SUCCESS OF CORPS-REQUIRED WETLAND MITIGATION IN NEW ENGLAND

Paul Minkin
Ruth Ladd

U.S. Army Corps of Engineers
New England District
3 April 2003

NH Route 101-15, Good use of snags.

Executive Summary

The Corps Regulatory Program has long been concerned with the success and effectiveness of compensatory mitigation, but comprehensive studies of this effectiveness have generally not been conducted. In June 2001, the National Academy of Sciences' National Research Council (NRC) issued a report on the effectiveness of mitigation in the Corps of Engineers Regulatory Program. This report, *Compensating for Wetland Losses Under the Clean Water Act*, identified a variety of weaknesses in the mitigation aspects of the Corps' program. In response to this report and general needs of the Regulatory Program, HQUSACE issued Regulatory Guidance Letter (RGL) 01-1, dealing with mitigation, on 31 October 2001, and RGL 02-2, dealing with the same subject and rescinding RGL 01-1, on 24 December 2002.

Prior to release of the NRC report, the Environmental Resources Section of the Policy Analysis and Technical Support Branch in the Regulatory Division was tasked with developing a study to analyze the effectiveness of compensatory mitigation projects in New England. One focus of the regulatory program in the New England District is to have staff dedicated to mitigation review and monitoring, which has helped with both collection and consistency of data relating to mitigation. This organization has helped track mitigation and made this type of study possible.

This study was designed to determine the effectiveness of compensatory mitigation (creation and restoration) for permitted impacts in New England, and to provide a basis for making programmatic improvements as warranted. There are two principal ways of addressing the issue of mitigation success. The first measures success against the permit requirements: does the mitigation meet the standards stated in the permit? The second has generally proven to be more difficult to assess: does the mitigation compensate for the lost functions from the permitted activities? This study addressed both aspects of success.

The methodology proposed for this study underwent review by members of a New England mitigation technical committee, comprised of wetlands scientists from academia, federal, state, and local governments, and the private sector. Their comments and recommendations were incorporated into the study methods. In addition, there was a final review of this study report by the committee.

A stratified random selection of 60 mitigation sites was studied in depth in order to determine if the mitigation was successful in terms of meeting the permit objectives and if the level of function approximated that of a natural wetland of the type proposed for creation (or restoration). Mitigation sites for the study were chosen from each of the six New England states, but more sites were selected in states where there were more permitted wetlands impacts requiring compensatory mitigation. Sites also covered the range of time periods from those just recently constructed to those that were several years old. Mitigation comprised of preservation or enhancement was not included in this study. Each site was visited and a variety of data collected, including wetland delineations, functions assessments, site photographs, species diversity, and site problems.

An early finding of the study was that there were not always adequate records and data management, particularly for older projects, making it difficult, and in some cases impossible, to determine what the initial impacts had been, the types, functions and values of the impacted wetlands, and the proposed compensatory mitigation. Improvements in compensatory mitigation and fully replacing functions lost to authorized impacts are first dependent upon adequate and available information. All mitigation site locations must be properly mapped and identified. Information on quality, type, and functions and values of impacted resources must be thorough. Mitigation plans should be retained and tracking of all mitigation project information complete. Several improvements in data management are underway to address these deficiencies, both in data generated (e.g., latitude and longitude for all new sites) and management of that data.

Forty of the mitigation projects (67%) were determined to meet permit conditions and would be considered successful by that standard. However, only ten (17%) were considered to be adequate functional replacements for the impacted wetlands. Information on permit conditions was missing for seven projects

(12%) and information on functions and values or types of impacted wetlands was missing for six projects (10%), making it impossible to determine success for those projects. Even where a specific function may have been replaced, it was often at a different or lower level than had been lost. Some of the reasons for this low functional replacement are clearly evident in this study. 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. Of these 24.74 acres, only approximately 17 acres appear to be reasonable precursors to forested wetland. At the same time, there were impacts to 6.81 acres of palustrine open water systems, but 47.41 acres of proposed open water systems as compensatory mitigation. This study found approximately 56 acres of palustrine open water systems as actual mitigation. Since there was considerable out-of-kind mitigation, there were increased losses in the more complex wetland types. The general replacement of forested wetlands with open water and emergent systems has resulted in considerable loss of function, particularly for wildlife habitat and water quality. It should be noted that non-vegetated open water systems do not constitute wetlands as defined by the Corps using the 1987 *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987) and therefore, are not “special aquatic sites” under the Clean Water Act. So, while these systems are still jurisdictional as waters, their functions are recognized as different from those of wetlands by the Clean Water Act.

The study results further indicate that insufficient compensatory mitigation has been required to offset project impacts on both an acreage and functional basis. With impacts to 352.31 acres of wetlands and proposed compensatory mitigation of 324.12 acres, of which no more than 317.65 acres are wetland, there is an overall net loss in acreage of wetlands. Enhancement and preservation had been part of the mitigation for some of the projects, however, this was not evaluated in this study as these mitigation methods do not replace lost acreage, and only in the case of enhancement or preservation of degraded uplands (which subsequently “heal” and eliminate degradation of adjacent wetlands) may replace some lost functions (preservation does prevent future losses of function, but that was not evaluated for this study). While there is a net loss in wetland function and acreage, over 300 acres of wetlands and waters have been restored or created as part of these mitigation projects and they do provide a variety of functions. The overall net loss of function is much less than the 352.31 impacted acres and on an individual project basis, there were some cases of net functional gain for the project where the impacts had been to highly degraded systems.

Causes of degradation of mitigation site functions resulted from adjacent land uses, improper hydrology, use of cultivars, inadequate maintenance and protective measures, and invasive plant species. All but eight of the study sites had invasive species, most commonly purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*).

Finally, development 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. These goals are consistent with current movement on mitigation at the national level, as seen in the National Wetlands Mitigation Action Plan and Regulatory Guidance Letter 02-2, both released on 24 December 2002.

Acknowledgements

Many people contributed to the completion of this study. In particular, graduate students Keith Wright and Kathleen McKee spent many weeks in the field collecting the raw data and many more weeks organizing and managing that data. This study would not have been possible without their extensive participation. Keith was also instrumental in the literature review. Several New England District project managers helped with field work and background data, especially the staff of the Maine and Vermont Project Offices. Alexine Raineri provided administrative support, developed many of the materials in the Appendix, and maintained the project files. Tanya Williams provided assistance with development of graphics. The Mitigation Taskforce provided useful comments on the research study plan, many of which were incorporated into the final project design. A few people from other federal and state agencies assisted in the field. Finally, this project would not have been possible without full support and encouragement from Christine Godfrey, Regulatory Division Chief, and Joanne Barry, Policy Analysis and Technical Support Branch Chief, New England District, U.S. Army Corps of Engineers.

Introduction

The Corps Regulatory Program has long been concerned with the success and effectiveness of compensatory mitigation required through the Clean Water Act Section 404 permit program. However, comprehensive studies of this effectiveness have generally not been conducted. There have been a few previous studies of mitigation success in New England. 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 an 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 scrub-shrub 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. However, success criteria were, again, fairly subjective.

In June 2001, the National Academy of Sciences' National Research Council (NRC) issued a report on the effectiveness of mitigation in the Corps of Engineers Regulatory Program. This report, *Compensating for Wetland Losses Under the Clean Water Act*, identified a variety of weaknesses in the mitigation aspects of the Corps' program. In response to this report and general needs of the Regulatory Program, Corps of Engineers Headquarters issued Regulatory Guidance Letter (RGL) 01-1, dealing with mitigation, on 31 October 2001, and RGL 02-2, dealing with the same subject and rescinding RGL 01-1, on 24 December 2002.

Prior to release of the NRC report, the Environmental Resources Section (ERS) of the Policy Analysis and Technical Support Branch in the New England District Regulatory Division was tasked with developing and conducting a study to analyze the effectiveness of compensatory mitigation projects required by the Corps in New England. The New England District has had staff dedicated to mitigation review and monitoring for more than 10 years, which helped with both collection and consistency of data relating to mitigation, making this type of study possible.

