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Discussion Paper**



**Developing Performance Standards
for the
MITIGATION AND RESTORATION
of
NORTHERN FORESTED WETLANDS**

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FORWARD

The following paper has been prepared to simultaneously serve several goals. First it is designed to stimulate discussion at a Northern Forested Wetland Restoration symposium, which will to be conducted as part of Wetlands 2006. Wetlands 2006 will be held near Travers City, Michigan on August 28-31, 2006. Second, it provides background information with regard to a list of issues posed by the Michigan Department of Transportation, a sponsor for preparation of the paper and the Symposium (see list below). Third, it leads the reader to more detailed sources of information for individuals or organizations wishing to mitigate impacts to or restore northern-forested wetlands. See Box 2, Bibliography, and Selected websites.

Preparation of the paper and the conduct of the forested wetland restoration symposium as part of Wetlands 2006 have been sponsored by the Michigan Department of Transportation (MDOT). The MDOT requested that the paper and the Symposium help:

- Describe the challenges associated with northern-forested wetland restoration/mitigation
- Describe the key controlling ecological and temporal characteristics of forested wetlands
- Describe the present engineering principles used in northern-forested wetland restoration/mitigation
- Describe the outcomes of projects undertaken to restore/mitigation northern-forested wetlands, and
- Define and develop the key science-based criteria for successful northern-forested wetland restoration/mitigation.

Per the request of the MDOT, focus in the paper and the Symposium is upon development of performance standards for mitigation and restoration of northern-forested wetlands in the Midwest and East including wetlands in Michigan, Minnesota, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, New York, New Jersey and the New England states.

This paper is based upon:

- A literature review pertaining to northern-forested wetland restoration and management,
- A web search pertaining to northern-forested wetland restoration,
- Discussions with selected federal and state agency regulatory staff, and
- Discussions with selected consultants concerning the restoration of northern-forested wetlands in the Midwest and East.
- A series of prior workshops, studies, and publications by the author concerning wetland restoration more generally. See, e.g., Kusler, J. & M. Kentula, (eds). 1990. *Wetland Creation and Restoration: The Status of the Science*. Island Press; Washington, D.C.; Kusler, J. and C. Lassoigne, (eds). 1992. *Effective Mitigation: Mitigation Banks and Joint Projects in the Context of Wetland Management Plans*. Association of State Wetland Managers, Inc., Berne, NY.

The paper should be considered an overview and discussion paper rather than an exhaustive investigation of science or policy, given the modest scope of the effort.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

Restoration of Northern Forested Wetlands

- **Northern forested wetlands.** Northern-forested wetlands in the North and East are of two principle types: swamp forests including bogs and fens located in depressions and floodplain forested wetlands located along rivers, creeks and streams. These two general types contain a broad range of more specific wetland types with somewhat different hydrology, soil, and vegetation characteristics and somewhat different fauna. Forested wetlands are the most common wetlands in the Midwest and Northeast.
- **Impacts to northern forested wetlands.** Mature timber has been removed from virtually all northern forested wetlands. Many have been drained or partially drained for timber production, agriculture, urbanization, and other activities. The greatest wetland losses both nationally and in the Midwest and Northeast are occurring in forested wetlands.
- **Restoration efforts to date.** There have been few efforts to restore northern-forested wetlands and even fewer to monitor these efforts. Monitoring, where it has been conducted, has been for limited time periods. Individuals wishing to damage or destroy forested wetlands often propose construction of other wetland types such as marshes as mitigation. Limited studies concerning restoration of northern-forested wetlands also suggest a relatively high rate of failure for restoration projects.

No level of government has apparently adopted performance standards specifically designed for restoration of northern-forested wetlands. Nevertheless, general guidelines and procedures and some more specific performance standards have been adopted for wetland restoration more broadly at federal, state, and local levels. These have been applied to northern-forested wetlands in the Midwest and East. This experience and experience with restoration of forested wetlands elsewhere (e.g., southern swamps) suggest some useful future directions for northern-forested wetland restoration efforts.

- **Challenges.** Restoration efforts for northern-forested wetlands poses a variety of challenges. Some major ones include:

- Northern forested wetlands may take 50 years or more to reach maturity and it is, therefore, very difficult to evaluate “success” based upon a few years of monitoring. Efforts to determine the “success” of restoration projects must rely upon “trajectory” indicators such as establishment of percent of plant cover of specified species over a specified time period. However there has been little long term testing of the predictive capabilities of such indicators with regard to the full range of wetland functions and values.

- The hydrologic and soil requirements of northern-forested wetlands are varied by type of wetland (e.g., floodplain forests, depressional swamps including bogs and fens). This complicates any effort to develop highly specific performance standards for these systems although the general standards (restoration of hydrology, plantings, etc.) remain the same.

- Limited restoration projects have been undertaken for northern forested wetlands; even fewer have been monitored.
- Hydrology of northern forested wetlands is typically complex involving both surface and ground water systems. There is no easy way to determine hydrology at a specific site and this greatly complicates mitigation and restoration efforts.
- Limited research has taken place with regard to the precise hydrology, soil and other requirements of many northern forest wetland plants, especially under-story species. This hinders efforts to create, enhance, or restore such wetlands.
- Regulators do not agree concerning the value of forested wetlands and the overall goals and standards (e.g., acreage, function, value) used for mitigation and restoration of wetlands in general including forested wetlands.
- Regulators do not agree with regard to the most appropriate assessment methods or methods to determine functions, condition, and values.

Performance Standards

- **Need for performance standards.** More specific performance standards to guide northern forested wetland restoration are desirable to meet a variety of needs. These include improving the “success” of restoration projects, facilitating the determination of mitigation requirements in regulatory permitting, facilitating wetland status and trends analyses, and determining restoration program performance pursuant to the federal Government Performance and Results Act.
- **Form of performance standards.** Performance standards may take the form of:
 - general goals (e.g., no net loss of function, acreage, and value),
 - more specific numerical performance goals such as % survival of specified tree within specified time periods,
 - assessment and design procedures (not really an output standard but containing inventory and assessment procedures which are critical in establishing output standards on a permit by permit basis), and
 - monitoring, management, and mid-course adjustment standards and procedures.

See more discussion below.

Performance standards might take the form of general written guidance, which applies, to all wetlands or, potentially, all northern forested wetlands. Standards may also take the form of requirements embodied in restoration plans and conditions attached to individual wetland permits (the case-by-case approach now taken).

- **General goals: the no net loss overall goal/standard.** “No net loss” of “function”, “value”, and “acreage” standard is now being broadly applied at all levels of government to wetland mitigation and restoration. It is being applied to northern forested wetlands as well as other types of wetlands although there are questions with regard to what combination of “functions”, “acreage” and “values” is to be achieved by restoration. There are also questions concerning definition of “functions”, “values”, and even acreage gains and losses and how success is to be determined. In many instances, agencies require large mitigation ratios for impacts to forested wetlands because of the perceived high risk of project failure.

- **More specific, numerical performance standards.** Regulatory agencies have applied a variety of more specific numerical and nonnumerical performance standards to wetland restoration projects in general including but not limited to forested wetland projects. Such performance standards are generally attached as mitigation requirements to individual permits for fill or drainage of wetlands. Topics addressed by these performance standards include a no net loss of function, acreage, value overall standard and more specific numerical and nonnumerical standards pertaining to:

- Area specifications (e.g., acres) for restoration of specific types of wetlands (e.g., marsh, wetland meadow, forested) meeting regulatory wetland definitions and more specific area requirements set forth in permits
- Water depths and duration for specific areas
- Water quality parameters for rivers, lakes, streams flowing through forested wetlands
- Wetland soil requirements
- Percent plant cover for designated species
- Percent survival for designated plant species
- Maximum extent cover for invasive species
- Buffers (around the wetland)
- Setbacks for activities in wetlands from rivers, streams, lakes
- Continuity, connectiveness

- **Assessment, planning, design, construction procedures.** The overall assessment, planning, design, and construction procedures and processes developed for restoration of wetlands in general appear to be applicable to restoration of northern forested wetlands as well. These include (where appropriate) careful inventories prior to proposed destruction/mitigation, assessment of functions and values, identification and use of “reference” wetlands to guide restoration, ecologic and ecological analysis of wetland landscape context, and careful project supervision and construction. More specifically:

- **Inventories.** Inventories of plant and animal species and wetland functions/values are needed before forested wetlands are destroyed or damaged to help evaluate the acceptability of such destruction or damage, to facilitate the design of restoration/mitigation measures, and to establish performance goals and standards attached to permits to determine the success of such mitigation/restoration measures over time.

- **Assessment of functions.** There is no agreement in the regulatory community concerning the most appropriate assessment technique or techniques to be used to evaluate “no net loss” of “functions” and “values” of a wetland before it is damaged or destroyed and the functions of restored, created or enhanced mitigation wetlands. Such assessments are needed to not only determine the acceptability of proposed impact reduction and restoration measures but to determine appropriate restoration designs. A variety of assessment approaches have been developed such as HGM and IBI models, but all are subject to limitations; due to the newness of assessment procedures; complexity and diversity of wetland types that need to be assessed; limited time allowed for evaluation under permit programs; and the wide range of functions that need to be addressed.

- **Identification and use of reference wetlands.** Reference wetlands (unaltered wetlands where available) may be productively used to guide restoration activities for northern forested wetlands as well as other wetland types including hydrology, soils, and planting requirements. Reference wetlands may also form a “benchmark” to evaluate success over time. However, it is often difficult to locate unaltered “reference” wetlands because of widespread timber harvest and hydrologic modifications. The use of altered “reference” wetlands or reference wetlands with altered hydrology may be useful where return to a natural condition is not possible or practical.
- **Regional or statewide** ecosystem and hydrologic assessments to assist in kind and out of kind and onsite and offsite restoration decisions. Restoration of northern, forested wetlands should, desirably, be carried out in regional or statewide ecosystem and hydrologic system contexts. Because northern forested wetlands are extensive and the dominant wetland type in some states and regions and are dependent upon regional hydrology and ecosystems, it may be ecologically desirable to replace some forested wetlands with other wetland types at specific sites. Conversely, it may also be desirable to replace other wetland types with forested wetlands. States and federal agencies need to establish regional analysis and planning procedures (e.g., watershed planning, ecosystem analyses) to help determine the desirability, from ecosystem and social value perspectives, of onsite and inkind versus offsite and out of kind mitigation and restoration.
- **Careful project construction including supervision.** Careful project construction is needed including supervision of bulldozer and other heavy equipment drivers to achieve the specific elevations need for restoration.
- **Monitoring, midcourse correction, and management procedures.** Monitoring is needed post construction to help guide management efforts and provide the basis for mid-course corrections. Monitoring requirements such as determination of percent survival of target plant species at specified intervals of time are now broadly applied to restoration projects. However, as indicated above, the accuracy of various types of “trajectory” standards in predicting long-term success has not been broadly investigated. The National Academy of Sciences has called for the design of wetland mitigation projects as self-sustaining systems. However, management (e.g., control of exotics) and midcourse correction capability is also desirable.

Restoration plans may productively contain short term and long-term management and mid-course correction elements dealing with:

- Fire management
- Control of exotic species
- Harvesting of timber and associated impacts on plants and animals, and
- Damage from hurricanes, tornadoes, ice storms and other acts of nature.

• **Research.** Monitoring and research are needed to develop more specific performance standards for restoration of specific types of northern forested wetlands. Some priority topics include (see text for a more detailed list of research needs) include:

- A northern forested wetland restoration database should be created by federal agencies, states, academic institutions, and timber companies
- Monitoring is needed for existing and new northern forest restoration projects
- Field research is needed to determine the requirements and tolerances of various plants in terms of hydrology (depth of inundation or saturation), soil (ph. Organic content, nutrients), temperature, and other features.
 - Field-testing is needed to help establish “trajectory” performance standards able to predict success over time in achieving no net loss function, value, acreage, and other goals. Some of this needs to be long term. For example, percent survival of specific target species (or exotics) need to be measured at 20, 30, and 40 years and not just 1, 3, and 5 years. HGM. IBI and other functional assessment models need to be tested for both accuracy and practicality in evaluating functions and values.
 - Regional analysis and planning protocols and techniques should be developed to identify priority restoration sites and suggest when in kind and out of kind restoration, creation, or enhancement are appropriate.

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PART 1: BACKGROUND

Compensatory Mitigation Requirements

Compensatory wetland mitigation is often required by federal, state, and in some instances, local regulatory agencies when northern forested wetlands and other wetlands are damaged or destroyed by fills or drainage. Regulations adopted by the U.S. Army Corps of Engineers (Corps) and U.S. Environmental Protection Agency (EPA) under section 404(b)(1) of the national Clean Water Act for all wetlands and other aquatic ecosystems require a public or private landowner proposing to destroy or damage a wetland (1) attempt to avoid wetland impacts, (2) minimize impacts, and (3) mitigate the remaining impacts. (See Memorandum of Agreement, 1990.) A 1990 Memorandum of Understanding between the Corps and EPA requires no net loss of wetland “functions” and “values”. See Appendix A. Many states have also adopted regulations requiring “no net loss” of wetland functions, functions and acreage, or functions, acreage and values. See Appendix A.

Specific compensatory mitigation requirements for forested wetlands and other types of wetlands have usually been determined by federal, state, and in some instances local regulators on a case-by-case basis, applying an overall “not net loss” of function and acreage, function and value, or some other no net loss standard. These requirements are typically attached to permits as conditions. The requirements include mitigation planning requirements, more specific performance goals, site design specifications, and monitoring and mid-course correction capabilities.

In the paper which follows we use the term “performance standards” generally to include observable or measurable attributes or outcomes of a restoration project to help determine whether the project meets its goals and objectives. As suggested by the Environmental Law Institute in a 2004 publication concerning “Measuring Mitigation” (ELI, 2004), “A number of biological metrics have been suggested for their use as wetland performance standards including, for example, measures of herbaceous plant density, cover by exotic species or native species, aquatic invertebrate diversity, and composition of fish assemblages. Abiotic metrics, such as soil conditions, hydrologic criteria, and nutrient thresholds have also been suggested.”

Restoration of northern forested wetlands to meet “function”, “value” and “acreage” goals and the development and application of more specific performance standards has, however, proven difficult for a variety of reasons which will be discussed in this paper. Apparently no regulatory agency has adopted performance standards specifically for restoration of northern forested wetlands. In general, project proponents have not attempted to restore forested wetlands but have created other, less difficult to create wetland types such as marshes. A number of studies of mitigation success in specific contexts have indicated relatively high rates of at least partial failure for forested wetland restoration efforts. See discussion in Part 3.

The paper begins with a brief description of northern forested wetlands and some of the key environmental parameters which determine their functions and values. Challenges to restoration and developing performance guidelines are next discussed. Efforts to restore such wetlands are

then described. The paper concludes with recommendations for research to help develop more quantitative performance standards.

Occurrence of Northern Forested Wetlands

Northern forested wetlands are widely distributed in the Midwest and East. They are found in depressions, floodplains, and other poorly drained areas. It is not surprising, therefore, that northern forested wetlands are often damaged or destroyed when road building, water resource projects (e.g., dams, levees, channelization), agricultural drainage, and various types of development occur in these areas. Project proponents typically propose a variety of measures to reduce and compensate for impacts including the restoration, creation or enhancement of wetlands. This may include the use of mitigation banks. Restoration of forested wetlands is also taking place in some nonregulatory contexts by private landowners, land trusts and government agencies although the extent of this activity is unknown.

