Towards a National Evaluation of Compensatory Mitigation Sites: A Proposed Study Methodology

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Abstract
Each year more than 40,000 acres of wetlands are restored, established, enhanced, and preserved to compensate for the approximately 20,000 acres of losses permitted through the federal wetlands regulatory program. Nationwide, an estimated $2.9 billion is spent annually on these compensatory mitigation projects. However, it is not clear whether this significant investment in compensation yields projects that are effectively replacing lost wetlands. State and regional studies on wetland compensatory mitigation suggest that a significant proportion of compensation sites are failing to meet administrative and ecological performance standards. In response, some studies have suggested that consolidating mitigation at fewer larger mitigation banks may help improve overall mitigation success; however, this assertion has never been rigorously tested. A national study is needed to comprehensively evaluate compensatory mitigation. Here we present a protocol, developed by a team of wetland experts, to assess the ecological outcomes of the three compensatory mitigation mechanisms – mitigation banking, in-lieu fee mitigation, and permittee-responsible mitigation – in a manner that will enable comparisons of the three mechanisms nationwide. The design is also meant to help establish a protocol for the on-going national assessment of mitigation sites.

Introduction

Section 404 of the federal Clean Water Act (33 U.S.C. §1344) regulates the discharge of dredge and fill material in waters of the U.S. – including wetlands and other aquatic resources. The program is carried out by the U.S. Army Corps of Engineers' (Corps), with oversight from the U.S. Environmental Protection Agency (EPA). Day-to-day permitting activities are carried out by the Corps' 38 district offices, while EPA has responsibility for enforcement and for development of the environmental criteria by which the Corps evaluates permit applications.

The §404 regulatory program is guided by two national goals, 1) the stated purpose of the Clean Water Act (33 U.S.C. §1251) which is to restore and maintain the "chemical, physical, and biological integrity of the Nation's waters," and 2) the national goal, set in 1989 by President Bush of "no net loss" of wetlands.[1] The basic premise of the regulatory program is that no discharge may be permitted if there is a practicable alternative that is less damaging to the environment, or the discharge would cause significant degradation to the Nation's waters. Before the Corps will issue a permit for an impact, the permittee must first demonstrate that steps have been taken to avoid impacts, that potential impacts have been minimized, and that compensation will be provided for all remaining unavoidable impacts. This three-part mitigation sequence – avoid, minimize, compensate – guides the agencies' compensatory mitigation decision-making.

Each year the Corps permits an estimated 20,000 acres of wetland losses (Martin et al. 2006). Permittees are required to restore, enhance, establish, or preserve more than 40,000 acres of wetlands or other aquatic resources to compensate for the permitted losses (USEPA 2011a). Aquatic resource compensation is accomplished through one of four methods: restoration, enhancement, preservation, and establishment (see Table 1). These methods vary with respect to the replacement of lost acres and functions and, therefore, how well they contribute to the no net loss goal. The agencies have a stated preference for restoration because it is seen as the method with the greatest potential to replace lost area and functions (33 CFR 332.3(a)(2)). Establishment (often referred to as creation), on the other hand, can also replace lost acres and functions, but its use has declined in recent years because of concerns over high failure rates. Enhancement offers functional improvements, but does not replace lost acres. And, preservation of intact aquatic resources does not replace lost acres and functions, and therefore does not directly contribute to the no net loss goal, but it can contribute to the maintenance of wetland types and locations (i.e., the landscape profile (Bedford 1996)) in the watershed and can improve overall function at the watershed scale. Compensatory mitigation regulations state that

[1] In 1990 the Corps and EPA clarified this goal as "no overall net loss of values and functions" in the 1990 Memorandum of Agreement between the Department of the Army and the Environmental Protection Agency entiltled: *The Determination of Mitigation Under the Clean Water Act Section 404(b)(1) Guidelines*. *Available at* http://water.epa.gov/lawsregs/guidance/wetlands/mitigate.cfm

preservation should be used on a limited basis only when certain prescribed circumstances are met (33 CFR 332.3(h)). In general, most compensation projects include a combination of methods. This can include “the establishment, enhancement, and preservation, as well as the maintenance, of riparian areas and/or buffers,” which may also be used as part of a mitigation plan in conjunction with one of the four methods described above.

There are three primary mechanisms that permittees can use to satisfy compensatory mitigation requirements, including purchasing credits from a mitigation bank (MB)**,** making a payment to an in-lieu fee (ILF) sponsor, or performing project-specific or permittee-responsible mitigation (PRM) (Table 1). Mitigation banking and in-lieu fee mitigation are referred to as “third party” mitigation because, upon purchasing MB or ILF credits, responsibility for completing the compensatory mitigation project and ensuring its success transfers from the permittee to a third party (e.g., mitigation banker or in-lieu fee program sponsor). Historically, most of the nationwide demand for mitigation has been satisfied through permittee-responsible compensation (Environmental Law Institute 2006). The use of mitigation banks, however, began as far back as 1982 and has expanded in recent years. As of 2010, about 26 percent of compensation was accomplished through banking annually (EPA 2011). The use of ILF began in the 1990s and accounted for around 7 percent of the annual compensation in 2010 (EPA 2011).

Table 1. Regulatory definitions of the 3 primary mitigation mechanisms and 4 mitigation methods (33 CFR pt. 332).