There have been several detailed studies done recently by states examining the effectiveness of state-required wetlands compensatory mitigation. States performing such studies include: Washington, New Jersey, Pennsylvania, Tennessee, Utah, New Hampshire, Rhode Island, and Massachusetts.

The Washington State Department of Ecology (Johnson, et al., 2000) conducted a two-phase study examining both permit compliance and ecological success. They found that most wetland compensatory mitigation projects (71%) were failing to meet basic permit requirements. They also noted that only 65% of the total acreage of wetlands lost was replaced by creating or restoring new wetland area and that only 63% of projects were at least partially compensating for the permitted wetland losses.

A study done by the New Jersey Department of Environmental Protection (NJDEP) (2002)[1] on freshwater wetland mitigation in that state found that, while the range of wetland area achieved at each of the mitigation sites was from 0 to 140%, the average was 45%, indicating that approximately 0.45 acre of wetlands was achieved for each acre of mitigation proposed. Mitigation which established emergent wetlands exceeded impacts to emergent wetlands (average compensation ratio of 1.29:1). However, forested wetlands only achieved an average compensation ratio of 0.01:1. NJDEP found that for each acre of impact to wetlands, 0.78 acre was actually achieved through mitigation.

Additional studies have been done in Pennsylvania, Tennessee, and Utah. A study of 23 mitigation projects in Pennsylvania (Cole and Shafer, 2002) found that only about 60% of the mitigation wetlands met their originally-defined success criteria, some after more than 10 years. While the permit process appeared to result in a net gain of nearly 0.12 acre of wetlands per project, mitigation practices including replacement of emergent, scrub-shrub, and forested wetlands with open water ponds or uplands likely led to a net loss of vegetated wetlands. The Tennessee study (Morgan and Roberts, 1999) found that for 93.4 acres of impact, the actual acreage produced by the mitigation process was 82.3 acres, yielding a ratio of wetland acreage replaced to that lost through the permitting process of approximately 0.88:1. In Utah (Utah Division of Wildlife Resources, 2001), 15% of mitigation projects examined lacked wetlands and many of the remaining sites were small depressions located adjacent to development and vulnerable to degradation from trash, contaminated runoff, grazing, vegetation clearing, and trails and paths.

In New England, recent studies evaluating mitigation have been done in New Hampshire, Rhode Island, and Massachusetts. Chase and Davis (1997) evaluated wetland mitigation in New Hampshire, collecting and analyzing data on a variety of factors including siting of mitigation projects, grading and topography, hydrology, vegetation, soils, and human disturbance. That project concluded with policy recommendations for future projects and provided broad generalizations regarding the success or failure of past wetland mitigation projects.

In Rhode Island, Cavallaro and Golet (2002) examined 26 freshwater sites where restoration of biological wetland was attempted. They found that 23 of the 26 sites had wetland hydrology and hydrophytic vegetation and performed at least one wetland function. However, the wetland types restored were typically wet meadow or marsh, while the pre-disturbance wetlands were predominantly forested. There were also problems noted with invasive plant species, which increased with urbanization of restoration sites.

Effectiveness of compensatory mitigation required by the Massachusetts regulatory program was examined by Brown and Veneman (2001). They found 54.4% of the projects examined were not in compliance with Massachusetts wetlands regulations, 21.9% of these failures resulted from no attempt to construct the mitigation. In addition, the majority of impacts (71.1%) were to forested wetlands, but only a small percentage of these systems were replaced. Scrub-shrub wetlands were designed to be produced for

[1] New Jersey is one of only two states nationally to have assumed the CWA S.404 program from the Corps.

61.4% of the projects, but the resulting projects actually built produced no wetland (38.6%), wet meadows (36.8%), or some other wetland type (24.5%). They concluded that the state's goal of no net wetland loss cannot be met unless the regulatory program succeeds in compensating for all authorized wetland impacts. It should be noted that the compensatory wetlands examined in this study were very small; 85% of them were less than 500 square feet in size and state law has requirements for them to be located on-site.

The New England District study plan was designed to collect and analyze the data necessary to determine the effectiveness of compensatory mitigation (creation and restoration only) for permitted impacts in New England, develop lessons learned, and make programmatic improvements as warranted. There were two principal ways of addressing the issue of success of mitigation. The first measured success against the permit requirements: did the mitigation meet the standards stated in the permit? The second generally proved to be more difficult to assess: did the mitigation compensate for the lost functions resulting from the permitted activities? This study addressed both aspects of success.

Methods

Study Plan

The methodology proposed for this study underwent review by members of a New England mitigation technical committee, comprised of wetlands scientists from academia, federal, state, and local governments, and the private sector. Their comments and recommendations were incorporated into the study methods.

A stratified random selection of 60 mitigation sites (Table 1) were studied in depth in order to determine if the mitigation was successful in terms of meeting the permit objectives and if the level of function approximated that of a natural wetland of the type created (or restored). The 60 sites were chosen randomly within stratified criteria, e.g., age of site, state, type of wetland, etc. All 60 sites underwent preliminary field evaluations for success, but 30 of the sites were intended to be retained for long term monitoring (shown in bold in Table 1). Mitigation sites for the study were chosen from each of the six New England states, but more sites were selected in states where there were more permits for wetlands impacts requiring compensatory mitigation involving creation and/or restoration. Sites also covered the range of time periods from those just recently constructed to those that were several years old.

Table 1 – Mitigation Study Sites

bold indicates detailed study sites

Permit #	Project Name	City	State
198100675	Syfeld - Keene Associates	Keene	NH
198300449	Pizza Rest., Michael McCoy	Wilmington	MA
198500874	**CTDOT - RT 7, NORWALK RIVER**	Norwalk	CT
198600168	**Ipswich Public Works**	Ipswich	MA
198601485	**CTDOT - Central Conn. Expressway**	Newington	CT
198700113	**Ocean Spray**	Middleboro/Lakeville	MA
198700124	Robertson Airport	Plainville	CT
198700130	Tara Development Co.	Rochester	NH
198700216	**MEDOT/Biddeford Connector**	Biddeford	ME
198700631	**NHDOT Rt. 25 - Effingham/Freedom**	Effingham	NH
198702200	RI DOT Route 138	Jamestown	RI
198707103	Sky Meadow Golf Course	Dunstable / Nashua	MA
198800859	CTDOT - I-91 Reconstruction	Windsor	CT
198802617	Lego Systems, Inc.	Enfield	CT
198802914	**NHDOT 101/51**	Epping/Hampton	NH
199010690	**River Woods Health Care**	Exeter	NH
199010710	**NHDOT Rt.101 Squamscott River Bridge**	Exeter / Stratham	NH
199010883	**CTDOT Cottage Grove Road**	Bloomfield	CT
199011150	**VTAOT, CCCH Segment 2**	Essex Junction	VT
199100575	MEDOT Topsham Fairgrounds	Topsham/Brunswick	ME

