tertiary treated effluent from sewage treatment plants (e.g., Jaques Marsh, northeastern Arizona, riparian zone restoration in Phoenix).
- **Sand and gravel reclamation** (e.g., Desplaines River near Chicago).
- **Restoration of strip mine areas** (e.g., Lakeland, Florida).
- **Highway, bridge construction** Wetlands are often restored or created in conjunction with highway and bridge construction.
- **Subdivision of lands.** Wetlands are often created or restored through the construction of stormwater detention areas and open space.
- **Construction of commercial, industrial and residential development.** Wetlands are quite often created as stormwater detention areas, as mitigation sites.
- **Education and research** (e.g., Oletangy project at Ohio State University).
- **Ecotourism** (e.g., Saco, New Brunswick).
- **Operating zoos (e.g., National Zoo, Washington, D.C. Brookfield Zoo, Chicago).**
- **Restoring natural areas** (e.g., private environmental organization programs, like those of the Nature Conservancy).
- **Restoring lands for fish and wildlife** (e.g., many hunting clubs in California).

This wetland restoration project at Weaver Bottoms, Mallard Island, Minn. uses dredge spoil. Source: U.S. Army Corps of Engineers. http://images.usace.army.mil/scripts/POrtWeb.dll?query&field=Image%20name&opt+matches &...



This is a wetland constructed for stormwater detention and pollution control. Source: Soil and Water Conservation Society of Metro Halifax. [*http://lakes.chebucto.org/SWT/swt.html*](http://lakes.chebucto.org/SWT/swt.html)

- **Develop and utilize reference wetlands and wetland reference systems.**

Development of wetland reference systems (e.g., Ohio, Pennsylvania) could assist watershed-based restoration efforts in many ways over time. Wetland managers now often use reference wetlands in designing wetland restoration projects to decide on elevations, plant species and other features. Reference wetlands may also be used to help gauge the success of restoration projects. Some of the wetland assessment methods, such as HGM and IBI, use reference to determine the relative condition of a wetland, and relative condition is used in calculating mitigation ratios for mitigation projects.

If reference wetlands are to be used (and this is an excellent idea), a broad concept of reference, which is not limited to ecological value, should be applied. For example, in suggesting design guidance for restoration for flood storage, a suite of flood storage reference wetlands that involve various degrees of disturbance and other characteristics relevant to flood storage should be identified.

Reference wetlands like this one in Massachusetts may be used to guide restoration efforts on wetland restoration sites and help determine project success over time.
Source: http://www.state.ma.us/czm/wea2.GIF

Monitor wetland restoration projects. Tracking can allow agencies to determine not only where projects are underway and completed, but also the relative success of projects over time. Tracking can help agencies and scientists determine the success and failure of various practices, and can provide the information base needed for mid-course corrections.

- **Carry out research.** Federal, state, tribal, and local governments, along with nonprofit organizations and the private sector (e.g. universities) need to carry out cooperative research projects to fill the gaps in scientific knowledge and to determine the effectiveness of alternative restoration strategies. Some priority research questions include:

  - **How accurate, cost effective, and user-friendly are various wetland assessment techniques as applied in watershed-based restoration contexts?**

  - **In what circumstances is replanting needed?**

- **To what extent do birds, amphibians, and other wildlife use multi-objective wetlands?**

- **What surrogates (if any) may be used to measure success?**

- **What combinations of upfront, areawide surveys and case-by-case evaluations are most cost effective in identifying and prioritizing restoration sites to meet watershed-based restoration goals?**

- **What combinations of area wide and case-by-case approaches are most cost-effective?**

Research and public education are conducted at Jackson Bottoms education center as part of a multiobjective restoration site in Oregon.
Source: http://www.jacksonbottom.org/educationcenter.htm

- **Promote international cooperation in research, guidance and training.** The United States is fortunate to have many areas suitable for restoration projects. But, these areas are dwindling due to increased population and population pressures. Many other countries already face more serious population pressures. There are few unaltered wetlands or landscapes.

Improved international cooperation is needed to move both habitat-oriented and multi-objective restoration projects forward in rural, developing, and developed watershed contexts. Many countries share migratory bird and fishery resources. They also share pollution and flooding problems from international rivers.

Some of the lessons learned in the U.S. with regard to habitat and multi-objective restoration projects, such as the need for landscape analyses, getting the hydrology right, monitoring, mid-course correction and the use of a range of implementation techniques, will be applicable in other countries. Conversely, much of the experience of other countries including cost-saving approaches may be applicable in the United States.

Increased international dialogue is needed to develop the science of restoration, and design and implementation practices for both habitat-oriented and multi-objective projects. Cooperation is needed to provide the guidance materials and training necessary across national borders, and to encourage the engineering and water resource development professions to incorporate restoration, creation and enhancement into project planning and implementation. For this to happen, the economic as well as environmental benefits of multi-objective restoration approaches need to be better documented. Guidance manuals of the type sought by engineers, water planners, biologists and botanists need to be developed and published on the Internet in many languages.

APPENDIX A: DEFINITIONS AND ACRONYMS

Definitions

In this report, terms are used in the following ways:

- *Artificial wetland:* A wetland constructed where one did not exist before.
- *Assessment:* Wetland-related data gathering, data analysis and the presentation of resulting information to decision-makers. It includes, but is not limited to, mapping, delineation, determination of ownership, natural hazards analysis, project impact analysis, analysis of functions and values, analysis of alternatives, determination of mitigation needs and the design of mitigation measures, the determination of compensation needs and the monitoring and enforcement of regulations.
- *Capacity:* The ability of a wetland and related water and floodplain/riparian resources to produce various goods and services of use to society. Capacity is primarily dependent on natural hydrologic, biological and chemical processes, but also depends on other characteristics such as soils, topography and size.
- *Creation (wetland):* Conversion of a non-wetland area into a wetland.
- *Compensatory mitigation:* Restoration, creation or enhancement of a wetland to replace the functions and values of a wetland that will be lost.
- *Data:* Raw information, such as aerial photos, vegetation information, soils information, topography, etc. not yet analyzed for a specific purpose.
- *Enhancement:* The alteration, maintenance or management of a wetland to increase or improve specific functions or values. However, this may be to the detriment of other functions and values.
- *Function:* Primarily used to refer to natural processes that contribute to the capacity of a wetland and related ecosystems to provide certain goods and services.
- *Functions/values or Services:* Refers to the goods and services provided by wetlands and their value to society. Functions/values are sometimes referred to in wetland literature as "functions," "values," "functional values," or "valuable functions."
- *Information:* Data analyzed for a specific purpose; the results of such analysis.
- *Mitigation banking:* Restoration, creation or enhancement of wetlands undertaken expressly for the purpose of creating credits for future wetland losses.
- *Natural:* In an unaltered or relatively unaltered condition.
- *Opportunity:* The ability of a wetland with certain capacities to deliver goods or services to society. Opportunity depends on overall context. For example, a wetland may have the natural capacity to intercept pollution, but may not do so because there are no pollution sources. The presence of up-slope pollution sources provides the opportunity for intercepting it.
- *Restoration:* Returning a former or degraded wetland to a prior, less degraded condition.
- *Social significance:* The existing and reasonably foreseen benefits and costs to people and their attitudes toward the benefits and costs. Social significance in a wetland function/value context depends not only on capacity and opportunity, but also on who and how many enjoy benefits and suffer adverse impacts, how they are benefited or negatively impacted, and how segments of society feel about the benefits and costs.

- *Value:* Primarily used to describe the attitudes of society toward various wetland goods and services.

