A Guide for the Public Containing:

• Background on wetlands and restoration
• Information on project planning, implementation, and monitoring
• Lists of resources, contacts, and funding sources

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This guide would not have been possible without the contributions of many individuals. The members of the Interagency Workgroup on Wetland Restoration were critical to the document's development from start to finish: Susan-Marie Stedman, National Oceanic and Atmospheric Administration (NOAA) Fisheries; John McShane, Lynne Trulio, Doreen Vetter, Mary Kentula, and , U.S. Environmental Protection Agency (EPA); Jack Arnold, U.S. Fish and Wildlife Service (FWS); Jeanne Christie, Natural Resources Conservation Service (NRCS) and now with the Association of State Wetland Managers; and Colleen Charles, US Army Corps of Engineers (Corps) and now with the US Geological Survey.

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LETTER TO THE READER

Over the past 200 years, more than 50 percent of the wetlands in the coterminous U.S. have been lost and many of the remaining wetlands are degraded. These losses and alterations compromise the important benefits provided by wetlands including protecting water quality, providing habitat for a wide variety of plants and animals, and reducing flood damage. While *preserving* remaining wetland resources is critical to our nation's environmental health, *restoring* wetlands also is essential to ensuring the quality of aquatic systems. Because wetlands are so important to the earth's ecosystems and human society, the National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), Fish and Wildlife Service (FWS), Natural Resources Conservation Service (NRCS), and Army Corps of Engineers (Corps) worked together to develop this document designed for people wishing to support or undertake wetland recovery projects.

Many documents about restoration and related activities are technical or scientific in nature and are designed for experts. This document, however, is not a scientific paper. It is designed specifically for individuals, community groups, municipalities, or others who have little or no experience in the restoration field. We have written to a general audience for a number of reasons:

- Most land in the U.S. is in private ownership; significant increases in wetland quality and quantity can be achieved if private landowners restore wetlands on their property.
- Many EPA, NOAA, FWS, and NRCS programs support public involvement in wetland recovery efforts; information on wetland restoration for the general public may enhance those programs.
- Restoration is an important, growing environmental field. The general public can benefit from access to basic information about restoration, and may become encouraged to become involved in and support restoration projects.

Developing a guide on wetland restoration, creation, and enhancement applicable across the nation is difficult for a number of reasons. First, the terms "restoration," "creation," and "enhancement"

As you read this document, it will become clear that wetland projects vary considerably in size and complexity. In some cases, one person's efforts (fencing out cows, mowing instead of tilling, or eliminating the use of pesticides) can substantially improve a degraded site. On the other hand, teamwork and the help of specialists is usually required for creating new wetlands or restoring sites with extensive damage. In her book *Restoring Streams in Cities*, Ann Riley (1998) states that most restoration projects require teams of people with expertise in areas such as ecology, hydrology, engineering, and planning, among others.

Many landowners enroll in federal or state programs in which the public agency puts together a team of specialists who help with the restoration work. Other landowners or citizen groups may not be eligible for these programs or simply may want to organize the project themselves. Whether you are enrolled in a wetland restoration program or are organizing a wetland project yourself, this guide will help you understand what types of people and resources to consult in order to plan, implement, and monitor your wetland project.

The agencies who have worked on this informational document want it to be as useful as possible. Please give us your thoughts and comments on the information provided here. Write us or e-mail us care of:

Susan-Marie Stedman
NOAA Fisheries F/HC
1315 East-West Highway
Silver Spring, MD 20910

susan.stedman@noaa.gov

The National Research Council's 1995 report entitled "Wetlands: Characteristics and Boundaries" lists several major classes of U.S. wetlands and some plants associated with each:

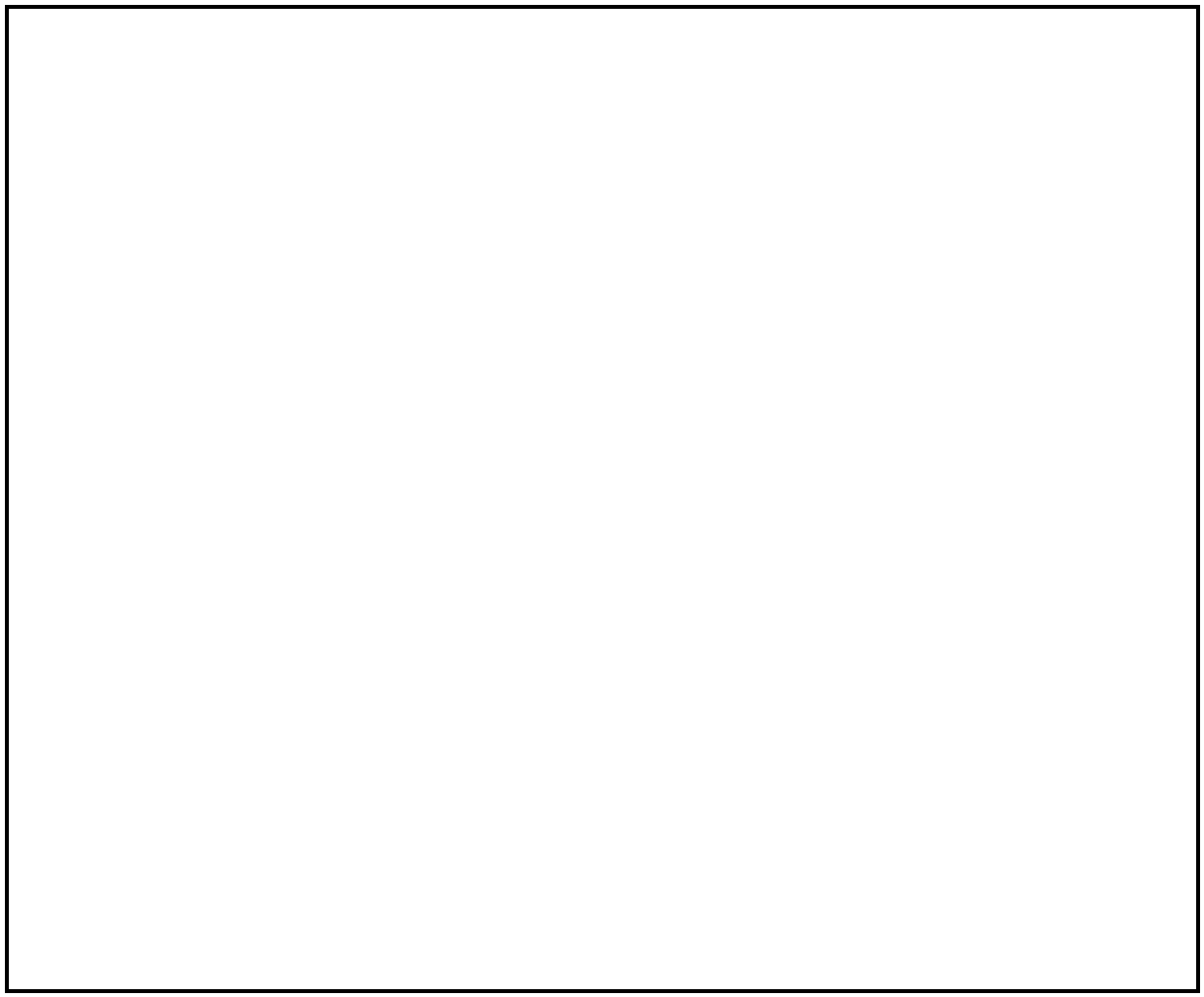
- Freshwater Marsh--grasses, sedges, herbs;
- Tidal Salt and Brackish Marsh--salt tolerant grasses, rushes;
- Prairie Potholes--grasses, sedges, herbs;
- Fens--sedges, grasses, shrubs;
- Bogs--sphagnum moss, shrubs, trees;
- Swamp Bottomland--cypress, gum, red maple; and
- Mangrove Forest--black, red, white mangroves.

Although wetland types are diverse, they all possess several ecological characteristics that distinguish them from upland or other aquatic ecosystems. Specifically, wetlands are characterized by unique hydrologic, soil (substrate), and biotic conditions. The hydrological regime, which is determined by the duration, flow, amount, and frequency of water on a site, is typically the *primary factor* driving the other ecological elements of the system. A site has wetland hydrology when it is wet enough to produce soils that can support hydrophytic vegetation (plants that are adapted to waterlogged environments). Wetland substrates are called hydric soils, meaning they are saturated with water for part or all of the year. Saturated soils become anaerobic (without oxygen) as water stimulates the growth of micro-organisms, which use up the oxygen in the spaces between soil particles. When soils become anaerobic, they change significantly in structure and chemistry. These factors all make wetland soils stressful to terrestrial plants.

As a result of waterlogged, anaerobic conditions, wetlands are dominated by hydrophytic plants that are *specifically adapted* to withstand these demanding conditions. The wide diversity of wetland plant species includes emergent plants (those with leaves that grow through the water column, such as cattails, sedges, and rushes), submerged plants (pondweeds, eelgrass), and floating-leaved plants (such as water lilies and duckweed). Wetland plants also include trees (such as cypress, red maple, and swamp oak), shrubs (such as willows and bayberry), moss, and many other vegetation types.

Because they exist where land and water meet, wetlands are often used by animals from both wet and dry environments. A number of invertebrate, fish, reptile, and amphibian species depend on wetland water cycles to survive or complete their lifecyles. For example, nearly all amphibians and at least 50 percent of migratory birds use wetlands regularly. Approximately 75 percent of all commercial marine fish species depend on estuaries, which in turn depend on their wetlands to maintain these productive ecosystems. See Technical Appendix T-II for more information on these attributes of wetlands.

Scientists have classified wetlands into various types. A well-known scheme, developed by Cowardin *et al.* (1979) for the FWS, has become the federally-accepted standard (see Box 1). Cowardin *et al.* state "Wetlands are defined by plants (hydrophytes), soils (hydric soils), and frequent flooding. Ecologically related areas of deep water, traditionally not considered wetlands, are included in the classification as deepwater habitats." For the complete national wetlands classification standard see http://wetlands.fws.gov/Pubs_Reports/pubs.html.



The Importance of Wetlands

The loss and degradation of wetlands in the U.S. has resulted in a decline in the important benefits that wetlands provide to society. These benefits or functions usually link to goods and services important to society. Some of the benefits wetlands provide include:

- Healthy fisheries. A 1991 study by James R. Chambers determined that approximately 75 percent (by weight) of commercially harvested fish and shellfish are dependent on estuaries and their wetlands. Nationally, commercial fisheries were valued at $3.5 billion in 2000. In California alone, the seafood industry generates approximately $800 million in sales annually. Virtually all freshwater species of fish are dependent to some degree on wetlands, often spawning in marshes adjacent to lakes or in riparian forests during spring flooding. These species are sought by recreational anglers, who spent $38 billion in 1996 to pursue their sport.

- Support for birds and other wildlife. Wetlands are probably best known for their value to waterfowl. The freshwater wetlands in the prairie pothole region of North America support an estimated 50 to 80 percent of the continental waterfowl production each year. The loss of wetlands in this region, which is estimated to be more than 50 percent of the original wetland acreage occurring at the time of settlement, has been considered a major factor in the decline in nesting success of duck

- Erosion control. By dissipating wave energy and stabilizing shorelines, wetland vegetation buffers the adjacent upland from wave action and intensive erosion.

- Flood damage reduction. Wetlands intercept runoff and store stormwater, thereby changing rapid and high peak flows to slower and smaller discharges over longer periods of time. Because it is usually the peak flows that cause flood damage, the effect of wetlands is to reduce the danger of flooding. A classic study by the Corps in the Charles River Basin in Massachusetts estimated that the loss of 3,400 hectares (approximately 8,100 acres) of forested wetlands would increase downstream flood damage, costing millions of dollars annually.

- Good water quality. Wetlands are known for their ability to capture sediments and filter pollutants, which improves water quality. For example, spring floods often carry very turbid water which, if not for the filtering that occurs in downstream wetlands, could deposit sediment that would smother plants and fish eggs. In addition, wetlands constructed to treat municipal runoff require only a fraction of the construction and operation budget of a conventional system.

- Aesthetics and recreation. Many recreational activities take place in and around wetlands. Hunting and fishing are popular activities associated with wetlands. Other recreational activities in wetlands include hiking, nature observation and photography, canoeing, and other boating. Many people simply enjoy the beauty and sounds of nature and spend their leisure time near wetlands observing plant and animal life. Wetlands are also important places for outdoor study and for gaining an appreciation of natural history and ecology. Properties bordering wetlands often have higher property values than those that do not. Urban wetlands are typically some of the last remaining pieces of "natural habitat" providing residents some sense of wildness and open space.

A primary goal of wetland recovery projects is to preserve and restore wetland benefits by re-establishing *natural ecological processes*. Some wetland functions can be mimicked with engineered structures, but engineered methods typically do not provide the maximum ecological benefit. For example, instead of re-establishing native vegetation on wetland edges to control erosion, a cement wall could be used to armor the bank. A cement wall could limit erosion for a time, but it does not provide the other ecosystem benefits of wetlands, such as filtering pollutants and providing fish habitat. For a more detailed list of wetland functions, see Technical Appendix T-I.