Permit #	Project Name	City	State
199100593	**NHDOT Rt 9, Nelson & Stoddard**	Nelson	NH
199100657	**Mill Creek**	Chelsea	MA
199101009	**NHDOT - F.E. Everett Turnpike**	Nashua	NH
199101291	**Neck River Farms**	Madison	CT
199101814	**VTAOT, CCCH Segment 3,4**	Colchester/Essex	VT
199200602	Waste Management Disposal, Phase 7	Norridgewock	ME
199201253	Berlin Properties	Berlin	VT
199201515	**Camden & Rockland Water Company**	Rockland	ME
199201570	**Polpis Bike Path**	Nantucket	MA
199202046	**Maine Turnpike Authority/Congress St.**	Portland	ME
199300436	Town of Ridgefield	Ridgefield	CT
199300719	Waste Management Disposal, Phase 10	Norridgewock	ME
199300836	**NHDOT Route 106, Concord to Laconia**	Loudon, Gilmanton	NH
199300976	Blackstone River Bikeway	Cumberland	RI
199301389	MEDOT Orrington Bypass/Ichabod Ln.	Orrington	ME
199400814	Sleepy Hollow Dev. - Fleet Westbrook	Westbrook	ME
199402710	NHDOT/Wallace Road	Bedford	NH
199402926	**Misquamicut Club**	Westerly	RI
199500378	MHD Rt. 1	Foxboro	MA
199500936	**VTAOT, Otter Creek**	Wallingford	VT
199501181	**Waste Management, Inc.**	Berkley	MA
199501396	Stop & Shop	Milford	CT
199501767	**Wallace Camp Auto Dealership**	Westbrook	ME
199501776	Town of Scarborough DPW	Scarborough	ME
199600361	**MEDOT/Road Upgrade - Route 3**	Bar Harbor	ME
199600376	Lochmere Golf and Country Club	Northfield	NH
199602547	Libbey Industrial Park - Western Atlantic	Weymouth	MA
199700270	Richard Russo	Guilford	CT
199700775	Southern Auto Sales	East Windsor	CT
199701040	David F. Cash	North Attleboro	MA
199701530	**Fairview Farms Golf Course**	Harwinton	CT
199701542	**Huber Resources Corporation**	Millinocket	ME
199701597	The Siemon Company	Watertown	CT
199701820	Robert Thibeault	Highgate Springs	VT
199800381	NHDOT I-95/Rt33 Interchange	Portsmouth	NH
199800920	Caler Cove Lobster Co.	Addison	ME
199801231	Five Town RCSD	Rockport	ME
199801738	Great River Golf Course	Milford	CT
199901240	NH International Speedway	Loudon	NH
199902381	**Portland Welding Supply**	Portland	ME

Site Selection Process

Administrative staff reviewed all projects listed in the Environmental Resources Section (ERS) Mitigation Database, which includes all mitigation projects tracked by the New England District's Regulatory Division (329 mitigation projects as of November 2002). A Microsoft Access table of all mitigation projects involving creation and/or restoration was developed from the information in the ERS Mitigation Database. Projects involved with solely preservation and/or enhancement were not included, nor were these aspects of the chosen projects included in this study. This omission is in no way meant to comment on the applicability or usefulness of these methods of mitigation; however, the concentration of this study was to be on effectiveness of wetland creation and restoration for mitigating wetland impacts and preventing net loss in function (often present with preservation and enhancement alone). The table information included state, permit file number, name of project, wetland types proposed for creation/restoration, wetland acreages proposed, apparent date of construction, if plans were available, and if permit conditions were available in the files.

A Senior Wetland Scientist reviewed the site table and further checked to insure that the impact occurred and that the mitigation site was planned to be greater than 0.1 acre in size. After unsuitable projects were eliminated, the data were sorted alphabetically by state. Every third project was selected in order to provide random selection of sites, but in proportion to their geographic distribution throughout the six New England states. The mitigation database information for all those projects selected was again reviewed by a Senior Wetland Scientist to eliminate projects which had incorrect information which should have ruled them out initially, had restoration solely as enforcement resolution, or were constructed subsequent to the 2000 growing season. This screening resulted in an inadequate number of remaining projects for the study, so, wherever a project was eliminated, the next project on the list was selected and reviewed using the above criteria. The result was 64 projects, with the excess projects deleted once the field work at 60 sites confirmed the applicability of these sites for the study. Every other project on this list was then chosen to be retained for the long term monitoring. Permittees and/or landowners were contacted for permission to visit the sites.

Data Collection

Each site was visited and a variety of data collected. The goal of the data collection was to be able to evaluate the mitigation for compliance with the success standards as included in the permits. Information such as whether the mitigation projects reached the required level of success was obtained. In addition, success was also measured in terms of whether the compensatory wetlands function as natural wetlands and have replaced the functions lost through permitted impacts.

It is understood that even mitigation which is considered successful and is several years old may still be quite different from a mature wetland system and the assessment takes this into consideration. We performed independent function and value assessments using the New England highway methodology workbook supplement functional assessment (U.S. Army Corps of Engineers, 1999) and collected detailed information on soils, vegetation, and hydrology at each mitigation site selected. Additionally, we collected information on water quality, wildlife usage, vegetation growth, etc. to better determine ecological and hydrological functioning of the site.

In order to make these assessments, the following was completed at each mitigation site. Wetlands at the mitigation sites were delineated using the 1987 *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987) to determine the extent of wetlands present and to compare to the proposed wetland creation and/or restoration. New England District wetland delineation data sheets were completed to document the delineation, unless the site was comprised of obvious waters or wetlands, e.g., ponds, pools, and marshes with steep banks. Boundaries were not field marked, but on sites over approximately 0.25 acre were located using a hand-held Garmin GPS III Plus global positioning system (GPS) unit to document current wetland boundaries for comparison with the proposed boundaries identified in the permit requirements and to generate a rough acreage estimate. For sites smaller than 0.25 acre, GPS points were taken to locate the sites and to be able to enter them into a geographic information system database. Sites were identified as to their National Wetland Inventory (NWI) classification (Cowardin, et al., 1979) and Hydrogeomorphic (HGM) classification (Brinson, 1993).

Simple shallow groundwater monitoring wells were placed at some of the sites intended for long term monitoring. However, hydrology data were not collected from the wells this first sampling season. Hydrology was assessed at the time of the site visit by measuring depths of inundation, depths to groundwater, and depths to saturation.

Soil profiles were examined for each site, unless the site was predominantly an open water area or inundation prevented obtaining adequate soil samples for examination. Profiles were generally to a minimum of 24 inches. More than one profile per site was examined if warranted by site heterogeneity. Particular attention was paid to development of redoximorphic features and amounts of organic matter.

Vegetation was examined at the sites for wetland delineation, assessment of species diversity, and evaluation of invasive species problems. Nomenclature follows Gleason and Cronquist (1991). Vegetation in complex or heterogeneous sites was sampled in several locations. The goal was to assure that all communities present were sampled, with particular attention paid to species composition and diversity, native species, natural regeneration, and appropriate structure and density. Invasive species were also noted.

Observations of wildlife usage were documented during all site visits. This includes visual observation, tracks, scat, and vocalizations.

Photographs were taken using either Epson PhotoPC 750Z or Olympus D-510 Zoom digital cameras. Locations of photographic stations were noted so that future photographs may be taken from the same locations during follow-up visits.

Landscape position and habitat continuity were noted for each site. Examination of remote sensing data, such as aerial photography, topographic maps, etc. were used to assess the surrounding landscape condition, land use, distance to nearest wetland/water body, and other parameters which may influence the site.

Data Analysis

The field data collected at the sites were compared to the permit conditions in order to determine compliance with the permit and success based upon meeting permit requirements. The mitigation wetlands were assessed regarding their size, NWI type, and functions and values and were then compared to the impacted wetlands using the same factors to determine the success of the mitigation in actually replacing the functions of the impacted areas. For calculation purposes, in systems of mixed NWI type, the wetlands total was divided by the number of types and each type received an equal portion to be used in determining NWI type totals. Sites that had inadequate preliminary information for comparison were not included in some of the calculations. The accuracy of the wetland impact types and acreages was dependent upon the data in the files. In some cases, the data were incomplete, incorrect, or lacking; however, due to the large number of projects involved in the study, it was determined that such data deficiencies for a few projects would not significantly affect the study results.

Results

Sixty compensatory mitigation projects were examined as part of this study (see Table 1). The acreage and types of impacts, proposed compensatory mitigation, and actual compensatory mitigation are shown at the end of this section in Table 4. Site information and data collected for each of the study sites is included in the Appendix.

The first finding of the study was that there were not always adequate records and data management, particularly for older projects, making it difficult, and in some cases impossible, to determine what the initial impacts had been, the types, functions and values of the impacted wetlands, and the proposed compensatory mitigation. This information is noted where necessary in the tables and graphs.