Acronyms

EPA: The U.S. Environmental Protection Agency.

GIS: Geoinformation System. A geo-referenced information storage and analytical system, usually computerized.

HEC: Hydrologic Engineering Center. A series of hydrologic and hydraulic assessment techniques developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers.

HEP: Habitat Evaluation Procedure. This is a wildlife assessment procedure developed by the U.S. Fish and Wildlife Service.

HGM: Hydrogeomorphic Assessment Method. This method is being developed by the U.S. Army Corps of Engineers in cooperation with other agencies.

IBI: Index of Biological Integrity. This is a biological reference standard of biological health and condition developed according to various biological indicator assessment approaches, collectively referred to in this report as IBI assessment approaches.

NRCS: The Natural Resources Conservation Service, U.S. Department of Agriculture.

WET: Wetland Evaluation Technique. This is a rapid assessment approach developed by the Federal Highway Administration in cooperation with the U.S. Army Corps of Engineers and other agencies.

APPENDIX B:
EXAMPLES OF MULTI-OBJECTIVE RESTORATION PROJECTS

This series of case studies illustrates various wetland restoration goals, scales and techniques.

1. Missouri River Wetland "String of Pearls" Project, Missouri

Special Features: Restoration after the Great Flood of 1993 to address flood and erosion problems, restore habitat. This restoration occurred in a post-flood disaster context. Much of the funding came from federal flood recovery funds.

Objectives: Fisheries and other wildlife restoration, flood loss reduction, erosion and sediment control.

Project Description: After massive flooding in 1993 caused many levee failures and $12 billion in federal flood damage, the U.S. Fish and Wildlife Service, in cooperation with the U.S. Army Corps of Engineers, the state of Missouri, local governments, landowners and nonprofit organizations, has undertaken large-scale wetland restoration, including the relocation of levees along the Missouri River. Some of the levees breached by the flood were relocated at a distance away from the river. The areas in front of the levees are reverting to wetland. Some of this area is being designated a national wildlife refuge.

Partnerships: Restoration has been a combined federal, state, local government and nonprofit organization effort.

Funding: A broad range of federal, state and local funding sources have been used to relocate structures, rebuild levees, plan and carry out restoration efforts.

Web Sites:

www.sierraclub.org/wetlands/reports/wetland_restoration/missouri.asp

www.nwo.usace.army.mil/html/pd-p/hidlake.htm

http://midwest.fws.gov/BigMuddy/

www.amrivers.org/pressrelease/missouri9.28.01.htm

http://midwest.fws.gov.ecosys/lowmiss.htm

Missouri River Wetland Restoration after the Great Flood of 1993. Multiobjective restoration has taken place along the Missouri to reduce future flooding, erosion and scour as well as improve water quality and provide habitat. Source: NRCS.
http://www.nrcs.usda.gov/programs/wrp/states/success_mo_river.html

2. Horseshoe Bend (formerly called Levee District Louisa 8) **Restoration, Iowa River, Iowa**

Special Features: Multi-objective Mississippi floodplain and wetland restoration after the Great Flood of 1993 to address flood problems, habitat loss. This restoration also occurred in a post-flood disaster context. Virtually all of the funding came from federal flood recovery funds.

Objectives: Fisheries and other wildlife restoration, flood loss reduction, erosion and sediment control.

Project Description: The federal government purchased one whole levee district located in Iowa along the Iowa River, and returned it to wetland status as part of the Mark Twain National Wildlife Refuge. This 3,000-acre agricultural area was acquired from private landowners.

Partnerships: The Iowa Natural Heritage Foundation, a nonprofit organization, took the lead in this restoration, which has been a federal, state, local government and private sector collaboration.

Funding: A broad range of federal, state and local funding sources have been used to plan and carry out restoration efforts.

Web Sites:

http://www.inhf.org/

http://midwest.fws.gov/portlouisa/info/horseshoebend.htm

http://midwest.fws.gov/portlouisa/info/louisa.htm

3. Kissimmee River Restoration, Florida

Special Features: River, multi-objective restoration to address habitat loss. A large section of river and floodplain is being restorted after the Corps of Engineers channelized the river.

Objectives: Fisheries and other wildlife restoration, flood loss reduction, erosion and sediment control.

Project Description: The Kissimmee River is a 106-mile river in southern Florida. Historically, the river was characterized by tight meanders and an extensive floodplain that was inundated by flood waters more than half the year. Much of this floodplain was wetland and characterized by large amounts of wildlife. From 1962 to 1971, the Corps of Engineers channelized the Kissimmee to create a 300-foot deep, 300-foot wide, 56-mile long drainage channel. The extensive floodplain and most of the wetlands were lost. In 1992, Congress authorized the Kissimmee River Restoration Project, which called for the removal of two water control structures and the re-meandering of 22 miles of river. As of March 2001, about 7.5 miles of canal had been filled and new river flow-ways had been created to restore a braided river.

Partnerships: U.S. Army Corps of Engineers, State of Florida, South Florida Water Management District, U.S. Fish and Wildlife Service, U.S. Geological Survey.

Funding: Federal (Congressional) Funding, State of Florida, South Florida Water Management District.

Web Sites:

www.battelle.org/Environment/publications/EnvUpdates/Summer2000/article5.html

www.state.fl.us/eog/govdocs/opbenv/saveglades/everglades/html/kissimee.htm

www.sfwmd.gov/org/erd/krr/

www.eng.fiu.edu/evglads/engineer/kissimme.htm

www.saj.usace.army.mil/dp/Kissimmee.html

www.nwf.org/everglades/kissimmee.html

www.audobonofflorida.org/science/kissrivrest.htm

Many restoration projects are multiobjective like the Kissimmee River Restoration in Florida. The South Florida Water Management District has purchased over 87,0090 acres for this $372 million restoration project. Source: South Florida Water Management District. *http://www.audubonofflorida.org/science/kissrivrest.htm*

4. Mississippi Delta Restoration, Louisiana

Special Features: This is the first large-scale restoration project dealing with sea level rise/subsidence. It is a regional multi-objective restoration to address land loss, incorporating broad-scale planning efforts and many sub-projects.

Objectives: Flood loss reduction, erosion and sediment control, fish and wildlife habitat restoration, recreation, restoration of lands being lost to subsidence and sea level rise.

Project Description: Historically, the Mississippi River built a huge delta in the Gulf of Mexico with sediments from the Midwest. With the construction of dams and locks along the Mississippi, and channelization and diversions of the river in the delta, wetland loss began to occur. This loss was accelerated by sea level rise, gas and oil extractions and dredging. Louisiana loses about 25-square miles of wetland annually. Nearly one million acres of wetland have been lost in the last 60 years. In November 1990, President Bush, Sr. signed the Coastal Wetlands Planning and Protection, and Restoration Act. A restoration plan has been prepared for the delta and selected elements are being implemented through a variety of techniques, including fresh water (and sediment) diversions, diking, erosion control structures, creating of new wetlands with dredge spoil, restoration of barrier islands with dredge materials and blocking channels. Many techniques have been applied on a pilot basis. For example, construction is near completion for the Davis Pond Freshwater Diversion Project. It has become increasingly clear that restoration must be more extensive than originally anticipated, and may exceed $7 billion in cost. Local oyster farms have also encountered problems with the fresh water diversions.

Partnerships: State of Louisiana, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service.