Definitions

The terms "restoration", "creation", and "enhancement" have been defined a variety of ways. The following commonly-accepted definitions for these terms, based on Lewis (1990), will be used in this document:

- - Returning a degraded wetland or former wetland to a pre-existing condition or as close to that condition as is possible.
- - Converting a non-wetland (either dry land or unvegetated water) to a wetland.
- - Increasing one or more of the functions performed by an existing wetland beyond what currently or previously existed in the wetland. There is often an accompanying decrease in other functions.

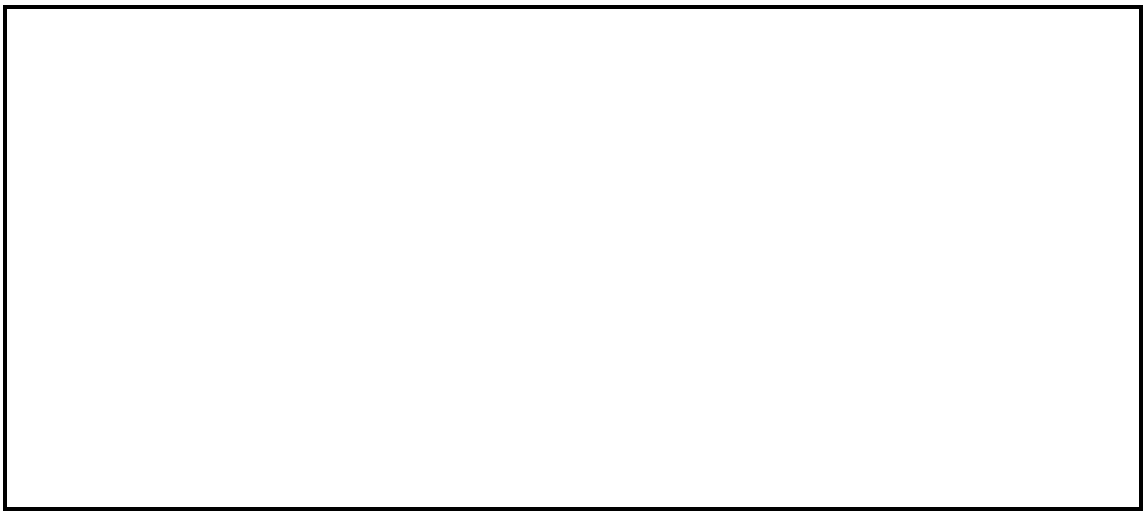
A similar set of definitions was adopted by a number of federal agencies in 2000 to keep track of federal wetland conservation projects. This set of definitions distinguishes between two types of restoration - "rehabilitation" (restoration in an existing wetland) and "reestablishment" (restoration in a former wetland). These definitions are in Appendix T-V.

Restoration and enhancement projects may be difficult to distinguish from each other, because both can encompass activities in existing degraded wetlands. According to the definitions above, restoration entails returning a wetland to a former state (e.g., filling a ditch so that a drained wetland becomes flooded again), while enhancement means changing the wetland so that one or more functions are increased beyond their original state. An example would be diverting a small stream into a wetland so that the area has deeper water.

Enhancing a wetland in one way often degrades it in another way. For example, adding more water to a wetland may create better habitat for fish, but it will decrease the ability of the wetland to hold flood waters. This trade-off is particularly true for enhancement in relatively undisturbed wetlands. Some common examples of the trade-offs that can occur with wetland enhancement include loss of fish habitat when salt marshes are impounded to provide waterfowl habitat, decreased water storage when seasonal wetlands are flooded to increase aquatic habitat, and loss of colonial waterbird habitat when mangroves are removed to provide shorebird habitat. When wetland enhancement is undertaken, the project goals should include minimizing any decrease in existing wetland functions.

Wetland creation - putting a wetland where it did not exist before - is usually a difficult undertaking. The primary challenges in creation projects are bringing water to a site where it does not naturally occur and establishing vegetation on soils that are not hydric. While creation is possible, it typically requires significantly more planning and effort than restoration projects, and the outcome of the effort is difficult to predict. Many attempts to convert uplands to wetlands result in ecosystems that do not closely resemble natural wetlands and that provide limited wetland functions (valuable upland habitat might be lost in the process as well). Creating wetlands from open water is less difficult with respect to establishing a water source, but it often requires placing dirt or other fill into existing aquatic habitats, which means destroying one kind of aquatic habitat to create another. While this trade-off

sometimes can be justified ecologically, the engineering and regulatory challenges of these projects are



Approaches to Restoration

Restoration practitioners typically implement only the actions necessary to re-establish natural wetland processes on a site. The first method to consider for renewing functions is to remove the factors causing wetland degradation or loss and let nature do the work of restoration. This method is often called the . For example, if wetland vegetation and water quality are degraded primarily as a result of cattle grazing, then removing the cows may be the only activity needed to restore the wetland system. Passive methods allow natural regeneration of wetland plant communities, natural re-colonization by animals, and re-establishment of wetland hydrology and soils. Passive approaches are most appropriate when the degraded site still retains basic wetland characteristics and the source of the degradation is an action that can be stopped. The success of passive methods usually depends on an accessible source of water, the close proximity of wetland plants and animals, and a mechanism for bringing species to the restoration site. The benefits of passive methods include low cost and a high degree of certainty that the resulting wetland will be compatible with the surrounding landscape.

For many sites, passive methods are not enough to restore the natural system and an is necessary. Active approaches involve physical intervention in which humans directly control site processes to restore, create, or enhance wetland systems. The active approach is most appropriate when a wetland is severely degraded or when goals cannot be achieved in any other way, as is the case with wetland creation and most enhancements. Active methods include re-contouring a site to the desired topography, changing the water flow with water control structures (i.e., weirs or culverts), intensive planting and seeding, intensive non-native species control, and bringing soils to the site to provide the proper substrate for native species. The design, engineering, construction, and costs for such work can be significant.

Enroll In a Restoration Program

There are a number of federal wetland restoration programs, in which landowners can enroll for help with a wetland recovery project. Federal programs provide technical and financial assistance to landowners, communities, and local governments interested in restoring native fish and wildlife habitats, including wetlands, uplands, riparian, and in-stream habitats. Many people take this route to restoration. Information on federal programs is given in Resource Appendix R-II. Several states, non-profit organizations, and local governments have similar programs. Check with your state department of natural resources to determine whether local restoration programs exist.

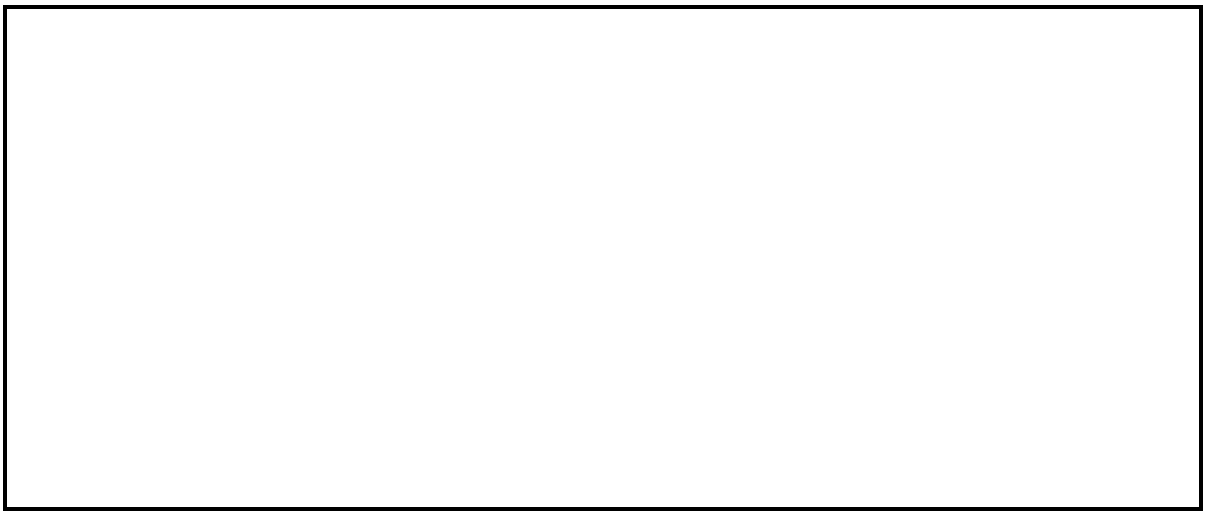
Hire a Project Manager

If you don't qualify for a federal or state program, another project approach is to hire someone with experience in wetland restoration to put together a plan and a team for you. There are consulting firms and some non-profit groups around the country who have the expertise in-house or can act as a

wetland restoration contractor to find those with the right kind of expertise. Check the Association of State Wetland Managers' "Directory of Wetland Professionals" at http://www.aswm.org or the Professional Certification section of the Society of Wetland Scientists' site at http://www.sws.org for lists of professional restorationists (and see Resource Appendix R-III).

Be Your Own Project Manager

If you (as an individual or citizen's group) choose to do the project yourself, you will want to assemble the people necessary to complete your wetland work. The type of technical advice and amount of physical help needed will depend on the project goals, the extent of degradation of the site, and the type of wetland; in short, it will depend on the complexity of the project. An example of a



districts, or state departments of natural resources may have staff with experience in wetland restoration. Ask for help in developing your restoration plan, reviewing it, or in providing specific information on the ecology of the wetland type you want to establish. If the agencies you contact do not have enough time or expertise to help you, ask for other contacts they would recommend. Some agencies have programs for funding restoration projects (see Resource Appendix R-II).

. Solicit restoration expertise from the local community. Post or send out flyers asking for volunteer experts in the community to help you. Many people with wetland restoration expertise are involved in wetland restoration efforts in their off hours. Not everyone who volunteers will have the expertise you need, so ask questions about what projects they've worked on, and look at the projects to see if they are meeting their goals.

. Check with the biology or environmental studies departments of local colleges and universities. They may offer ecological restoration courses or programs that could provide you with more background. The course instructors may be willing to help you with your project by providing technical advice and/or student volunteers. Local non-profit organizations may have restoration programs as well as access to advisors and volunteers. If local non-profits don't yet have a restoration program, you might convince them to team up with you to plan and undertake your project. Consider such organizations as the Izaak Walton League of America, the local Sierra Club or Audubon Society, native plant societies, and watershed protection groups.

Several large non-profit groups are significant supporters of restoration work. The National Fish and Wildlife Foundation helps groups find money to finance environmental projects, Ducks Unlimited provides funds and expertise to protect and restore wetland habitat, and The Nature Conservancy is a valuable source of information on restoration, creation, and enhancement projects. Find contact information for these and other groups in Resource Appendix R-III.

Many corporations sponsor wetland restoration, sometimes in partnership with government agencies and non-profits. For example, the National Corporate Wetlands Restoration Partnership, sponsored by the National Association of Manufactures, the Gillette Company, and Coastal America, is a public-private partnership between the federal government, state governments and private corporations to restore wetlands and other aquatic habitats (see http://www.coastalamerica.gov/text/cwrp.html).

The remainder of this document describes the four phases of a restoration project: planning, implementation, monitoring, and long-term management. If you are having someone conduct the restoration project for you, you will not be using this information yourself, but knowing the process will help you ask the right questions and understand the work. For those doing their own projects, the following information gives a basic overview of the restoration process and provides some resources. This document cannot provide the specific information on local wetland types, site conditions, watershed land uses, or implementation that is necessary to accomplish a project. That information must be obtained from sources with specific local knowledge. Some of these sources are listed in the Bibliographationsdy is a valces are l/u0y corpoij -0tion, s 0.4460c vapTj -0om om sotl

Why Plan?

Good planning is a critical, but often overlooked, stage of the restoration process. Inadequate planning is often cited as a major reason projects fail to restore self-sustaining, naturally-functioning

Maps with local topography and existing aerial photography can provide essential information on the primary sources of water in the watershed and the way wetlands are associated with them. Rivers, streams, lakes, bays, and the ocean are obvious sources of water that may have wetlands associated with them. Some wetlands are sustained by less obvious sources of water such as groundwater (springs, seeps, high water table) or rainfall and surface runoff. Obtain topography, drainage, and runoff information from the NRCS Field Office Technical Guides. Local water quality control districts, water management districts, or flood control districts (states often use different names) will have rainfall data and water level data for local water bodies. Look for data on the groundwater levels. The Federal Emergency Management Agency (FEMA) and local flood control districts have maps on the location and elevations of floodplains. These agencies can help you find out the frequency and magnitude of the flood events that occur in your community.

Soil maps for your watershed are available from the NRCS and are invaluable in locating where wetland soils exist or used to exist. Soil maps also often contain information about the location of springs, ponds, streams, and drainage ditches. Aerial photographs from the USGS or local aerial photography firms may provide data on some watershed features including the presence of wetlands and the amount and type of vegetation cover in an area. Information on local vegetation communities also may come from recent biological reports completed for planning agencies, Environmental Impact Statements, or other documents available from local planning agencies. Table 1 gives sources of information on soils, floodplains, and other watershed features.

Aerial photos are a valuable and commonly used source of data on watershed features such as topography, drainage and ponding patterns, land uses, vegetation communities and coverage, and habitat fragmentation and loss. Aerial photos cannot provide all of the information needed to evaluate watershed conditions; you will need to check with other sources to fully evaluate your watershed. Consult local agencies and other sources of information to get a full picture of current watershed conditions.