Northern forested wetlands in the Midwest and East include a variety of environments locally known as swamps, floodplain forests, riparian areas, bogs, fens, and by other names. Forested wetlands, wherever they are found, are characterized by frequently flooded or saturated soils with woody vegetation at least 20 feet tall (Cowardin et al, 1979). Nationally, forested wetlands cover about 50 million acres. This is the about 50% of the remaining wetlands of the U.S. and the single largest category of wetland. (USFWS, undated). See www.egocities.com/ntgreencitizen/forest.html.

Northern forested wetlands are extensive in the upper Midwest and East, particularly Minnesota, Wisconsin, Michigan, Ohio, Pennsylvania, New York, and the New England states. They constitute much of the remaining wetland acreage in these states. For example, New York has an estimated 2.4 million acres of wetlands. Forested wetlands are the most common wetland type (about 70%) followed by shrub/scrub (16%), emergent (9%), and open water (5%). See <http://www.dec.state.ny.us/website/dfwmr/habitat/fwvprog3.htm>.

Forested wetlands in these states encompass a range of more specific wetland types with varied hydrology, soils, and vegetation. Two principle types include:

Depressional “swamps”. These are found principally in glacially created depressions and flats including the beds of former glacial lakes. These include northern boreal swamps with predominantly evergreen species such as spruces, cedars and firs. They also include red maple swamps found slightly further south and characterized by deciduous hardwoods such as red maple, gums and ashes.

Floodplain, wetland forests. These occur on floodplains which are often flooded in the spring and sometimes the fall of each year. Silver and red maple, red ash, cottonwood and willows are common. Some southern trees such as honey locust and sycamore reach their northern ranges in these forests. Examples of birds inhabiting these forests include red-eyed vireo, northern oriel, indigo bunting, gray catbird, wood duck, black duck, great blue heron, woodcock, and wild turkey. Animals include salamanders, frogs, snakes,

coyotes, foxes, beaver, and rabbit. Rare and unique species include Indiana bat, smallmouth salamander, spotted turtle, cerulean warbler, and yellow-throated warbler.

Two other less frequently encountered but important types include the following. They may be considered depressional swamps but have unique hydrology and plants. They are often given special protection status by regulatory agencies.

Bogs. These have formed in glacial depressions by the slow growth of sphagnum moss and later by shrubs and trees. They are typically fed by direct precipitation and receive little water or nutrients from surrounding areas. Bogs are acidic and are characterized by northern conifers such as black spruce, white cedar, balsam fir, and tamarack. Other plant species include cranberry, blueberry, pine, Labrador tea, northern pitcher plants, and sundews.

Fens. These are rare peat wetlands characterized by cold, inflowing groundwater containing dissolved magnesium and calcium. They are found on slopes and support rare plants. They are given special protection in Minnesota under the Wetlands Conservation Act.

Within these two general types are a variety of more specific types. The Wisconsin Natural Areas Inventory lists a number of more specific types of northern, forested wetland types in Wisconsin including (See <http://dnr.wi.gov/org/land/er/communities/descriptions.htm>):

- Black Spruce Swamp
- Bog Relict
- Floodplain Forest
- Forested Seep
- Hardwood Swamp
- Mesic Floodplain Terrace
- Muskegs
- Northern Hardwood Swampe
- Northern Wetland Forest
- Northern Wetl-Mesic Forest
- Southern Hardwood Swamp
- Tamarack (poor) Swamp
- Tamarack (rich) Swamp
- White Pine-Red Maple Swamp

For another description of forested northern wetlands see Table I, Forest Associations in Dahl and Zoltai. (Dahl and Zoltai, 1997).



Red Maple (Swamp Maple)

www.nps.gov/plants/pubs/chesapeake/plant/1237.htm



Forested Floodplain Wetland in Maine During Flood Stage

www.state.me.us/dep/blwq/wetlands/flood.htm



**Forested Wetlands Are Often Part of a Mosaic of Wetland Types,
Forested, Open Water Wetland, Pennsylvania**
www.dep.state.pa.us/.../newdesign/eriephotos.htm



Forested Riparian Buffers
<http://www.ga.nrcs.usda.gov/programs/images/riparianbuffer.jpg>

As one would expect, differences in hydrology, soils, vegetation, and animal species among these types complicates development of detailed performance standards for restoration of forested wetland systems.

Forested wetlands are often part of a mosaic of wetlands in the landscape and are interspersed with other wetland and aquatic ecosystem types. Many contain ponds, lakes, rivers, streams, and creeks. Many also contain beaver ponds, shrub wetlands, and open marshes. Many contain houses, roads, utility lines, fields and other cultural features. This poses combined wetland and lake/pond and stream management challenges including the compliance at all levels of government with stream protection, lake and pond protection, land use and other protection and restoration requirements.

Impacts Upon Forested Wetlands

Dahl and Zoltai (1997) report that “Silviculture is the major threat to northern forested wetlands.” Timbering has occurred on all but a small portion of forested wetlands in the Midwest and East and demand for wood products is at record levels. They report that “During the period from 1830 to 1885, logging and settlement activities began to drastically alter the northern forested regions both at the forest stand scale (species composition and structure) and at the landscape level....” Removal of timber along with construction of access roads and drainage have altered the hydrology and ecosystems of most forested wetlands. This not only complicates assessment efforts but efforts to identify “reference” wetlands.

Swamps and floodplain, forested wetlands in the Midwest and East have been extensively drained for agriculture, forestry, mining, and urbanization (see generally Dahl et. al 2000). Other impacts include flood control projects and diseases. Because forested wetlands are the predominant wetland type in many northern locations, continued commercial, residential, road building, and other types of development impacts these wetlands. These impacts include not only direct, onsite damage or destruction but alteration of regional hydrologic regimes and water quality which, in turn, alter forested wetlands. See generally ASABE (2006). Impacts differ somewhat, depending upon the type of wetland. For example, fills and drainage for agriculture and urbanization are the principal threats to depressional swamps and flats. Runoff, pollution, and increased sediment also affect many. Floodplain forested wetlands are subject to many of the same threats with the addition of changed hydrologic and sediment regimes due to river and stream ditching, channelization, diking, and dams.

Dahl and Zoltai (1997) reported:

Evidence from the U.S. Wetland Status and Trends study suggests that while the rate of wetland loss is declining overall, the rate of loss of forested wetlands has accelerated. The results of a study of wetland losses between the 1950's and the 1970's revealed that 54 percent of freshwater wetland losses were losses of forested wetland...A similar study veering the mid-1970's and the 1970s revealed that 95 percent of freshwater wetland losses were forested wetland losses....”

It is to be noted, however, that these are national wetland loss figures not northern forested wetlands alone. Many of the forested wetland losses have been in the South.

Box 1
Definitions and Acronyms:

This paper uses terms in the following ways:

- **Capacity:** the ability of a wetland and related water and floodplain/riparian resources to produce various goods and services of use to society. Capacity depends on natural hydrologic, biological and chemical processes, as well as other characteristics, such as soils, topography and size.
- **Creation:**
- **Developmental trajectory:** the pathway that a created or restored wetland takes as it ages
- **Data:** raw information, such as aerial photos, vegetation and soils information or topography, not yet analyzed for a specific purpose.
- **Enhancement:**
- **Function:** primarily used to refer to natural processes that contribute to the capacity of a wetland and related ecosystems to provide certain goods and services.
- **Functional values:** the goods and services provided by wetlands and their value to society. These have sometimes been called “functions” and “values” but the term functional value is used in this paper to reduce confusion with the term function.
- **Opportunity:** the present or reasonably foreseen ability of a wetland with certain capacities to deliver goods or services to society. Opportunity depends on overall context. For example, a wetland may have the natural capacity to intercept pollution, but may not do so because there are no pollution sources.
- **Performance standards:** observable or measurable attributes or outcomes of a restoration project to help determine whether the project meets its goals and objectives.
- **Restoration:**
- **Social significance:** the existing and reasonably foreseen benefits and costs to people. Social significance in a wetland function/value context depends on not only capacity and opportunity, but also on **who** benefits and suffers adverse impacts, how **many** benefit and suffer adverse impacts, **how** they benefit or suffer costs, **how much** they benefit and suffer costs, and **how strongly segments of society** feel about the benefits and costs.
- **Value:** the ability of wetland function/values to meet cultural, educational, historic, economic needs of society. This may be measured in economic or other terms.
- **Wetland:** an ecosystem that depends on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate (NRC 1995)
- **Wetland creation:** conversion of a persistent upland or shallow water area into a wetland by human activity.
- **Wetland enhancement:** human activity that increases one or more functions of an existing wetland.
- **Wetland restoration:** the return of a wetland from a disturbed or altered condition by human activity to a previously existing condition (NRC 1992).

Acronyms. This paper uses the following acronyms:

EPA: U.S. Environmental Protection Agency.

GPRA: Government Performance and Results Act of 1993

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

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

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

NRCS: the United States Department of Agriculture Natural Resources Conservation Service.

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

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

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

Some Important Characteristics

As noted above, northern forested wetlands are varied in hydrology, soils, and vegetation. See, for example, the Wisconsin natural areas inventory description of wetland types above. These differences need to be reflected in efforts to mitigate forested wetland losses if a no net loss of “function” goal is to be achieved.

A number of key wetland characteristics determine the form and function of wetlands including wetland functions and values include:

Climate: Climate is a major determinant of wetland form and function including hydrology and wetland flora and fauna. Relevant climatic factors include air temperatures including minima and maxima and annual mean temperature, precipitation, and storm events. Climate determines wetland hydrology, growing season, and rates of evaporation and evapotranspiration. Climate also affects the frequency and intensity of fires.

Hydrology: Northern forested wetlands are characterized by high ground water levels and surface saturation at least a part of the year. Many aspects of hydrology are relevant to wetland form and function including depth and duration of flooding or saturation, water quality, water velocity and scour, and sediment regimes. Forested wetland hydrology is complex and typically difficult to replicate. See generally ASABE (2006).

Soils: Northern forested depression wetlands are, in general, characterized by high organic content soils including the build up of peat in some situations. In contrast, mineral soils are more common in wetland floodplain forests although some of these also have high organic content. Soils are relevant to habitat for salamanders and other amphibians. Soils are relevant to

pollution control functions, flood storage, and timber production. Soils are relevant to carbon storage and methane production.

Wetland trees and plants including species, density, condition. Saturation tolerant trees and other plants are found in northern forested wetlands. Common forest species include spruce, tamarack, white cedar, and red maple. Canopy, subcanopy, and ground plant species may all be important to wetland functions and values including habitat, flood conveyance and storage, pollution control, timber production, and other functions and values.

Animal species. Northern forested wetlands are habitat to a range of salamanders, turtles, beaver, otter, moose and many types of birds. Beaver dam small creeks and streams, producing ponds. Animal species are relevant to bird watching, hunting, wildlife conservation, and protection of rare and endangered species.

Invasive plants and animals. Invasive plant and animal species such as garlic mustard increasingly determine habitat characteristics of northern forested wetlands.

Landscape context. Wetland context including adjacent and interspersed uplands and aquatic ecosystems determine wetland hydrology, habitat functions and values, flood storage and conveyance functions and values, pollution control functions and values, and a broad range of other features. Many species such as birds, turtles, salamanders, and deer spend only a portion of their life in the forested wetlands. Adjacent uplands and aquatic as well as wetlands are essential components of species habitat.

Presence or absence of buffers. Buffers provide habitat for wetland species utilizing wetlands only a portion of the time such as salamanders, turtles and birds. Buffers help protect wetlands from nutrients and sediment.

Degree of connectivity fragmentation. Degree of connectivity/fragmentation affect wildlife habitat functions and values. Connectivity and fragmentation also affect flood storage, flood conveyance, erosion control, pollution control and other functions and values.

Social context. Wetland functions and social context determine the “value” of wetlands including but not limited to economic and cultural value. Value depends upon location and the existing and potential “users” of various wetland functions (e.g., flood storage, pollution control). See more discussion below and Appendix C.

Performance standards may relate to selected characteristics such as hydrology, soils, plants (trees, understory), animals, invasive plants and animals, landscape context, buffers, and connectivity/fragmentation. Standards may also relate to social context (e.g., no increase in flood heights affecting adjacent properties for alteration of floodplain wetlands).

Box 2
Recommended, Selected Publications
Dealing With Forested Wetlands and Restoration
See bibliography for a more detailed list of publications and web sites.

American Society of Agricultural and Biological Engineers (ASABE), 2006, Hydrology and Management of Forested Wetlands, 2006. Proceedings of an International Conference, April 8-12, 2006. Published by the American Society of Agricultural and Biological Engineers. This volume contains many papers concerning the hydrology of forested wetlands including some restoration projects.

Cole, A., T. Serfass, M. Brittingham, and R. Brooks. Managing Your Restored Wetland. Pennsylvania State University, College of Agricultural Sciences, Cooperative Extension. This 46-page publication addresses management of restored wetlands in general and not simply forested wetlands. Nevertheless, many of the recommendations appear applicable to forested wetlands. See <http://pubs.cas.psu.edu/FreePubs/pdfs/uh086.pdf>.

Golet, F. & J. Allen. 1993. Ecology of Red Maple Swamps in the Glaciated Northeast: A Community Profile. U.S. Fish and Wildlife Service, Washington, D.C. Excellent overall profile of Red Maple Swamps.

Hayes, D., T. Olin, & J. Craig Fishenich 2001. Wetlands Engineering Handbook, U.S. Army Corps of Engineers, Engineer Research and Development Center ERDC/EL TR-WRP-RE-21. This handbook provides forth a great deal of practical advice concerning wetland restoration, creation, and enhancement. <http://darwin.nap.edu/books/0309074320/html/197.html>.

Larson, J. & C. Neill (eds.). 1986. Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base. Publication 87-1. The Environmental Institute, University of Massachusetts, Amherst This publication is dated but, nevertheless, contains much useful information.

Marble, A. & X. Riva. 2002. Guidelines for Selecting Compensatory Wetlands Mitigation Options. NCHRP Report 482. Federal Highway Administration, Transportation Research Board. 2002. http://ttap.colostate.edu/Library/TRB/nchrp_rpt_482.pdf. This was not a before and after study but rather surveyed of the opinions of wetlands managers concerning the relative success of compensatory mitigation options.

Mitch. W. & J. Gosselink, 1993. 2d edition. Wetlands, Van Nostrand Reinhold, New York This is the best overall text of wetlands.

National Academy of Sciences (NAS), Board on Environmental Studies and Toxicology, 2001, Compensating for Wetland Losses Under the Clean Water Act. 322 Pages. National Academies Press. See <http://darwin.nap.edu/books/0309074320/html/233.html>. This excellent report addresses “mitigation” for Section 404 permits including restoration, creation and enhancement. It concludes that much mitigation is not working and makes many recommendations.

Nevel, B. 2004. Measuring Mitigation, A Review of the Science for Compensatory Mitigation Performance Standards. Environmental Law Institute. 281 pages. See http://www.elistore.org/reports_detail.asp?ID=10991&topic= . This report extensively reviews the scientific literature pertaining to the use of various biotic and abiotic performance standards for wetland mitigation.

Palmintier, C & B. Appleton. 1996. Restoration and Creation of Forested Wetlands: A Guide, Wetlands Program Technical Report No. 96-4. Virginia Institute of Marine Science, Gloucester Point. This 12-page publication focuses upon Virginia but contains quite specific recommendations that are more broadly applicable to forested wetlands.