For the projects involved in this study, there was a total of 352.31 acres of authorized wetland impacts. There was a total of 324.12 acres of compensatory wetland creation and restoration required for these impacts. Mitigation comprised of wetland enhancement and wetland and upland preservation, components in some of the total mitigation for these projects, was not examined in this study since these methods do not compensate for lost acreage, enhancement only replaces some lost functions, and preservation only replaces some lost functions when degraded upland is preserved and restored to healthier conditions which may result in less degradation of adjacent wetlands. The total authorized impacts (Table 2 and Figure 1), proposed creation and restoration (Table 2 and Figure 2), and actual field confirmed wetland mitigation (Table 2, Figure 3) are shown by wetland type, in acreage and percentage of total. The unknown category includes those projects where inadequate information was available in the files.

Table 2 – Wetland impacts, proposed compensatory mitigation (restoration and creation), and field confirmed compensatory mitigation (restoration and creation) by NWI type (PFO – palustrine forested, PSS – palustrine scrub-shrub, PEM – palustrine emergent, POW – palustrine open water, EEM – estuarine emergent) and percentage each comprises of total impacts, proposed mitigation, and actual mitigation, respectively.

Wetland type	Impacts (acres)	Percent of total	Proposed mitigation (acres)	Percent of total	Actual mitigation (acres)	Percent of total
PFO	177.69	50.4%	24.74	7.6%	0.48 (17.07)*	0.2 (5.3)*%
PSS	62.62	17.8%	88.40	27.3%	82.47	25.4%
PEM	47.97	13.6%	122.18	37.7%	167.40	51.6%
POW	6.81	1.9%	47.41	14.6%	55.61	17.2%
EEM	4.76	1.4%	11.69	3.6%	11.69	3.6%
unknown	52.46	14.9%	29.70	9.2%	0.00	0.0%
total	352.31	100%	324.12	100%	317.65	98.0%
non-wetland					6.47	2.0%

*only 0.48 acre could be classified as PFO, however it was determined that an additional 16.59 acres of PSS and PEM were good forest precursors and were likely to become PFO (this larger amount is used in Figure 3 below)

Figure 1 - Percentage of Wetland Impacts by Wetland Type

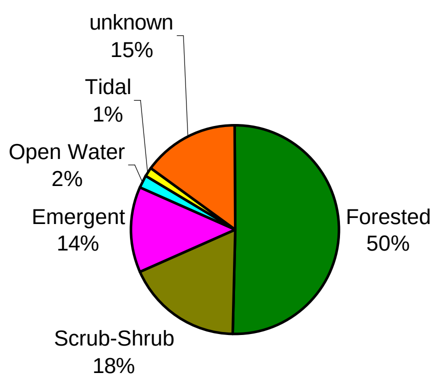


Figure 2 - Percentage of Proposed Mitigation by Wetland Type

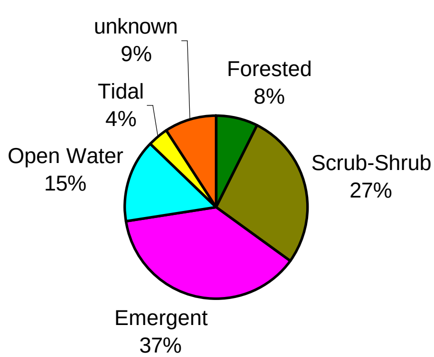
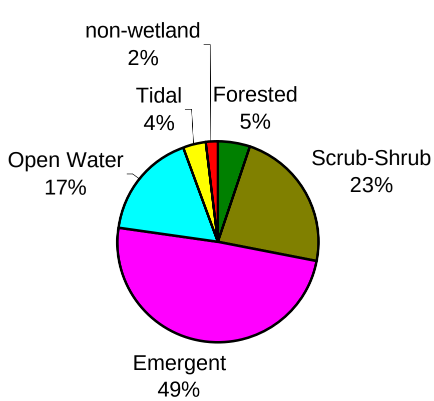
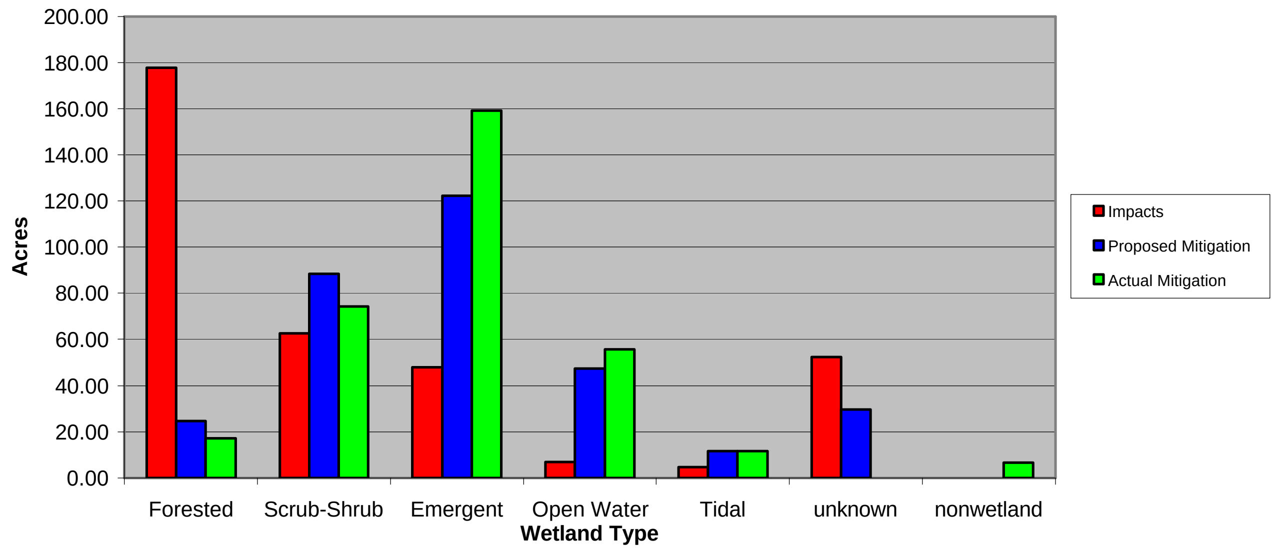


Figure 3 - Percentage of Field-Confirmed Mitigation by Wetland Type



A comparison of actual field-confirmed mitigation with impacts and proposed mitigation acreages can be seen in Figure 4. The non-wetland included those areas, largely lacking hydrology, which were not currently wetland and did not appear capable of developing wetland characteristics on their own. While GPS data were collected at most mitigation sites to delineate the wetland boundaries, these data will be analyzed subsequently and were not incorporated into the present study, hence precise acreages of created and restored wetlands were not determined. Estimates of the mitigation acreages were based on proposed acreages and examination of plans and comparisons to field observations.

Figure 4 - Impacts and Mitigation by Wetland Type



Forty of the mitigation projects (67%) were determined to meet permit conditions and would be considered successful by that standard. However, only ten projects (17%) were considered to be adequate functional replacements for the impacted wetlands; of these, nine also met success with the permit conditions. Information on permit conditions was missing for seven projects (12%) and information on functions and values or types of impacted wetlands was missing for six projects (10%), making it impossible to determine success for those projects. Only one mitigation project was considered to provide successful functional replacement without certainty of meeting the permit conditions. The numbers of projects examined per state and per year were too small a sample size to determine any patterns or trends relating to these variables.

A variety of problems were noted with the compensatory mitigation projects, which affected their success. Some of these problems resulted from inadequate detail in the plans or poor implementation of the plans. In some cases, monitoring had not been sufficiently stringent to catch problems before the end of the monitoring period, particularly for older projects where the monitoring period was no more than three years. Hydrology was found to be less than intended at nine sites and more than intended at many sites. Excess hydrology prevented establishment of intended hydrophytic communities, e.g., scrub-shrub communities with too much water often became emergent communities, as the hydrology was too excessive for establishment and maintenance of woody plants.

The main problem noted with soils was that some had low organic content. Soils were generally young, though many had developed or developing hydric morphologies, e.g., redoximorphic features.