Mitigation Mechanisms

- **Permittee-responsible mitigation (PRM)** is “an aquatic resource restoration, establishment, enhancement and/or preservation activity undertaken by the permittee (or an authorized agent or contractor) to provide compensatory mitigation for which the permittee retains full responsibility.”
- **Mitigation Banking (MB)**. A mitigation bank is a “site or suite of sites, where resources (e.g., wetlands, streams, riparian areas) are restored, established, enhanced, and/or preserved for the purpose of providing compensatory mitigation for impacts. In general, a mitigation bank sells compensatory mitigation credits to permittees whose obligation to provide compensatory mitigation is then transferred to the mitigation bank sponsor. The operation and use of a mitigation bank are governed by a mitigation banking instrument.”
- **In-Lieu Fee Mitigation (ILF)**. An in-lieu fee program is a “program involving the restoration, establishment, enhancement, and/or preservation of aquatic resources through

funds paid to a governmental or non-profit natural resource management entity to satisfy compensatory mitigation requirements for DA permits. Similar to a mitigation bank, an in-lieu fee program sells compensatory mitigation credits to permittees whose obligation to provide compensatory mitigation is then transferred to the in-lieu program sponsor. However, the rules governing the operation and use of in-lieu fee programs are somewhat different from the rules governing operation and use of mitigation banks. The operation and use of an in-lieu fee program are governed by an in-lieu fee program instrument."

Mitigation Methods

- **Restoration**. Restoration is the "manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded aquatic resource." Generally, restoration results in a gain of aquatic resource area and function.
- **Establishment.** Establishment is the "manipulation of the physical, chemical, or biological characteristics present to develop an aquatic resource that did not previously exist at an upland site. Sometimes referred to as wetland creations, establishment results in a gain of aquatic resource area and functions."
- **Enhancement.** Enhancement is "the manipulation of the physical, chemical, or biological characteristics of an aquatic resource to heighten, intensify, or improve a specific aquatic resource function(s). Enhancement results in the gain of selected aquatic resource function(s), but may also lead to a decline in other aquatic resource function(s). Enhancement does not result in a gain of aquatic resource area."
- **Preservation.** Preservation is the "removal of a threat to, or preventing the decline of, aquatic resources by an action in or near those aquatic resources. This term includes activities commonly associated with the protection and maintenance of aquatic resources through the implementation of appropriate legal and physical mechanisms. Preservation does not result in a gain of aquatic resource acres or functions."

State and regional studies on wetland compensatory mitigation suggest that a significant proportion of compensation sites are failing to meet administrative (permit) and ecological performance standards (Kihslinger 2008). For example, the National Academy of Sciences found that only 34 percent of the compensation required in permits (by acreage) was ever implemented on the ground (NRC 2001). Another 2001 review showed that completed compensation projects (primarily PRM wetland creation projects) showed only about 20% equivalency to the wetlands that had been lost (Turner et al. 2001). Further, administrative compliance does not appear to be an accurate indicator of ecological success. Meeting permit standards does not necessarily mean that the project will yield a regulatory wetland or provide wetlands equivalent to those lost at the impact site (Ambrose et al. 2007, FDER 1991). In some instances this may be due to permit standards that are poorly crafted and are not sufficient to reach the desired ecological outcome.

In 2008, the Corps and EPA jointly released regulations on compensatory mitigation under §404 of the Clean Water Act (33 CFR Parts 325 and 332 and 40 CFR Part 230 Subpart J). The new rule is intended to improve the planning, implementation, and management of compensatory mitigation by creating higher standards for compensatory mitigation, and requiring to the extent practicable and appropriate that all mitigation decisions be made within the context of a watershed approach (33 CFR 332.3(c)(1)). The reliance on a watershed approach, a clear hierarchy in the preference for which mitigation mechanism should be used to offset impacts (see below), and the establishment of equivalent standards for all three mitigation mechanisms are the three fundamental changes in compensatory mitigation practice.

Under the new rule, the preferred hierarchy for permittees to meet their compensatory mitigation obligations is mitigation bank credits, then in-lieu-fee program credits, then permittee-responsible mitigation under a watershed approach, permittee-responsible mitigation through on-site and in-kind mitigation, and finally permittee-responsible mitigation through off-site and/or out-of-kind mitigation. There are a variety of reasons for this new hierarchy, including an assumption that mitigation banks and in-lieu-fee programs "usually involve consolidating compensatory mitigation projects where ecologically appropriate, consolidating resources, providing financial planning and scientific expertise …, reducing temporal losses of functions, and reducing uncertainty over project success" (33 CFR 332.93(a)(1)). It also recognizes the fact that under the rule mitigation bank and in-lieu fee credits may be released in phases as specified performance targets are met, thereby reducing time lag between the loss of aquatic resources caused by permitted impacts and the replacement of aquatic resources at the compensation site. By contrast, PRM projects are typically implemented at the same time or after the wetland impact occurs, so the link between mitigation performance and wetland loss is more tenuous.