Trettin, C, M. Jurgensen, D. Grigal, M. Gale, & J. Jeglum, 1997. Northern Forested Wetlands, Ecology and Management. Lewis Publishers. This excellent 469-page publication contains 33 chapters authored by an international group of experts. It focuses primarily upon management of forested wetlands for forestry purposes.

U.S. Department of Agriculture et al, 2002, Forested Wetlands, Functions, Benefits and the Use of Best Management Practices. NA-PR-01-95. Available at http://www.na.fs.fed.us/spfo/pubs/n_resource/wetlands/index.htm.

Some Unique Characteristics of Northern Forested Wetlands

Although varied, northern forested wetlands also share a number of characteristics which make them somewhat distinct from their southern forested wetlands and other wetland counterparts. These characteristics also affect their functions and values.

- **Slow maturation.** Trees may take 50 or more years to mature. Slow maturation is characteristic of all forested wetlands but is exacerbated in the north by short growing season and low temperatures. This complicates efforts to determine the “success” of impact reduction and wetland restoration efforts because it is not practical to wait 50 years to determine whether a restoration project has succeeded and release project proponents from bonding and other requirements. This has required the use of “trajectory” standards.
- **Short growing season and low temperatures.** Northern forested wetlands grow slowly due to short growing season and low temperatures. Short growing season also creates a narrow “window” for plantings.
- **Low nutrient levels.** Bogs, fens, and some other northern forested wetlands are characterized by low nutrient levels and acidity (in some instances). This limits plant growth and may be relevant to allowable timber harvesting.
- **Organic soils.** Many wetlands in northern climates have considerable build-up of organic soils due to the continuous saturation and low temperatures. These organic soils and the functions associated with them (habitat, pollution control) are difficult to replicate in restoration efforts.

- **Tree cutting/vegetative removal.** Tree cutting has occurred for almost all northern forested wetlands because of the commercial value of forested wetland species and there are few stands left to serve as reference sites. Tree cutting may be restricted by performance standards.
- **Ice storms, snow, ice jams** (along rivers and streams). All northern wetlands are subject to ice and snow including periodic ice storms, which can seriously damage trees. On the other hand, those in the Midwest are not subject to hurricanes or Northeasters) and tornadoes are relatively uncommon in both the East and the Midwest. Damage from natural hazards is relevant to plant survival requirements and other “performance” standards.
- **Forest fires.** All forested wetlands are subject to forest fires although the frequency and intensity of such fires differ greatly. Extensive forest fires appear to be less common in the Midwest and East than in other parts of the country due to relatively high and even rainfall throughout the year, relatively low temperatures and rates of evaporation, ice and snow in the winter, fragmentation of forested wetlands by roads, fields and other open areas which act as fire breaks. This also complicates restoration where fire is a necessary component of long-term ecosystem function.

“Functions” and “Values”

As will be discussed in greater depth below, federal, state, and to some extent local wetland regulations require that agencies, organizations, and individuals destroying or damaging wetlands mitigate such losses through wetland restoration, creation, or enhancement in order to restore lost “functions”, “acreage”, and “values”. The combination required differs somewhat from state to state and federal agency to federal agency.

Northern forested wetlands are characterized by a variety of natural processes and features often called “functions”. Examples of “functions” from an “Interim Wetland Functional Assessment Model (Organic Soil Flats (Michigan) include:

- Surface water storage
- Retention of water in soil
- Nutrient uptake
- Long term storage of organic compounds
- Long term storage of nutrients
- Characteristic plant community
- Wildlife habitat structure
- Habitat interspersions, quality, connectivity

See www.pwrc.usgs.gov/wlistates/michigan.htm. Unfortunately, regulatory programs do not specifically define “function” or “value” and this hinders development of more specific performance standards.

Northern forested wetlands are also characterized by various “values” (also called “functional values”). See discussion below. Functional values are dependent upon not only natural processes but wetland size, depth, and topography. They are dependent upon the social context of wetlands including the “opportunity” wetlands may have to perform certain functions such as a pollution

control for society and the “social significance” of these functions and related characteristics. For example, a wetland in the Catskills protecting the New York water supply from sediments, nutrients, and pathogens has more “opportunity” to provide source water protection functions/values than a comparable wetland in the Adirondacks. The social services and value provided by the wetland in the Catskills for 8 million people may also be greater than a comparable wetland with pollution control potential in the Adirondacks.

Functional Values

Whatever terminology is used (i.e. “value”, “functional value”), northern forest wetlands perform a range of functions of value to society which need to be mitigated or restored if a “no net loss” of “function” and “values” standard is applied in mitigation and restoration efforts. These values (also called functional values) depend, in part, upon natural process but reflect other factors as well. They include but are not necessarily limited to the following. However, not all northern forested wetlands perform these functions/values nor are all functions equally valuable to society:

Flood conveyance. Some floodplain forested wetlands convey flood waters from upstream to downstream points, reducing flood heights. Restoration of this function requires consideration of river/floodplain hydrology (e.g., HEC models). Dikes, levees and other fills near a river may impair this function. This is one of the more measurable functions with numerical models such as the Corps HEC models available to analyze the impacts of proposed activities on flood conveyance and the potential role of restoration wetlands in restoring these functions. FEMA has mapped “floodways” in almost ten thousand communities. Dense wetland vegetation including under-story species often decrease flood conveyance although it may increase flood storage capacity.

Flood storage. This is also one of the more measurable and restorable functional/values. Floodplain forested wetlands and depressional swamps store floodwaters by retarding runoff. This, in general, reduces downstream flood heights. Regional flood analysis (e.g., HEC models) may be used to determine the flood storage contribution of a wetland proposed for destruction or a proposed restoration wetland.

Erosion control. Floodplain forested wetlands are important in stabilizing soil and perform erosion control functions. This function appears to be particularly important for floodplain forested wetlands adjacent to unstable, eroding rivers with high velocities and low sediment loads. Restoration of not only tree species but under-story shrubs and other vegetation may be necessary to restore this function. Re-meandering of river may be needed to stabilize a stream.

Pollution control. Forested wetlands remove sediment, nitrogen and phosphorous and other pollutants from agricultural runoff and stormwater. Understory plants and soils as well as trees may be important.

Bird nesting and feeding. Many bird species spend a portion of their life cycles in floodplain forested wetlands. It has been reported that in Massachusetts over 40 different bird species breed in maple swamps. Species differ depending upon predominant vegetation, density of cover,

presence or absence of open water, and other factors. Adjacent buffer areas as well as forested wetlands are often important to feeding and breeding.

Amphibian and reptile habitat. Forested wetlands are important habitat for a number of species of amphibians and reptiles such as salamander, Bog Turtles, and Blandings Turtles.

Mammal habitat. Forested wetlands are habitat for White Tailed deer, beaver, otter, raccoon, bear, beaver and red squirrel.

Recreational opportunities. Forested wetlands provide opportunities for bird and other nature watching. Floodplain forested wetlands may also provide hiking, walking, and hunting opportunities.

Timber production. Forested wetlands are an important source of timber. Restoration of timber production capability may require restoration of hydrology and the application of seeding, fertilization and other techniques. Much of the literature concerning forested wetland restoration is concerned with optimizing timber production while protecting other functions and values. See Trettin et. al. ed. (2001), Northern Forested Wetlands.



Carniverous plants like the Jack in the Pulpit grow in low nutrient bogs.

<http://www.state.me.us/dep/blwq/wetlands/jackinthepulpit.htm>

PART 2: CHALLENGES

Challenges and Impediments

Challenges and impediments to restoration of northern forested wetlands include:

- **Complex hydrology.** Because of the relatively narrow hydrologic and hydraulic tolerances of most wetland trees and under-story plants including depth and duration of inundation or saturation, “getting the hydrology right” is the most difficult requirement for mitigation of impacts and restoration of forested wetlands. See generally the many papers in Hydrology and Management of Forested Wetlands, Box 2, above. Surface water elevations and saturation often depend upon direct precipitation and ground water and surface runoff. Surface flooding typically occurs in the spring for both depressional and floodplain wetlands. Floodplain wetlands and some depressional wetlands typically dry out during the summer and fall. Many depressional wetlands are fed principally by ground water and there is less short-term variability but more long-term variability in saturation or surface ponding, reflecting longer-term rainfall cycles.

Hydrology is typically not only complicated but difficult and expensive to measure, requiring in some instances multiyear monitoring with piezometers and surface water runoff monitoring devices. In addition, the hydrology of both existing forested wetlands and proposed wetland restoration sites is often changing due to agriculture, urbanization, and other changes in the landscape.

- **Fluctuating water levels.** Water levels vary seasonally and from year to year in forested wetlands. Vegetation and animal use vary by water level. It is, therefore, very difficult to assess forested wetlands based upon a single visit or set of observations.
- **Differing requirements for soils, hydrology, and plants depending upon the type of wetland and site characteristics.** Northern forested wetlands are diverse, complicating any effort to generalize concerning the requirements of such systems.
- **Lack of reference wetlands.** It is difficult to find “reference” forested wetlands with natural or relatively natural conditions to act as a guide for restoration projects since the hydrology of most wetlands has been altered and virtually all old growth timber has been removed from.
- **Limited scientific knowledge suggesting the hydrologic requirements and tolerance of many wetland plants and animals.** Many scientific reports and articles are available concerning commercially harvestable tree species but few address specific hydrologic and water quality requirements of under-story plants including tolerances for depths and duration of inundation, sediment, and pollutants. The same is also true for many invertebrates.
- **Many of the animal species such as salamanders found in forested wetlands are difficult to observe due to dense vegetation and their use of wetlands for only a portion of the year.**

- **Limited forested wetland restoration projects have been undertaken to date and limited monitoring has occurred for the projects which have been undertaken.** The literature base is, therefore, quite small.
- **The success of alternative restoration approaches has not been extensively investigated.** Northern forested wetlands are slow to mature (e.g., more than 50 years) and there are few monitored restoration efforts more than a decade old. This makes it difficult to determine whether particular restoration practices lead to “success”.
- **Difficulties in defining precise surface elevations needed for restoration.** Precise elevations must be defined for filling and grading since trees and other plants are sensitive to not only depth of inundation or saturation but duration and timing.
- **Difficulties in achieving design elevations in grading and filling.** Careful supervision of bulldozer and other earthmovers is needed to implement precise grading plans. The use of laser altimeters and other precise guidance systems may be needed. This adds expense and difficulty to restoration efforts.
- **Project proponents do not want to be responsible for project monitoring, management and mid course corrections over a long period of time.**
- **Damage from natural hazards.** Northern forested wetlands are, like other wetlands, subject to a variety of natural hazards including fire, wind storms, ice storms, flooding, ice jams for floodplain wetlands, and predation by insects, deer, beaver, and other animals. There is little agreement how losses from these hazards are to be treated in mitigation and restoration efforts including efforts to evaluate project “success”. On the one hand, severe flooding, erosion and deposition, may bury and destroy a restoration project. On the other hand, losses occur in natural as well as restored wetlands and some of the damages from fire and other hazards may be critical to long term, natural succession of systems.
- **Short growing season.** This provides a narrow window for earth moving and planting.
- **Dependence of functions and values upon broader ecosystems and hydrologic systems.** The functions and values of northern forested wetlands like other wetlands depend, to a considerable extent upon, their larger ecosystem and hydrologic system contexts. More specifically, hydrologic functions and values such as flood conveyance and flood storage depend upon not only upon the depth, size, and configuration of a wetland but connections with rivers, streams, and other water bodies and the hydrology of these water bodies. For example, a restoration wetland will not provide flood conveyance if it is separated from an adjacent stream by a dike.

The wildlife value of forested wetlands often depends, in part, upon adjacent and interspersed uplands and aquatic ecosystems, the conditions of such ecosystems, the extent of fragmentation, and connections between the wetlands and these adjacent areas.

The need to consider and evaluate broader context increases cost and time requirements for restoration projects.

Disagreements among regulators concerning the functions and values of forested wetlands.

There are disagreements among regulators as to how forested wetlands are to be “valued”. Some consider them as sacrosanct; others believe them to be of less value than other wetland types. The attitude depends, in part, upon context. Forested wetlands are rare in some areas of the Midwest and Northeast such as urban areas. The remaining forested wetlands are, therefore, of particular value to birds and animals. But forested wetlands are common in other rural, northern areas of Midwest and East. It is here that the marshes and wet meadows may be rare.

Disagreements among regulators concerning the evaluation methodologies which are to be used. There is also no agreement among regulators concerning the most appropriate evaluation methodologies for evaluating the functions and values of wetlands which are to be damaged or destroyed and for proposed restoration wetlands. This includes the use of assessment techniques such as IBI and HGM.

Disagreements among regulators concerning risks of failure and appropriate compensation ratios. Regulators have typically required large compensation ratios for forested wetlands because of perceived risks of project failure. But, large compensation ratios also discourage restoration projects.

Limited testing of “surrogates” or “indicators”. Because long term hydrology and vegetation and the ability of a forested wetland to produce goods and services (e.g., production of species fish, shellfish, waterfowl, birds, etc.) cannot be easily observed, scientists have turned to a variety of soil and vegetative “indicators” or “surrogates” to deduce or imply the ability of specific wetlands to produce such goods and services. Deductions are based upon certain physical characteristics that are observable such as vegetation type, depth of water, and soils. But, field experience suggests such surrogates must be used with care because one plant or animal species is often not a good indicator for another species. And, habitat indicators may have limited correlation with flood storage, flood conveyance, pollution control and other functions.

Difficulties in restoring organic soils. Many northern forested wetlands are characterized by organic soils due to the continuous saturation and low temperatures. Once drained, oxidation and subsidence of organic matter occurs, complicating restoration.

PART 3: PERFORMANCE GUIDELINES

Performance Guidelines

As far as we could determine, numerical performance guidelines specific to forested wetlands have not been adopted at federal, state, or local levels. But regulatory agencies have adopted a variety of administrative regulations and policies for wetlands in general and applied these to forested wetlands along with other wetland types. Case-by-case guidelines are typically incorporated in project designs and attached as conditions to permits. In addition, a number of helpful publications exist suggesting design issues and procedures. See publications listed in Box 2 and discussion below.

Federal and state agencies have an interest in more specific guidelines for restoration of northern forested wetlands for a number of reasons:

- To increase successes and decrease failures of restoration projects.
- To provide greater certainty to landowners and regulatory agencies in carrying out mitigation efforts.
- To help regulatory agencies determine if the objectives of compensatory mitigation have been fulfilled and facilitate enforcement actions.
- To help federal and state agencies prepare wetland “status and trends” analyses reflecting statewide and national gains and losses. Such agencies must decide when to consider a northern forested wetland restoration project a “gain” or a “loss”.
- To help agencies undertaking forested wetland restoration on their lands (e.g., U.S. Forest Service, Bureau of Land Management) design and implement successful projects.
- To help federal agencies comply with the federal Government Performance and Results Act. The Government Performance and Results Act (GPRA) of 1993. See <http://www.whitehouse.gov/omb/mgmt-gpra/gplaw2m.html>. This Act requires all federal agencies, including agencies with wetland-related program missions, to determine the effectiveness of their programs. Agencies must define goals and what they hope to achieve, develop measures of accomplishment for those goals, establish and implement monitoring techniques to apply these measures, report performance, and integrate information gained from this monitoring into program activities.