The main problem with vegetation was the presence of invasive species (see Table 3). Only eight mitigation sites were found not to have invasive species. Native species such as *Typha latifolia* (cattail) were included as invasives at sites where they grew in an invasive manner, tending to form monocultures and crowding out other species, reducing the proposed species diversity and ecological structure at the sites. Vegetation at some sites was also impacted by inappropriate mowing. Excessive hydrology at some sites prevented the establishment of proposed woody plant communities.

The field data forms, functional assessment forms, and additional data are included for each site in Appendix A. Also included are maps, plans, and photographs.

Table 3 – Invasive plant species found at mitigation sites in study.

Scientific name	Common name	Occurring in number of sites
Lythrum salicaria	Purple loosestrife	34
Phragmites australis	Common reed	19
Typha latifolia	Broad-leaved cattail	8
Phalaris arundinacea	Reed canary grass	9
Elaeagnus spp.	Russian and autumn olive	6
Lotus corniculatus	Bird's foot trefoil	4
Rosa multiflora	Multiflora rose	3
Celastrus orbiculatus	Bittersweet	1
Polygonum cuspidatum	Japanese knotweed	1
Rhamnus frangula	Buckthorn	1
none		8

Table 4, below, lists all of the projects examined in this study, noting the wetland type and acreage of impacted wetlands, proposed compensatory restoration and creation mitigation, and actual field-identified mitigation. The table does not note functions under any of the categories, nor does it note success or failure of the mitigation at replacing lost functions or meeting permit conditions. Actual field-identified mitigation acreage is based on field estimates using mitigation plans and maps. GPS data collected to determine more precise boundaries was not evaluated for this initial report. The accuracy of the wetland impact types and acreages was dependent upon the data in the files. In some cases, the data were incomplete, incorrect, conflicting, or lacking. Because of this, some data may be erroneous.

Table 4 – Impacts, proposed mitigation, and actual mitigation by wetland type and acreage for mitigation study sites. **Bold indicates detailed study site.**

Permit #	Project Name	State	Impact Acres	Impact Type	Proposed Mitigation Acres	Proposed Mitigation Type	Actual Mitigation Acres	Actual Mitigation Type
198100675	Syfeld - Keene Associates	NH	9.80	PSS/FO/EM	?	POW/EM	?	ROW/EM
198300449	Pizza Rest., Michael McCoy	MA	0.06	non-tidal	0.24	?	0.24	PEM
198500874	**CTDOT - RT 7, NORWALK RIVER**	CT	10.69	PEM/SS/OW	8.10	PEM/SS	8.10	PEM
198600168	**Ipswich Public Works**	MA	0.16	saltmarsh	0.16	saltmarsh	0.16	EEM
198601485	**CTDOT - Central Conn. Expressway**	CT	6.00	PFO	11.50	PSS	11.50	PSS
			6.50	PSS	0.00		0.00	
			1.50	PEM	0.00		0.00	
198700113	**Ocean Spray**	MA	0.37	PSS	0.37	PSS	0.37	PEM/SS
198700124	Robertson Airport	CT	3.60	PEM/SS	1.52	POW	4.15	PSS/EM/OW
			0.00		0.72	PFO	0.00	
			0.00		0.63	PEM	0.00	
			0.00		1.28	PSS	0.00	
198700130	Tara Development Co.	NH	1.50	PFO/SS	1.00	PFO/SS	1.00	PSS
198700216	**MEDOT/Biddeford Connector**	ME	2.59	PSS	2.30	PEM	2.30	PEM
			0.16	PEM	0.00		0.00	
			0.35	POW	0.00		0.00	
198700631	**NHDOT Rt. 25 - Effingham/Freedom**	NH	5.90	PFO/SS	2.10	PSS	2.10	PEM
198702200	RI DOT Route 138	RI	1.10	mixed	1.30	PEM	1.30	PEM
198707103	Sky Meadow Golf Course	MA	?	?	3.00	PEM	5.00	POW/EM
			0.00		2.00	PSS	0.00	
198800859	CTDOT - I-91 Reconstruction	CT	2.80	PEM	4.80	POW	4.80	POW/EM/SS
			1.30	PFO	0.00		0.00	
198802617	Lego Systems, Inc.	CT	0.96	PEM	1.50	PEM	1.50	PEM
198802914	**NHDOT 101/51**	NH	103.00	PFO	105.00	POW/EM/SS	105.00	POW/EM/SS
199010690	**River Woods Health Care**	NH	0.85	PFO	0.21	POW/EM	0.21	POW/EM
***199010710**	**NHDOT Rt.101 Squamscott River Br.**	NH	*3.70	EEM*	3.70	EEM	3.70	EEM

Permit #	Project Name	State	Impact Acres	Impact type	Proposed Mitigation Acres	Proposed Mitigation Type	Actual Mitigation Acres	Actual Mitigation Type
199010883	**CTDOT Cottage Grove Road**	CT	3.08	PFO	6.20	PFO	6.20	PEM/OW
			0.14	PSS	0.00		0.00	
			0.60	PEM	0.00		0.00	
199011150	**VTAOT, CCCH Segment 2**	VT	20.20	other	?	?	?	PEM
			3.40	PEM	0.00		0.00	
			13.00	PEM ag	0.00		0.00	
			2.60	PFO	0.00		0.00	
			1.20	PSS	0.00		0.00	
199100575	MEDOT Topsham Fairgrounds	ME	2.75	PFO	1.90	PFO	1.90	PSS
			3.65	PSS	3.70	EEM	3.70	EEM
			0.36	EEM	0.00		0.00	
199100593	**NHDOT Rt 9, Nelson & Stoddard**	NH	3.99	PFO	2.00	?	3.30	PEM/OW
			0.06	PEM	1.30	PEM	0.00	
199100657	**Mill Creek**	MA	0.09	tidal EM	1.08	tidal EM	1.08	EEM
199101009	**NHDOT - F.E. Everett Turnpike**	NH	2.90	PEM	6.20	PEM	23.20	PEM/SS
			15.60	PFO	4.40	PFO	0.00	
			3.80	PSS	12.60	PSS	0.00	
			1.60	other	0.00		0.00	
199101291	**Neck River Farms**	CT	0.97	PFO	0.90	PEM	0.90	PSS/EM
199101814	**VTAOT, CCCH Segment 3,4**	VT	1.70	PEM	50.00	PEM	50.00	PEM
			19.70	PSS	0.00		0.00	
			5.40	PFO	0.00		0.00	
			3.40	mixed	0.00		0.00	
199200602	Waste Management , Phase 7	ME	1.80	PFO	2.20	PFO/SS/EM	2.20	PEM/SS
199201253	Berlin Properties	VT	1.30	PSS	0.80	PEM?	0.80	PEM
			5.30	PEM	0.00		0.00	
199201515	**Camden & Rockland Water Company**	ME	1.13	?	0.35	?	0.00	nonwetland
199201570	**Polpis Bike Path**	MA	1.47	PFO/SS/EM	2.74	PEM	2.74	PEM/SS