Nearly all studies of compensatory mitigation to date have concentrated on permittee-responsible wetland creation projects and their performance (Bishel-Machung et al. 1996, Zedler 1996, NRC 2001, Brooks et al. 2005, Fennessy et al. 2008). However, few scientific studies have tested the assumptions upon which the mitigation hierarchy is based. A 2006 Ohio Environmental Protection Agency study, the first comprehensive statewide assessment of the ecological effectiveness of banks, for example, found that only a small proportion of bank sites analyzed in the state (25 percent) were “mostly successful,” while the remaining banks were “successful in some areas but failed in others” or “mostly failed” (Mack and Micacchion 2006). Another study from Florida found that of the 29 banks evaluated, 70 percent fell within the moderate to optimal range of function (Reiss et al. 2007).

A national study of all three forms of mitigation – mitigation banking, in-lieu fee mitigation, and permittee-responsible mitigation – is needed to evaluate the ecological performance of compensatory mitigation and to allow for a comparison of these three mitigation mechanisms. There has been no consistent approach, methodology or effort at the national scale to assess the performance of mitigation, nor have essential study elements been described for comparing the three mitigation mechanisms. The lack of data on the condition of the impact sites (where wetland losses were permitted) precludes a study comparing mitigation sites to impacted sites and thus an evaluation of no net loss. Instead, we propose a scientifically valid assessment of mitigation practices in the U.S. and present a protocol for evaluating the ecological outcomes of the three compensatory mitigation mechanisms. The study design presented here will help answer the following questions:

- What is the ecological condition of wetland mitigation sites relative to both ambient wetland condition (ambient condition represents wetlands across the full range of human disturbance, i.e., from most disturbed to least-disturbed) and to reference wetlands (which are sometimes called ‘reference-standard’ sites, and are defined as the least disturbed condition). We will refer to them simply as reference sites (see Stoddard et al. (2006) for a discussion of definitions of reference condition and related implications of their use). We define ecological condition as the relative ability of a wetland to support and maintain its complexity and capacity for self-organization with respect to species composition, physico-chemical characteristics and functional processes as compared to wetlands of a similar class that are least disturbed by human alterations (Karr and Dudley 1981). Condition will be assessed using previously developed methods based on vegetation communities, soils and hydrology (e.g., Lopez and Fennessy 2002, Wardrop et al. 2007, Johnston et al. 2009, USEPA 2011b). The areal extent of each study wetland will be determined using the 1987 Corps of Engineers Wetland Delineation Manual and its appropriate regional supplements.

- Does the condition of mitigation sites vary with mitigation mechanism (mitigation banking, in-lieu fee mitigation, permittee-responsible mitigation)? We will evaluate the relative performance of the mitigation mechanisms by comparing their condition with the range of ambient and reference conditions of naturally occurring wetlands of the same type in the same region. This will allow us to determine where, along the full range of condition of natural wetlands, do the mitigation projects fall. It may also provide insight into which factors contribute to the successful performance of mitigation projects.
- Does the condition of a mitigation wetland vary with mitigation method (restoration, establishment, enhancement, preservation)?

Relation to USEPA's National Wetland Condition Assessment

Our approach to site selection and sampling will allow us to apply field methods developed for the National Wetland Condition Assessment (NWCA) (Scozzafava et al. 2007, Scozzafava 2009) and to compare the results from this study (both Pilot and National) to the results of the NWCA. The NWCA involves data collection at 900 randomly selected wetland locations (to capture the full range of ambient condition) and a minimum of 100 hand-picked candidate reference sites targeted to represent the least-disturbed wetlands across the nation. This will provide data for comparison, organized by regions and wetland class for sites that span the full range of ecological condition (most to least disturbed). Benefits of conducting our survey of compensatory mitigation in cooperation with the NWCA include the ability to:

- utilize the network of reference sites being developed for the NWCA,
- capitalize on the efforts of the NWCA to develop sampling, logistics and data analysis protocols,
- build on the efforts of the NWCA to develop capacity in state and tribal wetland programs, and
- interpret the results of the mitigation study relative to overall wetland condition. This will provide context for interpreting the results of this study.

Study Methodology

The lack of data on the condition of the impact sites (where wetland losses were permitted) precludes a study comparing mitigation sites to impacted sites and thus an evaluation of no net loss. Instead, we propose a scientifically valid assessment of mitigation practices in the U.S. and present a protocol for evaluating the ecological outcomes of the three compensatory mitigation mechanisms. To account for current limitations in nationwide data, the study is designed to be conducted in two phases: a Pilot Study phase and a National Study phase. The Pilot Study will be conducted in relatively data-rich states (or Corps Districts) and will allow the methodology to be tested in various locations. The National Study phase is designed to complement the National NWCA. Linking the two efforts will greatly increase the efficiency and completeness of the mitigation assessment by leveraging both field assessment protocols and data collected as part of the NWCA.

Survey Design and Site Selection

Site selection protocols are designed with the goal of selecting representative sites of each mitigation type. This will allow an evaluation of the ecological success of compensation both through a Pilot Study phase and as part of a long-term National Study. The proposed sampling design will allow us to report the results as estimates of the proportion by area by mitigation mechanism that meet desired ecological outcomes with a known level of confidence, as such this study design does not evaluate the success or failure of specific mitigation projects/sites. The study will operate under the assumption that the permitted wetland impacts, for which mitigation was required, took place as planned, and that information on the condition of the impacted site is not available (which is nearly always the case). Furthermore, comparing ecological condition at mitigation sites to ambient and reference condition allows an assessment of the relative performance of various mitigation strategies independent of the impacts for which they are mitigating. Although a comparison of impacts (losses) to mitigation (gains) is important, the lack of data on the condition of impacted sites necessary to answer this question limits its use as a study goal. Comparing the condition of impacted sites to mitigation sites would require a different experimental design.

