

COMMON QUESTIONS:

**WETLAND
RESTORATION,
CREATION,
AND
ENHANCEMENT**



Prepared by:

Jon Kusler
Association of State Wetland
Managers, Inc.

In Cooperation With:

The International Institute for
Wetland Science and Public Policy

PREFACE

The following guide addresses frequently asked questions with regard to wetland restoration, creation, and enhancement. It is designed for use by local government officials, land trusts and watershed councils, landowners and other interested in the restoration, creation, or enhancement of wetlands.

The guide draws upon a series of research projects carried out by the Association of State Wetland Managers including the preparation of a report: Kusler, J. and M. Kentula (eds.) 1990. Wetland Restoration and Creation: Status of the Science, Island Press. It reflects speaker presentations and conclusions and recommendations from wetland restoration national symposia and training workshops involving more than 1,600 individuals in Vicksburg, Mississippi; St. Paul, Minnesota; Fairlee, Vermont; Albuquerque, New Mexico; Plymouth, Massachusetts; Baton Rouge, Louisiana; and Annapolis, Maryland.

Funding support was provided by the U.S. Environmental Protection Agency, Region 2, Division of Wetlands. However, the opinions expressed are those of the author and not the sponsoring agency.

Photos in this report are mostly derived from websites. Please let us know, if you do not wish your photo to be included in this brochure.

Cover photo by U.S. Fish and Wildlife Service.

Photo on page 1 by Lake Champlain Ecosystem: Fish and Wildlife Resources Complex, U.S. Fish and Wildlife Service, <http://www.fws.gov/r5lcfwro/strategies.htm>

Photo on page 3 by NOAA, Great Lakes Environmental Research Laboratory

Photo on page 4 by Jon Kusler, Association of State Wetland Managers, Inc.

*Photo on page 5 by Samantha Christie, Ballona Wetlands Volunteer Restoration Program, Friends of Ballona Wetlands
http://www.ballonafriends.org/volunteer_restoration.htm*

*Photo on page 8 by Alberta Invasive Plants Council
http://www.invasiveplants.ab.ca/gallery_OR.htm*

COMMON QUESTIONS: WETLAND RESTORATION, CREATION, AND ENHANCEMENT

What are wetland “restoration”, “creation”, and “enhancement”?

A. The term wetland “restoration” is generally used to refer to the return of a wetland to a former condition. Creation is used to refer to establishment of a wetland in a location where it did not previously exist. Enhancement is used to refer to activities which increase particular functions of a wetland.

Is it possible to restore a wetland?

A. Yes and no. Natural, undisturbed wetlands are usually characterized by organic soils developed over thousands of years and subtle relationships of hydrology, soils, nutrients, vegetation, and animal life. Total restoration of a wetland in a manner that “totally duplicates” all aspects of a naturally occurring wetland including soils is impossible in a short period of time. Soils are particularly important to some pollution control, carbon storage and habitat functions. However, many wetlands characteristics including functions and values such as flood storage and conveyance, erosion control, pollution control, fisheries, and many other habitat functions can be partially restored.

Is it possible to create a wetland?

A. Also, yes and no. It is often possible to create an area which looks and functions very much like a natural wetland for a period of time although this is more difficult than restoring a wetland. It is not possible to quickly create mature wetland soils and the biota which inhabit such soils as noted above. Created wetlands are often more unstable in the landscape than natural wetlands and often quickly fill with sediment. Attempts to create wetlands also quite often fail because it is difficult to “get the hydrology” right. The exception is where an upland adjacent to an existing wetland or water body is excavated, using the existing wetland or nearby wetlands as a guide for bottom elevations, topography, and vegetation. This helps “get the hydrology” right, insures a source of water, and provides seed stocks.

Is it possible to “enhance” wetland functions and values?

A. Yes, but enhancement for one feature may result in reduced function for another. The U.S. Fish and Wildlife Service has used dikes, dams, and other water control techniques to manipulate water levels for many years for the purpose of enhancing wetlands for waterfowl habitat including maintenance of open water areas, maintaining preferred vegetation, and controlling exotic vegetation. Other types of management such as deepening portions of a wetland, animal control (e.g., muskrats), and planting of particular species can, in some instances, be used to increase (enhance) specific wetland functions. While it is often possible to enhance a particular function or



*Getting the hydrology right
is essential to wetland
restoration*

suit of functions, this may come at the expense of other functions. For example, cutting trees and other dense vegetation in a wetland adjacent to a river may enhance wetland flood conveyance capacity, but it may reduce pollution control, habitat, scenic and other functions and values.