Funding: State of Louisiana, U.S. Congress

Web Sites:

www.lacoast.gov/cwppra/reports/RestorationPlan/intro.htm

www.epa.gov/ecoplaces/part1/site13.html

www.coastalamerica.gov/text/regions/gmregion.html

www.mvn.usace.army.mil/prj/caernarvon/caernarvon.htm

www.attra.org/guide/wrp.htm

Davis Pond freshwater diversion (upstream from New Orleans). Source:
http://www.mvn.usace.army.mil/pao/dpond/davispond.htm

5. Everglades National Park, Florida

Special Features: Massive scale, regional, multi-objective restoration and protection to save a national park and heritage area. Hydrology is extremely complicated.

Objectives: Habitat restoration, water quality enhancement, flood loss reduction, ecotourism, protection of rare and endangered species.

Project Description: Historically, the Everglades park was a 4,000-square-mile sea of grass and slow moving surface water in southern Florida. It is the only large, subtropical wetland in the U.S., much of which is a national park comprised of freshwater marshes, pinelands, mangrove swamps, coastal waters and wetland tree islands. Everglades was characterized by yearly flooding, including hurricane flooding that killed thousands of people in the 1800s and early 1900s. Over a period of years, the Corps of Engineers built more than 1,700 miles of channels to drain lands for agricultural purposes, reduce flooding in urban areas to the east, and provide irrigation and water supply water. More than 1,000 square miles of new agricultural land was created for sugar farmers.

Deprived of water and subject to nutrient pollution from sugar cane operations, the Everglades were slowly dying until the state of Florida and the federal government developed an ambitious, $7.8 billion restoration plan. Florida passed the Everglades Forever Act in 1994. In 2000, Congress approved a Comprehensive Everglades Restoration Plan developed by the Corps of Engineers and other agencies. The goal of this plan is to restore natural water flow and reduce water pollution. The 40-year plan calls for new water management for the canal systems and efforts to reduce nitrogen and phosphorous through constructed wetlands and other techniques. The plan also calls for storage of water through reservoirs constructed by limestone mining. Water will also be stored underground through the use of massive injection wells. Implementation is slowly going forward.

Partnership: U.S. Army Corps of Engineers, National Park Service, U.S. Geological Survey, South Florida Water Management District

Funding: The state of Florida has spent $2.3 billion to acquire an additional one million acres of land. However, federal expenditures are modest to date. President George W. Bush has proposed a federal 2000 budget of $219 million for five federal agencies for Everglades Restoration.

Web Sites:

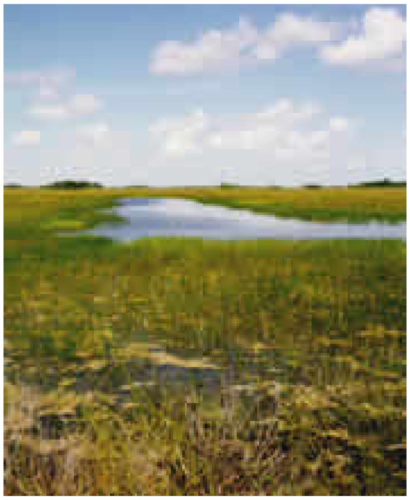
www.evergladesplan.org/

http://fl.water.usgs.gov/CERP/cerp.html

www.ermglades.org/

www.audubonofflorida.org/science/everglades.htm

www.geocities.com/oxfordcomma/everglades/



Everglades multiobjective restoration.
Source: USGS. http://fl.water.usgs.gov/CERP/cerp.html

6. Upper Mississippi, many States

Special Features: Massive scale, multi-objective regional restoration to address hypoxia.

Objectives: Water quality treatment to reduce hypoxia in the Gulf of Mexico, habitat restoration, water quality enhancement and flood loss reduction.

Project Description: The Mississippi River brings large quantities of nutrient rich water primarily from agricultural sources into the Gulf of Mexico. Abundant nutrients, such as nitrogen, result in massive algae blooms that deplete the gulf waters of almost all dissolved oxygen, creating 6,000 to 7,000 square miles of what has been called a "dead zone." When dissolved oxygen levels drop below two parts per million, the water becomes lethal to most aquatic life. Change in the distribution of fish and shrimp threatens the Gulf of Mexico's $4 billion-a-year seafood economy.

A $7-10 billion restoration effort for 5-13 million acres of wetlands is proposed for the Midwest and lower Mississippi River. However, the Upper Mississippi restoration plan is still in the conceptual stage and no funding has been provided.

Web Sites:

www.desplaineswatershed.org

www.epa.gov/msbasin/

www.epa.gov/msbasin/factsheet.htm

www.umesc.usgs.gov/umesc_about/about_umrs.html

Map of watershed area of "dead zone": www.osu.edu/units/research/scicoal/hypoxia.jpg

7. Charles River Natural Valley Storage, Massachusetts

Special Features: Multi-objective wetland restoration for flood storage and recreation.

Objectives: Provide flood storage and flood loss reduction, recreation, fish and wildlife management.

Project Description: Corps of Engineers studies revealed that communities along the Charles River above Newton, Massachusetts had a history of limited flooding because extensive wetlands in the upper watershed stored flood waters and slowly released them. In l974, Congress authorized the Charles River Natural Valley Storage Area (Public law 93-251). The act authorized the acquisition and permanent protection of 17 wetlands in the middle and upper watershed, with 8,103 acres. Of this total, 3,221 acres were acquired in fee, and 4,882 acres in flood easement.

Partnerships: U.S. Army Corps of Engineers, Metropolitan District Commission, Massachusetts Division of Fisheries and Wildlife, various towns.

Funding: Total project cost was $8,300,000, funded by the Corps of Engineers.

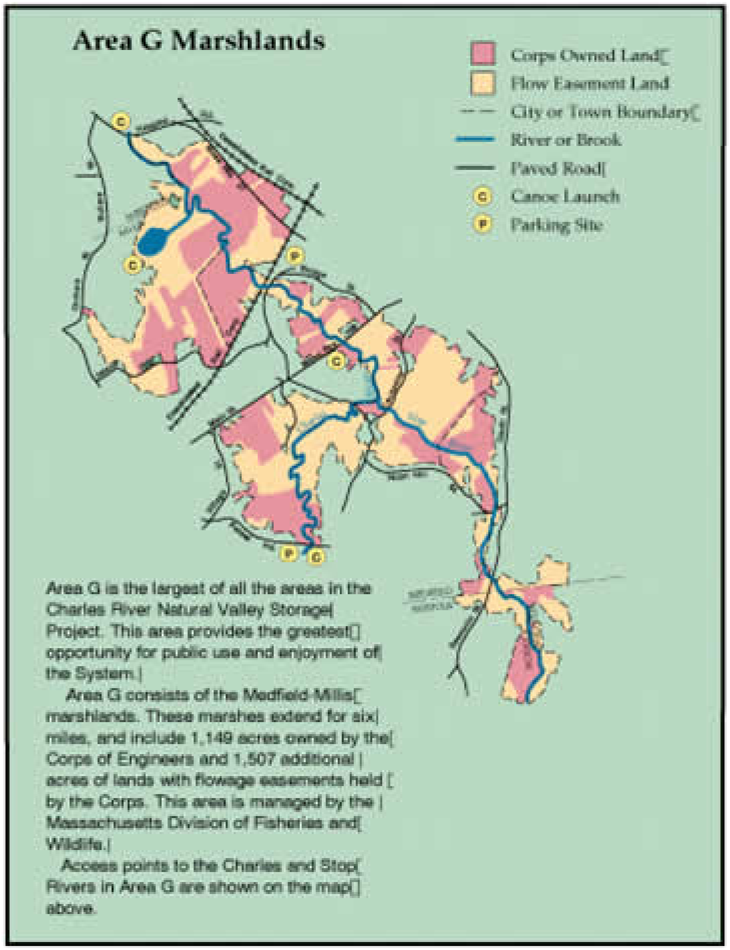
Web Sites:

www.nae.usace.army.mil/recreati/crn/crnhome.htm

www.amrivers.org/floodplainstoolkit/charles.htm

www.state.ma.us/envir/mwi/charles.htm

www.crwa.org/index.html?wavestop.html&0



Charles River wetlands.
Source: US Army Corps of Engineers.
http://www.nae.usace.army.mil/recreati/crn/crnpbm.htm

8. Michelson Memorial Wetlands, South Dakota

Special Features: Multi-objective wetland restoration for flood storage, using water control structures.