The Pilot Study will involve sampling 50 sites per mitigation mechanism, for a sample size of 150 per region (for example, ecoregion or Corps District) sampled. The EPA's Environmental Monitoring and Assessment Program (EMAP) has arrived at a "rule of thumb" that, absent any information on the variability of what is being measured, 50 sites *per treatment* (in our case mitigation mechanism) provides sufficient statistical power to detect differences between treatments. (See www.epa.gov/nheerl/arm/surdesignfaqs.htm for information on sample size and other monitoring design issues.)

The National Study will include sampling 400 locations per mitigation mechanism, for a sample size of 1200. Again, EMAP's experience in support of USEPA's National Aquatic Resource Surveys recommends that 50 sites *per category per reporting unit (i.e. treatment)* should be assessed to increase the likelihood that the sample will be adequate. In our case, 400 samples per mitigation mechanism will allow for reporting on the data after stratification into as many as eight different categories or subgroups. For example, if mitigation mechanism is the reporting unit then 400 samples could allow for reporting on at least eight subgroups of sites (e.g., PRM could be reported for eight geographic regions). The reporting units considered for EPA's NWCA are wetland type, ecoregion, major river basin, and EPA Region. The design is stratified by wetland type (e.g., U.S. Fish and Wildlife Service Status and Trends classes, or hydrogeomorphic (HGM) class) to ensure that there is adequate representation for reporting. This approach also provides good spatial coverage nationally to allow reporting by geographic unit.

The process of site selection is essentially the same for the Pilot and National studies. The difference is in the definition of the target population (i.e., the total set of wetlands that could be selected for inclusion in the study) and the approach used to develop the sample frame, i.e., the map of the target population that is used to draw the sample. How well the sample frame represents the target population will affect the quality of the estimates made from the data collected in the field. Differences in the definition of the target population and the development of the sample frame in the Pilot and National studies are discussed in the section below, then steps common to both studies are presented in the section on site selection.

Developing the Sample Frame: Which Sites will be Selected?

Pilot Study: The target population in the Pilot Study is composed of the compensatory mitigation projects (PRM, MB, or ILF) that were permitted in 2002 or later and have been determined to be "complete" by the permitting authority (typically the Corps).[2] We define projects to be 'complete' when construction is complete and the agencies have determined that the mitigation requirements (e.g., performance standards) have been met (although some of these sites may still be in the monitoring phase). Note that project age will be tracked and used in the final data analysis.

Site selection for the Pilot Study is complicated both by inconsistencies in record keeping on mitigation projects between regions, and the patchy distribution of the different mechanisms of mitigation across the country. ILF projects account for the smallest proportion of compensatory mitigation projects and so are likely to be the most limiting in terms of site availability. For the Pilot Study, we will identify three states or Corps Districts from around the county that are relatively rich in ILF projects, then MB and PRM projects will be identified in the selected regions.

The three states or Corps Districts chosen for the Pilot Study will be selected based on the completeness and accessibility of their permit records. Only states or Corps Districts for which records can be located in an electronic format will be considered for accessibility (including georeferenced data suitable for use in a GIS from which sample points can be selected; in some cases these data may be derived from the permit records if they are not explicitly presented). The minimum information necessary for developing the sample frame is location of the site and the mitigation mechanism.

[2] We chose to include projects that were permitted in 2002 or later in order to focus on more modern mitigation projects that were permitted after the 2001 publication of the NRC study and the subsequent 2002 adoption of the NRC operational guidelines by the Corps.

National Study: The target population for the National Study is the set of all compensatory mitigation projects identified by mechanism (Table 1) in the contiguous U.S. (not just those with data easily garnered from the Corps).

In developing the sample frame for the National Study, we will face the same constraints of data availability as the Pilot Study; therefore allowances will need to be made to handle poor permit records in many regions. The Corps of Engineers is implementing an automated information system, the Operations Management Business Information Link (OMBIL) Regulatory Module (ORM), which in conjunction with a linked GIS system, will be used to track permits and assist in the evaluation of projects. Ideally, ORM could be used to identify candidate sites and populate the sample frame. Until the time that ORM is fully implemented, we will need to rely on the existing records of the states and Corps Districts. As with the pilot study, the minimum information necessary for developing the sample frame for the national study is location of the site and the mitigation mechanism.

Previous studies have shown that the process of locating necessary project information, and making contact with the applicant, consultant and/or property owner can be extremely time consuming (Sudol and Ambrose 2002, Kettlewell 2005, Ambrose and Lee 2004 a, b, Ambrose et al. 2007). Time and resources must be built into the project design to allow for data collection from permits to be completed. Coordination with the Corps project managers and other state and federal agency personnel will be important in gaining access and identifying important site information.