Is it more difficult to create than to restore a wetland?

A. Yes, in most situations. For example, wetland restoration may be accomplished with relative ease for a partially drained wetland with intact soils in an agricultural area through filling a ditch or building a small dam (or letting beavers do this). In contrast, uncertainties concerning hydrology are often encountered with attempts to create a wetland from uplands. Considerable grading and filling is often necessary and it may not be possible to “get the hydrology right” even with these efforts.

On the other hand, creation of a riverine wetland may be accomplished by grading a floodplain more easily than removal of fill to restore a riverine wetland.

Is it more difficult to restore some types of wetlands in comparison with others?

A. Yes. A relatively high degree of success has been achieved in restoring coastal, estuarine, and freshwater marshes adjacent to lakes and streams and tidal waters due to the presence of adjacent water bodies which provide a source of water and relatively predictable elevation requirements. Adjacent wetlands can also often be used as a guide (“reference”) for restoration or creation efforts. Less success has been achieved for marshes with elevation-sensitive plant species such as *Spartina patens* and for shrub wetlands. Even less success has been achieved with sea grasses and forested wetlands which have precise hydrologic requirements.

Is it more difficult to restore some wetland functions than others?

A. Yes. It is often relatively easy to restore flood conveyance and flood storage which depend primarily upon topographic contours and, to a lesser extent, upon vegetation. Erosion control functions may also be restored by bioengineering stream banks and riverine wetlands and replanting native plants. Similarly, certain pollution prevention and control functions may be restored through natural revegetation and replanting. Water recreation and aesthetic functions may be restored by reestablishing original hydrology regime, recontouring and replanting. Forestry and other natural crop functions may be restored by natural revegetation and planting.

Certain habitat functions may also be restored with modest efforts such as waterfowl production by creating shallow marshes. Restoration efforts may draw upon a large amount of experience and scientific knowledge available for waterfowl nesting, feeding, and resting required. It is also relatively easy to create a combination of open water and vegetated marshes. However, other habitat functions which depend upon very precise hydrologic regimes and water quality such as habitat for many endangered plant and animal species are difficult to restore. Such restoration is particularly difficult if invasive species are present.

Certain heritage or archaeological functions such as a unique shell hidden in a marsh may be impossible to restore.

Will restoration, creation, or enhancement at one site compensate for loss of functions and values at another site?

A. Yes and no. Location is often extremely important in terms of ecological functions and values to people. Restoration, creation, or enhancement at a new site can sometimes restore or create new functions and values such as water quality protection, erosion control, and flood storage which are equal or exceed, overall, to those at an original site. But, this does not mean that the original, contextual functions are replicated at the new site and there may be significant loss of function in the overall ecosystem, depending upon the situation.

Wetland functions and values depend upon not only the size, shape, type, and other characteristics of a wetland but upon proximity and connections with other waters, water quality, adjacent upland buffers, threats, and a broad range of other factors. Creation or restoration of wetland characteristics alone will not insure replication of functions and values, particularly those which depend upon landscape and watershed context. And, at a minimum, different individuals or ecosystems will usually enjoy the benefits of those functions even if the created or restored wetland is in the same watershed. For example, it may be possible to create or restore a marsh on one lake to compensate for the destruction of a lakeshore marsh on a second lake. But, there may be a significant decline in Northern Pike populations on the second lake with resulting impacts on riparian homeowners and the public. Similarly, restoration or creation of a wetland at one site on a river or stream may to some extent compensate for loss of flood storage or conveyance or erosion control at another site. But, landowners damaged by flood or erosion near the first site will receive little comfort from the compensation at the other site and may, in fact, sue other landowners or governmental units for such damage.



Northern Pike

In other instances a shift in location will not be so important. A wetland constructed or restored on one portion of a lake or estuary to compensate for the loss of another wetland on the lake or estuary may serve as similar fish, shell fish, or waterfowl habitat for the estuary as a whole. Similarly a flood storage wetland constructed or restored on a river or stream may reduce flood damages for downstream landowners in a manner similar to those of an original wetland on this river or stream. A wetland constructed for waterfowl breeding may serve a function similar to another wetland at some distance which has been destroyed in terms of the overall waterfowl population because waterfowl can fly from one area to another.