Unlike earlier initiatives to improve the performance of government, the GPRA is mandatory in nature. It also, for the first time, utilizes the federal budgeting process to improve outcome-based planning and program implementation.

This Act does not directly apply to states and local governments who receive federal grants but indirectly applies because federal reporting requirements pursuant to such grant programs are subject to the GRPR and states and local government are significantly affected by federal

budgetary decisions based upon the GRPR. These include a broad range of federal programs which directly fund state wetland programs such as the EPA State Wetland Grant Program. They include wetland technical assistance, mapping, regulatory and other efforts.

Standards Applied by Regulatory Agencies

As indicated above, regulatory agencies have adopted a variety of general standards and policies for restoration of wetlands which have been applied to northern forested wetlands as well as other wetland types.

The goal of these regulations and more general policy guidance is to insure functioning restoration projects over time which, in the case of mitigation, means restoration, creation or enhancement of lost wetland functions (and values) when a wetland is damaged or destroyed. The regulations and general policy guidance include a variety of “performance” measures:

1. They state an overall no net loss performance goal which is to be achieved by restoration projects such as no net loss of “function”, “function and value”, or “function”, “value”, and “acreage”.
2. They often establish more specific performance measures related to this goal such as % cover within a specified period of time (see discussion below). These more specific performance measures are typically formulated and applied on a project-by-project basis.
3. They require that project proponents go through a series of analytical steps in planning and implementing a project. The steps and procedures are not performance standards per se. But they help define the site-specific performance measures which are to be met by the project and are attached to permits. They also help insure that projects will be successful (i.e., meet project goals). Going through the steps will not insure specifically functioning restoration projects but it increases the probability that functioning restoration projects will result.
4. They require that project proponents undertake monitoring of projects, report the results to the regulatory agency, and undertake agreed upon management and “mid-course corrections” if original goals are not met.

We will briefly examine each of these.

1. Adoption of a no net loss of “function”, “function and “value”, “function and acreage”, or “function, acreage, and value” goal.

Since 1989, most federal, state, and local regulatory agencies have often applied an overall “no net loss” goal standards applying to projects in wetlands. See Appendix A.

The Section 404 regulatory program is most broadly known but there are state and local regulations as well. These regulations typically require no net loss of “function”, “function and acreage”, “function and value”, or “function, value, and acreage” standard. As discussed above, the terms “function” and “value” have typically not been defined with any precision and this has

resulted in case-by-case determination of required mitigation measures by wetland regulators. Various more specific “performance standards” have been attached to permit approvals.

At the federal level, the Corps and EPA adopted a Memorandum of Understanding pertaining to mitigation in 1990 which states a no net loss of “functions” and “values” goal. See <http://www.epa.gov/owow/wetlands/regs/mitigate.html>. The no net loss of function and value goal was also incorporated in the federal agency Mitigation Action Plan in 2002. See <http://www.mitigationactionplan.gov/>. Recent (2006) draft Mitigation Guidance published in the Federal Register emphasizes the restoration of “function”. <http://www.epa.gov/wetlandsmitigation/#regs>.

One of the common issues with mitigation is: Should both no net loss acreage and function goals be achieved? In 2001 the National Academies of Science concluded (NAS, 2001) that:

The Clean Water Act Section 404 program should be improved to achieve the goal of no net loss of wetlands for both area and functions.

Most of the states in the Northeast and Midwest have adopted wetland regulations for freshwater wetlands. See Appendix A for a listing of state “no net loss” standards. See Wisconsin, Minnesota, Michigan, Illinois, Indiana, Ohio, Pennsylvania, New York, New Jersey, Virginia, Rhode Island, Connecticut, Massachusetts, and Maine. Most incorporate a no net loss of “function”, “acreage” and, in some instances, “value” standard.

Some states in the Midwest and East have also adopted more specific mitigation guidance. These apply to all mitigation wetlands, not simply forested wetlands. See, for example:

New Jersey. (undated) New Jersey Department of Environmental Protection, Land Use Regulation Program, Standard Individual Permit Conditions. Suggested standard conditions require restoration of area of “equal ecological value” and a minimum two-acre for one-acre loss permit condition along with 50 to 150 foot transition area. Slopes no greater than 10:1 are required. Monitoring is required for five full seasons for a forested wetland. The monitoring report must include documentation that the goals of the mitigation project are satisfied and the proposed hydrologic regime is met. 85 percent survival of plants and 85 percent areal coverage are required. The site must be 10 percent or less of invasive or noxious species. A minimum six inch layer of top-soil must be used with at least 8%-12% carbon content (by weight). If a project is a “failure” the project proponent must submit a revised mitigation plan to rectify the mitigation site. See generally <http://www.state.nj.us/dep/landuse/7-7a.pdf>.

Wisconsin. (2002) Guidelines for Wetland Compensatory Mitigation in Wisconsin. Wisconsin Department of Natural Resources. See http://www2.dnr.state.wi.us/org/es/science/publications/wetland_mitig.pdf. This document set forth quite detailed guidelines for compensatory mitigation projects. The standard compensation ratio is 1.5:1. A 1.1 compensation ratio may be allowed for the use of an established mitigation bank but not for hardwood, conifer, or cedar swamps (among other types) south of Highway 10. These guidelines call for restoration to historic (pre-European settlement) conditions. Restoration is the preferred mitigation approach. In-kind restoration is preferred, creation of ponds or

deepwater habitats as compensation discouraged. Low maintenance is preferred. Adjacent, vegetated upland areas of at least 100 feet are required to protect wetland sites. Requirements are set forth for a compensation site plan. Compensation sites must be protected in perpetuity. See also, Chapter NR 350, Wetland Compensatory Mitigation, Department of Natural Resources.

Michigan. (undated) Wetland Mitigation. See http://www.michigan.gov/deq/0,1607,7-135-3313_3687-86447--,00.html. No net loss of “similar type” as the impacted wetland wherever feasible and practical is required. A sliding scale of restoration or creation ratios is required: 5.0 acres for each acre of impacted wetland which rare or imperiled on a statewide basis; 2.0 acres for each acre of forested and coastal wetlands; 1.5 acres for each acre of other types of wetlands. Quite specific performance standards are set forth for wetland mitigation. See Appendix B.

Maryland. Maryland Nontidal Wetland Mitigation Guidance. (undated) See <http://www.mde.state.md/wetlands/mitguide.htm>. A sliding scale of mitigation ratios is required. Ratios of 2:1 or 3:1 for mitigation banks are required for forested wetlands. After five years, greater than 85 percent of the site shall be vegetated by planted species approved by the Department of Natural Resources; the wetland shall be dominated by native or adapted vegetation. Created, restored or enhanced wetlands must be protected in perpetuity by deed restrictions, conservation easements, restrictive covenants or deeding the protected area to an organization or public agency capable of protecting the area in perpetuity.

New York, Adirondack Park Agency. (1995) Compensatory Wetland Mitigation. See Guidelines. See http://www.apa.state.ny.us/Documents/Guidelines/Compensatory_Wetland_Gdlns.pdf. Mitigation ratios are suggested of 1.5 for 1 for in kind in the same subcatchment, 2 for 1, in the same major watershed or ecozone, 2.5 for 1 in an adjacent major watershed or ecozone; higher ratios for nonadjacent watersheds or ecozones.

Indiana. Wetlands and Habitat Mitigation. (Nonrule policy document) See <http://www.in.gov/nrc/policy/wetlands.html>. This document recommends mitigation ratios of 2:1 for palustrine emergent wetland, 2:1 for non-wetland forest, 3:1 for palustrine scrub-shrub wetland, and 4:1 for palustrine forested wetland. These ratios can be adjusted for proximity of the replacement habitat to the disturbed habitat, cumulative effect of the activity, location of the disturbed habitat, and other concerns.

2. More Specific Project Performance Standards

Federal, state, and local regulatory have attached specific performance standards to mitigation and restoration permits on a case-by-case basis. See Box 3 below for examples of such standards compiled from a variety of sources.

One source was the Washington Department of Ecology. 2002. Washington State Wetlands Mitigation Evaluation Study. See http://www.ser.org/sernw/pdf/WDOE_wetland_mitigation_eval_stud_2.pdf. This study was conducted in two phases to evaluate the success of 24 projects intended to compensate (mitigate) for wetlands lost to development activities. Appendix B of this report (Performance Standards) is

particularly interesting because the report not only presents actual performance standards from a wide range of projects but assesses the standards and characterizes them as “significant” and “not significant”. The authors of this report found many standards “insignificant” because they could not be measured on the ground, were too ambiguous, were too rigorous, or did not relate to wetland functions. The authors concluded that projects which had developed some performance standards often lacked the full suite of basic performance standards such as:

- “Wetland area,
- Water regime – permanently ponded, seasonally inundated, seasonally saturated, or a combination of these,
- Area of Cowardin class(es),
- Percent cover (relative or cumulative) of native wetland vegetation species desired,
- Maximum percent cover (relative or cumulative) of invasive vegetation species tolerated.”

Another source was a 2002 Transportation Research Board Report, Guidelines for Selecting Compensatory Wetlands. See <http://darwin.nap.edu/books/0309074320/html/138.html>. In preparing this report Anne Marble and Exavier Riva surveyed 142 state departments of transportation, federal and state resource agencies, and private mitigation banking entities concerning guidelines for compensatory mitigation. Fifty-five surveys were returned. Although limited in number and not “on the ground” investigations, this study was interesting. One survey question was: What are typical federal, state, and local permit requirements for your mitigation site? Out of 55 total survey responses, 41 answered “site must be monitored”, 35 answered “area requirements”, 35 answered “plant survivorship”, 33 answered “hydrology must meet specific criteria”, 29 answered “time frame for complying with site criteria”, 26 answered “wetland functions must be achieved”, 24 answered “must be in the same watershed”, 22 answered “plant density requirement”, 18 answered “development of wetland class”, 16 answered “plant type and number set”, 15 answered “canopy coverage % predetermined, and 12 answered “development of hydric soil”.

Box 3
EXAMPLES OF “PERFORMANCE STANDARDS”
APPLIED IN MITIGATION EFFORTS

The following examples of performance standards applied in mitigation efforts are drawn from efforts throughout the Nation, not just the East or Northeast. They have been derived, in part, from Appendix B, Performance Standards, Washington Department of Ecology 2002 Washington State Wetland Mitigation Evaluation Study, Phase 2, See <http://www.ecy.wa.gov/programs/sea/mit-study/index.html>; Evaluating Success; and Board on Environmental Studies and Toxicology, 2001. Compensating for Wetland Losses Under the Clean Water Act, The National Academies Press, See <http://darwin.nap.edu/books/0309074320/html/138.html>. Appendix E, Examples of Performance Standards for Wetland Creation and Restoration in Section 404 Permits and an Approach to Developing Performance Standards; and A. Marble and E. Riva, 2002 Transportation Research Board Report, Guidelines for Selecting Compensatory Wetlands. See http://ttap.colostate.edu/Library/TRB/nchrp_rpt_482.pdf.

Restoration of a specified acreages of wetland. Forested wetland restoration projects often contain a mosaic of types of wetlands including open water, marsh, scrub/shrub, and forested wetland. The area or areas required for each type may be based upon overall compensation ratios required in regulations **or** upon case-by-case analysis by regulators. Typically regulators require large mitigation ratios for forested wetlands.

Restored area must be “wetland” meeting federal Corps, state wetland definition, or other regulatory criteria. The restored area must meet the definition of wetland used in the regulatory program in terms of hydrology, soils, and wetland plants. Section 404 permits typically require compliance with the Corps 1987 Wetland Delineation Manual.

Restoration of particular type or types of wetlands (e.g., red maple, depressional swamp). The Cowardin et. al, HGM or another classification or descriptive system may be used.

Maximum % slope. Steep slopes often lead to erosion and sedimentation.

Required grading and creation of microtopography for specified portions of the restoration area at particular, defined elevations consistent with habitat requirements of target plant and animal species.

Attainment of specified depths of surface water or ground water saturation for specific periods (e.g. 30 days) during the growing season.

The planting of specified areas with specified densities of target plant species including, in some instances, canopy, subcanopy, understory species.

Attainment of % survival of plantings.

Attainment of total % of cover within a specified period of time such as one year, five years, ten years for designated canopy, subcanopy, and understory species.

Attainment of no more than % cover of invasives such as reed canary grass, purple loosestrife after specified time periods.

Design of wetland to achieve specified ratio of water edge to acreage ratio, other size and shape specifications.

Attainment of specified open water areas and construction of islands in open water related to particular, sizes and shapes.

Restoration of specific functions equal to or greater than the functions of wetlands proposed for damage or destruction.

Establishment of protected buffers of specified distances around the wetland.

Establishment of setbacks for tree-cutting and other activities in restored wetlands along streams, ponds, and other water bodies.

In creeks flowing through a forested wetland, attainment of temperature, dissolved oxygen, pH, conductivity, fecal coliform content and other water quality goals.

Documented use by amphibians, birds, reptiles, invertebrates determined by direct observation, observation of egg masses, other indicators.

Establishment of minimum levels of biodiversity (e.g., minimum number of specified types of plants/acre to be achieved by particular target dates).

3. Wetland Inventory, Functional Assessment, Site Design, and Construction

Federal and state regulatory agencies typically require quite detailed prior assessments and planning for larger restoration projects. These assessments and planning efforts are not performance standards, per se, but are designed to increase the likelihood that projects will achieve desired project goals.

Required elements may include:

- 1. The conduct of inventories for wetlands which are to be destroyed/damaged (in a mitigation context) and for the site or sites where proposed restoration is to occur in terms of acreage, topography, soils, plant species and other features.**
- 2. Functional assessment of both a wetland to be damaged or destroyed and proposed restoration/creation/enhancement wetland.** See, e.g., Bartoldus, 1999 for a description of 40 assessment techniques.

- 3. Evaluation of ecosystem/hydrologic system context including anticipated changes in hydrology due to urbanization and other land use changes (a desired component but rarely undertaken. See, e.g., Bedford, 1966.**
- 4. Definition of more specific project goals such as restoration of particular functions or creation of habitat for particular animal or plant species based on inventories and assessment.**
- 5. Preparation of a restoration plan with design specifications, restoration procedures, monitoring and mid-course correction requirements.**
- 6. Preparation of plans for project supervision and construction.**

Carefully inventories and planning by a project proponent is no guarantee that a restoration project will meet project goals over time, but such preparation will increase the likelihood of success.

The National Academies in 2001 (NAS, 2001) recommended:

The Corps of Engineers and other responsible regulatory authorities should establish and enforce clear compliance requirements for permittee-responsible compensation to assure that (1) projects are initiated no later than concurrent with permitted activity, (2) projects are implemented and constructed according to established design criteria and use an adaptive management approach specified in the permit, (3) the performance standards are specified in the permit and attained before permit compliance is achieved, and (4) the permittee provides a stewardship organization with an easement on, or title to, the compensatory wetland site and a cash contribution appropriate for the long-term monitoring, management and maintenance of the site.

The Academies further recommended that:

Dependence on subjective, best professional judgment in assessing wetland function should be replaced by science-based, rapid assessment procedures that incorporate at least the following characteristics: effectively assess goals of wetland mitigation projects; assess all recognized functions; incorporate effects of position in landscape; reliably indicate important wetland processes, or at least scientifically established structural surrogates of those processes; scale assessment results to results from reference sites; are sensitive to changes in performance over a dynamic range; are integrative over space and time; and generate parametric and dimensioned units, rather than nonparametric rank.