Site Selection

As described above, the sample frame for site selection is a map of the target population, with each project identified by mitigation mechanism. Point locations (latitude/longitude coordinates) for the sites to be sampled will be chosen using the Generalized Random Tesselation Stratified (GRTS) survey design for an areal resource developed by EPA’s EMAP (Stevens and Olsen 2004). This method has been widely employed in surveys of aquatic sites, including the NWCA. It provides a geospatially balanced (based on the location of the existing sites), probability sample of the target population. The power of this survey design is that it can be used to produce an unbiased estimate of the performance (with known probability and error rates) of the wetland resource over large geographic areas, despite the relatively small number of samples collected, i.e., 150 samples for each region in the Pilot Study and 1200 for the National Study.

This design also allows for the level of sampling to be increased selectively if desired. For example, states or local agencies might be able to secure additional funds to allow them to increase the sample size in their region to report on the status of mitigation in their locale and increase the sensitivity of the analyses. Data collected under such local intensifications would be available for both local and national assessments.

File Review

After the sites have been selected, the mitigation projects will be assessed in the field (see below). Before this can be accomplished, however, some details about each project must be gathered. Currently the electronic databases of mitigation projects contains minimal information about each project, so it will be necessary to examine the physical (paper) permit file to extract the information needed for field assessments. Many districts (e.g., Norfolk, Jacksonville, New Orleans, New England, and Sacramento) have loaded substantial amounts of project information, including bank or ILF project plans, detailed site boundaries, delineations, specific objectives, monitoring reports, and in some cases design and construction plans, and information on responsible parties in RIBITS (Regulatory In-lieu fee and Bank Information Tracking System). Gathering permit files and organizing the information in them is a time consuming process that may require some or all of the following steps to be completed in each region:

- assemble individual permit information to obtain mitigation plan and permit details,
- contact the applicant and the consulting company if necessary to augment mitigation plan details,
- identify the precise location and areal extent of the project, and
- obtain site access permission from the current landowner.

Files for each of the projects selected for study will need to be examined. Sufficient information must be derived from the site selection process to identify the projects with enough detail so that their physical files can be "pulled." Once the files have been pulled, their contents can be examined. If possible, the relevant information for the files should be copied rather than just examined on site, since inevitably many questions will need to be resolved during the analysis of the file contents. Although the contents of each file will vary depending on the project specifics and local policies, typically each file will contain the §404 permit, including special conditions related to mitigation, a mitigation plan, copies of other permits (e.g., §401 letter, endangered species consultations, and so forth), and possibly post-construction monitoring reports. The permit special conditions and mitigation plan provide the most relevant information for this study.

Although permit files contain the pertinent information, there are two main challenges to compiling this information: (1) acquiring the physical file, and (2) extracting the relevant information from the file. These challenges are discussed below.

Section 404 permits consist of hard (not electronic) copies of the permit documents. The physical files are stored in different locations. Although file information might be available from another agency (such as a water regulatory agency responsible for §401 permitting), the Corps will most likely be the agency with the best, most consistent permit files, especially for a study that encompasses more than one local area. Minimum information necessary to request a file would include the project name (as entered in the Corps database) and general location (such as County). This requirement for locating permit files limits the procedures that can be used to select sites because: 1) permit file databases are typically not linked to GIS (at least until ORM is implemented), and 2) sites cannot be selected based solely on geographic location because there would not be sufficient information to request a permit file. Because some files will inevitably not be located, more files should be requested than will be needed for the study.

Once a permit file is acquired, the relevant information must be extracted from it. The minimum information required would include the mitigation mechanism, the mitigation method, the permit file, the mitigation plan, and any monitoring reports. For bank sites and an increasing number of

ILF project sites this information can be obtained from RIBITS. Conceptually this is quite simple but in practice the volume of information and variability in file organization make this a complex and time-consuming task. A detailed understanding of the site and mitigation activities is necessary for the site assessments. For the field assessments, precise location of the mitigation site (or sites; many mitigation projects are distributed among multiple sites) is needed. This information is most likely presented in the permit itself, but information in the mitigation plan may also be needed to locate the site. The size of the proposed mitigation project must also be determined; again the mitigation plan is likely to be needed for this information.[3] In addition, permission to access the site will be necessary for many sites, and the relevant contact information will be available in the file. The permit files should also be examined to extract the mitigation performance standards, which could be used to collectively analyze the relationship between the types of performance standards utilized and the success of compensation sites. Performance standards are one of the factors that may contribute to the successful performance of mitigation projects. Another important component of the permit review is the acquisition of web-based aerial photographs (e.g., NAIP imagery, Terraserver - http://terraserver.microsoft.com, or Google Earth), which provide landscape context and aid in the location of project sites. Areal photos and maps can also be used to gather information on the position of the project within the watershed. Previous studies (e.g. Ruhl and Salzman 2006) have shown that MBs (for example) tend to result in the redistribution of wetland sites within watersheds, from downstream urban areas to less disturbed rural, upstream watershed positions. Information on landscape variables such as these might prove important in data analysis and interpretation of results. Finally, these photographs can be printed and referenced during the field assessment.