Objectives: Provide flood storage and flood loss reduction, provide wildlife habitat.

Project Description: Around 1910, a three-mile-long drainage ditch was dug through the middle of a large wetland basin of more than 1,000 acres adjacent to the Big Sioux and Stray Horse Rivers in South Dakota. This wetland in its natural state had stored large amounts of water. The drainage ditch effectively eliminated the storage capacity of the wetland, reducing the wetland size to approximately 57 acres and the storage capacity to 58 acre feet.

This project was carried out in two phases. The first phase involved the acquisition of approximately 1,800 acres of flood prone lands. Phase two involved the restoration of 700 acres of wetlands, with storage capacity of more than 1,500 acre-feet. Four water control structures were placed at various points in the existing drainage ditch to create storage pools.

This project has reduced federal disaster payments for crop losses, deficiency and flood insurance. It has reduced siltation and flooding in the Big Sioux River. Wetland and aquatic habitat has been provided.

Partnership: South Dakota Department of Game, Fish and Parks, FEMA Hazard Mitigation Grant Program, Friends of George Mickelson, Ducks Unlimited.

Funding: Total project cost was $1,010,286, funded in part with Federal Emergency Management Agency hazard reduction money.

Web Sites:

www.npwrc.usgs.gov/resource/1998/eastwet/eastwet.htm

www.nrcs.usda.gov/programs/wrp/states/sd.html

9. Bay Mills Wetlands, Michigan

Special Features: Wetland restoration to improve wild rice production and wetland habitat. This is a series of Native American restoration efforts at the Bay Mills reservation, located on the eastern end of Michigan's Upper Peninsula on the shoreline of Lake Superior.

Objectives: Provide wild rice, protect and improve habitat.

Projects Description: The Bay Mills Indian Community has completed a variety of wetland restoration and enhancement activities since 1994. Of the roughly 3,500 acres of land on the Bay Mills Reservation, approximately 1,014 acres are wetland. The tribe set aside 460 acres of wetland in 1996 as a preserve. The community has carried out a variety of wetland restoration and enhancement activities since 1994 including:

- The seeding of approximately 5,000 pounds of wild rice in Spectacle Lake and Wasihkey/Back Bay
- Monitoring waterfowl and placement of 20 wood duck boxes and five floating nest platforms
- Enhancing and monitoring Robinson Ponds, St. Martins Pond and McCloud Pond, including 82 acres of nesting islands and perimeter naturalization
- Carrying out wild rice and stream surveys
- Sampling plankton, water quality, vegetation, benthic macroinvertebrates and fish
- Surveying wetlands for possible cranberry operations
- Mapping of wetlands and creation of a geoinformation system as a planning tool

Partnerships: Bay Mills Indian Community, Circle of Flight, U.S. Forest Service, Michigan Department of Natural Resources, Inter-Tribal Council of Michigan, U.S. Fish and Wildlife Service, Bureau of Indiana Affairs.

Funding: Total project costs unclear. $86,800 of Circle of Flight funding, other Forest Service, and Tribal funding.
Web Sites:

www.epa.gov/reg5oopa/tribes/tribepages/baymills.htm

www.baymills.org/bio/framecofindex.htm

www.baymills.org/

Bay Mills Wildrice Production Multiobjective Restoration.
Source: http://www.baymills.org/bio/framericesur99.htm

10. Walkerwin Restoration Project, Wisconsin

Special Features: Creation of a multi-objective mitigation bank to compensate for habitat losses. Proceeds from this bank are being used to fund restoration projects in other areas of the state. Restoration techniques learned from this site have been used elsewhere in the state.

Objectives: Restore habitat, improve water quality, provide credits for habitat losses elsewhere.

Projects Description: This mitigation bank is located on 143 acres in Columbia County, Wisconsin. The entire site was an agriculture field drained by 3.5 miles of ditches, some 25-feet wide and 10-12-feet deep. Corn, soybeans and cattle bedding was grown on the site at times. Although heavily impacted, this site had good hydrology for construction because of a number of seeps. Construction began in May 1994 and is now complete.

Although not designed as waterfowl habitat, it is functioning as one, with over 1,400 birds reported during migration. The site has become a bird watching destination.

Partnerships: This site has been constructed by the Wisconsin Waterfowl Associates Wetland Mitigation Group.

Funding: Privately funded.

Web Sites: www.dnr.state.wi.us/org/water/fhp/wetlands/mitigation/mitigationbanks.shtml

11. Emeralda Marsh, Florida

Special Features: Multi-objective restoration for habitat, water quality, ecotourism. This is a cooperative restoration project involving many partners and the extensive restoration of many farms.

Objectives: Eliminate excess nutrient loading from former farms to Lake Griffin, restore habitat, provide flood storage, fish and waterfowl hunting opportunities, enhance ecotourism.

Project Description: The Emeralda Marsh Conservation Area encompasses about 10,000 acres in Marion and Lake Counties in Florida. Prior to 1940, the area supported saw grass marshes, wet prairies and other shallow marsh vegetation. The area was drained for vegetable production and cattle pasture through the construction of levees and canals. Since 1991, the St. Johns River Water Management District has purchased about 6,500 acres of farms and ranches that border the shore of Lake Griffin. It is proposed that 52.8 percent of the area will provide deeper water habitat for fishery development. The remaining 47.2 percent will provide wildlife and fish spawning habitat.

The St. Johns River Water Management District, in cooperation with the Lake County Department of Ecotourism, has constructed a 4.3-mile Emeralda Interpretive Wildlife Drive.

Partnerships: St. Johns Water Management District, Lake County, State 2000 and Save Our Rivers Programs.

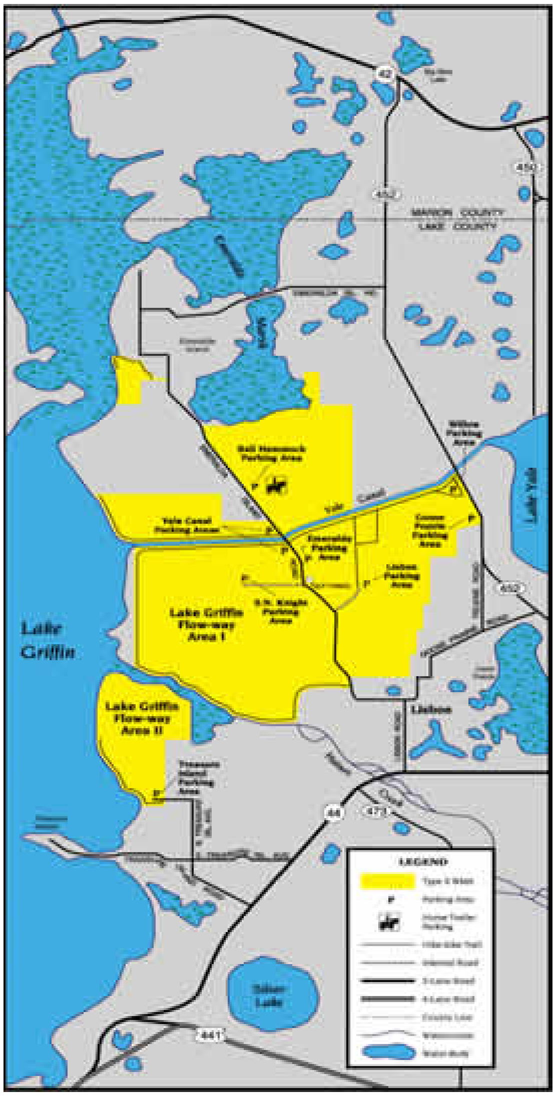
Funding: Preservation 2000 and Save Our Rivers programs.