In addition to information about present conditions, collect information on the history of the watershed for valuable insight into the ecosystems that used to be there and what factors have caused loss or degradation to wetlands in the area. There may be aerial photographs for the past several decades or other records of past watershed conditions that could provide some of this information. Reviewing aerial photos from several years probably will show that some features, such as topography, have not changed much but others, such as land use, drainage ditches, roads and other structures, and vegetation communities, have changed significantly.

After considering natural conditions, identify human influences and constructed features. Roads, ditches, dams, and large areas of impervious surfaces such as parking lots are all features of the landscape that could affect existing wetlands and proposed wetland projects. Adjacent or regional land uses may or may not be compatible with re-establishing a former wetland or with the goals of a wetland creation or enhancement. Typical land uses include urbanized lands (residential, industrial, commercial), agriculture, grazing, mining, forest harvesting, streams, lakes, wetlands, non-harvested forest, open grassland, or park/recreational open space.

Urban and industrial areas may be sources of excess sediment and pollutants, such as oil and heavy metals, that wash off paved areas into streams and wetlands. Agriculture is often a source of

pesticides and fertilizers that may harm wetlands. These land uses may impair the health of newly established wetlands. On the other hand, farms are capable of providing valuable adjacent upland habitat if there are uncultivated buffer areas between the wetland and the fields. Consider not only existing land uses, but also future changes to the landscape such as encroaching development. Local zoning and planning documents from cities and counties can be examined to identify proposed conservation areas and future development areas.

Two land use questions to address as you plan your project are:

- How might changes in land uses, roads, ditches, and other human-constructed features have affected water quality, surface water runoff, and drainage/ponding patterns?
- How might these changes in land use, and the presence of roads, buildings, and other human-constructed features affect your ability to restore, create, or enhance a wetland?

For more information on watershed features, check the data available on your watershed at the EPA website, http://www.epa.gov/surf. For another information source, check the USGS 7.5 minute quadrangle maps for your area; these maps have many relevant landscape features. Also, National Wetlands Inventory (NWI) maps from the FWS for your region will show the location of some (but not all) of the wetlands. Visit their web site at http://www.nwi.fws.gov/.

Topographic Maps	Local USGS office or USGS's "Map Finder" at: http://edcwww.cr.usgs.gov/Webglis/glisbin/finder_main.pl?dataset_name=MAPS_LARGE or call 1-800-ASK-USGS; local map or sporting goods stores.

Choosing the Project Site

Some people decide to do a wetland restoration project with a site already in mind--one they own or have a special interest in--but, for many people, site selection is part of the planning process. All restoration, creation, and enhancement projects must be carefully placed in the watershed to meet hydrologic, soil, and biotic requirements. Site selection is a process of setting goals and then looking for sites with characteristics that will support achieving your goals. In the early stages of planning, you may select one site and then switch to another as your goals are refined. The best approach to site selection is to be flexible.

The first place to start when looking for a project site is a local, regional, or state list of priority wetland restoration sites. By choosing a site from such as list, you will be taking advantage of local wetland restoration expertise. The contacts listed in Appendix R-III, as well as local and state wetland contacts, can help you find out if there is a list of priority restoration sites for your area. Talking to the people who created the list can help you pick the site that best fits your goals and resources.

When there are a number of potential project sites, you will need to evaluate them carefully. Hammer (1992) lists these six factors to consider when choosing a restoration, creation, or enhancement site:

- hydrology;
- topography and geology;
- soils;
- biotics;
- land ownership; and
- agency requirements.

Information on the first four factors may be provided when you conduct the landscape/watershed evaluation described in the previous section. When choosing a project site, specifically consider how to achieve the necessary amount and duration of water for your wetland type. Look for potential locations with the hydrology, topography, and geology typical of the type of wetland you want to restore. Look also for the presence of wetland soils (hydric soils) or drained wetland soils, which indicate places that would be appropriate for wetland restoration. Choosing a site that is close to an area with native wetland species or finding a site that already has native species might aid natural colonization of the site. The best sites are likely to be near wetlands similar to your target type.

If you are buying a site, determining the ownership of a potential project site is a critical step. Find out if there are easements, liens, covenants, water-rights issues, or other aspects of the parcel that may restrict its use for your project. Agency requirements also determine the suitability of a site for the intended project. Find out from local, state, and federal agencies what permits or authorizations may

be necessary to undertake your project. For more information on this topic, see the section below, "Government and Agency Requirements."

Successful site selection produces locations that will support your wetland project goals. You may need to revise your project goals to reflect the constraints of current conditions if available sites do not meet your original purposes.

Know Your Project Site

In addition to qualitative information, collecting site-specific, quantitative (numerical) data is often necessary to determine the causes and cures for wetland loss or degradation. Quantitative site measurements may be required to obtain permits or to design the project. Collecting quantitative data typically requires the help of local experts familiar with conducting biological assessments and wetland delineations, and who are knowledgeable about the local natural communities. Several quantitative parameters that are often measured in the field include:

- exact elevations and topography of features;
- levels of soil nutrients, organic matter, and moisture;
- water flow rates and timing;
- location of wetland soils, wetland plants, and wetland hydrology; and
- diversity and cover of native and invasive or non-native plant species.

You also should look for site conditions that could limit the project goals. Modifications to the project design or maintenance plan may be needed to address problems such as:

- poor water quality or lack of sufficient water;
- local pollutants;
- improper sun exposure for plantings;
- lack of native species nearby;
- invasive and non-native species on adjacent lands;
- herbivores that could decimate new plants (Canada geese, muskrats, etc.);
- human uses (of the site and adjacent sites) that are incompatible with restoration;
- future land uses (in and around the site) that are incompatible with restoration; and
- presence of cultural resources.

As noted earlier, watershed conditions play a major role in achieving restoration, creation, or enhancement goals. It is important to realize that it may be harder to reach your goals at an isolated site than at a site located near or adjacent to comparable wetlands. Isolated habitats may be more vulnerable to invasion by non-native species and are more difficult for native plants and animals to colonize. However, some wetland types such as prairie potholes and vernal pools are naturally separated from similar habitats. For these types of wetlands, it is appropriate to restore or create them where they typically occur in the landscape and in numbers typical to the watershed.

Setting Goals and Objectives

As you selected the project site and evaluated its condition, you did so with ideas of what you want to achieve. These , which are general statements about the desired project results, reflect your motivations for undertaking the project. Do you want to see your site support a diversity of native plant and animal species? Are you interested in improving the water quality in local streams? Do you hope to return the site to a condition you remember from years before? Examples of goals for wetland restoration projects might include “repair damage to seagrass beds from boat traffic” or “restore the native plant species and seasonal water cycle to a drained prairie pothole.”

Goals provide an overall framework. The next step is to develop that provide specific targets focused on hydrology, soils, topography, and/or biological factors that must be changed

on the project site to establish or restore a wetland. For the goal "restore the natural hydrology and vegetation of a degraded Atlantic coast salt marsh" the following objectives would be appropriate:

- Restore the natural tidal regime;
- Ensure the mudflat is returned to a level appropriate for vegetation;
- Re-establish dominance of the native plant community, e.g., *Spartina* and *Salicornia* species; and
- Limit the presence of non-native or invasive plant species.

Progress is determined by measuring performance standards or that are linked to each objective. Target criteria often include a numerical end-point and a time line to reach that end-point. For example, the objective "Restore the natural tidal regime" might be linked to this target criterion: "Remove enough of the dike so that within one year the tidal range upstream of the dike is

The Lane-Metro Youth Corps of Eugene, Oregon, undertook a 9-month wetland restoration project in the West Eugene Greenway, which is managed by the Army Corps of Engineers. The goal of the project was to complete work in endangered and threatened species habitat that would lead to natural re-colonization by the native species. The specific measurable target criteria to be achieved in nine-months included:

- Enhance and restore 5 acres of habitat to provide for the survival and reproduction of Bradshaw's lomatium and Willamette Valley daisies.
- Collect seeds from 40 acres of native wetlands.
- Construct 11 accessory water channels to enhance site hydrology to support rare daisies.
- Plant native species along 5,000 feet of levees to provide a diverse native plant community.

Using Reference Sites

How do restoration specialists determine what kind of hydrology, soil conditions, or specific organisms to establish at a project site? A standard method for setting restoration targets is to base them on the conditions of the wetland that existed on the site before it was altered. If hydrology, soil, and biotic data on the pre-damaged condition of the wetland are complete enough, this information can be used to set standards for partially or completely re-establishing the pre-disturbance conditions. Information collected from aerial photos and historical maps may show the former extent of vegetation and/or hydrology. Data from sources such as local water districts, universities, and citizens, may also provide the detail needed.

However, in most cases, there is not enough detailed background information on plant species and cover, animal species and abundance, soil conditions, or hydrology to set target criteria. Because historical information is often missing, most restorationists depend on local ," which are sites that represent the least disturbed wetlands of the target type in the area. The ecological conditions at reference sites are usually indicative of the natural communities that can be supported under current conditions. Even if we wanted to restore to a "pristine" ecosystem such as the Europeans first saw when they arrived in North America, changes to land uses, water sources, or other aspects of the surrounding landscape in the last 300 years usually make it difficult or impossible to restore a wetland to its pre-disturbance ecological condition (see Box 5). Reference sites provide insight into what is possible now.

A good example of altered regional hydrology and its effect on wetland restoration exists in northern New Jersey in "The Meadowlands." In colonial times, this area was an Atlantic white cedar swamp, but today the cedars are gone, replaced by fill, roads, buildings, some brackish marsh, and a tall reed known as *Phragmites*. There are numerous wetland restoration projects in The Meadowlands, but none of them have as their goal restoration of a white cedar swamp. In addition to all the other landscape changes, a dam on the Hackensack River has made the area too salty for cedars. Instead, wetland restoration efforts are focusing on establishing brackish water marsh, which is much more appropriate given the current regional ecological and hydrological conditions.

To collect reference site data, examine the least altered nearby wetlands that are in the same landscape position as your site (e.g., along a river, in an isolated depression) and appear to be similar to the pre-disturbance condition of the degraded wetland, if known. You may have already collected some information on similar wetlands when you were learning about the local watershed. Try to identify *several* reference wetlands, because wetlands of the same type can vary considerably in their characteristics. Looking at multiple wetlands of the type you hope to establish can help you understand the natural range of variation of the wetland type. Be sure you have the landowner's permission to enter any property you examine.

Restorationists also look for data on different phases of recovery to understand how the system will change over time. Some states are currently developing sets of data from reference wetlands. Contact your state water quality agency or department of natural resources to find out if your state is gathering information on reference wetlands. The wetlands division of your regional EPA office may also have information on reference sites. Look also for other restoration, creation, or enhancement

- What changes might restore hydrology and the correct relationship between soil and water levels?
- What design elements should be included to restore the typical hydrological regime and allow for extreme events?
- What soft engineering or bioengineering methods are available to rectify the problems?
- What factors might constrain restoring full hydrological functioning?
- What are likely reasons that the site might fail to reach its hydrological goals?
- What potential remediation or correction measures are available?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What parameters should be monitored? How often should they be monitored and for how long?

Ask about Water Quality:

- Are there indications of pollution? What are the likely sources?
- What water quality tests are necessary?
- What are the best methods for testing water quality (field kits, lab testing)?
- What methods are available for fixing pollution problems?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What parameters should be monitored? How often should they be monitored and for how long?

Ask about Wetland Soils and Substrates:

- Where can baseline information about local soils be found?
- Where can reference wetlands be found in the watershed or nearby watersheds?
- What are the typical characteristics of substrates in the wetland of interest? Levels of organic matter, nutrients, soil moisture? Particle sizes and soil structure?
- Are there impervious soil layers contributing to the wetland dynamics?
- What soil parameters should be sampled to characterize the site?
- What are typical substrate elevations and microtopographic features of this wetland type (including channels, islands, and mounding)?
- If toxic soils are found, can they be removed or remediated?
- What methods are available to bring the soil conditions and substrate elevation in line with observations from relatively undisturbed wetlands?
- What bioengineering or soft engineering implementation methods are available?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What soil and elevation parameters should be monitored? How often should they be monitored and for how long?

Ask about Wetland Plant Communities:

- What native plant species are found in pioneer and mature stages of the target wetland type? What are the dominant and rare species?
- What special status, threatened, or endangered species are found in the target wetland type?
- What natural disturbances are typical of this wetland type?
- On the potential restoration site, what plant species are present, including special status and listed species, non-native invasives, and species native to the target wetland?
- What soil and hydrolgical conditions on the potential restoration site would constrain establishing the native community? How should these conditions be changed?
- How should the site be prepared (adding soil amendments, removing non-natives, etc.) for establishing native plants?
- What methods are available for eliminating the most damaging non-native species?
- Is it likely that native species will colonize the site quickly? If not, what methods should be used to establish native plants?
- What are the threats to newly established plants (herbivores, flooding, intense sun, etc.) and how should they be combated?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What plant and plant community parameters should be monitored? How often should they be monitored and for how long?