The mitigation plan should provide a description of what was actually done to different portions of the mitigation site. The monitoring and/or progress reports will provide information as to what was actually implemented in the field, so at least the most recent report should be obtained where possible. This information is essential for the field assessment, and will allow a comparison of the size of the mitigation project and the area required in the permit. For

[3] Many districts have loaded the limits of bank sites (and in some cases ILF project sites) in RIBITS. This information can currently be downloaded as kml files. The Corps is currently working to broaden this capability, including adding the ability for users to download shapefiles and associated attribute tables.

example, some mitigation projects include both restoration and preservation elements and information on what was done and where is needed from the mitigation plan so the field assessment can avoid the preservation areas. It may be that necessary information about the mitigation project is not available in the file, and so contact information for the permittee, consultant, and project manager will be valuable for follow-up questions (this may be particularly true for ILF projects). The contact information can also be used to try to confirm that the mitigation project was actually completed before the assessment begins. It is not always possible to confirm the completion of mitigation without a site visit, but it is worth the effort to avoid unproductive and expensive field visits to inaccessible sites. These site assessments will ultimately provide information on the 'as-built' condition.

Site Assessment

<u>Quantitative Site Assessment in the Field</u>

For this study we will adopt a modified version of the National Wetland Condition Assessment Field Operations Manual (NWCA FOM; USEPA 2011) to evaluate the three mechanisms of compensatory mitigation. Indicators will largely follow those used in the NWCA; however, the sample design will be modified to provide an assessment of mitigation wetlands instead of a probabilistic sample of natural wetlands. To minimize sampling bias, we recommend that wetland assessment areas (AA) be established as a fixed area around a randomly selected sampling point (for instance, a 0.5 ha standardized assessment area as was used in the NWCA, which can be defined as the 40 m radius circle around a randomly selected point; see USEPA 2011). All data collection, as described below, is done within the AA. For small projects, such as small sized PRM projects, only one AA will be sampled. In large projects such as banks, it will be necessary to select and sample several. These may be selected by randomly choosing sample points within the site as a whole, or stratifying by differences in vegetation community types (to ensure differing vegetation communities are represented in the sample). The number of AAs that are necessary to adequately characterize a site can be based on the proportion of the overall area that is assessed (e.g., by establishing a minimum percent of the total wetland area that should be sampled), and the variance between the individual AAs. For example, if there is a high variance among the AAs, it suggests that more AAs are needed to capture overall condition in the larger area.

The proposed assessment protocol relies mostly on vegetation, soils, and hydrology, which are the defining features of wetlands and have proved useful for characterizing community structure and ecosystem condition. For example, measurements of vegetation describe habitat structure and provide qualitative measures of plant biomass and biodiversity. Soil properties indicate characteristics of biogeochemical (C, N, P, S) cycles. Measurements of hydrology provide information on water storage, source, and quality. Proposed field measurements are summarized in Table 2. The measurements are comprehensive enough to provide general information describing wetland condition, biological composition, biogeochemical states, and hydrology, but are simple enough to do in a reasonable (1-2 days) amount of time, except for very large sites.

Table 2. Proposed measurements for quantitative field assessment of wetland vegetation, soils and hydrology. See text for details on specific measurements.

Vegetation:

- NWI class
- Cover (by stratum, life form and species)
- Number of species
- Wetland indicator status
- Number of stems (trees)
- Height (by life form, species)

Soils (0-60 cm, characterize by horizon):

- Thickness, color, texture
- Bulk density of clod
- Cation exchange capacity, base cation (Ca, Mg. K, Na), electrical conductivity
- Total organic C, total N, S, P, extractable P

Hydrology:

- Water source
- Water depth
- Areal extent of surface water
- Hydrologic alterations

Jurisdictional status:

- Wetland boundary determination based on observed field indicators of hydrology, hydrophtic vegetation and hydric soils (all three indicators are present when delineated according to the Corps' Manual (1987).

Vegetation: Vegetation will be sampled using five 10 m by 10 m ($100m^2$) plots (USEPA 2011) located within a standardized assessment area (AA), typically 0.5 ha in size. (See USEPA 2011for directions on how to establish the standard plot and details on all sampling methods). More than one assessment area will be required in large sites. In this case, randomly selected points can be selected to encompass the variability within the site. For example, the state of California is assessing large mitigation sites by laying a grid over the site and randomly selecting assessment areas until 30% of the total area has been sampled (CWMW 2009).

In each 100 m^2 vegetation plot, the following data will be collected;

- the National Wetlands Inventory (NWI) class (Cowardin et al. 1979) of the wetland,
- HGM class,
- the presence of all plant species observed in nested $1m^2$ and $10m^2$ quadrats in two corners of each 100 m^2 plot, as well as the $100m^2$ plot as a whole,
- percent cover for all vascular plant species in the 100 m^2 plot and the primary height class to which each species belongs,
- percent cover for all non-vascular plant groups (e.g., bryophytes, lichens, algae)
- percent cover of vascular plants by vertical stratum (submerged aquatic vegetation, floating aquatic vegetation, lianas, vines and epiphytes, and all other vascular vegetation by height class);
- counts of trees by species and diameter class (diameter at breast height, dbh),
- percent cover for live trees by cover class, and
- counts of standing dead trees and snags by diameter class

Vegetation will be classified using the US Fish and Wildlife Service hydrophytic plant list (http://plants.usda.gov/wetland.html) to determine the percentage of hydrophytic vegetation (both by species number and as the percent of vegetated area) and the nativity of each species. Thus, the data will allow calculation of parameters such as the percent native species.