Permit #	Project Name	State	impact acres	impact type	proposed mitigation acres	proposed mitigation type	actual mitigation acres	actual mitigation type
199202046	**Maine Turnpike Authority/Congress St**	ME	12.66	"other"	2.93	PEM	11.66	PEM/SS/OW
			0.00		6.04	PSS	0.00	
			0.00		1.46	PEM	0.00	
			0.00		1.23	POW	0.00	
199300436	Town of Ridgefield	CT	0.76	PFO	2.00	PSS	2.00	PEM
199300719	Waste Management, Phase 10	ME	0.22	PFO	0.51	PFO	0.75	PEM/SS
			0.00		0.24	PSS	0.00	
199300836	**NHDOT Route 106, Concord to Laconia**	NH	8.70	POW/SS/FO	8.30	POW/EM/SS	8.30	PEM
199300976	Blackstone River Bikeway	RI	1.77	PEM/SS/FO	0.30	PEM	0.30	PEM/OW
199301389	MEDOT Orrington Bypass/Ichabod Ln.	ME	2.20	PEM/SS/FO	1.50	PSS	1.50	PSS
199400814	Sleepy Hollow Dev. - Fleet Westbrook	ME	0.71	?	0.42	?	0.42	PEM
199402710	NHDOT/Wallace Road	NH	0.62	PFO	0.14	POW	1.02	PEM/SS
			0.37	PSS	0.38	PSS	0.00	
			0.12	PEM	0.50	PEM	0.00	
199402926	**Misquamicut Club**	RI	0.48	PEM	0.56	PEM	0.56	PEM
199500378	MHD Rt. 1	MA	1.50	PFO	2.05	PSS	2.05	POW/EM
199500936	**VTAOT, Otter Creek**	VT	1.40	PSS	0.70	PSS	0.70	PEM
199501181	**Waste Management, Inc.**	MA	0.71	?	0.34	?	0.34	PEM
199501396	Stop & Shop	CT	0.34	?	0.36	PEM	0.36	PEM/SS
199501767	**Wallace Camp Auto Dealership**	ME	2.88	PEM	0.52	PSS	0.52	PEM
199501776	Town of Scarborough DPW	ME	0.59	PFO	0.75	tidal marsh	0.75	EEM
			0.03	PEM	0.00		0.00	
199600361	**MEDOT/Road Upgrade - Route 3**	ME	0.28	tidal EM	0.40	tidal marsh	0.40	EEM
			0.77	PFO	0.00		0.00	
			0.15	PEM	0.00		0.00	
			0.51	PSS	0.00		0.00	
199600376	Lochmere Golf and Country Club	NH	3.76	?	3.88	PEM/SS	3.88	PEM
199602547	Libbey Industrial Park - Western Atlantic	MA	0.69	?	0.58	?	0.58	PEM/SS

Permit #	Project Name	State	impact acres	impact type	proposed mitigation acres	proposed mitigation type	actual mitigation acres	actual mitigation type
199700270	Richard Russo	CT	0.80	PSS	1.40	?	1.40	PEM
199700775	Southern Auto Sales	CT	3.80	PFO	8.40	PFO	8.40	POW/EM
199701040	David F. Cash	MA	0.57	?	0.43	?	0.43	POW/EM
199701530	**Fairview Farms Golf Course**	CT	1.37	PEM	1.24	?	1.24	PEM/SS
			0.82	PSS/FO	0.00		0.00	
199701542	**Huber Resources Corporation**	ME	1.57	?	1.44	?	1.44	PSS/EM
199701597	The Siemon Company	CT	0.32	?	0.13	PSS	0.13	PSS
199701820	Robert Thibeault	VT	0.24	PFO/EM	0.48	PFO	0.48	PFO
199800381	NHDOT I-95/Rt33 Interchange	NH	2.84	PSS	2.35	?	2.35	PEM/SS/OW
199800920	Caler Cove Lobster Co.	ME	0.17	tidal EM	1.90	tidal EM	1.90	EEM
199801231	Five Town RCSD	ME	2.98	?	6.10	?	0.00	nonwetland
199801738	Great River Golf Course & Res. Comm.	CT	0.65	?	0.90	PFO	3.54	PEM
			0.00		0.80	PEM	0.00	
			0.00		1.84	POW	0.00	
			0.00		0.07	vernal pools	0.07	vernal pools
199901240	NH International Speedway	NH	9.88	PFO	12.40	?	12.40	PSS/EM
199902381	**Portland Welding Supply**	ME	?	?	0.35	?	0.35	PEM/SS
	total		352.31		324.12		317.67	

*alternative data in the file indicate impacts were to 3.30 acres of PFO/SS/EM

Discussion

The overall findings of this study match some of the national findings of the National Research Council's (2001) study, *Compensating for Wetland Losses Under the Clean Water Act*. The NRC noted the incomplete and inadequate data maintained by the Corps throughout the country on tracking of mitigation to follow permit compliance, functional losses (or gains), and levels of mitigation success. The New England District is actually superior to many districts in this area and has improved considerably over the years in tracking mitigation, something which allowed this type of study to be performed. By having staff dedicated to mitigation review and monitoring, the New England District has recognized the relative importance of compensatory mitigation to the Regulatory Program and in achieving the goals of the Clean Water Act, Section 404. This has also allowed for a certain level of consistency, often lacking in the program in other parts of the country. The New England District has improved in this area; however, there is still a need for improvement.

Additional areas for improvement of data management have been revealed by this study and some are already being included in The New England District's project review and tracking. It is necessary to be able to locate mitigation sites and have them permanently identified. Latitude and longitude information is currently required for all mitigation sites, however, this was not always the case. This is especially important when mitigation sites are not in the same location as the impact areas. In addition, topographic and street maps should be generated for all sites and maintained in the project files so that the sites can be found at any time in the future.

It is also important to have complete information on the impacted wetlands and maintain this information in the mitigation files so that mitigation functional success can be determined over time. Zedler (1996) noted that in order to have no net loss of wetland function, wetland mitigation efforts should create sites that equal or exceed the impacted area's functional value. Without information on the impacted wetlands, the success of the compensatory wetlands cannot truly be measured. The NRC (2001) noted that it is important to evaluate the compensatory mitigation using the same functional assessment tools as for the impacted wetlands. For some older projects, we had little or no information on what resources had been impacted, making evaluation of functional replacement impossible. Newer projects generally had this information, some quite detailed.

Successfully compensating for wetland losses requires duplication of wetland structure and function; however, simple measures of function do not exist (Zedler, 1996). Brinson and Rheinhardt (1996) proposed that reference wetlands should be central to the development of standards against which impacts to wetlands and restoration efforts are evaluated. These reference wetlands, in which hydrologic, biogeochemical, and biological functions are measured are a method by which wetland functions can be understood. Whigham (1999) also supported the use of reference wetlands, as well as taking into account landscapes and watersheds to better replace lost functions. He questioned whether there is any scientific justification for the underlying assumption of mitigation, that restored and created wetlands function similarly to natural wetlands with regard to biodiversity and nutrient cycling. He also noted that concentrating on replacing lost acreage amounts fails to account for the wetland degradation and functional loss resulting from creation and restoration of mitigation wetlands of lower functional value. In this regard, greater compensatory mitigation acreage is required to replace the lost functions of impacted systems, i.e., mitigation to impact ratio must be greater than 1:1.

Hydrology is the driving force of wetlands and what drives the functions, both type and level of function. Bedford (1996) noted that analyses of the success of wetland mitigation projects have generally failed to incorporate a detailed assessment of hydrology. She found that presence of a wetland plant community was a common measure of success and that this usually failed to take into account the type of community which was impacted. In such cases, it is unlikely that the compensatory mitigation will provide functional replacement for the impacted wetlands. The most common type of "successful" community was one characterized by an area of deep open water, surrounded by bands of shallower water and a band of emergent vegetation. The functions of these types of systems are very different than the forested wetlands they are often meant to replace.

If compensatory mitigation is truly meant to replace wetland functions lost to authorized impacts, rather than merely the cost for a permit, it is important that there be a thorough understanding of wetland function to adequately determine success of wetland creation and restoration in replacing lost functions (Mitsch and Wilson, 1996). The New England District has used its own functional assessment methodology (U.S. Army Corps of Engineers, 1999), a qualitative assessment, for several years. It is effective in identifying functions and values of wetland systems, but not the level of function. The more detailed the notes and information on the systems assessed with this methodology, the more useful the assessment is and this level of detail varies from project to project. Breaux and Serefiddin (1999) noted that there is often a lack of expertise, time, and economic resources necessary to ensure that functions and values are replaced. Longer monitoring periods should be established prior to determining success of mitigation. In cases where structural or functional goals are achieved, such an achievement may be transitory and the restoration may revert back to another state (Lockwood and Pimm, 1999), such as die back of woody species after the first few years.