Several examples of desired “steps” for carrying out restoration projects are provided in Boxes 4 and 5. These are not specific to northern forested wetlands but would appear generally applicable to wetlands.

Box 4
Recommended
Steps in Planning Process

From: Interagency Workgroup on Wetland Regulation, Wetland Restoration, Creation, and Enhancement, NOAA et. al., Washington, D.C.
<http://www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf>

- 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 agencies about appropriate regulations. Talk to adjacent landowners and identify important social or economic factors that could affect the project.
- 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.

Box 5
Recommended Steps in Wetland Restoration

From Cole, A., T. Serfass, M. Brittingham, and R. Brooks. Managing Your Restored Wetland. Pennsylvania State University, College of Agricultural Sciences, Cooperative Extension. See <http://pubs.cas.psu.edu/FreePubs/pdfs/uh086.pdf>

- Contact a government natural resource agency (such as your county conservation district) or a private project manager and discuss your objectives.
- Survey the site.
- Design wetland according to your needs.
- Obtain the necessary permits.
- Begin to move earth.
- Prepare the soil substrate for water and plants.
- Allow wetland plants to become established over time.
- Monitor the site and conduct routine maintenance.

4. Adoption of Monitoring, Mid-Course Correction, and Management Requirements

Regulatory agencies typically require that project proponents prepare and implement monitoring and management plans. Such plans may include yearly monitoring and reporting for a number of years:

Vegetative Success

Regulators typically require that project proponents submit evidence that a specified area of particular species of wetland trees and other vegetation has been achieved by specified target dates. Percent survival and/or density of coverage are typically part of monitoring requirements. Vegetative area changes are most readily identified and monitored features of restored wetlands because these changes are (usually) highly visible and can, to some extent, be tracked through remote sensing. In the absence of more detailed information, acreage by type of wetland has been used as a surrogate for functions although many functions are only partially dependent upon vegetation.

Limitations upon making accurate area determinations include fluctuating water levels over time, lack of agreement concerning remote sensing or other vegetation indicators for the wetland and nonwetland boundary, and natural succession in vegetation.

Restoration of Wetland Processes (Functions)

In the last decade, federal and state wetland regulations have increasingly required that mitigation measures restore lost “functions”. For example, the proposed Corps and EPA proposed mitigation rule provides (332.3) that “The district engineer must determine the compensatory mitigation to be required in a DA permit, based on what is available, practical, and capable of compensating for the aquatic resource functions that will be lost as a result of the permitted activity.” Section (f) Further provides that “The district engineer must require an amount of compensatory mitigation for unavoidable impacts to aquatic resources sufficient to replace lost aquatic resource functions.” Section 332.w (Definitions) of the proposed rule defines “functions” as the “physical, chemical, and biological processes that occur in aquatic resources and other ecosystems.”

To assess performance in terms of replacement of lost wetland processes (functions) requires the ability to measure, both pre and post project, the functions of wetlands proposed for damage or destruction (in a typical permitting situation) and wetlands restored.

Unfortunately, there is only limited agreement what “functions” need to be assessed and how these functions are to be assessed. A broad range of assessment models have been developed over the last two decades such HGM, and IBI to measure specific functions or suites of functions. However, few of these models have been extensively tested for “on the ground” validity. And, the models typically do not take into account societal context.

The National Academies in 2001 recommended that:

Because a particular floristic assemblage might not provide all the functions lost, both restoration of community structure (e.g., plant cover and composition) and restoration of wetland functions should be considered in setting goals and assessing outcomes. Relationships between structure and function should be better known.

Restoration of Wetland “Values”

As described above, a 1989 MOU adopted by the Corps and EPA pertaining to mitigation requires no net loss of “functions” and “value”. Some state wetland regulations similarly require mitigation of values as well as functions. See Appendix A. 2. In recent years, the Corps has minimized the assessment of “values” because values are subject and there are no accurate measures for value. Nevertheless, Section 320.4(a)(1) of the Corps Section 404 regulations direct the Corps regulators to consider in their public interest review “economics”, “aesthetics”, “historic properties”, “fish and wildlife values”, “hazards”, “navigation”, “recreation”, “safety”, “energy needs”, “consideration of property owners” and other factors. These factors clearly require more than consideration of wetland natural processes (functions) alone and the term “function” is scientifically used.

A wetland may be important (of value) to society in terms of:

- Health and safety,
- Historical, cultural significance,
- Education, research, scientific significance,
- Aesthetic significance,
- Economic significance,
- Or, for other reasons.

Assessment of “value” also requires consideration of “location”. Restoration, enhancement, or creation of a function (natural process) at one location as mitigation will not necessarily compensate for destruction at another because it will affect different ecosystems or portions of ecosystems and groups of individuals. Different people will benefit and suffer costs. Location and social context are important. For example, assume that a landowner wishes to fill a wetland in a city with stormwater and flooding problems. He or she may propose to replace a comparable amount of flood storage by restoring a wetland ten miles from the city and even in the same watershed but this will do little good for the landowners in the city flooded by destruction of the wetland. Failure to consider social context and value will result in important loss of services although comparable natural processes are provided at the two sites.

Although values are difficult to quantitatively measure, a number of qualitative options are available to regulatory agencies to help assess values. See Appendix C.

PART 4: THE SUCCESS OF NORTHERN FORESTED WETLAND RESTORATION PROJECTS

An examination of literature and websites, and telephone calls to selected state and federal wetland managers and consultants in the Midwest and East revealed only a small number of forested wetland restoration projects although it is likely that more have been conducted and that “passive” restoration has occurred at many wetland sites where timber was harvested, partial drainage occurred, agricultural was conducted but abandoned, and the site reverted to forested wetland.

Scientific Literature

A number of recent books and articles describe northern forested wetlands in some detail including some specific efforts to restore these wetlands after timbering or other impacts. See general publications listed in Box 2. See, particularly, Trettin et al. (ed.), 1997, *Northern Forested Wetlands: Ecology and Management* and *Proceedings and American Society of Agricultural and Biological Engineers, 2006, Hydrology and Management of Forested Wetlands*. These publications are useful for anyone wishing to restore forested wetlands in establishing goals, assessing and restoring hydrology, planting, management and monitoring. However these books and articles are primarily descriptive rather than prescriptive and stop short of the detailed recommendations concerning hydrology or other requirements for restoration.

Frank Golet and Nicholas Miller of the University of Rhode Island concisely summarized the literature pertaining to restoration of northern forested swamps in a 2001 project report to the Rhode Island Department of Environmental Management, Office of Water Resources. See <http://www.dem.ri.gov/programs/benviron/water/wetlands/pdfs/strategy.pdf>. This summary appears to be equally valid in 2006. They wrote:

Forested Swamps

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

most critical factor in forested wetland restoration (Clewell and Lea 1990, Tiner 1995). McLeod et al. (2000) reported that slight differences in elevation, and therefore hydrology, can substantially influence the survival and health of trees planted in swamps. This sensitivity to hydrologic regimes is long-term (Kusler and Kentula 1990); even mature forest vegetation can be damaged by wide-ranging hydrologic conditions. In an attempt to create forested wetland in New Hampshire, Barry et al. (1996) contended with this hydrologic sensitivity of woody species by mimicking the mound and pool microtopography found in natural wetlands. The rationale was that mounds provide a wide variety of water regimes (see Golet et al. 1993) and therefore may increase the probability that planted trees can survive prolonged periods of excessive inundation; i.e., there is more room for error. However, this technique may only be appropriate for the creation of swamps on non-organic substrates. Barry et al. (1996) cited an attempt by Crispin and Randall (1990) to restore microrelief in former forested wetland of southeastern Massachusetts; the attempt was unsuccessful because heavy equipment became mired”.

Based upon this analysis and the analysis of other wetland types, Golet and Miller suggested the relative degree of difficulty in restoring various types of wetland systems. See figure below. It is to be noted that forested swamps, fens, and bogs are rated the lowest.

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

Wetland type and Rating

Ponds	High
Marshes	High
Wet meadows	Moderate
Streams	Moderate
Vernal pools	Moderate
Shrub swamps	Moderate
Forested swamps	Low/Moderate
Fens	Low
Bogs	Low

Biotic and Abiotic Indicators of Success

In April 2004 the Environmental Law Institute published a report: Measuring Mitigation, A Review of the Science for Compensatory Mitigation Performance Standards. See http://www.elistore.org/reports_detail.asp?ID=10991&topic=. This report, which is available on the Internet, extensively reviewed the scientific literature pertaining to various types of biotic and abiotic compensatory mitigation performance standards. See this report for an article-by-article review of the literature. Much of what was written appears to be useful and applicable to northern forested wetlands although the report addressed performance standards more generally. The report concludes:

The findings in the literature suggest that performance standards can be developed and implemented. As articles reviewed for this report indicate, each biological and abiotic metric offers its own set of strengths and weaknesses for use as indicators of wetland condition and functional performance. However, the strategic use of a combination of

metrics could accentuate the strengths of some while minimizing the weaknesses of others. Through a well-chosen collection of performance standard metrics, regulators may ultimately be able to measure the ecological viability of functions in created, restored, and enhanced wetlands to understand better whether the site is on its way to becoming a self-sustaining wetland to replace the one lost.

The report more specifically concluded with regard to the use of specific attributes or outcomes as “performance standards”:

Amphibians. The ELI report concluded that “(A)lthough some amphibian metrics may be good indicators of wetland health on a regional scale the use of amphibians as indicators of individual wetland health may be limited.” A chief concern of the report was that “populations fluctuate greatly among years”. The report further concluded that “Efforts to separate natural from human-induced causes impacting populations are confounded by many known and unknown factors. The report also concluded that “Many types of amphibian monitoring require substantial resources in terms of labor and equipment. Because wide population fluctuations are typical of amphibians, long-term sampling is required, well beyond the 3-5 years typically required by regulatory agencies in the United States....”

Fish. The ELI report concludes that “Scientists only recently have begun developing fish IBI (Indices of Biological Integrity) for wetlands, although research in this area shows promise.”

Invertebrates. The ELI report concluded that invertebrates “are considered useful as indicators by many wetland scientists.” However, the report also noted a variety of problems with use of invertebrates including the need for “staff trained in invertebrate taxonomy...and high laboratory costs.”

Birds. The ELI report concluded that “our understanding of the usefulness of birds as wetland indicators is in its infancy, birds appear to exhibit several characteristics that make them potentially useful as indicators of environmental change.” The report noted that birds “are relatively easy to survey, and no specialized keys or extensive lab work are required to identify species.” However, the report also noted that “Many bird species are migratory, which introduces the uncertainty of whether the status of a population is influenced by local habitat conditions or events occurring away from the study area.”

Algae. The report concluded that “Studies suggest that patterns in algal growth and development can be reliable indicators of specific environmental conditions.” However, the report also noted a variety of problems with the use of algae including “insufficient research”. It concluded that “On the balance, algae-based performance metrics—while theoretically very useful—seem difficult to construct and implement.”

Mammals. The report concluded: “(O)nly a limited number of mammals (e.g., water shrews) would be appropriate as a biological indicators of wetland performance. Mammals, however, may be useful as one component of a set of indicators used in performance monitoring.”

Vegetation. The report concluded that “The use of vegetation in monitoring wetland performance is perhaps the most widely recognized and ubiquitous metric currently in use. However, many researchers caution against the use of vegetation alone, and other studies suggest that vegetation metrics such as percent cover may be misleading for gauging wetland functional performance.”

Hydrology. The report concluded that: “Hydrology is widely regarded as the most important factor determining wetland structure, function, and persistence.” However, the report also concluded that “Although hydrology is the most basic and perhaps the most essential part of wetland function, further research is needed to improve the ability of mitigation sites to mimic the hydrology of the natural wetlands they replace. In addition, many authors point out the importance of increasing monitoring time frames in order to better assess wetland hydrologic developments.”

Soil, Sediment, Substrate, Nutrients. The report concluded that “Wetland performance standards based on soil, sediment, substrate, or nutrient...indicators may be among the most valid metrics...especially when used in conjunction with biotic metrics.” However, the report also concluded that “Soil metrics cannot indicate wetland performance success in the typical 5 to 10 year mitigation site monitoring period because wetland soil attributes do not converge with reference expectations except in the long run.”

Developmental Trajectories

Because of the long time period for growth of trees in forested wetlands and the development of organic wetland soils, regulatory agencies have been particularly interested in “trajectory” performance standards. The ELI report concluded that:

“A developmental trajectory for compensatory mitigation wetlands—that is, the pathway that a created or restored wetland takes as it ages—is an attractive concept for performance standards, because it holds the possibility of monitoring a site in the early stages and, from those early measurements, begin able to predict the likelihood of the site attaining functional equivalency with the wetland it replaced.

The literature based on developmental trajectories for wetlands is growing, and many studies on the topic are ongoing, but ranks of published studies are sparse because of the relative newness of the subject.”

Although broadly attached as conditions to wetland restoration projects by regulators (e.g., % cover by designated tree species after 5 years), the long-term validity of many trajectory performance standards in predicting restoration of the full range of wetland functions and values remains to be demonstrated.

Engineering Principles and Wetland Restoration

In reviewing the literature we found limited publications concerning the application of engineering principles and practices to restoration of forested wetlands. Several publications do address engineering approaches to wetland restoration more broadly. See, for example, WRP

Technical Note HS-EM-3.1, August 1993, Hydraulic Structures for Wetlands. This report described the use of dikes and water control structures. See <http://el.erdc.usace.army.mil/elpubs/pdf/hsem3-1.pdf>. See also, United States Department of Agriculture, Soil Conservation Service, Engineering Field Handbook, Chapter 13, Wetland Restoration, Enhancement, or Creation. See <http://64.233.187.104/search?q=cache:C4aLfHmHHg4J:www.info.usda.gov/CED/ftp/CED/EFH>. See also Hayes, D., T. Olin, & J. Craig Fishenich 2001. Wetlands Engineering Handbook, U.S. Army Corps of Engineers, Engineer Research and Development Center ERDC/EL TR-WRP-RE-21. This handbook sets forth a great deal of practical advice concerning wetland restoration, creation, and enhancement. See <http://darwin.nap.edu/books/0309074320/html/197.html>.