Web Sites:

http://sjrwmd.com/programs/acq_restoration/s_water/uockr/emeralda/overview.html

www.flmnh.ufl.edu/wadingbirds/emeralda.htm

http://racpt.tripod.com/emeralda-sm-txt.html



http://sjrwmd.com/programs/acq_restoration/s_water/uockr/emeralda/images/emeralda.gif

12. Olentangy River Wetland Research Park, Ohio

Special Features: Wetland restoration on a major campus for educational, research and service programs related to wetland and river restoration.

Objectives: Education, research, habitat improvement.

Project Description: Implementation started in the spring of 1991. Development is continuing. This site is being developed in three phases:

1. Phase 1 — Construction of two experimental wetland basins and their water delivery system

2. Phase 2 — Development of a research and teaching infrastructure at the site, including boardwalks, experimental mesocosms, a plant material greenhouse, additional wetlands, instrumentation for long-term research and a visitor pavilion
3. Phase 3 — Development and construction of a wetland research/education building on the site

Partnership: Ohio State University, private funding, State of Ohio support.

Funding: $1.8 million in private donations, $1.5 million in state support, several million in research grants

Web Sites:

http://swamp.ag.ohio-state.edu

http://www.olentangywatershed.org/index.html

Olentangy Multiobject Education Site, The Ohio State University
Source: http://swamp.ag.ohio-state.edu/images/orwbirview97.jpg

13. Duffy's Marsh,Wisconsin

Special Features: Restoration of private wetlands for habitat and flood storage. Restoration integrated into a university research and education program.

Objectives: Habitat restoration, flood storage

Project Description: This 1,732 acre restoration project in Marquette County, Wisconsin covers about 1,000 acres of water and 700 acres of grassy wetlands and uplands. Nine landowners have worked with NRCS to restore this marsh through the Wetlands Reserve program. NRCS has purchased conservation easements for the lands and has reimbursed the costs of construction and seeding. Three thousand feet of newly constructed dikes connect remnant spoil piles from old ditching to create a continuous embankment for four miles around the marsh.

Construction on the project, which plugged the network of ditches that drained former mint, carrot, onion and corn farms, was completed in about a month. The marsh was restored with 13 ditch plugs. A single rock spillway provides an outlet for the water. The marsh has the capacity to hold 55 million cubic feet of water.

Partnership: NRCS, private landowners, Wisconsin Department of Natural Resources

Funding: Total amount unclear.

Web Sites:

www.wi.nrcs.usda.gov/programs/duff.asp

www.nrcs.usda.gov/programs/wrp/states/success_wi.html

Duffy's Marsh multiobjective wildlife habitat and flood reduction project, Wisconsin. Source: NRCS. http://www.nrcs.usda.gov/programs/wrp/states/success_wi.html

14. Lakeland Wetland Treatment System, Florida

Special Features: This is a treatment wetland that includes both restored and created wetlands.

Objectives: Water quality improvement, habitat.

Project Description: Lakeland, Florida operates a 1,400-acre treatment wetland near the town of Mulberry. The wetland system provides final treatment for a wastewater treatment systems for a population of approximately 79,000. This system was formerly a series of ponds used as a phosphate settling area. The site consists of seven cells surrounded by levees.

Partnership: City of Lakeland
Funding: Project capital costs were $6,680,000.

Web Sites:

www.epa.gov/owow/wetlands/construc/lakeland.html

www.lakelandgov.net/publicworks/lakes/projects.html

Source: www.epa.gov/owow/wetlands/construc/Lakeland/16design.html

15. Jackson Bottoms Wetlands Preserve, Hillsboro, Oregon

Special Features: This innovative site combines habitat restoration, education, and waste water treatment.

Objectives: Habitat restoration, passive recreation, education and research, water quality management.

Project Description: The Jackson Bottoms Wetlands Preserve includes 650 acres of low-lying floodplain on the edge of the Tualatin River, about 80 percent of which is classified as wetlands. Since 1979, a Jackson Bottom Steering Committee has been working to restore the swamp, which had been highly degraded by agriculture and sewage disposal. Restoration projects have created and restored several types of wetlands in the basin, including deep and shallow ponds, wet meadows, riparian wetlands and fresh-water marshes. In 1988, a 15-acre experimental wetland was constructed of 17 parallel cells. This has been used to measure the success rates of soils and vegetation to polish effluent. In l989, a Jackson Bottom Concept Master Plan was completed. Research and education are a major component of the 1989 Concept Master Plan. Trails, view sites and viewing structures have been constructed along with a mile-long Kingfisher Marsh Interpretive Trail. The Friends of Jackson Bottom have developed a wetlands curriculum and sponsor year-round events.

Partnership: 13 organizations are represented on the Jackson Bottom Steering Committee.
Funding: Total unclear

Web Sites:

www.jacksonbottom.org/about.htm

www.epa.gov/owow/wetlands/construc/jackbott/22intro.html

Jackson Bottoms education center. Source: http://www.jacksonbottom.org/educationcenter.htm

APPENDIX C:
RESTORATION BY WETLAND TYPE

RIVER FRINGE WETLAND RESTORATION

Settings and Description: Riverine wetland restoration projects are located in rivers, creeks, stream beds and on floodplains. Restoration has, to some extent, occurred along large, low gradient rivers like the Mississippi, but is more common many smaller perennial creeks, streams and drainage ditches. Riverine wetlands are characterized by uni-directional, flowing water with periodic deep flooding.

Many bank bioengineering projects have been carried out for rivers and streams. Increasingly, stream buffers are also being established to control nonpoint source pollution and dams are being removed in some states, such as Wisconsin. Thousands of local communities, such as Baltimore County and Milwaukee County, have acquired all or a portion of floodplains to establish greenways. Thousands of small bioengineering projects have been carried out to stabilize banks. Exotic plant removal efforts are underway for some areas, such as Salt cedar removal along the Rio Grande. Many stream restoration projects are underway in the Pacific Northwest to help restore salmon.

Activities that Damage Wetlands: Dams, dikes, levees, channelization, engineering for bank stabilization, fills, grading, structures (urbanization), cattle grazing, water pollution, excessive sedimentation from watershed sources.

Restoration Techniques by Wetland Function/Value (Service)

- Flood conveyance: Remove dams, levees, dikes, fills, structures. Reduce vegetation, log jams.
- Flood storage: Removes levees, dikes, fills, structures.
- Wave buffer and retardation: Bioengineer, allow natural vegetation to return.
- Erosion control: Remove dams, remeander rivers and streams, bioengineer banks and riparian areas, allow natural vegetation to return.
- Pollution prevention and treatment: Establish vegetated buffers, allow natural vegetation to return, replant.
- Water recreation: Remove dams.
- Fisheries (larger rivers and streams): Remove dikes and levees, remeander streams, re-establish wetlands, create pools, bioengineer banks.
- Waterfowl and other habitat (larger rivers and streams): Remove dikes, levees, fills to open areas and reconnect streams, floodplains, riparian areas, wetlands. Allow natural vegetation to return. Plant when necessary.