Ask about Wetland Animal Communities:

- What native animal species are found in pioneer and mature stages of the target wetland type? What are the dominant and rare species?
- What special status, threatened, or endangered animal species are found in the target wetland type?
- What natural disturbances affect animal species in this wetland type?
- On the potential restoration site, what animal species are present, including special status and listed species, non-native invasives, and species native to the target wetland?
- What soil, hydrolgical and plant community conditions on the potential restoration site would constrain establishing the native community? How should these conditions be changed?
- What habitat conditions will attract the typical animal species and what specific habitat features can be added to attract specific valuable and/or rare species?
- What methods are available for eliminating the damaging non-native species?
- Is it likely that native species will colonize the site quickly? If not, what can be done?
- What are the threats to newly established animal populations on the site (predators, flooding, pollution, human impacts, etc.) and how should they be managed?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What parameters should be monitored? How often should they be monitored and for how long?

Using Adaptive Management

Natural ecosystems are complex. Even if you start out with detailed information about a site, the way it responds to changes can be unpredictable. Unforseen events may occur, such as a unexpected plant species colonizing the site, or new information may become available, such as the presence of a natural spring on the site. These unforseen elements may be beneficial or detrimental to the project. In either case, you will need to make decisions about how to adapt your project to account for the new element.

Adaptive management is a technique that involves incorporating new information into all stages of a wetland project. Using adaptive management means you continuously evaluate your project in light of new information, generating ideas and making decisions about how to further refine the project. This process also can be thought of as a "feedback loop" in which information about what is happening with your project currently helps you determine how best to go forward with the next step of project. Monitoring (covered in detail in Part 6) provides the information, you and/or your project team provide the decisions. Adaptive management is a repeated process that should be applied through the lifetime of the project.

Heritage" or rare species programs that can tell you whether there are plants and animals protected by state or federal regulations on or near your site. Alternatively, you can contact state fish and wildlife agencies and/or local offices of the FWS and NMFS for information. See Resource Appendix R-II for contact information. In addition, you should talk to your city and county planning offices about local requirements or permits for your project.

Be sure to avoid or minimize adverse environmental impacts that may result from wetland project construction activities. For example, earth moving, which can be a part of more complex projects, can cause erosion, increases in particulate matter in the air, and potential disturbance to locally nesting bird species. Avoid impacts by following the requirements of regulating agencies and by implementing the Best Management Practices (BMPs) recommended by the agencies and local municipalities. BMPs to limit erosion may include using silt fences and hay bales to capture silt, avoiding work during rainy periods, and/or capturing runoff in a holding pond.

. For many projects, restoration potential is restricted by societal factors. Some of these include availability of funds, volunteer resources, local landowner concerns, community support, and legal issues (such as water rights). The relevant societal issues must be considered in your project design and implementation, with the hope that someday in the future some of the limitations to a more complete restoration may be removed.

A major limiting factor is, of course, money. Some projects are relatively inexpensive, but others can be major financial undertakings. Typically, the more engineering that is needed, the more expensive your project will be. To help finance your project, begin with the list of funding sources in Resource Appendix R-II. Other sources of money or information on funding are:

- local cities or counties;
- state programs, especially through parks and recreation, wildlife, or other resource agencies; and
- local corporations, some of which have philanthropy programs for local projects.

On Maryland's eastern shore, Marshy Hope Creek winds its way to the Chesapeake Bay. Along most of its reaches it is a meandering stream with lush riparian vegetation. However, where it flows through the town of Fredericksburg, the Creek was straightened and channelized with levees. Much of the vegetation was removed and the historical floodplain had been filled. The levees containing the modified portion of the Creek prevented flooding of adjacent properties and local landowners did not want these embankments to be removed. The Maryland Department of Natural Resources (DNR) worked with the town to develop a plan that enhanced the Creek's ecological values while leaving the levees in place. DNR removed fill from the floodplain and created channels through the levee that allowed river water to flow to newly sculpted depressions on the floodplain. The channels also connected the river with existing deep ponds adjacent to the floodplain that were remnants of former mining operations. Soil excavated from the floodplain was used to fill part of the mining ponds to create shallow water habitat for fish. Native vegetation recolonized the floodplain and fish quickly began to use the channels and ponds. Although total restoration was not possible, enhancing the conditions adjacent to Marshy Hope Creek increased overall wetland values of the area.

Choose the Simple Approach

You now have a better idea of what your site conditions are like and what you want to achieve. What, then, will need to be done for your site to meet its restoration, creation, or enhancement goals? This question links goals with implementation. Methods for implementing projects are very diverse and should be developed with as much ecological, hydrological, and/or soils expertise as you can muster. In general, the best approach is to use the simplest methods possible, because the more complex a wetland project is, the greater the chance that something could go wrong. Implementation should be achieved through the least destructive means and the most ecologically sound solutions. Passive methods should be considered before more active interventions.

If natural processes cannot be initiated with passive methods, then implementation should focus on bioengineering or soft engineering solutions over traditional hard engineering solutions. Soft or bioengineering methods are based on working with natural processes. This approach is an alternative to the traditional, hard engineering solutions that often replace ecosystem functions with human-designed structures. For example, hard engineering solutions to controlling erosion along a stream bank such as rip rap or cementing the stream banks destroy natural wetland processes. Soft engineering uses physical solutions that reinstate ecological processes and allow the system to become as self-sustaining as possible. In addition to being ecologically preferable, bioengineering methods are often more economical than traditional techniques. Some researchers have found that hard engineering for erosion control can cost up to four times as much as soft engineering methods. Examples of soft engineering solutions to stream bank erosion include:

- planting native vegetation, especially fast growing species such as willows;
- shoring the banks with logs that will decompose in time; or

- stabilizing the bank with “geotextile materials” that do not decompose, but are covered with soil and allow root growth through the material.

Table 2 contains some of the most common and obvious examples of wetland damage and typical corrective measures. The table also lists some cautions. If the damage is severe or has been present for a long time, reversing the damage may not be as simple as it initially seemed. Some of these corrective measures are also applicable to implementing enhancement or creation projects. Technical Appendix T-III contains additional information on typical measures for restoring, creating, or enhancing wetlands.

Hydrology			
Water Quality Impairment	Excess sediment or nutrients in runoff from adjacent area	Work to change local land use practices; install vegetated buffers/ swales/constructed treatment wetlands; install sediment traps.	
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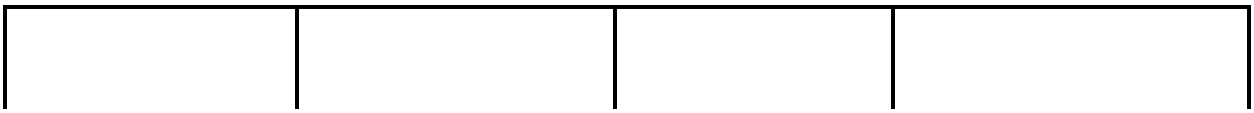

Prepare for Implementation

After determining what site changes are necessary, prepare to implement the changes by developing project designs such as field protocols or construction plans and specifications. Protocols are written guidelines for field crews on how to undertake the work. They should be as specific as possible, but in easy-to-understand language, especially if volunteers will be doing the work. Even with protocols, volunteers will need direction in the field.

Most projects will need some level of documentation to direct implementation; more complex projects will probably need construction plans. Good designs include at least these elements:

- specifications/diagrams for all installation/construction features;
- descriptions of site preparation needed;
- descriptions of how to install features, such as plants, etc.;
- plans to prevent construction impacts, such as erosion;
- lists of plant species, numbers of each to be planted, and planting locations;
- plans for site maintenance; and
- monitoring features, such as groundwater wells, staff gauges, or boardwalks.

The design of restoration, creation, or enhancement projects can be highly technical and may require hydrologists, ecologists, geotechnical experts, engineers, and/or landscape architects. Construction documents are usually prepared by engineers for use by contractors in the field for constructing a project. If construction documents are necessary, take the time to find engineering and construction firms that are flexible and willing to undertake non-traditional designs and soft engineering methods. Try to find firms that have done wetland restoration work in the past. Talk to their former clients to see what their work was like. Be sure your ecological advisors work with the engineers to produce plans that accurately reflect the methods you want used for the project. During construction, have the work inspected by your ecological experts to be sure that the plans are being followed accurately.

Publicize Your Project

- Collect past and present information on the local watershed.
- Choose a project site.
- Collect past and present information on the project site.
- Collect data on reference sites.
- Develop objectives and target criteria based on watershed, project site, and reference site information.
- Talk to the agencies about appropriate regulations. Talk to adjacent landowners and identify important social or economic factors that could affect the restoration.
- Refine goals and objectives.
- Decide on methods for implementing changes designed to rectify damage and meet planning goals and objectives.
- Prepare designs, such as protocols or construction documents, to direct implementation.
- Publicize your project.

Stages of Implementation

Implementation is the physical process of actually doing the restoration, creation, or enhancement project according to the design developed in the planning stage. This phase of the restoration process is popular with volunteers and it is the most visible phase to the public. Implementation may require a series of steps depending on the wetland type, your project goals and objectives, and the extent of the degradation. Steps in implementation typically include site preparation, plant preparation, installation, maintenance, and continuous adaptive management.

. During site preparation, the project site is altered either to allow natural processes to operate or to prepare it for additional human intervention. Common activities in this stage are:

- removing non-native species (See Box 6);
- removing piles of soil, debris and trash;
- amending soil with nutrients or other enhancements;
- removing polluted soils;
- bringing in appropriate soils or substrates;
- plugging or removing drains;
- fencing out cattle or other herbivores;
- breaching levees; and
- mowing or burning the site to reinstate the natural disturbance regime.

. For many restoration projects you can rely on natural re-vegetation to re-

Discuss your project with the volunteer coordinator for a local nonprofit group to determine any issues that may arise from using volunteers. While volunteers can be great additions to a project, weigh the benefits against these potential complications:

•

- collecting and testing water samples periodically to evaluate changes in water quality;
- collecting a representative sample of sediment cores to test for organic matter and other soil characteristics;
- surveying surface elevations at permanent transects once a year;
- recording plant species and cover by species along randomly established transects across the site; and
- setting traps for small mammals at randomized locations to determine species diversity and abundance.

Quantitative monitoring is often carried out by experts in hydrology, soils, or biota. However, volunteers may be used to collect numerical data if they are supervised by an advisor who knows the

also beginning wetland monitoring projects. Check out the EPA website for information on volunteer monitoring at http://www.epa.gov/OWOW/wetlands/wqual.html#Volunteer.

How Long Should I Monitor?

Like most ecosystems, wetlands change over many years. This is especially true for restored, created, or enhanced wetlands that may take decades to reach a condition close to that of a mature, naturally-occurring wetland. Research on wetlands created from dredged material in the Gulf of Mexico suggests that these wetlands are still changing and maturing 20 years after they were created. Consider monitoring to be a long-term activity, not just something you do for the first year or two. At a minimum, a site should be monitored until it meets all performance standards, which can take from several years to decades. Future managers of wetlands will thank you for monitoring for as long as you can. Even after it reaches maturity, your wetland will be a dynamic system that varies over time.

The Stevens Creek Tidal Marsh restoration project in the City of Mountain View is a compensatory mitigation site with the primary goal of providing vegetated tidal marsh habitat for rare species such as the salt marsh harvest mouse. The site began as a deep pit with ponded water. Project objectives included restoring tidal influence, building up the mudflat, and establishing native tidal salt marsh vegetation. Target criteria included:

- Re-establish tidal influence.
- Within 3 years, develop mudflat on 50 percent of the site at an elevation available to vegetation.
- Restore native salt marsh vegetation on 50 percent of the site within 5 years.

To assess progress, the City monitored the following parameters once a year:

- Amount of tidal exchange: measurements were taken by an automatic tide gauge and interpreted by a hydrologist.
- Elevation of the mudflat: measurements were taken by a qualified surveyor.
- Amount of vegetation on the mudflat: measurements were taken on the ground using transects and taken from aerial photographs, then interpreted by an ecologist.
- Extent of channel formation: measurements were taken from aerial photographs and interpreted by a hydrologist.

These quantitative methods were supplemented by qualitative observations on tidal flow, non-native

What Should I Do With the Monitoring Information?

Monitoring information can be used in several ways. First, monitoring data are essential for determining whether your project goals are being met. Organize, summarize, and graph (if possible) the monitoring data at least annually to show how the restoration site is developing. Monitoring information should be compared to the target standards to assess whether the site is developing as planned. If it is not, determine whether remedial measures should be taken or whether the original goals should be reevaluated (see section above on adaptive management).

Second, monitoring data can be used to determine whether the target criteria were good measures of the project goals you hoped to achieve. If you were to do this again, would you do anything differently? Third, use long-term monitoring to assist in maintaining structures and managing the site to keep it functioning well. See Part 7 for more on long-term management.

Finally, use your monitoring data to inform others. Provide copies of your findings to your local planning and wetland regulatory authority, and the local offices of the Corps, EPA, FWS, NMFS, or NRCS. Present your work to local groups and ecological societies or at professional meetings of the Society of Wetland Scientists, Society for Ecological Restoration, and others (see Appendices for contact information). Write an article for the local newspaper or a journal, such as *Ecological Restoration*, which publishes reports from landowners, community groups, and restoration practitioners. All too often, years of irreplaceable data are lost if they are not shared, archived, or published. Don't assume no one is interested in your project; every wetland restoration, creation, and enhancement project that is monitored provides wetland scientists and restorationists with additional knowledge about how wetlands function and develop over time. With this additional information, scientists, policy-makers, and landowners can make better decisions about wetland conservation, including the use of wetland restoration, creation, and enhancement.