Studies of the “Success” of Mitigation Projects

A modest number of studies over the last two decades have attempted to determine the on the ground “success” of wetland mitigation (restoration, creation, enhancement) projects. Some address forested wetlands along with other types of wetlands. Examples include:

- Board on Environmental Studies and Toxicology, 2001. Compensating for Wetland Losses Under the Clean Water Act, The National Academies Press
See <http://darwin.nap.edu/books/0309074320/html/138.html>. The National Academy investigated mitigation requirements for the federal Section 404 program and compiled examples of performance standards. Appendix E, Examples of Performance Standards for Wetland Creation and Restoration in Section 404 Permits and an Approach to Developing Performance Standards. At least 6 of the 20 examples of performance standards summarized addressed forested wetlands. This study concluded that, overall, Section 404 wetland mitigation efforts were not meeting their intended goals. The report made a broad range of recommendations for addressing deficiencies.
- Cole, A. and D. Shafer (2002) Section 404 Wetland Mitigation and Permit Success Criteria in Pennsylvania, USA, 1986-1999. *Environmental Management* 30:508-515. This study of 23 mitigation projects in Pennsylvania found that only about 60% of the mitigation wetlands met their success criteria after more than 10 years. The study concluded that replacement of emergent, scrub-shrub, and forested wetlands with uplands or open ponds likely led to a net loss of forested wetlands.
- Brown, S. and P. Veneman. (undated). Effectiveness of Compensatory Wetland Mitigation in Massachusetts, USA. *Wetlands* Volume: 21, pages 508-518. See <http://www.sws.org/wetlands/abstracts/volume21n4/BROWN.html>. This study involved the analysis of 391 project files and 114 field sites. The majority of projects were not in compliance with Massachusetts wetland regulations including no attempt to build the project (21.9%), insufficient size or hydrology (29.8%), or insufficient cover of wetland plants (2.6%). The majority of constructed projects involved impacts to forested wetlands (71.1%). But most replication projects were designed to produce scrub/shrub wetlands.
- Perry, M., (1998) Evaluation of Forested Wetlands Constructed for Mitigation in Comparison to Natural Systems. See <http://www.pwrc.usgs.gov/resshow/perry/forwetlands.htm>. This study

reported the results of an intensive research project for six constructed forested wetlands in Central Maryland conducted in 1993 to 1996. These were “mitigation” wetlands constructed to compensate for highway construction and other activities. Areas ranged in size from 2 to 35 acres. Adjacent natural forested wetlands were used as reference sites. The authors concluded that it would take 35-50 years before the constructed wetlands would have forested wetland vegetation and wildlife similar to that found on mature forested wetlands. The long time period was related to high mortality and slow growth resulting from excessive water on the sites and predation by wildlife. Wood frogs and salamanders were uncommon or absent on the constructed sites.

- Natasha A Reed (undated) A Decade of Recovery in Three Wetland Ecosystems: Differences and Policy Implications. This study summarized several papers which examined the recovery over a 12-year period of three wetland sites in Northeastern Massachusetts heavily impacted by construction of a transmission line. These included a shrub-swamp bog, a wooded swamp and an open marsh, Assessment of recovery focused on plant recolonization. The author concluded that “There were significant differences in how each wetland type rebounded from the disturbance. The cattail marsh showed complete recovered after two years in both numbers and community composition values. The wooded swamp recovered more slowly, still showing signs of reduced numbers (but not of species richness, diversity or evenness) at five years but not ten. The bog was least resilient, with significant numbers of individuals reduced in cleared and managed areas still at five years. This discrepancy of the disturbed area persisted in the ten-year observation data.”
- Marble, A. & X. Riva. 2002. Guidelines for Selecting Compensatory Wetlands Mitigation Options. NCHRP Report 482. Federal Highway Administration, Transportation Research Board. 2002. See http://tmap.colostate.edu/Library/TRB/nchrp_rpt_482.pdf. This was not a before and after study but rather a survey of the opinions of 55 wetlands managers concerning the relative success of compensatory mitigation options. The study documented what wetland managers perceived as “working” and not “working”. The survey indicated that “emergent and open water wetlands were the most successfully mitigated in palustrine and estuarine systems; forested wetlands were the least successfully mitigated”. The authors concluded that “(F)orested wetlands require more precision in grading and more time to develop. Saplings may not be able to tolerate the fluctuations in hydrology tolerated by mature trees. Furthermore, forested wetlands may require 50 to 100 years to fully mature, which makes it difficult to know if any given site will be ultimately successful.”
- Deni, P. 2003. An Inventory of Ohio Wetland Compensatory Mitigation. http://www.epa.state.oh.us/dsw/wetlands/WetlandMitigationInventory_Nov2003.pdf. This report was based upon a study of mitigation wetlands in Ohio constructed from 1992 to 1999 under 401 water quality certifications. The study examined 76 projects (117 wetlands). Over 88% of all wetlands were constructed as emergent marshes. Only 66.3% of the required wetland replacement acreage was constructed. The author wrote that “Due to the lack of data on impacted wetlands, it is difficult (to) quantify the overall amount of forested wetland impacts for the projects included in this study. However, a review of the types of wetlands whose losses are being mitigated at three mitigation bank operating in central Ohio shows that 40-60% of all impacts are to forested wetlands...On the other hand, a more detailed survey of replacement

wetlands...indicates that amphibians associated with forested wetlands are extremely rare or completely absent from replacement wetlands. It is therefore of paramount importance that we clearly define criteria and work within existing regulations to assure the terrestrial habitat around wetlands is replicated, especially for impacts to forested wetlands.”

- Balzano, S., A. Ertman, L. Brancheau, & W. Smejkal. (2002) Creating Indicators of Wetland Status (Quantity and Quality), Freshwater Wetland Mitigation in New Jersey. This study conducted field evaluations for 90 freshwater mitigation sites (out of 171 approved freshwater wetland mitigation projects in the New Jersey DEP’s database at the time of study. Forested wetlands and emergent wetlands were the most common type of freshwater wetlands proposed account for 41% and 33% of the total proposed freshwater wetland area. The study revealed that only .45 acre of wetland was achieved for each acre of mitigation proposed. The study concluded that “On average, 92% of proposed emergent wetland acreage was achieved, while 1% of proposed forested wetland acreage was achieved. Open water acreage was achieved almost three times in excess of that proposed.
- Washington Department of Ecology. 2002. Washington State Wetlands Mitigation Evaluation Study. See http://www.ser.org/sernw/pdf/WDOE_wetland_mitigation_eval_stud_2.pdf. This study was conducted in two phases to evaluate the success of projects intended to compensate (mitigate) for wetlands lost to development activities. Twenty-four projects were examined in depth. The study concluded that “Although mitigation may be doing better than it was 10 years ago and better than some previous studies have shown, this study suggests that the state of Washington is still experiencing a net loss of wetland acreage and functions due to authorized wetland impacts.” Only 29 percent of projects were achieving all measures of success. Only 65 percent of total acreage of lost wetlands was replaced with new wetland area.
- Minkin, P. & R. Ladd (2003). Success of Corps-Required Wetland Mitigation in New England. U.S. Army Corps of Engineers, New England District. In this study, a stratified random selection of 60 mitigation sites in the New England District of the Corps were studied in depth to determine the success of mitigation projects. Of this total, only ten (17%) were considered to achieve adequate functional replacements. The authors concluded that: “While 177.69 acres of forested wetlands were impacted by the 60 study projects, only 24.74 acres of mitigation were proposed to be forested. Few forested wetlands were proposed as mitigation for a variety of reasons, including focus on only a few functions, fear of failure, difficulty to establish, and non-specific information on impacted functions to be replaced.” This finding was consistent with several earlier studies:

A New England District survey of 59 wetland mitigation sites in New England (Smigelski, 1996) found that, with largely subjective evaluation, only 46% were considered to be successful or somewhat successful. In particular, it was noted that there was extremely low success rate in creating or restoring forested wetlands. A subsequent New England District study (Gaudet, 1999) examined ten mitigation sites which were intended to be forested or scub-scrub wetlands. It was determined that of the ten sites examined, only six were successful or somewhat successful, though none of the sites were complete failures.

Minkin and Lad concluded that while 50% of the impacts were to forested wetlands, only 8% of the mitigation was forested wetland and only 5% of the field-confirmed wetland was forested wetland. Minkin and Lad concluded that “(D)evlopment and approval of compensatory mitigation should concentrate on identifying and replacing the functions proposed to be impacted. In order to truly replace lost functions, increased quality or quantity efforts should be considered, especially for forested habitat replacement. This is especially important for mitigating impacts to systems which entail large temporal losses in function, e.g., forested wetlands.”

Based upon these limited studies and conversations with regulatory agencies and consultants, several conclusions may be suggested:

- Few forested wetland restoration projects are being undertaken.
- The projects which have been undertaken have not been extensively monitored.
- No attempt is often being made to restore forested wetlands when forested wetlands are damaged or destroyed. Instead, mitigation wetlands constructed or restored are more likely to be ponds, marshes, or shrub/scrub wetlands.
- There is a relatively high failure rate for the projects which have been undertaken.
- It is too early to tell whether many projects will be successful.
- Regulatory agencies are requiring large mitigation ratios for restoration of forested wetlands.

Factors Contributing to the Success of Projects

Several studies evaluating the success of wetland restoration projects also evaluated the factors contributing to success of projects. These factors are summarized in Boxes 6-8. These factors, of course, apply broadly to mitigation and restoration and not simply to restoration forested wetlands in the Midwest and Northeast. Nevertheless, they appear to be generally applicable to restoration of forested wetlands as well.

Box 6 Putting It All Together

From: Interagency Workgroup on Wetland Regulation, Wetland Restoration, Creation, and Enhancement, NOAA et. al., Washington, D.C.

<http://www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf>

- Be patient.
- Talk to many people.
- Be flexible.
- Take your time.
- Plan well.
- Let reference sites be your guide.
- Use low impact implementation methods.
- Monitor and manage your site.
- Do your best to recover as much of the wetland system as possible.

Box 7

Ten Top Factors That Contributed to Success of Projects

From: Washington Department of Ecology 2002 Washington State Wetland Mitigation Evaluation Study, Phase 2: Evaluating Success

http://www.ser.org/sernw/pdf/WDOE_wetland_mitigation_eval_stud_2.pdf

- Adequate source of hydrology present.
- Same consultant involved from the very beginning of the project (from delineation of impacts to mitigation monitoring and maintenance).
- Good site selection.
- Oversight and follow-up by regulatory agencies.
- Mitigation designer on-site during construction.
- Good mitigation design.
- Natural revegetation (native seed source present) or native hydroseed mix used.
- Maintenance conducted on site.
- Irrigation was used for at least one growing season.
- Hydrologic monitoring was conducted prior to mitigation plan implementation.

Box 8

Top Ten Factors That Contributed to Lack of Success of Projects

From: Washington Department of Ecology 2002 Washington State Wetland Mitigation Evaluation Study, Phase 2: Evaluating Success

- No irrigation of planted material.
- Poor site location.
- Lack of maintenance (e.g., invasive species control) or a poor job of maintaining planted material (moved over).
- Poor design.
- Poor planning and lack of prior hydrologic monitoring.
- Lack of follow-up by applicant and regulatory agencies.
- Compacted soil or lack of soil amendments creating a poor substrate for plant growth.
- A buffer that was too small or unvegetated.
- Lack of consistence between project goals and mitigation plan (e.g, not enough planted material to provide the required shrub cover).
- Lack of experience by heavy equipment operators and/or planting crew.

Box 9

Reasons for Successful Project-specific Mitigation Sites

From A. Marble & E. Riva, 2002 Transportation Research Board Report, Guidelines for Selecting Compensatory Wetlands. Out of a total of 55 survey responses. See <http://darwin.nap.edu/books/0309074320/html/138.html>

- Appropriate hydrology for site requirements 41
- Good coordination among designer, agency, and contractor 29
- Appropriate site grading 29
- Plants placed at appropriate elevations and hydroperiods 22
- Planting techniques (quality of plants and time of planting) 18
- Good understanding of groundwater and surface water influx 17
- Good soil physical attributes (e.g., texture) 16
- Good understanding of local geology and geomorphology 9
- Well-designed physical structures (e.g., bulkheads, culverts) 9
- Top soil stored and placed with care 9 1
- Control of animal predation 2
- Good soil chemical attributes (e.g, pH, salinity) 2
- Good seed germination 0
- Control of litter and debris 0
- No plant disease 0
- Good nutrient fertilization program 0

Box 10

Problems With Establishing Project-Specific Mitigation Sites

From A. Marble & E. Riva, 2002 Transportation Research Board Report, Guidelines for Selecting Compensatory Wetlands. Out of a total of 55 survey responses. See <http://darwin.nap.edu/books/0309074320/html/138.html>

- Insufficient hydrology 28
- Poor site selection 22
- Invasive plants 21
- Contractor/designer lack necessary training/skills 18
- Poor soil (physical attributes) 15
- Poor coordination between designer and contractor 11
- Too wet 11
- Destruction by animals 11
- Contractor's inaccurate interpretation of plans 9
- Site grades too steep (erosion and gully development) 9
- Unusual climatological conditions 8
- Plants placed at incorrect elevations and hydroperiods 8
- Vandalism 7
- Poor soil (chemical attributes) 7
- Improper planting techniques 5

- Unsuccessful seed germination 5
- Problems with physical structures (e.g., bulkheads, culverts) 4
- Ice damage 1
- Litter and debris deposits 0
- Shading 0
- High salt content in soils (tidal only)

Evaluating Wetland Hydrologic and Ecological Context

Many wetland functions and values and the success of restoration projects often depend upon broader hydrologic and ecological context. For this reason the federal agency Mitigation Action Plan and recently proposed federal mitigation guidelines emphasize watershed approaches to restoration.

The National Academy in 2001 (NAS 2001) recommended:

Site selection for wetland conservation and mitigation should be conducted on a watershed scale in order to maintain wetland diversity, connectivity, and appropriate proportions of upland and wetland systems needed to enhance the long-term stability of the wetland and riparian systems. Regional watershed evaluation would greatly enhance the protection of wetlands and/or the creation of wetland corridors that mimic natural distributions of wetlands in the landscape.

However the National Academy in 2001 (NAS 2001) also concluded:

Even with a suitable position in the landscape, the ability to establish desired wetland functions will depend on the particular function, the restoration or creation approach used, and the degree of degradation at the compensation site. Landscape position, hydrological variability, species richness, biological dynamics, and hydrological regime all are important factors that affect wetland restoration and mitigation of loss. Some wetland types—in particular, fens and bogs—cannot be effectively restored with present knowledge. Mitigation efforts that do not include a proper assessment of such factors are unlikely to contribute to the goals of the Clean Water Act.

Many states in the Midwest and Northeast have initiated statewide wetland restoration strategies to help provide a larger context for restoration decision-making. Examples include:

Rhode Island. See Miller, N. and F. Golet. 2001. Development of a Freshwater Wetland Restoration Strategy, Site Identification and Prioritization Methods. Rhode Island Department of Environmental Management, Office of Water Resources. See <http://www.dem.ri.gov/programs/benviron/water/wetlands/pdfs/strategy.pdf>. See, particularly, Table A1 which summarizes state wetland restoration programs.

Ohio. See Ohio EPA. 1999. Ohio Wetland Restoration and Mitigation Strategy Blueprint. Ohio EPA. See <http://www.ohiodnr.com/wetlands/pdf/owrmsb.pdf>. The goal of this wetland restoration and mitigation strategy is “To develop a plan that identifies priority areas throughout

Ohio for the development of wetland mitigation and restoration projects and identifies high quality wetland areas statewide.”

Commonwealth of Pennsylvania, (undated) Department of Environmental Protection, Wetlands Net Gain Strategy. See www.dep.state.pa.us/dep/watermgt/wc/subject/.

North Carolina Wetlands Restoration Program. See <http://itre.ncsu.edu/cte/S6-rferrel.html>.