Special Characteristics Relevant to Restoration:

- Simultaneous evaluation and restoration of river/stream and adjacent riverine wetland, riparian and floodplain area is needed if the riverine ecosystem is to be protected/restored.
- Understanding and getting the hydrology right for both the river/stream wetland and the floodplain wetland is essential. Natural water regimes have often been altered within streams and for the floodplains. Water levels are partially controlled by dams in many wetlands on major rivers and channelization has taken place on many others.
- Sediment regimes have often been changed, affecting erosion and depositional processes. Remeandering the river or stream to re-establish stability may be essential.
- Wetlands along smaller creeks are particularly susceptible to watershed changes that affect flow rates and water quality.
- Many riverine wetlands have been partially isolated from adjacent waters by levees. Reconnection is needed.
- Many riverine wetlands are subject to severe flooding, with resulting temporary removal of vegetation and deposition of sediments or erosion. However, such wetlands are also adapted to flooding. Replication or simulation of natural flow regimes is often needed to restore a full range of functions (e.g. fisheries food chain support by floodplain vegetation).

Restoration Potential: Often high for riverine marshes in rivers and shrub wetlands on banks and floodplains due to relatively predictable water sources; more difficult for forested floodplain wetlands due to problems predicting and duplicating sensitive water regimes.

Use of Mitigation Banks: A mitigation bank at a riverine location on the same river may serve similar flood storage, fish production, waterfowl production and water pollution control, among other functions, as a nearby location on the river. However, a mitigation bank on another river or at a nonriverine location will not compensate for damage to the original wetland site. In some instances loss of function, such as flood conveyance, at one location, with an attempt to restore it at another location but with increased damages to some landowners, may result in successful lawsuits.

Data Availability

- NWI maps exist for most wetlands along major rivers in the lower 48 states.
- Many state wetland maps exist for wetlands along major rivers.
- FEMA, Corps of Engineers, US Geological Survey and NRCS flood maps exist for major rivers and streams.
- Stream gauging records are available for many larger rivers and streams.
- Water quality information is available for many larger rivers and streams.

Permit Requirements: Most riverine wetland fill or channel alternation projects require a permit from the Section 404 program, although individual permits may not be required in headwater areas. Smaller restoration projects may qualify under general permits. Most larger riverine wetlands are also regulated at state levels by freshwater wetland programs, floodplain, scenic and wild river programs, shoreland zoning or public water programs. Most riverine floodplain wetlands along major rivers are also regulated by local governments. Local and state floodplain, local wetland, state dam, public water statutes, scenic and wild river statutes may also apply.

LAKE FRINGE WETLANDS

Settings and Description: Lake fringe wetland restoration projects are located along the margins of the Great Lakes, inland lakes, reservoirs and ponds. They are moderately common in the northern tier of glaciated states (e.g., Wisconsin, Minnesota, Michigan, New York, Maine) but have also been undertaken for reservoir fringe wetlands elsewhere as well. These wetlands are characterized by multi-directional flows. Often, much of the water in restored wetlands comes from the adjacent lake.

Activities that Damage Wetland: Fills, roads, drainage, lakeshore development, water pollution and stabilization of water levels that leads to rapid successional sequences.

Restoration Techniques by Function/Value (Service)

- Fisheries: Remove dams, levees, fills and culverts that impede movement of fish from lake to wetland. Design restoration wetland with deep portions consistent with fish spawning and feeding needs.
- Water recreation: Remove fills, dikes and other measures that prevent access to wetlands from lake by boats. Design restoration wetland for boat access.
- Ecotourism: Design restoration to provide bird habitat, aesthetic qualities. Provide boardwalks, trails adjacent to the wetland.
- Pollution prevention and treatment: Allow natural vegetation to return or revegetate wetland buffers along lake shores, bioengineer stream banks.
- Water supply protection: Allow natural vegetation to return or revegetate wetland buffers along lake shores, bioengineer if necessary.
- Erosion control: Revegetate wetlands particularly in wave action zones. Bioengineer stream banks.
- Waterfowl and bird habitat: Provide open water areas and other areas needed for bird habitat in restoration design.
- Mammal and amphibian habitat: Remove fills and levees, block drainage ditches to allow restoration of wetland and to re-establish connections to lake.

Special Characteristics Relevant to Restoration:

- Many lakes have been dammed to control water levels, which also reduces lake fringe wetland diversity and long-term sustainability of wetlands.
- Restrictive water quality standards have been developed for most lakes because of their use for water-based recreation and water supply.

Restoration Potential: High restoration potential for partially drained lake fringe wetlands. Lake elevations are often known for larger lakes. This helps establish restoration elevation requirements. Examples of other lake fringe wetlands may also be used to guide elevation determinations. Water from other wetlands along the lakeshore will bring in seed stock.

Use of Mitigation Banks: A mitigation bank at a lakeshore location, on the same lake some miles from damage sites, may serve similar fish and waterfowl production, water pollution control, and other functions. Benefits and burdens may be similar to the ecosystem and to human beings. However, a bank on another lake or at another location will not compensate for damages to the original lake, or the residents and public use of this lake.

Data Availability:

- NWI, state and local maps are available for wetlands along larger lakes in many states.
- Relatively precise lake elevation data is available for larger lakes, particularly those with water control structures.
- FEMA flood maps are available for the Great Lakes, some larger lakes, mid-size and smaller lakes with flood problems.

Permit Requirements: Restoration projects in wetlands along all major lakes and reservoirs are subject to Section 404 regulation requirements. Virtually all larger lakes and reservoirs are also regulated by states in keeping with water quality and public water statutes, and shoreland zoning statutes. Local governments regulate many privately owned, lake fringe wetlands.

ESTUARINE AND COASTAL FRINGE WETLANDS

Settings and Description: Estuarine and coastal fringe wetland restoration projects are located on deltas, behind barrier islands, along shores and estuarine rivers, and at low energy open coastal environments along the Pacific, Atlantic and Gulf coasts.

Activities that Damage Wetlands: Fill, water pollution, diking, levees, dredging, upstream dams and other water extractions along tributary streams that alters the flow of freshwater, sediment starvation due to upstream dams and sea level rise.

Restoration Techniques by Function/value (Service)

- Fisheries and shellfish: Remove or breach levees; fill mosquitoe ditches, reestablish salt marshes
- Water-based recreation: Remove dikes and levees; remove dams.
- Pollution prevention and treatment: Establish vegetated buffers, replant.
- Wave retardation and erosion control: Replant.
- Shorebird habitat: Replant; remove dikes and levees.
- Waterfowl habitat: Replant, remove dikes and levees.

Special Characteristics Relevant to Restoration:

- These wetlands are tidally controlled at least to the high tide line.
- They are periodically flushed by hurricanes and coastal storms.

Restoration Potential:
Restoration potential for partially drained and diked coastal and estuarine wetlands is high because drainage channels can be filled and dikes breached. Tides provide a constant and reliable water supply. Tidal elevations are often known with fair accuracy from tide records at various locations. Elevations may also be deduced from topography, vegetation and soils. Tides may bring in seed stock.

Use of Mitigation Banks: A mitigation bank at a coastal and estuarine location on the same estuary at some distance from the damage site may serve similar habitat functions. Benefits and burdens may be similar to the ecosystem and to human beings.

Data Availability:
- NWI, state and local wetland maps in virtually all states.
- Recent aerial photography for many areas.
- Tide data and coastal flood data available in many locations.
- FEMA flood maps available for many coastal locations.

