Compensatory Mitigation: Success Rates, Causes of Failure, and Future Directions

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Introduction

Objectives

The objectives of this paper are to present the efficacy of compensatory mitigation, the short-comings of successful mitigation, and future directions in mitigation policy and technical application of mitigation tools.

Background

The greatest losses to wetland ecosystems have occurred in emergent and forested freshwater wetlands, losing 4.6 and 2.3 percent of their respective areas between 1986 and 1997 (Dahl, 2000). In contrast, there was an increase of open water systems by 13.0 percent during this same time period. Likewise, between 2004 and 2009 wetland losses outdistanced wetland gains (Dahl, 2011). Freshwater ponds continued to increase during the evaluation period. Because wetland acreage losses outpaced gains, mitigation, reestablishment, or creation of wetlands has not been "in-kind" to replace wetland class or area.

Even though there was a gain in freshwater wetlands overall, it was negated by the loss in freshwater forested wetlands. The cumulative effects of losses in freshwater wetlands have had consequences for hydrologic and ecosystem connectivity. The effect has resulted in habitat loss, fragmentation, and limited opportunities for reestablishment and watershed rehabilitation. Hydrologic disconnection influences how wetlands function as landscape components and may require re-evaluation of wetland protection, conservation, mitigation, and reestablishment programs in specific watersheds or physiographic settings.

Success of Wetland Mitigation. The U.S. Army Corps of Engineers (ACE), the U.S. Environmental Protection Agency (EPA), state agencies, and various non-government organizations have been concerned in regards to the success and effectiveness of compensatory mitigation as required through the Clean Water Act, Section 404 permit program. The National Academy of Sciences' National Research Council (NRC) recognized this problem and identified numerous weaknesses in the mitigation aspects of the ACE program (NRC, 2001). Consequently, over the past several years, considerable time has been devoted to address this concern.

Intensive studies examining the effectiveness of state-required wetlands compensatory mitigation have been conducted in several states including Washington, New Jersey, Ohio, Pennsylvania, Tennessee, Utah, New Hampshire, Rhode Island, Massachusetts, and New England.

Washington. In Washington State, 71 percent wetland compensatory mitigation projects were failing to meet basic permit requirements (Johnson, et al., 2000). In addition, only 65% of the total acreage of wetlands lost was replaced by wetland creation or restoration of new wetland area and only 63% of projects were at least partially compensating for the permitted wetland losses.

New Jersey[1]. The results of an investigation conducted by the New Jersey Department of Environmental Protection found that the success of freshwater wetland mitigation ranged from 0 to 140%, the average was 45% (NJDEP, 2002). Consequently, only 0.45 acres for each acre of mitigation proposed was successful restored. Mitigation of forested wetlands received was least successful with only an average compensation ratio of 0.01:1.

Ohio. Mitigation banks have not faired better than direct compensatory mitigation (e.g., on-site, in-kind). A study in Ohio, found that, out of twelve mitigation banks, only three were "mostly successful," five were "successful in some areas but failed in other areas," and four were "mostly failed" (Pruitt, 2010).

Pennsylvania. An investigation of 23 mitigation projects in Pennsylvania concluded that only about 60% of the mitigation wetlands met their originally-defined success criteria, some after more than 10 years (Cole and Shafer, 2002).

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[1] Pursuant to the Clean Water Act, New Jersey along with Michigan and Florida are the only states that have assumed the Section 404 permitting process for non-Section 10 waters (see Pruitt, Winter 2010 issue of the State Bar of Georgia, Environmental Law Section).

Tennessee. In Tennessee, out of 93.4 acres of wetlands displaced in the study sample, 82.3 acres were replaced, yielding a ratio of wetland acreage replaced to that lost through the permitting process of approximately 0.88:1 (Morgan and Roberts, 1999).

Utah. In Utah, 15% of mitigation projects examined did not meet minimum wetland criteria. Furthermore, of the remaining sites, many were small depressions located adjacent to development and exposed to direct and indirect degradation (Utah Division of Wildlife Resources, 2001).

New Hampshire. Several factors were considered in an investigation of mitigation projects in New Hampshire including landscape position, grading and topography, hydrology, vegetation, soils, and human disturbance (Chase and Davis, 1997). Findings of the study included a critique on success or failure of past wetland mitigation projects, which were the basis of recommendations for future management.

Rhode Island. Twenty-six freshwater wetland mitigation sites were assessed on Rhode Island where restoration of biological integrity was the primary objective (Cavallaro and Golet, 2002). Twenty-three of the 26 assessment sites had wetland hydrology and hydrophytic vegetation and were achieving at least one wetland function. However, the wetland types restored represented a change in wetland class (i.e., out of kind), in that, forested wetlands (prior to impacts) were replaced with wet meadows or marshes. In addition, an increase invasive plant species was observed on mitigation sites as a result of increased urbanization nearby.

Massachusetts. In Massachusetts, 54.4 percent of the wetland mitigation projects were not in compliance with Massachusetts wetlands regulations, of which, 21.9% of these failures resulted from no attempt to construct the mitigation (Brown and Veneman, 2001). Forested wetlands comprised the majority of wetland impacts (71.1%); however, only a small percentage of these systems were mitigated.

New England. Sixty compensatory mitigation projects were evaluated in New England (Minkin and Ladd, 2003). Permit conditions were met on 40 of the mitigation projects (67%) and were 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.

Results

Major Causes of Mitigation Failure

Location of mitigation sites unknown. For older projects, location information was either totally lacking or sketchy. In 1995, Pruitt (unpublished) was charged by EPA to evaluate all ACE mitigation projects within a 50-mile radius of Athens, Georgia. Out of the 45 projects obtained from ACE-Savannah District, only 22 were located.