PART 5. LOOKING TO THE FUTURE

General Recommendations

What can be done to develop more specific performance guidelines for northern forested wetlands? Some recommendations include:

- **Build upon existing efforts.** Efforts to develop performance guidelines for northern forested wetlands should build upon broader federal, state, local and private experience in developing and applying performance standards more generally. These include the efforts to develop and apply general “no net loss” of “function”, “acreage”, and “value” standards, efforts to develop and apply more specific performance standards, the specification of assessment and planning requirements, and the specification of monitoring, mid-course correction, and management requirements.
- **Monitor.** Include monitoring, mid-course correction and management capabilities in projects. The best way to learn what works and does not work will be to monitor forested wetland restoration sites over time. Long term monitoring (e.g., 10-40 years) is needed to determine whether “trajectory” standards are accurate in predicting future “success” in meeting stated goals. Private landowners often object to long term monitoring. However, this problem may be addressed by placing forested wetland restoration projects in the hands of land trusts or other entities with long range management motivation and capability (e.g., state fish and wildlife agencies).
- **Undertake “demonstration” projects.** Project proponents may more be willing to undertake forested wetland restoration projects despite the problems and limitations outlined in Part 2 if the projects are conducted as “demonstration” projects with somewhat more lenient success criteria.
- **Recognize that somewhat different standards pertaining to hydrology, soils, and other features will be needed** for restoration, creation, and enhancement of different types of northern forested wetlands. One size will not fit all.
- **Define “no net loss”, “function”, “value” with greater specificity.** Efforts to develop performance standards for restoring “functions” and “values” must, first, involve more specific definition of the terms “no net loss”, “function” and “values”. Lack of definitions has led to great confusion in permitting and in the development and application of assessment methods and more specific performance standards.
- **Develop and test numeric performance standards for project design and post construction monitoring for specific types of northern, forested wetlands.** Such numeric standards may pertain to (at a minimum).
 - water depths and duration for specific types of northern forested wetlands including particular target plant and animal species

- minimum acceptable % cover by specified tree and under-story species at specified time intervals
 - maximum allowable % invasive species at specified time intervals
 - target soil depths and organic content
 - minimum frequency of occurrence of target animal species
 - minimum buffers for wetlands
 - minimum rivers, stream, lake setbacks for forestry and other activities within wetlands
 - standards for attainment of biodiversity goals
- **Develop and test assessment tools to be used for both sites proposed for wetland destruction and damage and proposed restoration/creation/enhancement sites.** Functional assessment methods such as HGM and IBI models should be tested for accuracy and practicality. For example, does a wetland which is characterized by a model as having high salamander habitat potential actually serve as salamander habitat?
- **Identify and provide benchmark studies for reference wetlands.** Identify forested reference wetlands regionally or statewide and undertake benchmark studies of these wetlands to help guide restoration efforts to end point conditions similar to those for natural wetlands wherever this is practical. Robert Brooks at Penn State has identified such a suite of reference wetlands (not confined to forested) in Pennsylvania and studies are underway for many of these wetlands. However, where the hydrology of a restored wetland is substantially different from natural conditions, altered “reference” wetlands may need to be used to guide restoration efforts.
- **Establish regional analysis and planning procedures.** States and federal agencies could establish regional analysis and planning procedures (e.g., watershed planning, ecosystem analyses) to help determine the desirability from ecosystem and social value perspectives of onsite and in-kind versus offsite and out of kind mitigation and restoration. North Carolina and Rhode Island have established such procedures. Such procedures could be used to help define project-specific goals and performance standards.
- **Identify priority forested wetland restoration, creation, and identification sites.** Priority forested wetland restoration sites should be identified on a regional or statewide basis. Priority sites may include cleared wetlands with intact hydrology and soils or partially drained wetlands where hydrology may be restored. Size, land ownership, connectivity to other wetlands and waters, sources of seed stock, reference wetlands and other factors may be relevant to identification of priority restoration sites. These sites could be utilized for mitigation efforts and for various research and demonstration projects.
- **Establish forested wetland mitigation banks.** Mitigation banks can provide research and demonstration sites for the development and testing of performance standards. In some instances, creation of forested wetland restoration mitigation banks may be an ecologically sound in comparison with restoration or creation onsite of many small forested wetland restoration projects. See Marble, A. et. al. Mitigation banks may allow the selection of mitigation sites with intact hydrology. They may permit more expertise in design and construction. They may provide long term monitoring and management capability. They may facilitate the analysis of alternative restoration procedures. Nevertheless, such banks may also shift the benefits of restoration to

rural areas where banks are typically located while retaining the ecological and societal burdens of wetland destruction in urban areas. This also needs to be investigated. Some combination is also needed of onsite mitigation for potentially nuisance impacts such as flooding and erosion with offsite mitigation for habitat values.

- **Report findings on the web.** It is important that any information pertaining to the success and failure of particular restoration practices and projects including the development of performance standards be broadly shared through presentations at national workshops, publication of papers in journals, and posting of information to the Internet.

Research Needs

Some priority northern forested wetland research topics for federal, states, local agencies, and academic institutions include the following (note, there is some overlap with recommendations above):

- **Regulatory and land management agencies at all levels should establish a national forested wetland restoration data base.** The U.S. Forest Service might best take the lead in such an effort.
- **Develop improved criteria for determining the “success” of forested wetland restoration sites taking into account fluctuating water levels, natural variability, impediments to monitoring fauna such as salamanders, losses from natural hazards, and other factors.**
- **Developed standardized monitoring methods and procedures for created, restored, and enhanced forested wetlands with flexibility to take into account variations in types of wetlands and contexts.**
- **Test “trajectory” performance standards and other performance standards of the sort listed in Box 3.** For example, does % cover at five years accurately predict desired forest growth at twenty years?
- **Document the hydrologic regimes of various forested wetland types.**
- **Investigate the requirements and tolerances of various flora and fauna in terms of hydrology (minimum/maximum water levels and stage duration), water quality, sediment regimes, soil (ph. organic content, nutrients), temperature, and other processes and characteristics.**
- **Develop design criteria for particular types of forested wetlands such as species composition, size and density of plants/trees to be planted, water depths and duration, soils, landscape character**
- **Investigate how mitigation ratios are being determined. Suggest improvements.**

- **Document the factors affecting the success of “desirable” versus nuisance vegetation.**
- **Document the use of reference sites in project design and monitoring; prepare guidelines for selection and use of sites**
- **Investigate the use of “nurse” plant species.**
- **Investigate macroinvertebrate and other fauna community establishment rates.**
- **Develop techniques and criteria for identifying priority northern forested wetland restoration sites (e.g. GIS).**
- **Investigate the compatibility of forested wetland tree harvesting and accomplishment of restoration project goals.**
- **Investigate desirable ratios of upland buffers and forested wetland.**
- **Improve methods to assess the risk of project failure and how damage to projects from hurricanes, storms, predation, and other causes are to be treated.**
- **Develop exotic/nuisance plant species eradication methodologies.**
- **Investigate in greater depth the role of fire in long term management/maintenance of northern forested wetlands.**
- **Further develop and test methods for evaluation of wetland “function” and “values”. If HGM. IBI models are to be used to evaluate functions, they need to be tested for accuracy and practicality.**
- **Further investigate the potential impacts of climate change on forested wetland restoration projects and how such impacts might be minimized.**
- **Investigate the long term success of mitigation banks in restoring forested wetland functions and values including the extent to which mitigation banks shift costs and benefits.**
- **Investigate the impacts of various types of management practices such as timbering practices on wetland functions and values.**



**Forested Wetland Restoration. Restoration of 200 acres of southern Swamp
by Ducks Unlimited**
southern.ducks.org/PantherSwamp.php

APPENDIX A: SUGGESTED LITERATURE AND WEB SITES

(Note, most but not all have been cited in the text.)

Suggested Literature

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Environmental Law Institute (ELI), 2004. Measuring Mitigation, A Review of the Science for Compensatory Mitigation Performance Standards. See http://www.elistore.org/reports_detail.asp?ID=10991&topic=

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Hayes, D., T. Olin, & J. Craig Fishenich. 2001. Wetlands Engineering Handbook, US Army Corps of Engineers, Engineer Research and Development Center ERDC/EL TR-WRP-RE-21. See <http://darwin.nap.edu/books/0309074320/html/197.html>.

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United States Department of Agriculture, Soil Conservation Service, Engineering Field Handbook, Chapter 13, Wetland Restoration, Enhancement, or Creation. See <http://64.233.187.104/search?q=cache:C4aLfHmHHg4J:www.info.usda.gov/CED/ftp/CED/EFH>

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Suggested Websites

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

NOAA Coastal Services Center. The Landscape Characterization and Restoration Program

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

<http://www.nal.usda.gov/wqic/Bibliographies/conwet2.html>
Constructed Wetlands and Water Quality Improvement (II)

http://www.nmfs.noaa.gov/habitat/habitatprotection/pdf/Wet%20Res%20Guidance_FINAL.pdf
Interagency Workgroup on Wetland Restoration. 2003. An Introduction and User's Guide to Wetland Restoration, Creation, and Enhancement. National Oceanic and Atmospheric Administration. Washington, D.C.

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

http://www.vims.edu/ccrm/cci/adv_id/funcassess.pdf
Virginia Institute of Marine Sciences identification of potential restoration sites to serve specific functions.

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

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

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

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

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

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

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

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

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

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

<http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/wwec/general/wetlands/WetRepla ceFd-2000.htm>;

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

Description of state wetland restoration projects in Pennsylvania with many before and after pictures. Examination of 69 mitigation sites.

<http://www.suscon.org/pir/watersheds/elkhorn.asp>

Case study restoration examples from Sustainable Conservation (a not for profit organization).

<http://www.nrcs.usda.gov/programs/wrp/states/success.html>

NRCS Wetland Reserve Program Success Stories (17 quite detailed profiles)

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

Description of 17 salt marsh cooperative restoration sites in New Hampshire.

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

Quite detailed description of Florida restoration case studies.

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

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

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

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

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

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

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

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

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

USDA Natural Resources Conservation Service. Hydric soils list.

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

USDA Natural Resources Conservation Service, National Plant Database

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

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

www.npwrc.usgs.gov/resource/literatr/wetresto/wetresto.htm

Bibliography of Wetland Restoration

www.glhabitat.org/mwac/chapter6.html

Citizen involvement in wetland restoration...good guidebook

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

www.srs.fs.usda.gov/pubs/viewpub.jsp?index+482

Ecosystem Restoration: Fact or Fancy

www.pwrc.usgs.gov/WLI/wetres.htm

Department of Agriculture: National Resource Conservation Service: Wetland Science Institute–
Wetland Restoration

www.usda.gov/stream_restoration/

Department of Agriculture: Stream Corridor Restoration Principles, Practices and Processes

www.fb-net.org/wrp.htm

Department of Agriculture Wetlands Reserve Program

www.epa.gov/owow/wetlands/restore/links/

EPA Division of Wetlands Web Site – Wetland Restoration Links

www.epa.gov/owow/wetlands/restore/5star/index.html E

PA Five Star Program

www.epa.gov/owow/wetlands/restore/

EPA River Corridor and Wetland Restoration

www.geocities.com/oxfordcomma/everglades/

Everglades Restoration

www.evergladesplan.org

Everglades Comprehensive Restoration Plan

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

Kissimmee River Restoration

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

Louisiana Coastal Wetlands Restoration Plan

www.bae.ncsu.edu/programs/extension/wqg/sri/proceedings.htm

North Carolina Stream Restoration and Protection: Building on Success

swamp.ag.ohio-state.edu/ORW.html

Olentangy River Wetland Research Park

<http://partners.fws.gov/>

Partners for Fish and Wildlife; U.S. Fish and Wildlife Service

www.ramsar.org/strp_rest_links.htm

Ramsar Convention's Resources on Wetland Restoration Links

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

Regional Conservation Projects - Gulf of Mexico Projects

www.ce.utexas.edu/prof/maidment/grad/dugger/GLADES/glades.html

South Florida Everglades Restoration Project

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

Successful Mitigation

www.vims.edu/welcome/tour/tmarsh/index.html

VIMS Teaching Marsh

http://www.dsirealestate.com/company_info/wetland.html

Wetland Banking: A Developer's Point of View

www.bwsr.state.mn.us/programs/major/wca/5/factsheet.html

Wetland Banking Procedures: Minnesota Board of Water and Soil Resources

www.infomine.com/technology/enviromine/wetlands/welcome.htm

Wetlands for Treatment of Mine Drainage

Use of GIS to Target Restoration

<http://www.lcd.state.or.us/coast/demis/docs/fuss/fussrpt.htm>

MS Thesis concerning the use of GIS for identifying wetland restoration sites for estuary-wide restoration planning in Oregon.

<http://www.nysgis.state.ny.us/datcoord/partners/wetrest.htm>

Use of GIS for tidal restoration planning in Long Island, N.Y.

<http://gis.esri.com/library/userconf/proc02/pap0994/p0994.htm>

Use of GIS system by the North Carolina DOT to identify restoration sites.

<http://www.conservationgis.org/ctsp/iowanhf/inhf.html>

Use of GIS system to prioritize wetland restoration sites in Iowa Great Lakes Watershed

<http://www.epa.state.oh.us/dsw/gis/cuyahoga/demo.html>

Use of GIS to identify wetland restoration sites in the Cuyahoga Watershed Demonstration Project.

http://www.estuaries.org/objects/docs/W8B_2.PDF

Use of GIS in the Chesapeake Watershed by Ducks Unlimited to target conservation priorities.

http://www.vims.edu/ccrm/cci/adv_id/advid.pdf

GIS based protocols for selecting wetland restoration sites in Virginia.

<http://www.bwsr.state.mn.us/wetlands/publications/PotentiallyRestorableWetlands.pdf>

Use of GIS to identify restoration sites for drained wetlands in Minnesota.

<http://www.state.ri.us/dem/programs/benviron/water/wetlands/wetplan.htm>

Use of GIS to identify and evaluate potential wetland restoration sites in Rhode Island.

<http://www.dnr.state.md.us/greenways/gi/restoration/restoration.html>

Restoration targeting in Maryland's Green Infrastructure Program using GIS.

<http://maphost.dfg.ca.gov/wetlands/document/wetrip.htm>

GIS based wetland and riparian maps for the California Central Valley

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

Use of GIS to store information concerning wetland restoration sites in Florida.

http://grunwald.ifas.ufl.edu/Publications/abstract_poster_EPH2003.pdf

Use of a wetland GIS system to characterize wetlands in Florida, track restoration.

<http://nespal.cpes.peachnet.edu/Water/Sediment.Reduction.Conceptual.Model.pdf>

Use of GIS to prioritize wetland restoration for sediment yield reduction.

**APPENDIX B:
“NO NET LOSS” STANDARDS IN FEDERAL AND STATE STATUTES,
REGULATIONS, POLICIES**

FEDERAL

EPA and Department of Army

Memorandum of Agreement Concerning the Determination of Mitigation Under the Clean Water Act Section 404(b)(1) Guidelines, 54 FR 51319, December 14, 1989

“...will strive to achieve a goal of no overall net loss of values and functions.”

“...no net loss of functions and values...”

“In most cases a minimum of 1 to 1 acreage replacement of wetlands will be required to achieve no net loss of values. However, this ratio may be greater where the functional values of the area being impacted are demonstrably high. Conversely, the ration may be less than 1 for 1 for areas where the functional values associated with the area being impacted are demonstrably low and the likelihood of success associated with the mitigation proposal is high.”

National Wetlands Mitigation Action Plan, December 24, 2002

“Commitment of the goal of no net loss of the Nation’s wetlands....begin increasing overall functions and values”

“...help insure effective restoration and protection of the functions and values of our Nation’s wetlands....”

Regulatory Guidance Letter, No. 02-2, December 24, 2002. U.S. Army Corps of Engineers, Compensatory Mitigation Projects for Resource Impacts: Section 404 and Section 10 Programs

“no overall net loss”

“replace functional losses to aquatic resources”

“functional assessment methods”

“functional scores”

“functional replacement”

STATE

Alaska. Alaska Admin. Code 60.315 (2003), Title 18. Solid Waste Management. “...steps have been taken to achieve no net loss of wetlands, as defined by acreage and function...”