- Select the parameters you will monitor based on the target criteria established in the planning stage. Include observations to assist in site maintenance.
- Develop procedures for qualitative and quantitative monitoring methods.
- Collect data at intervals that will provide information necessary to monitor the progress of the site relative to the target criteria.
- If monitoring shows that site conditions are not meeting target criteria, use an adaptive process to identify corrective measures.
- Continue long-term monitoring and maintenance to ensure that the site continues to provide the maximum ecological value.
- Provide your monitoring data and results to local groups and publish in newsletters.

In addition to providing data on whether a site is developing in a way that will achieve the project goals, monitoring is essential for the long-term management of wetland projects. A wetland is an ecosystem that evolves and changes in response to the surrounding environment. It is not realistic to expect that when the implementation stage is complete, the work is done. Long-term management is often required to keep the site functioning as it was designed to function and to keep human impacts to a minimum. For example, long-term management is often needed to:

- maintain existing structures such as berms, water control structures, or levees;
- maintain a specific desirable plant community by burning, mowing, or otherwise managing the vegetation on a periodic basis;
- address problems such as invasive species or excessive sediment deposition; or
- address unexpected events such as structural failure.

Adaptive Management, introduced in Part 4 as an iterative process of monitoring conditions and then taking appropriate action, should be an integral part of long-term management and stewardship of your site. If your site is not developing as anticipated, there are two basic options: make changes to the site to try to get it "back on track," or allow the site to continue developing in the new direction. Which option to pick should be decided in consultation with your local experts.

Consider whether current progress at the site might achieve your overall goals in a different way than you originally intended. Also consider whether any deviation from the expected development is within the ecological norms for that wetland type and the region. Since natural systems are variable, sites may diverge from objectives, but this difference may not require significant changes to the site. For example, your site may be developing a native wetland community, but one that is different from what was expected. If this new community is within the norms of the wetland type and the watershed, it may not be necessary to change it.

If, however, your site is growing a crop of invasive or non-native species or otherwise falling far short of restoration objectives, then corrective action is probably necessary. Significant corrections to a site are called remedial measures. Work with local experts or your technical team to determine the

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The Middle Waterway Shore Restoration project is an attempt to re-establish some of the salt marsh that once covered thousands of acres of Commencement Bay. In a cooperative effort, federal, state, tribal, and private interests planned and implemented a restoration project that included re-grading fill material to intertidal elevations and planting salt marsh plants salvaged from the same area, as well as some provided by a nursery. One year after project implementation, monitoring showed that few of the plants had survived. A review of the planting procedures pointed to a number of possible causes for the low plant survival, including soil that was too sandy, nursery plants that weren't from the local area, and planting during the summer. The goal of the project (increasing the acreage of fringing marsh) could not be achieved without better plant growth, so a decision was made to replace some of the soil and re-plant. The top eighteen inches of the sandy fill was replaced with topsoil. A local nursery collected seeds from plants in the local area and grew them into seedlings, which were planted on the site in the spring. A year after this new planting, salt grass, seaside plantain, seaside arrowgrass, and other species were thriving. Monitoring will continue in case other remedial actions are needed, but for now the project seems to be on the right track.

Long-term management often is needed to compensate for changes in the surrounding landscape. In many cases, the surrounding land use, hydrology, or other features of the local watershed will change over time, possibly affecting your wetland site. Ideally, those changes were at least partially anticipated, and your site was designed to withstand or adapt to their effects. If something unanticipated happens, such as a substantial reduction of the water source or conversion of what had been an adjacent park area to development, you will need to reevaluate how your wetland site fits into the changed landscape, and whether the goals or management of the site will need to change. The overall goal of long-term management is a wetland that provides a maximum amount of wetland function and value within the context of the landscape and that requires a minimum amount of intervention by humans.

Finally, a plan for long-term management is needed to identify who will be responsible for the site and what kinds of activities should or should not occur there. The responsible party may be you, the landowner, or some combination of people. One approach to long-term management of a restoration site is to establish a stewardship program for the site. Local schools, scout groups, or citizen conservation groups may be willing to "adopt" the site and provide the kind of observation, care taking, and even remedial action that would be difficult for one person to provide. The kinds of activities you need to think about are recreational (do you want to allow hikers, campers, bird-watchers, or hunters on the property?) and possibly commercial (does the landowner want to allow grazing or tree-cutting on the property?). The answers to these questions should be included in a long-term management plan.

Long-term legal protection of a wetland site is also an important consideration. Do you want to take steps to ensure the wetland restoration will be permanently protected? One way might be to place a deed restriction on the site or establish a conservation easement. These arrangements should

effectively restrict harmful activities that might otherwise jeopardize achieving the goals of the wetland project. When needed, the acquisition and protection of water rights should be secured. One of the best ways to secure long-term protection is to donate or sell the land to a local, state, or federal natural resource agency or a non-profit organization such as a land trust.

Words to the Wise

While restoration, creation, or enhancement projects can be complex and time-consuming, most restorationists find their projects are very rewarding. As you undertake a project, keep in mind the following points:

- *Be patient*. Restoration is a process, not a product. Restoration is a creative activity and there is no cookbook for it.
- *Talk to many people*. There are many elements and phases to wetland projects and many different views on how to accomplish them. Talk to a range of people to collect as much information as possible and to get different perspectives on the process.
- *Be flexible.* Your ideas and goals may be clear at the outset, but for many reasons it may be best to change some, add some, and throw others out. As you go through the process, be flexible but keep your goals in mind.
- *Take your time.* Try not to rush the process. Get the technical help you need. Get the permits required. Develop a community support base, if necessary.
- *Plan well*. A well-considered and thorough plan will guide you through the project as directly as possible. A good plan will result in reasonable, measurable, and ecologically beneficial goals. A good plan will help you get money and help.
- *Let reference sites be your guide*. Reference sites are valuable models of what ecological conditions are achievable.
- *Use low impact implementation methods*. Use soft engineering and passive methods whenever possible. Consider the impact the project construction will have and minimize those impacts.
- *Monitor and manage your site.* Restoration does not end after the plants and structures are

A Wetland Restoration/Creation/Enhancement Checklist

Use this checklist to help guide you through the wetland project process.

- ❒ Talk to local wetland experts. Visit local wetland restoration, creation, or enhancement sites as well as relatively undisturbed wetlands.
- ❒ Ask about getting help through programs that support wetland restoration with cost-sharing and technical assistance.
- ❒ Get to know the local landscape and watershed characteristics.
- ❒ Give first priority to restoring degraded wetlands.
- ❒ Set goals. Pick a site that is most appropriate for achieving your goals.
- ❒

Below is a list of sources of information on wetlands and wetland restoration. It is not a comprehensive list, just a way to introduce you to the wealth of information available.

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- *http://www.npwrc.usgs.gov/resource/literatr/wetresto/wetresto.htm* - A searchable wetland restoration bibliography with over 3,000 entries, developed by the Northern Prairie Science Center and the Midcontinent Ecological Science Center.

- *http://www.wetlands.agro.nl/wetl_publications.html* - A 1996 compilation of over 1,000 wetland restoration and creation literature references is available for download from Wetlands International and the Association of State Wetland Managers.

- *http://www.nwrc.gov/library_catalog.html* - National Wetlands Research Center's Library (11,000 documents)

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Facsimile: (202) 260-2356
E-mail: pai.john@epa.gov
Web Site: http://www.epa.gov/owow/wetlands/restore/5star/

Nonpoint Source Implementation Grants (319 Program)

Purpose: To help States, Territories, and Tribes develop and implement programs to prevent and control nonpoint source pollution, such as creating constructed wetlands to clean-up urban runoff and agricultural wastes.

Projects: State, Territories, and Tribes receive grant money (and may then provide funding and assistance to local groups) to support a wide variety of activities, such as technical assistance, financial assistance, technical programs, education, training, technology transfer, demonstration projects (e.g. best management practices), and monitoring specific to nonpoint source implementation.

Assistance: Grants are first awarded to state agencies. Local organizations can then apply for grants through the agencies, but they must provide 40 percent of the total project or program cost as non-federal dollars.

Eligibility: State, local, and tribal governments, nonprofit and local organizations, etc. (check with your state contact).

Address: U.S. EPA, Office of Wetlands, Oceans, and Watersheds, 1300 Pennsylvania Avenue, Washington, DC 20460
Phone: (202) 260-7100
Facsimile: (202) 260-7024
E-mail: ow-general@epa.gov
Web Site: http://www.epa.gov/owow/NPS

Facsimile: (901) 758-3850
E-mail: cragland@ducks.org
Web Site: http://www.fs.fed.us/outdoors/wildlife

USDA - Farm Service Agency

Conservation Reserve Program

Purpose: To establish long-term resource-conserving covers on eligible cropland to conserve soil, water, and wildlife.

Projects: Voluntary program where landowners receive rental payments or enter into a cost-share restoration agreement, while maintaining private ownership, to plant cover on marginal cropland.

Assistance: Three options: 1) receive annual rental payments of up to $50,000/year; 2) receive payment of up to 50% of cost to establish cover; 3) receive payment of up to 25% of cost for wetland hydrology restoration. Contracts are typically 10-15 years in length.

Eligibility: Individuals, states, local govenments, tribes, or any other entity who owns private land for at least 1 year that is: either cropland planted with a crop in 2 of the last 5 crop years or marginal cropland that is enrolled in the Water Bank program or suitable to be used as a riparian buffer. Also, the land must be either highly erodible land, a cropped wetland, be devoted to highly beneficial environmental practices, subject to scour erosion, located in a CRP priority area, or be a cropland associated with or surrounding non-cropped wetlands.

Address: Contact your local or state Farm Service Agency office (see "http://www.fsa.usda.gov/dapdfo/"); otherwise: Department of Agriculture, Farm Service Agency, Conservation Reserve Program Specialist, Stop 0513, Washington, D.C. 20250-0513

Phone: (202) 720-6221
Facsimile: n/a
E-mail: info@fsa.usda.gov
Web Site: http://www.fsa.usda.gov/pas/publications/facts/pubfacts.htm

USDA - Natural Resources Conservation Service

Conservation Technical Assistance

Purpose: To assist land-users, communities, units of state and local government, and other federal agencies in planning and implementing conservation systems.

Projects: Projects that reduce erosion, improve soil and water quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range condition, reduce upstream flooding, and improve woodlands

Assistance: Technical assistance available to land users who voluntarily applying conservation and to those who must comply with local or state laws and regulations, such as the wetland

(Swampbuster) provisions of the 1985 Food Security Act and the wetlands requirements of Section 404 of the Clean Water Act.

Eligibility: Individual landusers, communities, conservation districts, and other units of State and local government and Federal agencies.

Address: Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html"); otherwise: Department of Agriculture, National Resources Conservation Service, P.O. Box 2890, Washington, D.C. 20013

Phone: (202) 720-4527

Facsimile: n/a

E-mail: n/a

Web Site: http://www.nrcs.usda.gov/NRCSProg.html

Emergency Watershed Protection Program

Purpose: To protect lives and property threatened by natural disasters such as floods, hurricanes, tornados, and wildfires.

Projects: Examples: Clearing debris from clogged waterways, restoring vegetation, stabilizing river banks, restoring wetland flood retainers.

Assistance: Funds cover up to 75% of costs to restore the natural function of a watershed. Another option is to offer land for a floodplain easement that would permanently restore the hydrology of the natural floodplain as an alternative to traditional attempts to restore damaged levees, lands, and structures. Funds can cover up to 100% of the agricultural value of the land, costs associated with environmental measures taken, and costs associated with establishing the easement. A sponsor must assist you in applying for assistance. Sponsors can be any legal subdivision of state, local, or tribal governments, including soil conservation districts, U.S. Forest Service, and watershed authorities.

Eligibility: Owners, managers, and users of public, private, or tribal lands if their watershed area has been damaged by a natural disaster.

Address: Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html"); otherwise: Department of Agriculture, National Resources Conservation Service, Watersheds and Wetlands Division, P.O. Box 2890, Washington, D.C. 20013

Phone: See above

Facsimile: n/a

E-mail: n/a

Web Site: http://www.nhq.nrcs.usda.gov/CCS/ewpFs.html

Environmental Quality Incentives Program

Purpose: To install or implement structural, vegetative, and management practices in priority areas.

Projects: Conservation practices, such as grassed waterways, filter strips, manure management facilities, capping abandoned wells, and other practices important to improving and

maintaining water quality and the general health of natural resources in the area; and land management practices such as nutrient management, manure management, integrated pest management, irrigation water management, and wildlife habitat management.

Assistance: Cost sharing may pay up to 75 percent of the costs of certain conservation practices. Incentive payments may also be made to encourage a producer to perform land management practices for up to three years. Offers 5-10 year contracts. Maximum of $10,000 per person per year and $50,000 for the length of the contract.

Eligibility: Eligibility is limited to persons who are engaged in livestock or agricultural production, excluding most large confined livestock operations.

Address: Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html"); otherwise: Department of Agriculture, National Resources Conservation Service, P.O. Box 2890, Washington, D.C. 20013

Phone: (202) 720-1873 or (202) 720-1845

Facsimile: n/a

E-mail: n/a

Web Site: http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/eqipfact.html

Watershed Protection and Flood Prevention

Purpose: Works through local government sponsors to help participants voluntarily plan and install watershed-based projects on private lands.