Most regulatory agencies now require that some onsite impact reduction and restoration take place at a proposed site to address onsite problems such as flooding, erosion and deterioration of water quality even if offsite compensation for habitat loss through restoration or the use of a mitigation banks is allowed.

Why do regulators often favor onsite and in-kind restoration for certain types of impacts?

A. Regulators often but not always favor onsite and in-kind restoration because the restored wetland may play a similar role in the local ecosystem and the benefits of functions and values may continue to be enjoyed by the same individuals. However, onsite and in-kind restoration are not always possible or practical. In addition it may be desirable in some instances from an ecosystem perspective to restore or recreate a wetland at another site and “out of kind”. For example, it may be desirable to replace a marsh with a forested wetland if marshes are common and forested wetlands rare..

How long will it take for a restored or recreated system to approximate the original system?

A. The answer depends upon the type of wetland, the wetland functions, and the target plants and animals. It may be possible to restore or recreate a marsh with a lush stand of marsh vegetation in three or four years. Restoration of a red maple swamp may take thirty years or more. And wetland functions dependent upon mature soils may take hundreds or thousands of years. Although these recreated or restored systems may visually resemble the originals quite quickly, restoration of soils with pollution control capabilities and suitability of habitat for certain amphibians may be quite different.

The speed at which restoration or creation of particular functions and values may occur also varies. Flood storage and flood conveyance capability may be quickly recreated since these functions depend almost entirely upon topography which may be manipulated. Waterfowl habitat capability which depends upon open water and marsh vegetation may also be restored quite quickly. But, amphibian habitat which depends upon wetland soils may take much longer.

What techniques are needed/available to restore, create, or enhance wetlands?

A. A broad range of techniques have been used to restore, create, and enhance wetlands and may be appropriate in specific circumstances. Examples include:

- Filling drainage ditches,
- Excavating fill,
- Breaching dikes and levees,
- Restoring stream flows and other hydrologic regimes,
- Controlling sedimentation and other pollutants; restoring water quality,
- Controlling exotic species,
- Replanting,
- Reintroducing fish, beavers, other wildlife,
- Providing bird nesting boxes,
- Controlling predators,
- Restoring buffers, and
- Restoring connections between wetlands and adjacent waters, wetlands, and uplands (e.g. removing structure, dams, fills).



Forested wetlands are rare in some areas of the nation

What factors influence the techniques needed for restoration of different types of wetlands?

A. The techniques needed in a specific circumstance depend, in part, upon the type of activity causing the damage. For example, restoration of a drained agricultural wetland may be accomplished by filling the ditches or crushing the drainage tiles. Restoration of a filled wetland will require removing the fill. The techniques required will also often depend upon the type of wetland. For example, restoration of riverine wetland will often require restoring the river contours through grading and stabilization of banks through bioengineering. In contrast, restoration of a depressional wetland will often require removal of fill or installation of water control structures.

How much does it cost to restore or create a wetland?

A. Costs per acre vary greatly, depending upon land values, the technique or techniques used, the amount of expertise required, and other factors. Some agricultural wetlands have been restored for less than \$300 an acre by filling drainage ditches or crushing tiles. In contrast, complex restoration or creation projects in urban areas involving extensive excavation, replanting, and exotic weed control may cost more than \$300,000 an acre.



Use of volunteers for restoration

Are there cost-saving approaches for restoration, creation, or enhancement?

A. Yes. Some examples include:

- Use volunteers to carry out the manual aspects of restoration or creation.
- Don't replant but rather let natural reseedling occur (not always possible or wise).
- Undertake "assisted" restoration (see discussion below).
- Undertake restoration "opportunistically" such as restoration of riverine wetlands after a flood disaster when funds and political will may support such efforts.

What are the keys to successful restoration, creation, or enhancement projects?

A. Keys to success in restoration, creation, and enhancement projects vary somewhat, depending upon the type of wetland and context. However, overall keys to success include:

- Project goals need to be clearly defined and realistic,
- Adequate hydrology is needed,
- Project design must be competent,
- Implementation (e.g., grading elevations) must be carefully supervised,
- Mid course correction capability should be built into many projects (e.g., control of exotics), and
- Long term protection, monitoring and management is needed (in some but not all cases).