Restoration generally has greater success rates than creation. Ready sources of hydrology and appropriate landscape position are the chief reasons for the greater success of restoration. Some of the most apparently successful mitigation sites in the New England study were tidal marshes. These areas, especially restorations, have a known and reliable source of hydrology, the most difficult factor to establish in compensatory wetlands. The tidal marsh mitigation sites in this study all were considered to be successful in that they resulted in the type of system intended, though some were not considered to replace the lost functions of dissimilar systems for which they were mitigation. However, even though they often appeared indistinguishable from the adjacent natural marshes, they may not have had the same level of function. Matthews and Minello (1994) have found that created salt marshes generally have lower sediment organic content, below ground biomass, densities of benthic infaunal prey organisms, and densities of nekton on the marsh surface. Some habitat functions may develop quite slowly, if at all. This present study was not designed to assess the level of detail necessary to determine true functional replacement.

The U.S. Fish and Wildlife Service (Dahl, 2000), examining wetlands status and trends, reports the greatest losses are to emergent and forested freshwater wetlands, losing 4.6 and 2.3 percent of their respective areas between 1986 and 1997. During this same time period, the type of system with the greatest estimated area increase was open water systems, increasing by 13.0 percent. Some of the reasons for these trends are clearly evident in this study. 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. Of these, only approximately 17 acres appear to be reasonable precursors to forested wetland. At the same time, there were impacts to 6.81 acres of palustrine open water systems, but 47.41 acres of proposed open water systems as compensatory mitigation. This study found approximately 56 acres of palustrine open water systems as actual mitigation. It should be noted that non-vegetated open water systems do not constitute wetlands as defined by the Corps using the 1987 *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987) and therefore, are not "special aquatic sites" under the Clean Water Act. So, while these systems are still jurisdictional as waters, their functions are recognized as different from those of wetlands by the Clean Water Act.

Even in situations where forested wetland was designed, and perhaps succeeded, as replacement for forested wetland impacts, the lost functions may not have been adequately mitigated. In a study concentrating on soils, Stolt, et al., (2000) examined forested and scrub-shrub mitigation wetlands in comparison to adjacent natural wetlands. The data from their study suggest that constructed wetlands may not function in the same capacity as natural, undisturbed wetlands. In some cases, the factors controlling the functions may need more time, decades to centuries, to develop. In some cases, the mitigation site substrate is not appropriate, regarding texture, organic matter content, etc. The New England District has increased the level of detail requested for mitigation site substrates and soil treatments in recent years.

A common problem at a majority of the New England study sites was the presence of invasive plant species. The Natural Resources Conservation Service's Wetland Science Institute (1999) noted that such plant species threaten the success of wetland restoration and creation by replacing native vegetation, reducing biodiversity, reducing wildlife habitat and food, changing ecosystem processes, and increasing hybridization. Kourtev, et al. (2002), found that exotic invasive species can have profound effects on the microbial community of the soil. This, in turn, affects the functions performed by the microbial community, including nutrient retention and transformation and other water quality functions. All but eight of the study sites had invasive species, most commonly purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*). Other common invasive plants included reed canary grass (*Phalaris arundinacea*), broad-leaved cattail (*Typha latifolia*), Russian and autumn olive (*Elaeagnus* spp.), bird's foot trefoil (*Lotus corniculatus*), and multiflora rose (*Rosa multiflora*). This is a difficult problem to resolve as many natural wetland systems are subject to colonization by invasive species. Expanding the list of species to be controlled for on mitigation sites would be helpful. In addition, choosing sites further from disturbance and impact areas, e.g., not adjacent to roads, parking lots, etc., reduces the likelihood of invasion. It is currently requested that soils used at mitigation sites be free from seeds of recognized invasive species.

A related problem is the use of cultivars, cultivated varieties of native species in compensatory mitigation. The different genotypes introduced into the ecosystems by this practice can affect both function of the compensatory mitigation and nearby systems "contaminated" by the alien genotypes. Loss of disease and cold resistance are some of the potential problems resulting from this gene flow. Some of the cultivars noted at mitigation sites included cultivated genotypes of blueberry (*Vaccinium corymbosum*) and alder (*Alnus* spp.).

Assorted other problems were noted with the mitigation sites in the study. At least one forested site was regularly mowed. This may have given an advantage to establishment of planted woody seedlings, however, it reduced herbaceous diversity, structural complexity, and function. At another site, the wetland shrubs were cut down just prior to our site visit by careless roadside maintenance workers. This highlights problems with long term protection of many of the sites. Once they are outside the monitoring period, there may be insufficient protection mechanisms. Even within the monitoring period, improper controls and information transfer result in site degradation.

Location of compensatory mitigation is very important in determining, developing, and preserving functions. The original strong preference for onsite mitigation led to construction of wetlands adjacent to roadways, within highway ramp infields, next to parking lots and industrial development, within golf course features, and in other highly degraded areas. It can be difficult to establish a high level of function in these areas where surrounding land use places a constant stress on these compensatory mitigation systems. The functions, and success, of a number of the mitigation wetlands included in this study were compromised by degradation from adjacent land use. In addition to concerns over surrounding land use, location is important to the success of establishing compensatory functions. Landscape position often dictates the site hydrology, type of wetland that could be successfully created, and likelihood of success of that creation. The NRC (2001) noted that landscape position should be an important factor in choosing mitigation sites and also that adjacent land use should be seriously considered. This has been difficult in parts of New England where state laws dictate that wetland mitigation must be placed onsite. If the New England District is to improve the success of Corps-required compensatory mitigation, it will likely have to require better site locations, and separate mitigation, where state requirements lead to poorly placed mitigation where success at replacing lost functions is not likely to occur. However, good mitigation sites are limited in New England. Modernization of state laws, to reflect the status of wetland mitigation science (e.g., NRC recommendations), could improve mitigation success.

The study also seems to indicate that insufficient compensatory mitigation has been required to offset project impacts. With impacts to 352.31 acres of wetlands and proposed compensatory mitigation of 324.12, of which no more than 317.65 became wetland, there would be an overall net loss in acreage of wetlands. Since there was considerable out-of-kind mitigation, there were increased losses in the more complex wetland types. The general replacement of forested wetlands with open water and emergent systems has resulted in considerable loss of function, particularly forested wildlife habitat and water quality functions such as denitrification, which occur best in seasonally saturated wetlands. Later mitigation projects tended to be more ecologically based than earlier projects, some of which were no more detailed than to build a wet depression in the landscape. An examination of enhancement and preservation, included in the overall mitigation proposals for several of the study projects was not reviewed in this study. Although preservation and enhancement can be important parts of a mitigation proposal, they do not prevent a net loss in wetland acreage and may not prevent a net loss in wetland function. The prevention of future losses of functions due to preservation was not examined in this study.

Approximately 67% of the mitigation projects complied with permit conditions, while 12% were lacking information to determine success. Older projects complied slightly more than newer projects since later permits contained more detailed compensatory mitigation conditions, as the Corps attempted to improve the quality and success of mitigation. Race and Fonseca (1996) have noted studies from around the country supporting the claim that it is common for mitigation sites to be out of compliance with permit conditions. They also note that stronger emphasis on permit compliance and enforcement is needed in order to achieve the goal of no overall net loss in function.

While 10% of the projects lacked sufficient information to determine ecological success, only about 17% of the mitigation projects in the study seemed to be capable, currently or in the foreseeable future, of replacing the lost functions (particularly wildlife habitat and water quality functions) of the impacted wetlands. This is due in part to inadequate mitigation amounts for permitted impacts and also for inappropriate functional replacements, e.g., replacing forested wetlands with open water, emergent, and/or scrub-shrub systems. Some proposed forested wetlands were too wet to support tree species and become forest. Those that were deemed successful at replacing lost functions tended to be well-planned and had the goal of replacing the impacted system(s). Careful attention to grading, soil organic matter, and invasive species control were all important to creating successful wetlands. Using the block transplant method (removing a block of wetlands to be impacted, complete with plants, soil, and accompanying microfauna, and placing it in the mitigation area) for restoring and creating forested or scrub-shrub wetlands, is particularly effective.