The following ground surface attributes will also be measured

- percent cover of water with no vegetation;
- floating/submerged aquatic vegetation or emergent vegetation;

- depth of standing water;
- percent cover of bare ground that is soil/sediment, gravel/cobble, or rock/boulder;
- percent cover of litter;
- litter depth and type (i.e., sod, coniferous, broadleaf, evergreen, deciduous forb); and
- percent cover of coarse and fine (<5 cm diameter) woody debris.

Soils

Sampling Protocol: Soil sampling will be conducted using soil pits. Four soil pits (60 cm deep) will be established at standardized locations adjacent to the four vegetation plots (described above) that are furthest from the center of the AA (USEPA 2011). A vertical slice of soil will be extracted from each pit to complete a soil profile description for the 0-60 cm depth. The profile will be characterized by describing the horizons characteristics such as soil color (matrix and redoximorphic features) using a Munsell color book (Munsell Color Corporation 1998). Soil texture is measured in the field as a prerequisite for determining hydric soil field indicators (U.S. Department of Agriculture 2010; http://soils.usda.gov/use/hydric/). This process will be repeated until four pits have been dug. In soils where standing water or high ground water is present (within 60 cm of the surface), alternate sampling methods such as augers, may be used to sample to a depth of 60 cm, or as close to that depth as possible (USEPA 2011).

The soil pit deemed most representative of the site will be further excavated to a depth of 125 cm. Samples will be collected from each horizon greater than 8 cm thick (O, A, E, B, C, L, R) and placed in labeled plastic bags. Samples will then be sent to a laboratory for measurement of soil physical and chemical properties (see below). Bulk density will also be determined for cores of a known volume.

Regardless of the sampling method used, soil samples from each horizon will be analyzed for particle size (sand, silt, clay), cation exchange capacity and base cations (Ca, Mg, K, Na), electrical conductivity, total organic C, total N, P and S and extractable P. Soil analyses will follow the protocols developed in consultation with the USDA NRCS Soil Survey Laboratory in Lincoln, Nebraska. Where appropriate, soils can be analyzed for selected metals to test for contamination.

Hydrology

Measurements of hydrology will include water source(s), depth and area, as well as the Corp's hydrology indicators drawn from the regional supplements to the Corps delineation manual (USACoE 2009, as described in USEPA 2011). The depth of any ditches within the AA will be assessed. Source(s) of surface water and connectivity to other aquatic ecosystems can be inferred by surveying the wetland, looking for inlets and outlets and recording their number and size. Groundwater input may be evaluated by field measurements of pH and electrical conductivity of surface water, as well as observable field characteristics such as iron-oxidizing bacteria/fungus (Fairfax County 2003). This is especially useful in wetlands underlain by limestone or calcareous soils. Depth to groundwater is determined in the soil pits as described in the *Soils* section.

Any hydrologic alterations to the wetland will also be documented by conducting the USA-Rapid Assessment Method (USA-RAM) developed for the NWCA, including a metric that describes hydrologic stressors (Collins and Fennessy 2011). This entails surveying for the presence of hydrologic stressors such as ditches, dikes, dams, berms, fill material, and water control structures such as culverts, gates, and risers. USA-RAM will also provide information on other stressors, such as those to water quality, the substrate, and vegetation.

Wetland Status

Whether or not the site meets the Corps definition of wetland will be determined based on hydrophytic vegetation data and field indicators of hydric soils and hydrology data collected previously. The three-parameter rule outlined in the appropriate regional supplement to the U.S. Army Corps of Engineers Wetland Delineation manual (1987) will be used to determine whether (and where) wetland hydrology, hydrophytic vegetation, and hydric soils exist at the site.

Wetland Size

For most mitigation projects, one or more of the permit criteria will relate to the area of mitigation required. This can be assessed by mapping the perimeter of the mitigation site using a GPS. If the project consists of multiple mitigation sites, each discrete site must be surveyed and evaluated separately. In practice, the mitigation boundaries are often not obvious, so considerable effort using all possible information sources (mitigation plan, aerial photographs, monitoring reports, on-site signs such as irrigation pipes or planting stakes) may be necessary to generate the best estimate of the wetland boundaries so that area can be estimated.

Reference Sites

Least-disturbed reference sites across the Nation were sampled as part of the NWCA. Reference sites will come from two sources. A certain percentage of the randomly picked NWCA probability sites will be of reference quality (as determined by comparison to hand picked reference sites). Based on previous national aquatic resource surveys, we expect about 20% of the probability sites (~200 sites) to qualify as reference sites (Herlihy et al., 2008). In addition, more than 100 hand-picked candidate reference sites were sampled along with the probability sites as part of the overall NWCA. Thus, there will be about 300-400 reference sites available from the NWCA to serve as benchmarks for least-disturbed wetland condition in this study. This will provide data to compare the ecological condition of mitigation wetlands.

Data Analysis

For both the Pilot and National studies, wetland condition metrics will be analyzed to answer four main questions:

- Is condition in mitigated sites different than least-disturbed reference condition?
- How does the condition of mitigated sites compare to the current ambient population of wetlands?
- Does the condition of mitigated sites differ as a function of the three mitigation *mechanisms* (PRM, MB, ILF)?
- Does the condition of mitigated sites differ as a function of the four mitigation *methods* (restoration, establishment, enhancement, preservation)?