Permit Requirements: Restoration projects for most estuarine and coastal fringe wetlands are subject to the Section 404 program permitting requirements. Virtually all of these wetlands are also regulated by states in keeping with wetland, coastal zone management, water quality and public water statutes, and shoreland zoning statutes. Local governments regulate some of the privately owned wetlands, and local and state statutes and plans broadly apply.

SLOPE WETLANDS

Settings and Descriptions: Slope wetland restoration projects are not common because most slope wetlands are not subject to federal, state or local regulations with mitigation requirements. Slope wetlands are located in a wide range of settings, principally on the sides or at the bottoms of hills and mountains; also in some river fringe, lake fringe and coastal/estuarine fringe settings, where the ground surface intersects the groundwater. Ground and surface water are the main sources of water.

Activities that Damage Wetlands: Agricultural and other drainage, ground water pumping, grading, some fills, grazing and vegetation removal.

Restoration Techniques by Function/value (Service)
- Habitat: Restore the wetland hydrology; allow natural vegetation to return.
- Pollution control: Plant native species, create buffers.
- Control erosion. Replant or bioengineer where appropriate.

Special Characteristics Relevant to Restoration:
- Slope wetlands depend on ground water discharge and, to a lesser extent, surface runoff.
- Large numbers of slope wetlands are found throughout landscape in humid and temperate climates, particularly in mountain states.
- Many slope wetlands are not connected to other waters for at least a portion of the year.

Restoration Potential: Varied. Restoration potential is relatively high for partially drained (as opposed to filled) slope wetlands, where the ground and surface water regimes are intact. Restoration potential is poor where wetlands are filled or water regimes have been altered.

Use of Mitigation Banks: The original loss of function, such as flood conveyance, at one location, with an attempt to recreate or restore it at an another location, may provide equal benefits to the overall ecosystem but will not necessary provide equal pollution control benefits for specific lakes, rivers and other water bodies down gradient from the slope wetland.

Data Availability: Slope wetlands are poorly identified on wetland maps because maps do not show smaller wetlands. They are also difficult to spot on aerial photos. Flood maps are almost never available for such wetlands nor are surface water elevations or hydrologic records.

Permit Requirements: Some slope wetlands are subject to the individual permit requirements of the Section 404 program, but many are exempt because they are isolated wetlands. Most smaller slope wetlands are not regulated by states and local governments according to wetland statutes, but may be regulated by local governments in accordance with broader zoning.

ORGANIC AND MINERAL FLATS

Settings and Description: Organic and mineral flat restoration projects are common in some Midwestern agricultural areas (e.g., Wetland Reserve sites). Such wetlands are found in a wide range of settings with moderate to abundant rainfall and low topographic gradients, including wetlands in old glacial lake beds, coastal plain wetlands, and bogs.

Activities that Damage Wetlands: Agricultural and other types of drainage, fills, water pollution, water diversions and climate change.

Restoration Techniques by Function/value (Service)

- Habitat: Plug drainage ditches, let natural vegetation return or plant with desired species; remove fill.
- Improve carbon storage (many of these wetlands have deep organic soils): Re-establish natural water regimes.

Special Characteristics Relevant to Restoration:

- Many flats are without outlets and subject to long-term fluctuations in precipitation and ground water levels.
- Many flats depend on runoff from the immediate watersheds.
- Many flats are partially isolated from other waters and wetlands for at least a portion of the year.
- In general, flats are not flood conveyance areas or fisheries habitat, and have limited water recreation value.
- Some flats, such as bogs, are rare and serve as habitat for endangered species; it may be very difficult to restore endangered species habitat or carbon stores.
- Most flats are sinks and particularly susceptible to sedimentation, pollution.

Use of Mitigation Banks: Restoration of a wetland may be difficult for some flat wetlands (e.g. forested wetlands) due to sensitive hydrologic requirements. It may be impossible to recreate carbon stores. While the original loss of function, such as food chain support, at one location may be recreated or restored at another location to provide equal benefits to the ecosystem, it will not necessary provide equal benefits for specific lakes, rivers and other water bodies adjacent to or down gradient from the damaged wetland.

Data Availability for Restoration:

- Many flats are poorly identified on wetland maps because maps do not show smaller wetlands and forested flats may be difficult to spot on aerial photos.
- Flood maps almost never available for such wetlands.
- Other types of surface water elevations and records are almost never available for such wetlands.

Permit Requirements: Not all projects are subject to the individual permit requirements of the Section 404 program. Many flats may be isolated wetlands and not subject to Section 404 permitting. Some larger, flat wetlands are regulated by states and local governments in accordance with wetland statutes or broader zoning.

DEPRESSIONAL WETLANDS

Settings and Description: Restoration projects for depressional wetlands are quite common in the Midwest and Northeast. Depressional wetlands (kettleholes, potholes) are located principally in the northern tier of glaciated states, where there are millions of depressions in glacial tills and moraines. These wetlands and lakes were created by melting ice blocks during retreat of the glaciers. Some depressional wetlands have also been created by solution (karst), wind action (Sand Hills of Nebraska), erosion and deposition (oxbows, vernal pools), and human activities (e.g., gravel pits, excavation). Some depressional wetlands depend almost entirely on surface water (e.g., vernal pools). Others depend on ground water and many on a combination of ground and surface waters.

Activities that Damage Wetlands: Most common is draining for agriculture or other purposes, filling, use of sites for solid waste disposal, removal of vegetation, and exotic species.

Restoration Techniques by Function/value (Service)

- Habitat: Remove fill; block drainage ditches.
- Pollution control: create upland buffers and revegetate them.
- Establish waterfowl habitat. Deepen wetland; construct small water control structures; remove exotic or nuisance species (e.g., cattail) to provide open water.

Special Characteristics Relevant to Restoration:

- Many depressional wetlands depend on ground water discharge. This complicates evaluation of hydrology.
- Many depressional wetlands are isolated or partially isolated from other rivers, steams during normal hydrologic conditions, which also complicates evaluation of hydrology.
- Water level fluctuations based on short and longer-term climatic cycles are pronounced in depressional wetlands, making calculation of correct hydrology difficult.
- Many depressional wetlands are highly susceptible to watershed changes and resulting changes in runoff, sediment regimes and water quality. An effort should be made to predict future watershed hydrology.

Restoration Potential: Variable. High for partially drained depressional wetlands, poor for wetlands filled by sediment, pollutants or other materials due to limited flushing action and long detention times.

Use of Mitigation Banks: The original loss of function, such as flood storage or pollution control, at one location, with an attempt to recreate or restore it at an another location may provide equal benefits to the overall ecosystem, but will not necessary provide equal flood storage or pollution control benefits for specific lakes, rivers and other water bodies down gradient from a depressional wetland.

Data Availability for Restoration:

- Poorly identified on wetland maps because many maps do not show smaller wetlands; difficult to spot on aerial photos.
- Flood maps are rarely available.
- Surface water elevations and elevation records are rarely available.

Permit Requirements: Some depressional wetlands are subject to the individual Section 404 permits. Totally isolated wetlands are not. Some depressional wetlands are regulated by states and local governments in accordance with wetland, public water or broader zoning statutes.