Projects: Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres.

Assistance: Provides technical and financial assistance. Funds can cover 100% of flood prevention construction costs, 50% of costs associated with agricultural water management, recreation and fish and wildlife, and none of the costs for other municipal and industrial water management.

Eligibility: Local or state agency, county, municipality, town or township, soil and water conservation district, flood prevention or flood control district, tribe or tribal organization, or nonprofit agency with authority to carry out, maintain, and operate watershed improvement works.

Address: Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html"); otherwise: Department of Agriculture, National Resources Conservation Service, Watersheds and Wetlands Division, P.O. Box 2890, Washington, D.C. 20013

Phone: (202) 720-3527

Facsimile: n/a

E-mail: n/a

Web Site: http://www.nrcs.usda.gov/NRCSProg.html

Wetlands Reserve Program

Purpose:	Protect and restore wetlands, riparian areas and buffer zones.
Projects:	Voluntary program where landowners may sell a conservation easement or enter into a cost-share restoration agreement, while maintaining private ownership.
Assistance:	Three options: 1) permanent easement - USDA purchases easement (payment will be the lesser of: the agricultural value of the land, an established payment cap, or an amount offered by the landowner) and pays 100% of restoration costs; 2) 30-year easement - USDA pays 75% of what would be paid for permanent easement and 75% of restoration costs; 3) restoration cost share agreement - 10-year minimum agreement to restore degraded habitat where USDA pays 75% of restoration costs.
Eligibility:	Individuals, states, local governments, tribes, or any other entity who owns private land. The land must be owned for at least 1 year and be restorable and suitable for wildlife.
Address:	Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html"); otherwise: Department of Agriculture, National Resources Conservation Service, Watersheds and Wetlands Division, P.O. Box 2890, Washington, D.C. 20013
Phone:	(202) 690-0848
Facsimile:	n/a
E-mail:	RMisso@usda.gov
Web Site:	http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WetRule.html or http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WRPfact.html (fact sheet)

Wildlife Habitat Incentives Program

Purpose:	To develop and improve fish and wildlife habitat on private lands.
Projects:	Participants prepare a wildlife habitat development plan in consultation with the local conservation district. The plan describes the landowner's goals for improving wildlife habitat, includes a list of practices and a schedule for installing them, and details the steps necessary to maintain the habitat for the life of the agreement.
Assistance:	Technical assistance and cost-share agreements where NRCS pays up to 75% of cost of installing wildlife practices. Typically 5-10 year contracts.
Eligibility:	Must own or have control of the land and cannot have it enrolled in other programs with a wildlife focus, such as the Wetlands Reserve Program, or use the land for mitigation. Other restrictions may apply.
Address:	Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html"); otherwise: Department of Agriculture, National Resources Conservation Service, P.O. Box 2890, Washington, D.C. 20013
Phone:	(202) 720-3534
E-mail:	n/a
Web Site:	http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WhipFact.html

DEPARTMENT OF INTERIOR (DOI)
DOI - Fish and Wildlife Service

Coastal Program

Purpose: To conserve healthy coastal ecosystems for the benefit of fish, wildlife, and people.

Projects: Examples of protection include use of conservation easements and fee title acquisition to protect relatively pristine coastal wetlands, salt marshes, prairies, dunes, bottomland hardwood forests, and riparian areas. Examples of coastal habitat restoration include: reintroduction of tidal flow to formerly-diked mud flat and salt marsh habitat, planting of native vegetation (including submerged aquatic grasses), control and monitoring of exotic invasive species, fencing to restore riparian salmon spawning habitat, and removal or retrofit of small dams and culverts to allow for passage of anadromous fish in coastal streams and estuaries.

Assistance: Technical and financial assistance is available. The program focuses exclusively on coastal watersheds. It applies an ecosystem-level approach to resolving resource problems, and targets efforts for a strategic (rather than opportunistic) approach. The program is a non-regulatory, pro-active program that relies on voluntary partnership building. Partners include other federal and state agencies, local and tribal governments, businesses, conservation organizations, and private landowners. Matching grants are also awarded annually, on a competitive basis. States that border the Atlantic, the Gulf of Mexico, Pacific and Great Lakes are eligible to apply for grants. The one exception is the State of Louisiana, which has its own coastal wetlands program. Trust Territories and Commonwealths of the United States are also eligible for grants.

Eligibility: The Coastal Program funds projects on private and public lands.

Address: Department of Interior, U.S. Fish and Wildlife Service, Division of Fish and Wildlife Management Assistance and Habitat Restoration, 4401 N. Fairfax Drive, Room 400,

workers from timber dependent communities to conduct project work. Projects are focused on implementing habitat improvements to benefit federally listed, proposed or candidate species, under the ESA.

Assistance: The Service provides the grants and assists applicants with obtaining permits and complying with federal laws, including the ESA, NEPA, NHPA, and the Clean Water Act. Most funded projects involve grants of under $100,000.

Eligibility: Projects must occur on non-federal lands. Non-profit organizations, individuals, private businesses, Native American tribes and state and local governments are eligible.

Address: U.S. Fish and Wildlife Service, Arcata FWO; Jobs in the Woods Watershed Restoration Program; 1125 16th Street, Room 209; Arcata, CA 95521.

Phone: (707) 822-7201

however, a 50:50 cost share is required. Partners for Fish and Wildlife funds are not used to purchase or lease real property interest or to make rental or other incentive payments to landowners. Minimum 10-year contract.

Eligibility: Although the primary partners are private landowners, anyone interested in restoring and protecting wildlife habitat on private or tribal lands can get involved in the Partners for Fish and Wildlife Program, including other federal, state and local agencies, private organizations, corporations, and educational institutions.

Address: Contact your state office for assistance. National, regional and state contacts are listed at http://www.fws.gov/r9dhcpfw/CONTACTS/altcont.html; U.S. Fish and Wildlife Service, Division of Fish and Wildlife Management Assistance and Habitat Restoration, 4401 N. Fairfax Drive, Room 400, Arlington, VA 22203

Phone: (703) 358-2161

Facsimile: (703) 358-2232

Web Site: http://www.fws.gov/r9dhcpfw/

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)
NOAA - National Marine Fisheries Service

NOAA Community-Based Restoration Program

Purpose: To restore marine fish habitat by fostering partnerships with local communities

Projects: Community-based restoration efforts that benefit marine fish habitat (including coastal wetlands and anadromous fish streams)

Assistance: Small grants available - should be developed in partnership with local National Marine Fisheries Service office

Eligibility: non-profits, state and local agencies, tribes

Address: National Marine Fisheries Service, Office of Habitat Conservation, Restoration Division, 1315 East-West Highway, Silver Spring, MD 20910.

Phone: (301) 713-0174

Facsimile: (301) 713-0184

E-mail: chris.doley@noaa.gov or robin.bruckner@noaa.gov

Web Site: http://www.nmfs.gov/habitat/restoration

ARMY CORPS OF ENGINEERS (CORPS)
CORPS Civil Works Directorate

Planning Assistance to States Program, Section 22 of the Water Resources Development Act

Purpose: To allow the Corps of Engineers to perform technical studies for management of water and related land resources to help states and Indian tribes deal with their water resources problems. The program is limited to a maximum of $500,000 per state or tribe in any year.

Projects: Typical activities studied under this Program are flood damage reduction, water resources development, water supply, water conservation, water quality, erosion, wetlands evaluation, and navigation.

Assistance: This is not a grant program. The local sponsor of the study shares in the cost of the study.

Eligibility: Studies are initiated based on requests to the appropriate Corps of Engineers District office by the local sponsor.

Example: In Louisiana, Section 22 funds were used to cost-share in a study to plan and design a hiking/biking/recreation trail compatible with existing levee systems and other floodplain improvements. The local sponsor then implemented the trail design using non-Federal funding sources.

Address: Contact your local district office of the Army Corps of Engineers.

Phone: n/a

Facsimile: n/a

Email: n/a

Website: http://www.usace.army.mil/

Beneficial Uses of Dredged Material, Section 204 of the Water Resources Development Act

Purpose: To allow the Secretary of the Army to carry out projects for the protection, restoration, and creation of aquatic and ecologically related habitats, including wetlands, in connection with dredging for construction, operation, or maintenance by the Secretary of an authorized navigation project.

Projects: Work must be for the protection, restoration and creation of aquatic and ecologically related habitat, including wetlands. Examples include: placement in subsiding wetlands to re-establish necessary elevations for vegetation, additions to offshore islands to re-establish submerged areas and nesting habitat, filling deep holes to re-establish wetlands.

Assistance: This is not a grant program. A local sponsor, a governmental entity, must partner with the Corps. The non-federal share is 25% of the costs in excess of the costs necessary to carry out the dredging for the authorized navigation project.

Eligibility: Studies are initiated based on request to the appropriate Corps of Engineers District office by the local sponsor.

Example: Battery Island Bird Habitat Preservation, Cape Fear River, North Carolina. Battery Island is owned by the State of North Carolina and administered by the North Carolina Division of Parks and Recreation. The Ecosystem Restoration Project will protect 10 acres of upland nesting habitat for colonial waterbirds from further erosion. The project will also restore 5.5 acres of valuable colonial waterbird nesting habitat by placement of dredged material obtained from periodic dredging of the adjacent Wilmington Harbor navigation project.

Address: Contact your local district office of the Army Corps of Engineers.
Phone: n/a
Facsimile: n/a
Email: n/a
Website: http://www.usace.army.mil/

Aquatic Ecosystem Restoration, Section 206 of the Water Resources Development Act

Purpose: To allow the Corps to carry out aquatic ecosystem restoration projects that will improve the quality of the environment, are in the public interest and are cost-effective.

Projects: Work has to be related to aquatic restoration. Examples include reforestation of bottomland hardwoods, modification of stream channels to stabilize channels, while introducing complexity and fish habitat, riparian re-vegetation, improvement of fish passage, which may include dam removal, re-establishing submerged vegetation, restoration of reclaimed land, restoration of wetlands.

Assistance: A non-federal sponsor, a public entity, must partner with the Corps. The non-Federal share is 35% of the total project cost, including study phase cost. The non-Federal sponsor is also responsible for 100% of the operation, maintenance, repair and rehabilitation cost.

Eligibility: Studies are initiated based on request to the appropriate District office of the Corps by the local sponsor.

Example: At the Ladd Marsh Wildlife Area, 6 miles southeast of LaGrande, Oregon, the State of Oregon teamed with the Corps to restore the meandering pattern and riparian vegetation of an approximately 4,000-foot section of Ladd Creek and a 2,000-foot section of Barney Creek. This project enhances habitat for resident rainbow trout as well as the steelhead trout, which is listed under the Endangered Species Act for protection in the entire Snake River Basin.

Address: Contact your local district office of the Army Corps of Engineers.
Phone: n/a
Facsimile: n/a
Email: n/a
Website: http://www.usace.army.mil/

Other Funding Source Documents:

"Catalog of Federal Domestic Assistance". Published biannually by General Services Administration. *http://aspe.os.dhhs.gov/cfda,* (202) 708-5126.

"Catalog of Federal Funding Sources for Watershed Protection, 2nd Edition" (1999). EPA's Watershed Academy, Office of Water, Publication No. EPA 841-B-99-003. *http://www.epa.gov/OWOW/watershed/wacademy/fund.html* , National Center for Environmental Publications and Information (NCEPI), (800) 490-9198.

"Environmental Grantmaking Foundations". Published annually by Resources for Global Sustainability, Inc. *http://home.eznet.net/~rgs*, (716) 473-3090.

"Exploring Wetlands Stewardship- A Reference Guide for Assisting Washington Landowners" (1996). Washington State Department of Ecology Publication No. 96-120.
http://www.wa.gov/ecology/sea/shorelan.html, (360) 407-7472.

"Financing Clean Water Action Plan Activities" (1998), EPA Clean Water Act State Revolving Fund Branch, Office of Water. *www.epa.gov/owm/finan.htm*, (202) 260-2036.

"Wetland and Riparian Stewardship in Pennsylvania: A Guide to Voluntary Options for Landowners, Local Governments and Organizations" (1997). Alliance for the Chesapeake Bay. Contact the Bureau of Watershed Conservation, Pennsylvania Deptartment of Environmental Protection, (717) 236-8825.

"Wetands Assistance Guide for Landowners (in Texas)". Texas Parks and Wildlife. *http://www.tpwd.state.tx.us/conserve/wetlands/wetintro.htm* or (512) 389-4328.