What have been the causes of project failures?

A. Project failures are particularly common for “mitigation” projects proposed to compensate for wetland losses at another site. The private or private individual proposing such losses often wants to carry out as little mitigation as possible and to “walk away” from the mitigation project as soon as possible. Reasons for failures include:

- projects are not constructed,
- projects are not constructed consistent with plans,
- plans lack clear goals and designs related to those goals,
- project designers lack adequate expertise,
- inadequate understanding and replication of hydrology occurs (too dry, too wet, wrong water depths),
- project supervision in implementation is lacking,
- vegetation or substrate is destroyed after construction by floods, erosion, fires, grazing and predation (e.g., geese),
- exotic species invade the site,
- threats from adjacent lands occur such as sediment or toxic laden runoff, and
- project monitoring and mid-course corrections are not undertaken.

Should restoration, creation, and enhancement projects be designed as self-sustaining systems?

A. The design of projects as self-sustaining systems without outside intervention is a useful goal. Self-sustaining systems are particularly important for “mitigation” wetlands where the project proponent wishes to complete the project and quickly move on. However, totally self-sustaining systems may not be possible where sediment rates or nutrient levels are high, watershed hydrology continues to be altered (e.g. urbanizing conditions), or there are threats from exotic species or predators. In such situations, continued management or maintenance over a period of years is essential. This may include water level manipulation, replanting, control of exotics, protection of the wetland from cattle, grazing, or off the road vehicles, and other measures. Long term maintenance is more likely where a wetland is owned and managed by a resource management entity such as a federal or state wildlife agency or not for profit corporations like the Nature Conservancy.

Does wetland restoration, enhancement, or creation require a high level of expertise?

A. Yes and no, depending upon the type of wetland, type of interference with natural functions, size of the project and other factors. Expertise requirements also depend upon the phase of project implementation. For example, project design often requires considerable expertise. However, project implementation including grading work and replanting may be carried out by relatively unskilled labor with adequate supervision (boy scouts, Job Corps, etc.).

The amount of expertise required also depends upon the type of wetland and the causes of degradation. Considerable multidisciplinary expertise is needed to restore the meanders and slope for an unstable stream or to restore the topography for a forested wetland with highly sensitive water levels. On the other hand, less expertise is needed where the cause of wetland damage or destruction is a drainage ditch and the

remedy of filling the ditch is obvious. Similarly, it is possible to restore a partially drained wetland in an agricultural field by filling a drainage ditch or crushing drainage tiles with a backhoe or bulldozer with limited expertise. No replanting or special management may be needed. Similarly, it may be possible to restore or create a marsh adjacent to an existing marsh by excavating fills or uplands with modest expertise if the elevations of the existing nearby marsh are used as a template. Much more expertise is needed to restore forested wetlands with highly sensitive hydrologic requirements or wetlands created in high energy zones of lakes, rivers, and coastal areas.

Why is “getting the hydrology right” so important?

A. Hydrology is so important because primary wetland characteristics including soils, vegetation, and animal life depend upon the depth of water, the area of inundation, the hydroperiod, and other hydrologic features. Functions and values also, therefore, depend upon hydrology. Inadequate hydrology is the most common cause of failure of restoration and creation projects.

Must a restored or created wetland be replanted?

A. Yes, and no, depending upon the circumstances. Often natural seed stocks from the soil or adjacent wetlands will reestablish vegetation in a restored or created wetland without replanting, particularly if the restored or created wetland is adjacent to natural wetland or is flooded with water from a lake, stream, or an ocean. However, there are exceptions. Replanting is desirable for high energy areas where erosion may occur. Replanting is needed where exotics may quickly invade a site and planting may give particular species a competitive advantage. Replanting is needed where habitat must be quickly recreated (e.g., new habitat for an endangered species which has been disturbed).

Is any single wetland assessment method most desirable for wetland restoration or creation projects?

A. There is strong disagreement among scientists concerning the use of rapid and more detailed wetland assessment methods to evaluate proposed sites of wetland destruction or damage, potential restoration sites, and restoration sites after construction. This is particularly true where wetland restoration, creation, or enhancement at one site is proposed to compensate for destruction at another.