APPENDIX D:
BIBLIOGRAPHY OF SELECTED REFERENCES

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APPENDIX E: SELECTED WEB SITES
(See also Appendix B)

Selected Web Sites
With
Profiles of Restoration Projects

http://www.csc.noaa.gov/lcr/habitat.html NOAA Coastal Resources Center Habitat Characterization and Restoration Program

http://www.csc.noaa.gov/lcr/swamp/text/p661.htm NOAA SWAMP MODEL. See examples of applications for the SWAMP Model

http://www.state.ma.us/czm/wrp/updates/currentupdate.htm Massachusetts Restoration projects are described.

http://www.coastalamerica.gov/text/projects/projects.html Coastal America restoration projects (listed regionally) Several hundred projects described.

http://www.coastalamerica.gov/text/cwrpprojdesc.html Corporate wetland restoration partnership. Brief description of many projects.

http://www.gulfofmaine.org/library/habitat/restoration2.htm Gulf of Maine Council on the Marine Environment. List 355 restoration sites or sites with restoration potential.

http://www.gulfofmaine.org/library/habitat/restoration2.htm EPA's five star restoration program. Brief profiles are provided on 300 projects.

http://www.savelawetlands.org/site/alphabet.html This site has descriptions and links to more than 200 Louisiana coastal restoration projects (many of them wetlands).

http://www.evergladesplan.org/utilities/search.cfm Listing and description of many separate Everglades restoration projects.

http://www.saj.usace.army.mil/projects/index.html Corps of Engineers restoration projects in the Everglades

http://www.nrcs.usda.gov/programs/wrp/photo_gallery/Gallery.html State by state photo gallery of NRCS Wetland Reserve projects.

http://www.photolib.noaa.gov/habrest/bar.htm Brief descriptions and hundreds of photos of NOAA restoration projects.

http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/wwec/general/wetlands/WetReplaceFd-2000.htm; http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/wwec/general/wetlands/Wetlands.htm Description of state wetland restoration projects in Pennsylvania with many before and after pictures. Examination of 69 mitigation sites.

http://www.suscon.org/pir/watersheds/elkhorn.asp Case study restoration examples from Sustainable Conservation (a not for profit organization).

http://www.nrcs.usda.gov/programs/wrp/states/success.html NRCS Wetland Reserve Program Success Stories (17 quite detailed profiles)

http://www.nh.nrcs.usda.gov/technical/Ecosystem_Restoration/Salt_marsh_projects.html#Stuart%20Farm Description of 17 salt marsh cooperative restoration sites in New Hampshire.

http://feri.dep.state.fl.us/ Quite detailed description of Florida restoration case studies.

General List of Restoration Web Sites:

www.npwrc.usgs.gov/resource/literatr/wetresto/wetresto.htm Bibliography of Wetland Restoration

www.mvn.usace.army.mil/prj/caernarvon/caernarvon.htm Caernarvon Freshwater Diversion Project

www.glhabitat.org/mwac/chapter6.html Citizen involvement in wetland restoration…good guidebook

www.eng.auburn.edu/users/paytojd/wetland.html Constructed wetlands

www.lacoast.gov/Programs/DavisPond/Index.htm Davis Pond Freshwater Diversion Project

www.srs.fs.usda.gov/pubs/viewpub.jsp?index+482 Ecosystem Restoration: Fact or Fancy

www.pwrc.usgs.gov/WLI/wetres.htm Department of Agriculture: National Resource Conservation Service: Wetland Science Institute–Wetland Restoration

www.usda.gov/stream_restoration/ Department of Agriculture: Stream Corridor Restoration Principles, Practices and Processes

www.fb-net.org/wrp.htm Department of Agriculture Wetlands Reserve Program

www.desplaineswatershed.org/ The Des Plaines Watershed Team www.epa.gov/owow/wetlands/restore/links/ EPA Division of Wetlands Web Site – Wetland Restoration Links

www.epa.gov/owow/wetlands/restore/5star/index.html EPA Five Star Program

www.epa.gov/owow/wetlands/restore/ EPA River Corridor and Wetland Restoration

www.geocities.com/oxfordcomma/everglades/ Everglades Restoration

www.evergladesplan.org Everglades Comprehensive Restoration Plan

www.saveoureverglades.org/about/about_sister_trust.html The Everglades Trust

www.sfwmd.gov/org/erd/krr/ Kissimmee River Restoration

www.lacoast.gov/cwppra/reports/RestorationPlan/contents.htm Louisiana Coastal Wetlands Restoration Plan

www.bae.ncsu.edu/programs/extension/wqg/sri/proceedings.htm North Carolina Stream Restoration and Protection: Building on Success

swamp.ag.ohio-state.edu/ORW.html Olentangy River Wetland Research Park

http://partners.fws.gov/ Partners for Fish and Wildlife; U.S. Fish and Wildlife Service

www.ramsar.org/strp_rest_links.htm Ramsar Convention’s Resources on Wetland Restoration Links

www.coastalamerica.gov/text/regions/gmregion.html Regional Conservation Projects - Gulf of Mexico Projects

www.ce.utexas.edu/prof/maidment/grad/dugger/GLADES/glades.html South Florida Everglades Restoration Project

www.h2osparc.wq.ncsu.edu/info/wetlands/mitsucc.html Successful Mitigation

www.vims.edu/welcome/tour/tmarsh/index.html VIMS Teaching Marsh

http://www.dsirealestate.com/company_info/wetland.html Wetland Banking: A Developer’s Point of View

www.bwsr.state.mn.us/programs/major/wca/5/factsheet.html Wetland Banking Procedures: Minnesota Board of Water and Soil Resources

www.infomine.com/technology/enviromine/wetlands/welcome.htm Wetlands for Treatment of Mine Drainage

Use of GIS
To Target Restoration

http://www.lcd.state.or.us/coast/demis/docs/fuss/fussrpt.htm MS Thesis concerning the use of GIS for identifying wetland restoration sites for estuary-wide restoration planning in Oregon.

http://www.nysgis.state.ny.us/datcoord/partners/wetrest.htm Use of GIS for tidal restoration planning in Long Island, N.Y.

http://gis.esri.com/library/userconf/proc02/pap0994/p0994.htm Use of GIS system by the North Carolina DOT to identify restoration sites.

http://www.conservationgis.org/ctsp/iowanhf/inhf.html Use of GIS system to prioritize wetland restoration sites in Iowa Great Lakes Watershed

http://www.epa.state.oh.us/dsw/gis/cuyahoga/demo.html Use of GIS to identify wetland restoration sites in the Cuyahoga Watershed Demonstration Project.

http://www.estuaries.org/objects/docs/W8B_2.PDF Use of GIS in the Chesapeake Watershed by Ducks Unlimited to target conservation priorities.

http://www.vims.edu/ccrm/cci/adv_id/advid.pdf GIS based protocols for selecting wetland restoration sites in Virginia.

http://www.bwsr.state.mn.us/wetlands/publications/PotentiallyRestorableWetlands.pdf Use of GIS to identify restoration sites for drained wetlands in Minnesota.

http://www.state.ri.us/dem/programs/benviron/water/wetlands/wetplan.htm Use of GIS to identify and evaluate potential wetland restoration sites in Rhode Island.

http://www.dnr.state.md.us/greenways/gi/restoration/restoration.html Restoration targeting in Maryland's Green Infrastructure Program using GIS.

http://maphost.dfg.ca.gov/wetlands/document/wetrip.htm GIS based wetland and riparian maps for the California Central Valley

http://feri.dep.state.fl.us/ Use of GIS to store information concerning wetland restoration sites in Florida.

http://grunwald.ifas.ufl.edu/Publications/abstract_poster_EPH2003.pdf Use of a wetland GIS system to characterize wetlands in Florida, track restoration.

http://nespal.cpes.peachnet.edu/Water/Sediment.Reduction.Conceptual.Model.pdf Use of GIS to prioritize wetland restoration for sediment yield reduction.