Arizona. Regulation of Solid Waste. A.R.S. 49-772 (2003). “no net loss of wetlands defined in acreage and functions....”

California. CCR 3912, Title 23 (2003). Regional Water Quality Control Boards. San Francisco Bay Region. “...by adding policy of no-net-loss of wetland acreage and no-net-loss of wetland value within the Region...”

California. Cal. Fish and Game Code 1780 (2003). Sacramento-San Joaquin Valley Wetlands Mitigation Bank Act of 1993. “The purpose of this chapter is to ensure that no net loss of wetland acreage or habitat values...”

Delaware. CDR 70-500-001 (2003) Marina Regulations. “Compensation plans must provide for the creation or restoration of an area of wetlands that is of equal or greater value than the area that will be compensated or destroyed so that there is no net loss of wetlands.”

Hawaii. WCHR 11-58.1 WCHR 11-58.1, Title 11 (2003). Department of Health, Solid Waste Management Control “...taken to achieve no net loss of wetlands” (as defined by acreage and function)

Kansas. K.R.R. 28-29-102 (2003). Solid Waste Management Plans. “...steps have been taken to attempt to achieve no net loss of wetlands, as defined by acreage and function....”

Louisiana. LAC 33:VII.709, Title 33. Solid Waste Standards. “...taken to attempt to achieve no net loss of wetlands (as defined by acreage and functions....)”

Maine. CMR 06-096-310 (2003), Wetland Protection Rules. “...the Board of Environmental Protection supports the nation-wide goal of no net loss of wetland functions and values....” “...mitigation necessary to achieve no net loss of wetland functions and values through...” “...goal of compensation is to achieve no net loss of wetland functions and values....”

Massachusetts. 779 MAREG 29 (Issue date, 1995), Executive Office of Transportation and Construction, “Adhere to the policy of “no net loss of wetlands” due to transportation projects....”

Minnesota. Minn. Stat. 103G.2243 (2003), Water. Waters of the State. Local comprehensive wetland protection and management plans. “Provided there is no net loss of wetland values....”

Minnesota. Minn. R. 8420.0650. Wetland Conservation. Local Comprehensive Wetland Protection and Management Plans “...must result in no net loss of wetland quantity, quality, and biological diversity....”

Missouri. 10 CSR 80-3.010 (2003), Title 10. Sanitary Landfill.” “...Steps have been taken to attempt to achieve no net loss of wetlands (as defined by acreage and function...)”

Nevada. NAC 444.679 NAC. Solid Waste Disposal “...actions have been taken to achieve no net loss of wetlands as defined by acreage and function”

North Carolina. 15N.C.A.C. 13B.1622 Solid Waste Management. “...steps have been taken to attempt to achieve no net loss of wetlands (as defined by acreage and function...)”

Oregon. Or. Admin. R. 141-120-0030. Division of State Lands. Wetland Conservation Plan Wetland Resource Designations and Analysis of Alternatives. ““Functions and Values” means no net loss of wetlands functions or values.”

Ohio. 2003 OH Reg. 8110009 (2003). Sanitary Landfill Facility Permit to Install. "...steps have been taken to attempt to achieve no net loss of wetlands (as defined by acreage and function...."

Rhode Island. CRIR 04-000-017 (2003). Rules and Regulations Governing the Protection and Management of Freshwater Wetlands in the Vicinity of the Coast. "The Council supports a goal of no net loss of wetland area or functions and values of freshwater wetlands in the vicinity of the coast."

Rhode Island. CRIR 12-030-022 (2003). Solid Waste Regulation. "...steps have been taken to achieve no net loss of wetlands (as defined by acreage and function)...."

South Carolina. S.C. Code Regs. 61-107.13 (2003). Solid Waste Management. "...steps have been taken to attempt to achieve no net loss of wetlands (as defined by acreage and function."

Tennessee. Tenn. Comp. R. & Regs. R. 1200-1-7-.04 (2003). Solid Waste Processing and Disposal. "demonstrate that ecological resources in the wetland are sufficiently protected." "...steps have been taken to attempt to achieve no net loss of wetlands (as defined by acreage and function)...."

Texas. 30 TAC 297.53 (2003). Issuance and Conditions of Water Rights. "The goal of the mitigation of wetlands is to achieve "no net loss" of wetland functions and values. In addition to aquatic and wildlife habitat, wetland functions also include, but are not limited to, water quality protection through sediment catchment and filtration, storage plans for flood control...."

Texas. 21 TEXREG 10383 (TAC 352.10-352.32) Industrial Solid Waste. "...steps have been taken to attempt to achieve no net loss of wetlands (as defined by acreage and function)...."

Utah. U.A.C. R315-302-1 (2003). Solid Waste Facility Location Standards. "...steps have been taken to attempt to achieve no net loss of wetlands, as defined by acreage and function...."

Vermont. CVR 12-004-056 (2003). Vermont Wetland Rules. "It is the policy of the State of Vermont to identify and protect significant wetlands and the values and functions they serve in such a manner that the goal of no net loss of such wetlands and their functions is achieved."

Virginia. Va. Code Ann. 62.1-44.15.5 (2003). State Water Control Law. "...dedicated to achieving no net loss of wetland acreage and functions."

Virginia. 9 VAC 20-80-260 (2003). Solid Waste Disposal Facility Standards. "...steps have been taken to attempt to achieve no net loss of wetlands (as defined by acreage and function)...."

Virginia. 9 VAC 20-80-270 (2003). Virginia Water Protection Permit Program Regulation. "In order for contribution to an in-lieu fee fund to be an acceptable form of compensatory mitigation, the fund must be approved for use by the board and must be dedicated to the achievement of no net loss of wetland or stream acreage and function through the preservation, restoration and creation of wetlands and streams."

Washington. WAC 173-26-220 (2003) State Master Program Approval/Amendment Procedures and Shoreline Master Program Guidelines. “Use regulations shall address the following uses to achieve, at a minimum, no net loss of wetland area and functions, including the lost time when the wetland does not perform the function:”....”Master program provisions addressing alterations to wetlands shall be consistent with the policy of no net loss of wetland area and functions, wetland rating, scientific and technical information, and the mitigation priority sequence defined in”

Washington. WAC 173-351-130 (2003). Criteria for Municipal Solid Waste Landfills. “...steps have been taken to attempt to achieve no net loss of wetlands (as defined by acreage and function) by: “

Washington. WAC 222-24-015 (2003). Forest Practices Board, Road Construction and Maintenance.

”In order to assure that there is no net loss of wetland function....”

Wyoming. WCWR 020-120-002 (2003). Sanitary Landfill Regulations. “There will be no net loss of wetlands, considering any mitigation steps taken by the owner;”

APPENDIX C: AN EXAMPLE OF STATE PERFORMANCE STANDARDS FOR WETLAND MITIGATION

State of Michigan. See <http://www.deq.state.mi.us/documents/deq-glm-water-wetlands-perfstandfactsheets.pdf>.

“The administrative rules for Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, require that performance standards be established for all wetland mitigation projects. These are the criteria by which the mitigation wetland will be evaluated to determine if the wetland mitigation requirements of the permit have been met. If the mitigation wetland does not satisfactorily meet these standards by the end of the monitoring period, or is not satisfactorily progressing during the monitoring period, the permittee will be required to take corrective actions. The following are considered standard performance standards for wetland mitigation projects:

1. Construction has been completed in accordance with the Geological and Land Management Division approved plans and specifications referenced in the permit.
2. The mitigation wetland is characterized by the presence of water at a frequency and duration sufficient to support a predominance of wetland vegetation and the wetland types specified in the mitigation plan at the end of the monitoring period.
3. A layer of high-quality soil, from the A horizon of an organic or loamy surface texture soil, is placed over the entire created wetland area at a minimum thickness of 6 inches.
4. The mitigation wetland shall be free of oil, grease, debris, and all other contaminants.
5. A minimum of 6 habitat structures, consisting of at least 3 types, have been placed per acre of mitigation wetland. At least 50 percent of each structure shall extend above the normal water level. The types of acceptable wildlife habitat structures are as follows:
 - a. Tree stumps laid horizontally within the wetland area. Acceptable stumps shall be a minimum of 6 feet long (log and root ball combined) and 12 inches in diameter.
 - b. Logs laid horizontally within the wetland area. Acceptable logs shall be a minimum of 10 feet long and 6 inches in diameter.
 - c. Whole trees laid horizontally within the wetland area. Acceptable whole trees shall have all of their fine structure left intact (i.e., not trimmed down to major branches for installation) and be a minimum of 20 feet long (tree and root ball) and a minimum of 12 inches in diameter at breast height (DBH).
 - d. Snags which include whole trees left standing that are dead or dying, or live trees that will be flooded and die, or whole trees installed upright into the wetland. A variety of tree species should be used for the creation of snag habitat. Acceptable snags shall be a minimum of

20 feet tall (above the ground surface) and a minimum of 12 inches DBH. Snags should be grouped together so as to provide mutual functional support as nesting, feeding, and perching sites.

e. Sand mounds at least 18 inches in depth and placed so that they are surrounded by a minimum of 30 feet of water measuring at least 18 inches in depth. The sand mound shall have at least a 200 square foot area that is 18 inches above the projected high water level and oriented to receive maximum amounts of sunlight.

6. Mean percent cover of native wetland species in the herbaceous layer at the end of the monitoring period is not less than:

- 80 percent for forested wetland.
- 80 percent for scrub-shrub wetland.
- 60 percent for emergent wetland.
- 80 percent for wet meadow wetland.

Extensive open water and submergent vegetation areas having no emergent and/or floating vegetation shall not exceed 20 percent of the mitigation wetland area. Extensive areas of bare soil shall not exceed 5 percent of the mitigation wetland area. For the purposes of these performance standards, extensive refers to areas greater than 0.01 acre in size.

The total percent cover of wetland species in each plot shall be averaged for plots taken in the same wetland type to obtain a mean percent cover value for each wetland type. Plots within identified extensive open water and submergent areas, bare soil areas, and areas without a predominance of wetland vegetation shall not be included in this average. Wetland species refers to species listed as Facultative and wetter (FAC, FAC+, FACW-, FACW, FACW+, OBL) on the U.S. Fish and Wildlife Service's "National List of Plant Species That Occur in Wetlands" for Region 3.

7. The mitigation wetland supports a predominance of wetland vegetation (as defined in the "MDEQ Wetland Identification Manual") in each vegetative layer, represented by a minimum number of native wetland species, at the end of the monitoring period. The minimum number of native wetland species per wetland type shall not be less than:

- 15 species within the forested wetland.
- 15 species within the scrub-shrub wetland.
- 15 species within the emergent wetland.
- 20 species within the wet meadow wetland.

The total number of native wetland plant species shall be determined by a sum of all species identified in sample plots of the same wetland type.

8. At the end of the monitoring period, the mitigation wetland supports a minimum of:

- 300 individual surviving, established, and free-to-grow trees per acre in the forested

wetland that are classified as native wetland species and consisting of at least three different plant species.

300 individual surviving, established, and free-to-grow shrubs per acre in the scrub-shrub wetland that are classified as native wetland species and consisting of at least four different plant species.

8 native wetland species of grasses, sedges, or rushes in the wet meadow wetland.

9. The mean percent cover of invasive species including, but not limited to, *Phragmites australis* (Common Reed), *Lythrum salicaria* (Purple Loosestrife), and *Phalaris arundinacea* (Reed Canary Grass) shall in combination be limited to no more than 10 percent within each wetland type. Invasive species shall not dominate the vegetation in any extensive area of the mitigation wetland.

If the mean percent cover of invasive species is more than 10 percent within any wetland type or if there are extensive areas of the mitigation wetland in which an invasive species is one of the dominant plant species, the permittee shall submit an evaluation of the problem to the MDEQ. If the permittee determines that it is infeasible to reduce the cover of invasive species to meet the above performance standard, the permittee must submit an assessment of the problem, a control plan, and the projected percent cover that can be achieved for review by the MDEQ. Based on this information, the MDEQ may approve an alternative invasive species standard. Any alternative invasive species standard must be approved in writing by the MDEQ.

Additional performance standards specific to the goals and objectives of the mitigation may be required.”

APPENDIX D: ASSESSING VALUES

It is sometimes argued that “value” including social context should not be considered in permitting and mitigation. It is difficult to quantitatively measure value but that does not mean that values should not be evaluated at all. Wetland managers have available a variety of qualitative techniques available to evaluate social context and social services. These qualitative techniques can be incorporated into watershed planning, comprehensive planning, or case-by-case permit reviews.

In some instances it is possible to directly measure social services provided by a wetland or complex of wetlands. For example, it is possible to quantitatively determine the flood conveyance and flood storage of a specific wetland for a particular frequency of flood (e.g. 100-year) using hydraulic and hydrologic models. It is possible to link this to anticipated flood damage to existing and reasonably anticipated structures in a floodplain. Such studies can be conducted by a regulatory agency or by a developer or other landowner proposing to destroy a wetland although they may be time consuming and expensive.

In other instances, a wetland manager can **qualitatively** analyze social significance by answering the following sorts of questions:

- **Who will be affected by a change in a wetland including proposed mitigation?** This can help determine whether a wetland impact and any proposed or required mitigation may be of statewide or national significance. It can also help identify the legal rights involved, such as private landowner riparian rights or public trust rights. The question is relevant to social equity and social justice as well as the broad “public interest”.
- **How many people will be impacted?** An overview evaluation of the number of individuals that may suffer impacts from a proposed activity including any mitigation measures is also relevant to the public interest. For example, a wetland that helps protect the New York City water supply may benefit more than eight million people, while many fewer people may benefit from protection of another wetland.
- **In what ways will people be impacted?** For example, protection of a wetland that stores flood waters, thereby reducing downstream flash flooding, may have important health and safety implications in a specific setting. Similarly, protection of a wetland that serves as a water supply reservoir may have important health and safety implications.

These questions cannot be answered definitively on the typical permit. But even a preliminary, qualitative analysis can be used to identify any “red flags” with regard to impacts of people.. If such a preliminary analysis raises any “red flags”, the regulatory agency may carry out more detailed fact-finding. It may

- Provide notices of proposed plans, permit applications, other actions to other regulatory agencies and the public; examine feedback. Providing notices is the most broadly used technique by wetland regulators to assess public opinion. Responses give the agency some idea of the types, numbers and seriousness of interests and concerns.

- Conduct hearings. Agencies also broadly use public hearings to gather information and gauge public opinion, particularly on controversial projects.
- Consult with local groups and organizations to determine priorities for protection and restoration. For example, the Lane County Regional Planning Agency undertook a wetland assessment process and prepared a detailed plan for West Eugene, Oregon. This process used a broad range of techniques, including one-on-one consultations, questionnaires and public workshops, to gain feedback from various groups and individuals concerning community wetlands. The plan was ultimately submitted to the electorate for approval and is now used as the basis for regulatory permitting.
- Undertake economic analyses for wetland functions and values at specific sites. Economic valuation is rare because it is time consuming and expensive. But, analyses have been used, particularly by agencies like the Corps in preparing cost/benefit ratios for proposed water projects including restoration projects.
- Pose the question of value or preferences to local elected officials, executive commissions. A wetland regulatory agency may submit a proposed plan, variance, wetland permit or other action to local governments, soil and water conservation boards, commissions or planning agencies for reaction and comment.

These measures will only provide a qualitative sense of social context. But a qualitative sense of social context is better than none in determining the “public interest”.