None of the rapid wetland assessment methods have proven both accurate and “rapid” to quantitatively evaluate the functions and values of the original wetland (to be damaged or destroyed) or projecting the functions and values of a restored, created, or enhanced wetland. The Hydrogeomorphic Method (HGM) has proven useful in analyzing wetland processes but it provides no information concerning wetland values and little information concerning many other critical parameters. Specific, detailed assessment methods have proven more useful for evaluating particular functions, issues, and problems such as the use of hydrological models for evaluating flood storage and conveyance.

Are “reference” wetlands useful in carrying out wetland assessments and in restoring, creating, or enhancing wetlands?

A. Yes. Reference sites have proven very useful for reestablishment of elevations, hydrology, and plants in wetland restoration, creation, and enhancement projects and to provide comparative monitoring over time. A naturally occurring “reference” wetland in the vicinity of a proposed restoration, creation, or enhancement can be used to help determine appropriate water depths, wetland configuration, vegetation, and other factors. The HGM wetland assessment method utilizes wetland reference sites; so do various biocriteria approaches.

Reference sites may also be a source of wetland seeds and plants. Reference sites can be used, over time, to help measure the success or failure of a project.

What sorts of “adaptive management” measures may be needed for restoration, creation, or enhancement projects?

A. The goal of many restoration, creation and enhancement projects is to “get it right” in the beginning with regard to wetland hydrology and to create self maintaining systems. Unfortunately, wetland hydrology is often difficult to predict, particularly where watershed conditions are changing. Many unforeseen threats may develop to wetland systems such as the growth of exotic plant species. And, active management such as control of cattle grazing may be needed over time. Therefore, many if not most larger restoration, creation, or enhancement projects need to involve monitoring during and after construction to determine whether “adjustments” are needed in design or in management.

The degree or type of monitoring, mid course correction, and adaptive management capability needed for a restoration or creation project will depend upon a variety of both onsite and offsite project factors. More monitoring, mid course correction, and adaptive management capacity are needed for high risk projects involving difficult to create wetland types (such as some forested wetlands), uncertain hydrology, changing hydrology, and threats such as invasion of exotics.

Perhaps the most common adaptive wetland management measure in project design is the installation of small dams in a project which will allow the adjustment of water levels over time to achieve desired vegetation. The use of small dams is very common with marsh management projects. Such water level adjustments may be necessary because initial evaluation of hydrology was incorrect or because watershed hydrology changes over time. Adjustments may also be necessary to help control exotic plants.

Other adaptive management measures may include control of exotic plant species such as purple loosestrife or indigenous plants such as cattail which tend toward a monoculture in some contexts.



Control of purple loosestrife

What factors are relevant to establishment of compensation ratios for mitigation of impacts and losses?

A. A broad range of factors are relevant to the establishment of “ratios” for wetland restoration, creation, or enhancement to “compensate” for wetland damage or losses which may be caused by proposed development. Some of these factors include the following:

- The type of wetland and the degree of difficulty in restoring that type,
- The types of functions/values including difficulty likely to be encountered in restoring or creating particular functions/values and length of time it will take to restore or create the functions/values,
 - The soils, topography, existing condition, and other features of the site,
 - The adequacy of the project design,
 - Degrees of threat to the proposed project such as sedimentation, water quality, predation,
 - The extent to which the “public” and original landowners will benefit from the restored or created wetland,
 - The experience and expertise of the individual or organization proposing to carry out the restoration, and
 - Whether the project incorporates mid-course correction and long term maintenance capability.

States and federal agencies have adopted a variety of standards for mitigation ratios. Ratios usually operate on a sliding scale depending upon the type of wetland and problems which may be encountered with restoration.

What factors should be considered in identifying priority wetland restoration sites in a geographical area?

A. A variety of natural and cultural factors are relevant to the identification and prioritization of potential wetland restoration sites. Some natural resource characteristics include:

- Evidence of past drainage. Wetland areas which have been drained are often good potential restoration sites. Soil maps, air photos, topographic maps, agricultural maps, and onsite inspections can be used to indicate areas subject to past drainage.
 - Organic soils. Soil maps can be used to identify areas with organic soils including drained areas. Organic soils often indicate historical wetlands and areas with high restoration potential.
 - Low-lying topography. Topographic maps can be used to identify valley bottoms, depressions, and other low-lying areas and drainage paths which may have been historical wetlands and may constitute good restoration and creation sites.
 - Tidal inundation. Tide maps and a combination of topographic maps and tidal elevations can be used to suggest good potential coastal and estuarine wetland restoration, creation, or enhancement sites.
 - Proximity to other wetlands, water bodies, parks, wildlife areas, and adjacent upland buffers. Air photos, topographic maps, satellite imagery, and land use maps can be used to identify areas which would be, if restored or created, be near to or connected with wetlands or water bodies. These areas may also be high priority restoration sites.