Ambient condition will be defined from the randomly drawn (probability) sites analyzed by the NWCA. The NWCA will use a reference-based approach to assess wetland quality nationally and regionally. Survey data will be compared to data from high quality, reference sites, as well as to the range of ambient condition for wetlands of similar type and geographic region. Ultimately, the data will be combined and summarized in a variety of ways, with a particular focus on the development of Multi-Metric Indices (MMI). A MMI summarizes various wetland attributes or metrics into one score or index (Karr and Chu 1999). This index is then used to place wetlands into broad condition categories. The MMIs derived from the NWCA data analysis effort will be available for use in this study. Stressor data, derived primarily from a rapid assessment method designed for the NWCA, the USA-RAM (Collins and Fennessy 2011), will be reported based on how commonly stressors were observed and how severely they impact NWCA sample sites. The final results will be aggregated to describe the condition of wetlands by type across the Nation and in regions where a statistically significant number of sites were sampled.

As a first step in data analysis, box and whisker plots will be made to show the distribution of each condition metric score by treatment group (Ambient, Reference, PRM, MB, and ILF). In these plots, the boxes show the median and interquartile range and the whiskers the minimum and maximum values. Visually, these plots display distributions of wetland condition scores among the different treatments. Overall project performance might be judged to be acceptable, for example, if the range of scores for that group (PRM, MB, ILF) falls above the 25th percentile of the ambient condition group. Data will be tested to determine if they meet assumptions for analysis of variance or if transformations are needed. If data are suitable, metric scores will be analyzed statistically for differences among treatments. The analysis will be done nationally as well as within subpopulations of interest where sample size is large enough to conduct the analysis.

Besides the use of plant-based MMIs derived from the NWCA, plant species abundance data will also be analyzed by multivariate methods that assess similarity between all pairs of sites, resulting in a site-by site-similarity matrix. Ordination of the sites will be done using non-metric multidimensional scaling (NMS) to identify major patterns in the community data. The patterns as quantified in the NMS axis scores will be used to identify if there are any signs of treatment effects (e.g., mitigation vs. ambient, PRM vs. MB). Group treatment effects in the community similarity data will be tested using the multi-response permutation procedure (MRPP) and permutation-based nonparametric multivariate analysis of variance (PerMANOVA).

Data Compilation and Reporting

The primary goal of this study is to provide a snapshot of the ecological effectiveness of the various forms of compensatory mitigation. In addition, we encourage further analyses of compensation sites, to inform decisions about essential indicators of performance, provide background data to support development and implementation of appropriate rapid performance monitoring protocols, provide feedback to improve the performance of mitigation overall, and ensure national data compilation to provide scientists, managers, and regulators with the status of compensatory mitigation in the U.S. over time. Partnerships among state and federal agencies will be needed to ensure effective data sharing and to build capacity at the local level for ongoing data management.

To allow objective comparisons, all of the resulting data will be submitted in a nationally-consistent reporting framework. ORM is an appropriate structure for storing these data, but it is unclear whether or not this database will be made available to the public.

The National Wetland Condition Assessment is also developing standardized databases and archive protocols that could be used to manage and store data collected through this study. All NWCA data will be archived in the EPA's agency-wide Water Quality Exchange (WQX) data management system. Further, the data generated from this study could be incorporated into the NWCA reports that will be made available to Congress, local, state, and federal agencies; universities, environmental organizations, and the public.

Conclusion

The methodology outlined here is intended to lay the groundwork for undertaking a comprehensive national study of the ecological performance of compensatory mitigation. Once the study is completed the results can be used to improve mitigation practices, both as a function of mitigation method and mitigation mechanism. It is our intent that this national study will be conducted in cooperation with the National Wetland Condition Assessment to be conducted by EPA. This methodology was written by a panel of wetland experts and was reviewed by representatives from federal, state and local wetland agencies, mitigation providers such as MB and ILF sponsors, environmental interests, and others to ensure its feasibility and efficiency. The study methodology is designed to allow qualified environmental professionals to conduct objective, comparable assessments of compensatory mitigation project performance in any district, region, or state. While some portions of the study outlined here are specific to this study's goals (for example determining the sample frame), most aspects of the protocol could be readily adapted in other assessments (for example at the state, district, or watershed level). Future studies that employ this protocol would also benefit from use of the NWCA and national study data for context. Building a set of consistently collected wetland mitigation assessment data over time could provide extremely valuable information for improving mitigation practice in the nation.

The study methodology is designed to compare the three compensatory mitigation mechanisms – mitigation banking, in-lieu fee mitigation, and permittee-responsible mitigation. The site selection protocol also allows for other comparisons such as the assessment of compensatory mitigation within and across geographic regions; within and across time frames, and within aquatic resource categories. For example, policy makers may be interested in whether ecological performance (relative to reference condition) varies between more recent contemporary compensation sites and sites constructed in the mid-1990s when the practice of compensatory mitigation was relatively young. Although this protocol is not designed to specifically test these variables, a large sample size would allow researchers to answer this question, and the sampling effort can be increased where there is interest. For example, states or local agencies might be able to secure additional funds to allow them to increase the sample size in their region to make additional comparisons.

This study, and any subsequent studies employing its methodology, will yield information to help policy makers assess current policies and guidelines. Its results can be used to help ensure that the ecological goals of the mitigation program are being met, and aid in developing more effective performance standards and adaptive management prescriptions. This will improve the design of mitigation sites and help ensure that the intent of the §404 program is met.

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