Below is a list of sources of assistance and information on wetland restoration. It is not a

Society of Wetland Scientists	P.O. Box 1897, Lawrence, Kansas 66044-8897, 1(800)627-0629, http://www.sws.org/, sws@allenpress.com
Terrene Institute	4 Herbert Street, Alexandria, VA 22305, (703)548-5473, http://www.e2b2.com/index.ht, terrinst@aol.com
Water Environment Federation	601 Wythe Street, Alexandria, VA 22314-1994 USA, 1(800)666-0206, http://www.wef.org/, msc@wef.org

Federal Agency Web Sites:

Army Corps of Engineers	http://www.usace.army.mil/
Bureau of Reclamation	http://www.usbr.gov/
Bureau of Land Management	http://www.blm.gov/
Council on Environmental Quality	http://www.whitehouse.gov/CEQ/About.html
Department of Agriculture	http://www.usda.gov/
Environmental Protection Agency's Office of Wetlands, Oceans and Watersheds	http://www.epa.gov/OWOW/wetlands/restore
Farm Service Agency	http://www.fsa.usda.gov/pas/default.asp
Fish and Wildlife Service	http://www.fws.gov/
Forest Service	http://www.fs.fed.us/
Geological Survey	http://www.usgs.gov/
National Oceanic and Atmospheric Administration, National Marine Fisheries Service	http://www.nmfs.noaa.gov/habitat/habitatprotection/wetlands.htm http://www.nmfs.noaa.gov/habitat/restoration/

National Park Service	http://www.nps.gov/
Natural Resources Conservation Service	http://www.nrcs.usda.gov/
Office of Surface Mining	http://www.osmre.gov/osm.htm
State Department's Bureau of Oceans and International Environmental and Scientific Affairs	http://www.state.gov/www/global/oes/

Other Web Sites:

Better Wetlands: More Than a Dozen Ideas to Improve Restored Wetlands for Wildlife and Personal Enjoyment (U.S. Natural Resources Conservation Service)	http://www.ia.nrcs.usda.gov/enhance/bwtoc.html
Do Created Wetlands Replace the Wetlands that are Destroyed? (U.S. Geological Survey)	http://wwwdwimdn.er.usgs.gov/widocs/wetlands/FS_246-96.html
Evaluation of Restored Wetlands in the Prairie Pothole Region	http://www.NPWRC.USGS.GOV/wetland/
Monitoring Water Quality Web Page: Resources for Volunteer Monitors (USEPA)	http://www.epa.gov/OWOW/monitoring/
"Riverine Wetlands: Succesion and Restoration" - bibliography and abstracts of scientific articles, dissertations and books (University of Lyon, France)	http://limnologie.univ-lyon1.fr/htdocs_limno/publications.html
Stream Corridor Restoration: Principles, Practices, and Processes (Interagency)	http://www.usda.gov/stream_restoration/
Volunteer Estuary Monitoring (USEPA)	http://earth1.epa.gov/OWOW/monitoring/volunteer/estuary/index.html
Wetland Bioassessment Fact Sheets (USEPA)	http://www.epa.gov/owow/wetlands/wqual/bio_fact/
Wetland Creation and Restoration: The Status of the Science (USEPA)	http://www.epa.gov/OWOW/wetlands/kusler.html

Wetland-related academic programs and training courses - two internet listings	Society of Wetland Scientists Business Office, P.O. Box 1897, Lawrence, Kansas 66044-8897, USA, 1(800)627-0629. For academic programs - http://www.sws.org/colleges/ For training courses - http://www.sws.org/training/, sws@allenpress.com or mingst@mail.modot.state.mo.us
U.S. Army Corps of Engineers Proponent-Sponsored Engineer Corps Training (PROSPECT) environmental training courses on wetlands and restoration	http://www.wes.army.mil/el/nrrdc/train.html

Social Goal	*Ecological Function*	*Ecological Effects*	*Physical Indicator**	*Measurement Parameters*
Provide fish and shellfish habitat	Long-term surface water storage	Maintain base flows	Basin capacity; presence of water during fish lifecycle (hydrological regime); typical water quality; substrate to water level elevations allow water flow and retention	* Basin volume * Water level changes * Water quality measures (temp, salinity, etc.) * Substrate elevations * Channelization patterns
	Support typical communities	Food, cover abundance	Plant species diversity and richness	* Species number, abundance * Species height, cover, structure * Growth, reproductive rates
Support waterfowl and furbearers	Maintain typical plant communities	Food, nesting, cover for animals	Mature wetland vegetation; typical mosaic of plant community succession stages	* Species number, abundance * Population growth parameters: breeding pairs, offspring produced, mortality, immigration/emigration * Sources of mortality
Provide useful plants	Support typical plant communities	Maintain nutrient levels within wetland	Survival and reproduction of particular species	* Growth, reproduction rates * Sustainable crop yields

Societal Value	*Ecological Function*	*Ecological Effects*	*Physical Indicator*	*Measurement Parameters*
Maintain water quality	Retention, removal of dissolved materials	Reduced transport of nutrients	Nutrient outflow lower than inflow	* N and P levels in incoming versus outgoing waters; * N and P levels in wetland sediments
	Accumulation of peat (organic matter)	Retain pollutants, nutrients, metals	Increase in depth of peat; presence of pollutants in peat	* Change in depth of peat layer * Analysis of heavy metals and other pollutants in soil cores
	Accumulation of sediments (inorganic)	Retain sediments, some nutrients	Increase in depth of sediment	* Change in depth of sediment layer
Reduced shoreline erosion	Maintain vegetated wetland edges	Stable shoreline edges	Erosion and deposition rates typical of wetland type; lack of eroded or undercut shore; presence of stable vegetation	* Soil loss rates from edges * Undercutting and down cutting changes * Plant loss from edges
Reduced damage from floodwaters	Short-term surface water storage	Reduced down-stream flood peaks	Presence of floodplain along river corridor; wide vegetation buffer; basin capacity	* Width of floodplain and riparian vegetation * Basin volume
Maintain biodiversity	Maintain high water table	Support typical plant community	Presence of diverse native plant species	* Species number, abundance, richness * Complete food chain
	Maintain typical energy flow	Support for animal populations	High diversity of animal species	* Few to no non-native * Rare and dominant species * Species succession

* Physical Indicators include both measurable processes and structures of the system.

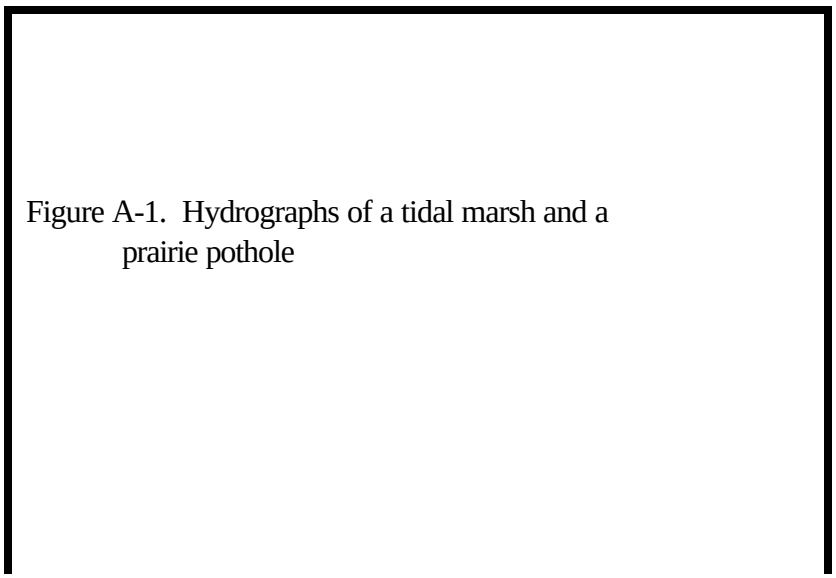

Figure A-1. Hydrographs of a tidal marsh and a prairie pothole

but predictable changes in wetland size and shape. Extreme events, such as hurricanes, may have less predictable effects.

If wetland hydrology can be established at your site, there is a good chance that other wetland characteristics will develop over time. When a wetland project does not develop as planned, or does not develop into a wetland at all, it is most often because the hydrologic characteristics of the site are not what they need to be to achieve the goals. The first step in trouble-shooting wetland projects is to check the hydrologic characteristics of the site.

For many sites, establishing the proper hydrology requires the services of a hydrologist who will assess current conditions on your site, evaluate the local disturbance regime, and determine what changes are necessary to achieve the hydrological regime typical of the wetland you wish to establish.

Water contains a number of dissolved and suspended materials including nutrients (e.g., nitrogen, phosphorus, dissolved carbon), contaminants (e.g., pesticides, petroleum hydrocarbons), and other constituents (e.g., dissolved oxygen, salts, metals, suspended sediments). Some chemicals (e.g., nutrients) can be either beneficial or toxic, depending on how much is present. Water quality usually refers to how "healthy" the water is for humans, animals and plants. An aquatic area with "good" water quality has the water chemistry typical of the ecosystem and region, including the levels of dissolved oxygen, contaminants, and other constituents (nutrients, suspended sediments) that result in healthy populations of native plants and animals.

Because wetland types vary, good water quality varies from one wetland type to another. For example, significant amounts of suspended sediments are typical of good conditions for some tidal marshes because, as sediments settle out, they help to build up the marsh surface, which allows the growth of marsh vegetation. Conversely, too much suspended sediment in coastal waters can be harmful to seagrass beds because it reduces the amount of light penetrating the water to the plants. If you suspect that the water quality might be a problem, you will need to compare the water condition at your site with those at reference wetlands, i.e., sites in your region that are relatively undisturbed examples of your wetland type. This work will almost always require the expertise of a water quality specialist.

Figure A-2. Water quality monitoring by volunteers in Chesapeake Bay

Wetland Soils and their Qualities

Wetland soils or substrates are hydric soils, meaning they are waterlogged for all or part of the year which results in anaerobic conditions. In hydric soils, water fills the air spaces between soil particles and forces the oxygen out causing soils to become anaerobic (depleted in oxygen) in the zones closest to the surface. Waterlogged, anaerobic conditions are very hostile to terrestrial plants and these conditions will quickly kill most upland species. As a result, wetlands are dominated by plants that are specifically adapted to these tough, waterlogged,

anaerobic soil conditions. When soils lose their oxygen, they change significantly in structure and

swamp oak), shrubs (like bayberry), moss, and many other types. The wetland's water source (fresh, saline (salty), or brackish) will affect the composition of the wetland plant community, as will the amount and duration of water in the wetland.

Plant species also can be regionally and locally specific: the dominant native plant in Atlantic coast tidal systems is smooth cordgrass (*Spartina alternaflora*) whereas the dominant native plant in central Pacific coast salt marshes is Pacific cordgrass (*Spartina foliosa*). Some wetlands may be degraded because they contain non-native species, that is, plants from other regions. These non-natives may be invasive and displace more typical wetland plants. Sometimes non-native species can completely replace the natural wetland plant community, which alters the ecological functioning of the site. Purple loosestrife, reed canary grass, and common reed are examples of non-native invasive wetland plants. Atlantic cordgrass becomes an invasive, exotic species when it occurs along the Pacific coast, outside its native range.

The spread of non-native species is a huge ecological problem in the U.S. The U.S. Fish and Wildlife Service estimates that approximately 4600 acres per day in public natural areas are lost to non-native plants and animals. For many restoration and enhancement projects, significant effort is devoted to removing the invaders so that the native species can re-establish.

Nutrient, turbidity, and salinity levels are key parameters determining the composition of wetland plant community. Another critical element is the relationship of water levels to substrate elevation. If water is too deep, emergent and sub-emergent vegetation will not establish. If the substrate elevation is too high, then what you may get is an upland. In some habitats, such as vernal pools, microtopographic changes must be re-created to establish the very sensitive endemic species that occur there.

Wetland Animals

Wetlands are inhabited by creatures large and small: water fleas and alligators; shrews and bears; minnows and salmon; wrens and herons. Because wetlands exist where land and water meet, they are often used by animals from both wet and dry environments. Many species depend on wetlands for all or part of their lives. For example, the salt marsh harvest mouse lives its entire life in the tidal salt marshes around the San Francisco Bay. It is so well adapted to this habitat that it has developed special kidney functions that allow it to eat salt marsh vegetation and survive the ingestion of sea water. Wetlands are very important in maintaining biodiversity; they are used by 43 percent of the species listed as endangered or threatened under the Endangered Species Act.

Some of the smallest wetland animals are invertebrates (animals without backbones) such as beetles, water fleas, crayfish, dragonflies, snails, and clams. Invertebrates are an important food source for other animals, both as adults and in their egg and larval forms. Amphibians and, to a lesser extent,

Birds are some of the best-known inhabitants of wetlands. Ducks, in particular, are valuable to people who enjoy hunting or birding. However, wetlands are also important to shorebirds (plovers, sandpipers) that feed in mudflats, wading birds (herons, egrets, bitterns) that feed in shallow water, songbirds (red-winged blackbirds, rails, marsh wrens) that perch on or nest in tall grasses or shrubs, and other birds such as terns and hawks that are all common inhabitants of wetlands. Finally, mammals such as beavers, raccoons, shrews, mice, moose, and bear are common residents of wetlands, although their tracks are usually seen more often than the animals themselves.

While the ecological requirements for animals vary with the species, here are a few general requirements of major taxa using wetlands:

- Invertebrates process nutrients and organic matter and are important for supporting much of the wetland food chain. Invertebrate species are numerous and live in a range of ecological conditions. In general, like most aquatic animals, most invertebrates need well-oxygenated water. Temperature levels and food sources are essential to support invertebrate diversity. A reliable source of water, a diversity of typical plant species, and buffers around the wetland will support invertebrates by filtering out pollutants, moderating temperature, providing a variety of habitats, and providing food sources.