- Areas with low velocity waters. Topographic maps, air photos, and flood maps including post flood damage surveys can suggest coastal, riverine, isolated wetland, and lakeshore areas with low velocity waters. Low energy sites often make the best restoration and creation sites because wetland vegetation is destroyed by high energy waves or high velocity flows.
- Areas with relatively low sedimentation rates. Flood maps, topographic maps, erosion surveys can be used to identify areas subject to low sedimentation rates from runoff. Such areas often make preferred restoration and creation sites because high rates of sedimentation will quickly destroy a wetland.

Cultural factors relevant to restoration or creation potential include:

- Land ownership. Land in public ownership is often a priority for restoration or creation because of the reduced costs and the possibility of providing upland buffers.
- Land use. Land in open space is, obviously, a better candidate for restoration than land used for housing, other development, or agriculture.
- Land costs. In general, sites with lower land costs are preferred candidates for restoration by public agencies or not for profits than higher priced developed or partly developed areas.
- Water pollution, flooding, erosion and other watershed “problems”. Areas subject to severe pollution, flooding, or erosion or other problems make higher risk restoration sites. On the other hand, lands subject to problems which can be ameliorated through wetland restoration or creation may also be high priority sites.
- Parcel or lot size. In general, land in large parcel ownership is a higher priority for restoration or creation than land owned by many parties. Multiple, small scale ownership complicates assembling parcels for restoration.
- Landowner attitudes toward restoration. Sites owned by individuals wanting to restore their lands are often a priority.

What is a mitigation bank?

A. A mitigation bank is a wetland which has been restored, created, or enhanced to help compensate for future wetland losses. Individuals wishing to destroy or damage a wetland may buy credits in a bank to compensate for such destruction or damage.

What are the advantages and disadvantages of mitigation banks?

A. Mitigation banks have a number of advantages over small onsite and in-kind projects to compensate for wetland losses. They can often be more carefully planned with greater expertise than such smaller projects. They can often be more advantageously located than smaller projects. They may also be better managed over time.

But, there are disadvantages as well. Most importantly, they often do not replace lost functions and values in the original setting. For example, providing flood storage many miles from the destruction of a wetland may benefit some adjacent landowners but it will not prevent flooding at the original location.

Where can I go to find more information concerning wetland restoration, enhancement or creation?

A. See selected bibliography and web sites below.

SUGGESTED READINGS

- Bartoldus, C. 1999. A Comprehensive Review of Wetland Assessment Procedures: A Guide for Wetland Practitioners. Environmental Concern, Inc., St. Michaels, MD.
- Bartoldus, C., E. Garbisch, and M. Kraus. 1994. Evaluation for Planned Wetlands (EPW). Environmental Concern, Inc., St. Michaels, MD.
- Berger, J. (ed.) 1990. Environmental Restoration: Science and Strategies for Restoring the Earth. Island Press. Washington, D.C.
- Coastal America Technology Transfer Report. 1996. Coastal Restoration and Protection Lessons Learned. Silver Spring, MD.
- Dennison, M, and J. Schmid. 1997. Wetland Mitigation: Mitigation Banking and other Strategies for Development and Compliance. Government Institutes, Rockville, MD.
- Erwin, K. 1996. A Bibliography of Wetland Creation and Restoration Literature. Association of State Wetland Managers, Inc., Berne, NY.
- Florida Department of Environmental Regulation. 1991. Report on the Effectiveness of Permitted Mitigation.
- Good J. and C. Sawyer. 1997. Recommendations for a Nonregulatory Wetland Restoration Program for Oregon. Oregon Sea Grant and the Marine Resource Management Program, College of Oceanic and Atmospheric Sciences, Oregon State University.
- Hammer, D. 1989. Constructed Wetlands for Wastewater Treatment. Lewis Publishers, Boca Raton, FL.
- Hymanson, Z. and H. Kingma-Rymek. 1994. "A Conceptual Model for Wetland Performance Guidelines." California Coastal Commission, San Francisco, CA.
- Janiec, D. 1999. "Delaware Technology Park Revisited: Wetland Mitigation Integrated with a Stormwater BMP Design." Land and Water. Fort Dodge, IA.
- Kadlec, R. and R. Knight. 1995. Treatment Wetlands: Theory and Implementation. Lewis Publishers. Boca Raton, FL.
- Kentula, M., R. Brooks, S. Gwin, C. Holland, A. Sherman, and J. Sifneos. 1992. An Approach to Improving Decision Making in Wetland Restoration and Creation. Island Press, Washington, D.C.
- King, D. and C. Bohlen. 1994. "Estimating the Costs of Wetland Mitigation." National Wetlands Newsletter. Vol. 16, Issue 3. The Environmental Law Institute, Washington, D.C.
- Kusler, J. (ed). 1988. Wetland Hydrology (Proceedings of a national wetland symposium). Association of State Wetland Managers, Inc. Berne, NY.
- Kusler, J. 2005. Multi-Objective Wetland Restoration in Watershed Contexts. Association of State Wetland Managers, Berne, New York.