It is important to note, that while the 317.65 acres of field verified compensatory mitigation did not fully replace the impacted functions from the 352.31 acres of authorized wetland impacts, over 300 acres of wetlands and waters were restored and created. Many wetland functions are performed at these mitigation sites, making the net loss of function much smaller than the total impacts alone would cause. In fact, a few mitigation projects resulted in a net gain in function for the overall project, where the impacts had been to highly degraded systems. Some sites were ecologically successful as functioning wetlands, however, they were the wrong types of wetlands to replace the impacted functions; e.g., a very nice tidal marsh was created for non-tidal forested wetlands impacts. While both have wildlife functions, they provide forage and habitat for very different species.

In this study, 60 mitigation sites were evaluated using the same protocols and standards. This allowed for examination of a variety of compensatory mitigation projects with regard to age, size, wetland type impacted, wetland type proposed, state, landscape position, and land use. Some mitigation sites were indistinguishable from adjacent wetlands. Others appeared as scars in the landscape, oddities that did not belong in those locations. Some were tidal marshes, fringes of golf course ponds, fields, detention basins, and scrub. There were 324.12 acres of wetland restoration and creation as compensation for 352.31 acres of wetland impact. In addition to the net loss in wetland acreage, the impacts and mitigation yielded further loss of functions as complex forested systems were replaced by open water and emergent systems. Degradation of mitigation site functions resulted from adjacent land uses, improper hydrology, invasive plant species, cultivars, and inadequate maintenance and protective measures.

In summary, compensatory mitigation is expected to replace the lost current and future functions of impacted wetlands. It is important to keep that goal in mind when reviewing, approving, monitoring, and tracking mitigation projects. Improvements in compensatory mitigation and fully replacing functions lost to authorized impacts are first dependent upon adequate data management. Not only must the information be complete, but it must be retained and accessible. All mitigation site locations should be properly mapped and identified, and directions to the sites are helpful. The information should allow these sites to be easily locatable by anyone who has not been to the site. Information on quality, type, and functions and values of impacted resources must be thorough. Design , assessment, and monitoring of appropriate mitigation are contingent upon this. Mitigation plans should be retained and tracking of all mitigation project information complete. It often requires several years for development of even rudimentary wetland functions, so this information is necessary for determining programmatic success.

Development and approval of compensatory mitigation should concentrate on identifying and replacing the functions proposed to be impacted. It is important to understand the wetland systems and the functions being impacted to determine appropriate mitigation. This understanding has improved considerably over the years and emphasis on soil organic matter, coarse woody debris, and local plant genotypes in modern mitigation plans has reflected this understanding. Mitigation should be designed to replace the impacted wetlands as closely as possible to compensate for the lost impacts. In order to fully, or even approximately, replace lost functions, increased quality and quantity efforts should be considered. This is especially important for mitigating impacts to systems which entail large temporal losses in function, e.g., forested wetlands.

Literature Cited

Bedford, B. 1996. The need to define hydrologic equivalence at the landscape scale for freshwater wetland mitigation. Ecological Applications 6(1):57-68.

Breaux, A. and F. Serefiddin (1999). Validity of performance criteria and a tentative model for regulatory use in compensatory wetland mitigation permitting. Environmental Management 24(3):327-336.

Brinson, M. M. 1993. A hydrogeomorphic classification for wetlands. U.S. Army Engineer Waterways Experiment Station, Technical Report WRP-DE-4. Vicksburg, MS.

Brinson, M.M. and R. Rheinhardt. 1996. The role of reference wetlands in functional assessment and mitigation. Ecological Applications 6(1):69-76.

Brown, S. and P.L.M. Veneman. 2001. Effectiveness of compensatory wetland mitigation in Massachusetts, USA. Wetlands 21(4):508-518.

Cavallaro, L.M. and F.C. Golet. 2002. Outcome of freshwater restorations ordered by the RIDEM Office of Compliance and Inspection. University of Rhode Island. Kingston, RI.

Chase, V. and V. Davis. 1997. Evaluation of wetland mitigation in New Hampshire. Audubon Society of New Hampshire.

Cole, C.A. and D. Shafer. 2002. Section 404 wetland mitigation and permit success criteria in Pennsylvania, USA, 1986-1999. Environmental Management 30:508-515.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T LaRoe. 1979. Classification of wetlands and deepwater habitats. Office of Biological Services, U.S. Fish and Wildlife Service. FWS/OBS-79/31. Washington, DC.

Dahl, T.E. 2000. Status and trends of wetlands in the conterminous United States 1986 to 1997. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C. 82 pp.

Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual, Technical Report Y-87-1. U.S. Army Engineer Waterways Experiment Station. Vicksburg, MS.

Gaudet, J. 1999. Mitigation survey. New England District, U.S. Army Corps of Engineers. Concord, MA.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. New York Botanical Garden. Bronx, NY. 910 pp.

Johnson, P.A., D.L. Mock, E.J. Teachout, and A. McMillan. 2000. Washington state wetland mitigation evaluation study. Washington State Department of Ecology. Publication No. 00-06-016. Olympia, WA.

Kourtev, P.S., J.G. Ehrenfeld, and M. Haggblom. 2002. Exotic plant species alter the microbial community structure and function in the soil. Ecology 83(11):3152-3166.

Lockwood, J.L. and S.L. Pimm. 1999. When does restoration succeed? Pages 338-362. *In* E. Weiher and P. A. Keddy, eds. Ecological Assembly Rules: Perspectives, Advances, Retreats. Cambridge University Press. New York, NY.

Matthews, G.A. and T.J. Minello. 1994. Technology and success in restoration creation, and enhancement of *Spartina alterniflora* marshes in the United States. Vol. 1. – Executive summary and annotated bibliography. NOAA Coastal Ocean Program decision Analysis Series No. 2 NOAA Coastal Ocean Office, Silver Spring, MD.

Mitsch, W.J., R.F. Wilson. 1996. Improving the success of wetland creation and restoration with know-how, time, and self design. Ecological Applications 6(1):77-83.

Morgan, K.L. and T.H. Roberts. 1999. An assessment of wetland mitigation in Tennessee. Tennessee Technological University. Cookeville, TN.

National Research Council. 2001. Compensating for Wetland Losses Under the Clean Water Act. National Academy Press. Washington, DC. 322 pp.

New Jersey Department of Environmental Protection. 2002. Creating indicators of wetland status (quantity and quality): freshwater wetland mitigation in New Jersey. Trenton, NJ.

Race, M.S. and M.S. Fonseca. 1996. Fixing compensatory mitigation: what will it take? Ecological Applications 6(1):94-101.

Smigelski, F. 1996. A survey of wetland mitigation sites in New England (draft). New England Division, U.S. Army Corps of Engineers. Waltham, MA.

Stolt, Mark H., Michael H. Genther, W. Lee Daniels, Velva A. Groover, Steven Nagle and Katie Haering. Comparison of soil and other environmental conditions in constructed and adjacent palustrine reference wetlands. Wetlands 20(4):671-683.

U.S. Army Corps of Engineers. 2002. Guidance on compensatory mitigation projects for aquatic resource impacts under the Corps Regulatory Program pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899. Regulatory Guidance Letter No. 02-2.

U.S. Army Corps of Engineers. 2001. Guidance for the establishment and maintenance compensatory mitigation projects under the Corps Regulatory Program pursuant to Section 404(a) of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899. Regulatory Guidance Letter No. 01-1.

U.S. Army Corps of Engineers. 1999. The highway methodology workbook supplement. New England District, U.S. Army Corps of Engineers. NAEEP-360-1-30a. Concord, MA.

Utah Division of Wildlife Resources. 2001. Assessment of Section 404 compensatory mitigation compliance in northern Utah. Salt Lake City, UT.

Wetland Science Institute. 1999. Noxious, invasive, and alien plant species: a challenge in wetland restoration & enhancement. USGS Patuxent Wildlife Research Center. Laurel, MD.

Whigham, D.F. 1999. Ecological issues related to wetland preservation, restoration, creation and assessment. The Science of the Total Environment 240:31-40.

Zedler, J.B. 1996. Ecological issues in wetland mitigation: an introduction to the forum. Ecological Applications 6(1):33-37.