- Amphibians and reptiles (herptiles) require a range of habitats during their lifecycles. Plant structural diversity, such as brush, leaf litter, and small dense stands of grass or reeds, can give these species cover, foraging and nesting habitat. Larger debris like logs are attractive for basking. Areas of sandy soil with a warm, southern exposure encourage turtle reproduction. Deep water areas will support species that overwinter by burrowing in mud. Shallow water (usually with vegetation) is important for hiding egg masses and protecting tadpoles from predators. Gradual slopes from the wetland to the upland help animals move easily between habitats. Habitat requirements vary by species and restorations should be designed with the needs of local herptile species in mind.
- Fish need both shallow water to protect eggs and young fish, and deeper water for adults. Fish may move in and out of wetlands as water depths fluctuate. Some wetlands support no fish or only small fish because the wetland is shallow or temporary. Temperature, dissolved oxygen (DO), and salinity levels are parameters that will determine the species present. Shade, streambed/wetland structure, and food sources (such as invertebrates) will also determine the species richness. Trees for shade and large debris for hiding can be very beneficial. Some fish can provide insect control in the wetland. However, others, such as bottom-feeding fish can destroy submerged plant communities and thereby reduce light levels by stirring up sediment.

- Birds occupy a variety of habitats in and around wetlands and are important indicators of

species, including wrens, sparrows, and yellowthroats, live and nest in wetlands or where the wetlands interface with the upland. Adjacent uplands, especially grass, willow, and tree dominated zones, are important as high tide refuges for wetland birds and offer millions of migratory birds places to stop and forage. In developing wetland enhancement activities to attract particular species, carefully weigh the potential effects on other species that use the wetland. Restorationists have also found that some birds can be very destructive to newly installed plants; geese, for example, are able to denude acres of newly planted stems in one night and they can be one of the biggest challenges to new wetland restoration sites.

- Mammals generally need adjacent uplands or upland islands for escape during high-water periods. Therefore, undisturbed upland buffers and corridors connecting adjacent habitats are critical to these taxa. Nest boxes may attract bats, which can provide insect control in the wetlands. Muskrats can help to control vegetation, but can also "eat-out" the vegetation and be a nuisance with burrowing activities. Beavers, a keystone species of wetlands throughout North America, can aid wetland restoration by creating the very water control structures that are needed to keep water in a wetland, but they also can *redesign* your site by creating dams where you didn't plan for them.

Nutria are large (8-18 lb) beaver-like rodents native to South America. Accidentally introduced into Maryland's eastern shore marshes in the 1940's, nutria have been implicated in the loss of emergent brackish marsh.

First noticeable in the 1950s, marsh loss along the Blackwater River in Dorchester County, Maryland, has accelerated at an alarming rate as nutria populations have grown. What was once continuous marshland now appears as fragmented remnants.

Nutria forage directly on the vegetation root mat and cut the marsh into finer and finer fragments. Erosion by tidal and wave action lowers the unvegetated marsh bottom and prevents plants from recolonizing.

A recent study found that within the Blackwater National Wildlife Refuge alone, over 6 square miles of marsh have been lost to open water since 1938. Over 50 percent of the remaining marsh has significant damage and may likely be lost in the near future.

The conversion of wetland vegetation to non-native plants alters the habitat for native animals and results in the loss of species from local wetlands. In addition, non-native animals are as big a problem as non-native plants. Non-native animals are causing losses of wetland communities and biodiversity (see box on nutria).

Animal communities vary with wetland type and region, but in general, healthy wetlands are rich in wildlife and very productive biologically. For example, approximately three-quarters of the Nation's commercially harvested fish and shellfish depend on bays and other estuarine habitats, of which wetlands are an integral part. According to some estimates, each year the production associated with

these wetlands accounts for more than $100 billion dollars in sales of fish and shellfish and provides one and a half million jobs.

Each wetland has its own distinctive animal community. Relatively undisturbed wetlands in your region will give you an idea of what you can expect to inhabit your wetland, as long as your wetland project results in typical wetland hydrology and native plant communities. If you are interested in attracting a particular animal or animals to your wetland, a wetland biologist or ecologist may be able to help you pick specific plants or take other actions designed to accomplish that goal.

Typical Activities Used to Restore or Change Hydrology:

- Try to reverse the actions that caused the loss or alteration of a wetland's hydrologic characteristics. Some measures include:
  * Remove dams or other water control structures
  * Fill or plug ditches or drains
  * Remove fill that has elevated the land surface
- Bring additional water to the site if the current water supply is inadequate. Methods include:
  * Dig channels to bring water to additional areas
  * Pumping water in from other sites
  * Installing pipes to bring in water
- Control water levels by installing water control structures. Some structures include:
  * Open culverts
  * Culverts with manual or automatic gates
  * Weirs
-

* Plant wetland vegetation, using local plants or seeds from local nurseries and seed distributors (see USDA's Plant Materials Program for sources of seeds and plants at "http://Plant-Materials.nrcs.usda.gov/). If you are using seeds, ask for a germination test result before you buy.
* Salvage plants that would otherwise have been destroyed from local land development, road

- Create a variety of gentle slopes of 3:1 to 20:1 (3:1 means three feet of length for every one foot of rise) similar to those in the reference wetlands.
- Establish connections to other habitats (*e.g.*,channels connecting to larger water bodies, forested corridors connecting to wildlife refuges) unless those areas contain invasive species or other threats.

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GENERAL			
Location	use existing map or create map with property boundaries, scale, north arrow, county, state, and landmarks		
Wetland Type	classify existing (if appropriate) and intended type(s) (Cowardin *et al.*, 1979)	classify actual type(s)	classify actual type(s)
Drainage area	identify USGS hydrologic unit from state maps or state watershed unit		map using GIS and appropriate base maps
Surrounding land use	estimate % surrounding land use and photograph major types w/in 1,000 feet of site (Anderson *et al.* 1976)	estimate % surrounding land use and photograph major types w/in 1,000 feet of site (Anderson *et al.* 1976)	estimate % surrounding land use and photograph major types w/in 1,000 feet of site (Anderson *et al.* 1976)
Wetland area	determine wetland boundary and use basic survey techniques to create a map of the site		delineate wetland boundary and use basic survey techniques to create a map of the site
Slope	measure slope at intervals along a transect		survey elevations

microtopography	survey elevations every foot or meter on transects traversing the wetland		survey elevations every foot or meter on transects traversing the wetland
HYDROLOGY			
Water depth	above ground: use staff gauge, below ground: use shallow well or 2-3" slotted PVC pipe	above ground: use staff gauge, below ground: use shallow well or 2-3" slotted PVC pipe and read on site	above ground: use automatic water level gauge, below ground: use shallow well or 2-3" slotted PVC pipe with automatic recorder
Flow patterns	direct observation to indicate major pathways and channels on map	direct observation to indicate major pathways and channels on map	regular direct observation or aerial photography to indicate major pathways/channels on map
Flow rates	measure inflow or outflow (if present) with flumes or weirs, measure interior flow with current meters	estimate flow based on rates typical for the area and estimated wetland size	measure inflow or outflow (if present) with flumes or weirs, measure interior flow with current meters
Indirect observations	record observations of high-water marks, drift lines, etc.	record observations of high-water marks, drift lines, etc.	
SOIL (sample using soil auger or pit)			
Soil depth	dig to compacted soil or at least 18 inches, observe changes in soil color and structure	dig to compacted soil or at least 18 inches, observe changes in soil color and structure	take soil core to at least 18 inches deep and have soil expert analyze the soil horizons and their composition

Soil color	use Munsell color chart to determine color of matrix (the dominant color) and any mottles or streaks		use Munsell color chart to determine color of matrix (the dominant color) and any mottles or streaks
Soil texture	use soil texture triangle to classify based on feel (Horner and Raedeke, 1989)	use soil texture triangle to classify based on feel (Horner and Raedeke, 1989)	take a soil core to soils lab for particle size analysis of the different soil horizons
Organic matter	lab analysis for percent organic matter in top layer; include soil moisture measurement		lab analysis for percent organic matter in top layer; include soil moisture measurement
Sedimentation	survey base elevations of completed project	read changes in sediment depth from a staff gauge	survey topography or bathymetry on a yearly basis; or, take sediment cores on a yearly basis for analysis by soils experts
VEGETATION			
Species diversity	identify species, document planting locations	identify common species and note number of unidentified species	identify all species, native and non-native
Coverage	estimate coverage to 10%, map plant communities	estimate coverage to 10%, map plant communities	collect plot data along transects, calculate coverage, map plant communities

Survivorship	count plants and determine % of plants alive	visually determine % of plants alive	count plants and determine % of plants alive
Height		measure heights of particular plants on a regular basis	measure heights of randomly chosen plants for a valid statistical comparison
Structure		count stems and branching of particular plants on a regular basis	count stems and branching of randomly chosen plants for a valid statistical comparison
Reproduction		of particular plants, determine the number blooming and setting seed each year	determine percentage of randomly chosen plants blooming and setting seed each year; count new seedlings in randomly chosen plots

ANIMALS			
Observations	record direct and indirect observations of wildlife, fish, and invertebrates	record direct and indirect observations of wildlife, fish, and invertebrates	
Habitat evaluations	Use Habitat Evaluation Procedures (FWS 1980) or comparable method for selected species		use Habitat Evaluation Procedures (FWS 1980) or comparable method for selected species
Species diversity and abundance	use trapping or point count methods as required to determine diversity and abundance of indicator species	count bird species and their abundances on a regular (at least quarterly) basis; ask local Audubon chapter for any data	use trapping, point count or other quantitative method as required to determine diversity and abundance of indicator spp
Species survivorship			mark and recapture study
Breeding success		record any species breeding on site and number of young	use point counts, surveys, or other protocols to determine percent of population breeding and numbers of young produced
Rare species			conduct studies as legally permitted by the jurisdictional wildlife or resource agency
WATER QUALITY			

Water samples (pH, salinity, nutrients, pollutants, heavy metals, etc.)	when construction is over, measure appropriate attributes based on project targets using field kits, meters, or lab analysis	on a regular basis, measure appropriate attributes based on project targets using field kits and/or field meters	on a set schedule designed to show seasonal differences, measure appropriate attributes based on project target using field meters or lab analysis

- the manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland[b] or deepwater[c] site that did not previously exist. Establishment results in a gain in wetland acres.

- the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into:

- the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to former wetland[d]. Re-establishment results in rebuilding a former wetland and results in a gain in wetland acres.

- the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions of degraded wetland[e]. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres.

- the manipulation of the physical, chemical, or biological characteristics of a wetland (undisturbed or degraded) site to heighten, intensify, or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for a purpose such as water quality improvement, flood water retention or wildlife habitat. Enhancement results in a change in wetland function(s), and can lead to a decline in other wetland functions, but does not result in a gain in wetland acres. This term includes activities commonly associated with the terms enhancement, management, manipulation, directed alteration.

- the removal of a threat to, or preventing decline of, wetland conditions by an action in or near a wetland. Includes purchase of land or easements, repairing water control structures or fences, or structural protection such as repairing a barrier island. This term also includes activities commonly associated with the term preservation. Protection/Maintenance does not result in a gain of wetland acres or function.

The COE (Federal Register 1982) and the EPA (Federal Register 1980) jointly define wetlands as: Those areas that are inundated or saturated by surface or

ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

1985 Food Security Act. Wetland is defined as land that; 1. has a predominance of hydric soils 2. is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances does support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions. "Normal circumstances" refers to the soil and hydrologic conditions that are normally present, without regard to whether the vegetation has been removed. All three wetland criteria, hydric soils, hydrophytic vegetation, and wetland hydrology, normally must be met for an area to be identified as wetland.

Conservation activities conducted on all wetlands that meet the national standard for classifying wetlands ("Classification of Wetlands and Deepwater Habitats of the United States"), will be reported even if they are not considered to be regulatory wetlands. The regulatory jurisdictional nature of a wetland is not relevant to its status for these accounting activities.

: Uplands are neither deepwater habitats nor wetlands. They are seldom or never inundated, or if frequently inundated, they have saturated soils for only brief periods during the growing season, and, if vegetated, they normally support a prevalence of vegetation typically adapted for life only in aerobic soil conditions.

Deepwater habitats are permanently flooded lands lying below the deepwater boundary of wetlands. The boundary between wetland and deepwater habitat in tidal areas is the elevation of the extreme low water of spring tides. The boundary between wetlands and the deepwater habitats of lakes and rivers lies at a depth of 2 meters (6.6 feet) below low water. If emergents, shrubs, or trees grow beyond this depth at any time, their deepwater edge is the boundary.

An area that once was a wetland but it has been modified to the point it no longer has the hydrologic characteristics of a wetland. The area is considered to be upland. Formerly vegetated shallow coastal open water areas are also considered to be "former wetlands" because when they were converted from wetland marshes to open water areas, this conversion was considered to be a loss of wetland acreage both by the Fish and Wildlife Service's wetlands Status and Trends and Natural Resources Conservation Service's National Resources Inventory. Former wetlands include by definition Prior Converted Croplands (PC) and, by determination, other areas that no longer meet the jurisdictional criteria for wetlands.

Wetlands that before December 23, 1985, were drained, dredged, filled, leveled, or otherwise manipulated for the purpose of, or to have the effect of, making the production of an agricultural commodity possible. (National Food Security Act Manual)

: A wetland with one or more functions reduced, impaired, or damaged due to human activity. When determining whether or not a wetland is degraded, consider: physical alteration, including the conversion of a wetland from one system (e.g., estuarine or marine) to a different system; chemical contamination; and biological alteration, including the significant presence of non-indigenous invasive species.