- Kusler, J. and C. Lassonde (eds). 1992. *Effective Mitigation: Mitigation Banks and Joint Projects in the Context of Wetland Management Plans*. Association of State Wetland Managers, Berne, New York.
- Kusler, J. and M. Kentula (eds). 1990. *Wetland Creation and Restoration: The Status of the Science*. Island Press, Washington, D.C.
- Kusler, J., D. Willard and H. Hull Jr. (eds). 1997. *Wetlands and Watershed Management: A Collection of Papers*. Association of State Wetland Managers, Berne, New York.
- Kusler, J., W. Mitsch and J. Larson. 1994. "Wetlands." *Scientific American*. Vol. 270, Issue 1.
- Mitsch, W. and J. Gosselink. 1993. *Wetlands: Second Edition*. Von Nostrand Reinhold, New York, New York.
- Mitsch, W. and N. Wang, V. Wu, S. Johnson, and U. Özesmi. 1998. *Enhancing the Roles of Great Lakes Coastal Wetlands: A Case Study on Sandusky Bay, Lake Erie, Ohio*. Ohio State University, Columbus, Ohio.
- Mitsch, W., X. Wu, R. Nairn, P. Weihe, N. Wang, R. Deal, and C. Boucher. 1998. "Creating and Restoring Wetlands: A Whole-Ecosystem Experiment in Self-Design." *BioScience*. Vol. 48, Issue 12; 1019-1030.
- Moshiri, G. *Constructed Wetlands for Water Quality Improvement*. Lewis Publishers, Boca Raton, Florida.
- National Research Council. 2001. *Compensating for Wetland Losses Under the Clean Water Act*. National Academy Press, Washington, D.C.
- National Research Council. 1995. *Wetlands: Characteristics and Boundaries*. National Academy Press, Washington, D.C.
- National Research Council. 1992. *Restoration of Aquatic Ecosystems*. National Academy Press, Washington, D.C.
- Pacific Estuarine Research Laboratory. 1990. *A Manual for Assessing Restored and Natural Coastal Wetlands: With Examples from Southern California*. California Sea Grant Report No. T-CSGCP-021. La Jolla, California.
- Pease, J. M. Rankin, J. Verdon, and R. Reisz. 1997. "Why Landowners Restore Wetlands: A National Survey." Iowa State University Extension, Department of Animal Ecology, Ames, Iowa.
- Schueler, T. 1995. *Site Planning for Urban Stream Protection*. Metropolitan Washington Council of Governments, Washington, D.C.
- U.S. Department of Agriculture, Forest Service, Southwestern Division. 1996. *Managing Roads for Wet Meadow Ecosystem Recovery*. USDA; Washington, DC.
- U.S. Environmental Protection Agency. 1996. *Protecting Natural Wetlands: A Guide to Stormwater Best Management Practices*. Washington, D.C.

Waters, E. 1999. Principles of Estuarine Habitat Restoration: Report on the RAE-ERF Partnership, Year One. Restore America's Estuaries, Estuarine Research Federation.

Wetland Functions, Rehabilitation and Creation in the Pacific Northwest: The State of Our Understanding. 1986. Pub. 86-14. Washington State Department of Ecology; Olympia, Washington.

SUGGESTED WEB SITES

<http://www.csc.noaa.gov/lcr/habitat.html>

NOAA Coastal Services Center. The Landscape Characterization and Restoration Program

http://www.nal.usda.gov/wqic/Constructed_Wetlands_all/index.html

Constructed Wetlands Bibliography

<http://www.nal.usda.gov/wqic/Bibliographies/conwet2.html>

Constructed Wetlands and Water Quality Improvement (II)

http://www.nmfs.noaa.gov/habitat/habitatprotection/pdf/Wet%20Res%20Guidance_FIN_AL.pdf

Interagency Workgroup on Wetland Restoration. 2003. An Introduction and User's Guide to Wetland Restoration, Creation, and Enhancement. National Oceanic and Atmospheric Administration. Washington, D.C.

<http://www.csc.noaa.gov/lcr/swamp/text/p661.htm>

NOAA SWAMP model. See examples of applications for the SWAMP Model.

http://www.vims.edu/ccrm/ci/adv_id/funcassess.pdf

Virginia Institute of Marine Sciences identification of potential restoration sites to serve specific functions.

http://www.mass.gov/czm/wrp/projects_pages/projects_overview.htm

Massachusetts Office of Coastal Zone Management. Wetlands Restoration Program. Massachusetts restoration projects are described.

<http://www.coastalamerica.gov/text/projects/projects.html>

Coastal America. Regional Conservation Projects. Restoration projects (listed regionally). Several hundred projects described.

<http://www.coastalamerica.gov/text/cwrpprojdesc.html>

Corporate Wetlands Restoration Partnership. Brief description of many projects.

<http://www.gulfofmaine.org/library/habitat/restoration2.htm>

Gulf of Maine Council on the Marine Environment. Gulf of Maine Projects. List of 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>

Louisiana Department of Natural Resource. Coastal Restoration Division. 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 Everglade's restoration projects. Most are wetlands.

<http://www.saj.usace.army.mil/projects/index.html>

U.S. Army 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 Wetlands Reserve projects.

<http://www.photolib.noaa.gov/habrest/bar.htm>

NOAA Restoration Center Image Catalog. Brief descriptions and hundreds of photos of NOAA restoration projects.

<http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/wwec/general/wetlands/Wetlands.htm>

Pennsylvania Department of Environmental Protection. Waterways, Wetlands, and Erosion Control. 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>

USDA Natural Resources Conservation Service, Wetlands Reserve Program Success Stories (17 quite detailed profiles).

http://www.nh.nrcs.usda.gov/technical/Ecosystem_Restoration/Salt_marsh_projects.html#Stuart%20Farm

USDA Natural Resources Conservation Service. New Hampshire Cooperative Salt Marsh Projects. Description of 17 salt marsh cooperative restoration sites in New Hampshire.

<http://feri.dep.state.fl.us/>

Florida Ecological Restoration Inventory. Florida restoration case studies.

<http://www.epa.gov/owow/wetlands/restore/links>

Wetlands Restoration Links by State. U.S. Environmental Protection Agency

<http://www.srs.fs.usda.gov/charleston/>

USDA Forest Service, Southern Research Station. Center for Forested Wetlands Research.

http://www.nrcs.usda.gov/technical/stream_restoration/

Federal Interagency Stream Restoration Working Group, Stream Corridor Restoration: Principles, Processes, and Practices.

<http://search.nap.edu/books/0309074320/html/>

The National Academy Press. Compensating for Wetland Losses under the Clean Water Act (2001).

<http://www.soils.usda.gov/use/hydric/>

USDA Natural Resources Conservation Service. Hydric soils list.

<http://plants.usda.gov/>

USDA Natural Resources Conservation Service, National Plant Database

<http://www.nwrc.usgs.gov/>

U.S. Geological Survey's National Wetlands Research Center online publications.



Association of State Wetland Managers, Inc.

1434 Helderberg Trail, Berne, NY 12023

Phone (518) 872-1804; Fax (518) 872-2171; www.aswm.org

An electronic version of this brochure is available in PDF at:
<http://www.aswm.org/brochure/restoration.pdf>