Inadequate tracking system. For older projects, little or no information was available in regards to the type of resource that had been adversely affected or displaced, making evaluation of functional replacement impossible. In some cases, it is not even know if the mitigation plan was even implemented.

Inadequate baseline hydrology and target restored hydrology. Hydrology is the driving force of wetlands and streams. Wetland mitigation projects have generally failed due to inadequate incorporation of a hydrologic assessment (Bedford, 1996). A keen understanding of hydrologic and hydraulic processes is essential to a successful mitigation project.

Lack of consideration of wetland processes. Effective mitigation requires an understanding of processes and the effects of predominant water source(s), the hydrodynamics of the water sources, and the influence of geomorphic position on water source and hydrodynamics.

Inadequate assessment of current and future adjacent land use practices. Mitigation plans should include a detailed assessment of land uses at local, watershed and regional scales including projected changes in land use and development.

Inadequate assessment of ecosystem integrity and quality. Success criteria has been often developed for permit requirements without regards to restoration of ecosystem integrity which encompasses the physiochemical and biological attributes of the wetland or stream.

Adaptive management and monitoring plan not adequately developed. "Because of the changing conditions and uncertainties, ecosystem stability can only be viewed as a short-term objective. Lon-term restoration must be an ongoing process whereby restoration implementation becomes a continuing series of management decisions. Each decision should be based upon a growing pool of research information, updated measurements of ecosystem responses, and evaluations of degrees of progress in reaching a set of goals or targets that have been identified as indicative of ecosystem vitality" (Davis and Ogden, 1994). Adaptive Management prescribes a process wherein management actions can be changed in response to monitored system response, so as to maximize restoration efficacy or achieve a desired ecological state (Fischenich and Vogt, 2012).

Inadequate water quality investigation. Not only is water quantity an important consideration, but also water quality. The quality of surface or ground water to the wetland system can reduce biogeochemical processes and adversely affect habitat and life support requirements of plants and animals.

Use of cultivars. The use of cultivars, cultivated varieties of native species in compensatory mitigation, can affect both the functions 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.) (Minkin and Ladd, 2003).

Invasion and colonization by undesirable or exotic species. A common problem at a majority of mitigation sites is 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. Invasion by exotic species in tropical regions are numerous and wide spread. However, common invasive species that occur in northern zones include, but are not limited to: purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*), 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*). Control of invasive species 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 on mitigation sites would be helpful.

Steps to Successful Mitigation

1. Identify watershed and regional goals.
2. Recognize what is achievable and attainable given constraints and confinement within a given landscape and land use perspective.
3. Maximize success: Enhancement or restoration has been shown to be more successful than creation.
4. Maximize wetland size or stream length.
5. Specify, in detail, on-site enhancement or restoration goals and objectives.
6. Compare on-site conditions with regional goals including priority species, species in decline, threatened and endangered species and habitat.
7. Develop detailed documentation of past and present hydrologic, soils and vegetative conditions (e.g., historic aerial photography, land use history).

8. As an integral part of the mitigation plan, develop an adaptive management and monitoring plan which allows for not only maintenance and contingencies but also adjustments to monitoring requirements.
9. Classify wetlands (Brinson, 1993) and streams (Rosgen, 1994).
10. Establish reference conditions (Brinson and Rheinhardt, 1996 and Pruitt et.al., 2013)
11. Use a functional assessment approach in the context of the watershed.
12. Assess, mitigate and restore hydrologic and biogeochemical processes.

Other Considerations

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).

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.

Choosing sites further from disturbance and impact areas, e.g., not adjacent to roads, parking lots, etc., reduces the likelihood of invasion. Soil amendments and plant materials introduced at mitigation sites should be free from seeds recognized as invasive or undesirable species.

Discussion

Successful compensatory mitigation for wetland losses and stream impacts requires restoration of dynamic processes, function, and structure. The intent of restoration is to partially or fully reestablish the attributes of a naturalistic, functioning, self-regulating system (USACE, 1999). Wetland mitigation projects have generally failed due to inadequate incorporation of a hydrologic assessment (Bedford, 1996). The key to a successful stream or wetland restoration is an understanding of the underlying hydrogeomorphic processes, how to measure them and how to replace or incorporation those processes into the restoration project.

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, represent an appropriate 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.

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 (Minkin and Ladd, 2003). 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 the 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. 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. NRC (2001) noted that it is important to evaluate the compensatory mitigation using the same functional assessment tools as for the impacted wetlands.

Future Trends and Needs

1. Foster greater predictability, increased transparency and improved performance of compensatory mitigation projects.
2. Establish equivalent standards for all forms of mitigation.
3. Respond to recommendations of the National Research Council to improve the success of wetland restoration and replacement projects.

4. Set clear science-based and results-oriented standards nationwide while allowing for regional variations.
5. Increase and expand public participation.
6. Encourage watershed-based decisions.
7. Emphasize and enforce the Section 404-B(1) Guidelines by requiring proposed projects to avoid and minimize potential wetland and stream impacts before proceeding to compensatory mitigation.

Future Actions

a. Stream Mitigation Advisory Committee composed of representatives from EPA, ACE, USFWS, various State agencies, TNC, and environmental consultants. Host: EPA
b. EPA Science Advisory Board composed of several Federal and State agencies, Universities, and environmental consultants. Topic: Connectivity of Streams and Wetlands to Downstream Waters. Host: EPA

Conclusions

Historically, the success rate of compensatory mitigation has been limited. Based on several investigations of mitigation sites, successful mitigation was attributed to an understanding of past and current hydrologic processes and implementing a process-based restoration action. In reality, a successful mitigation project is constructed based on accurate measurements and restoration of hydrologic processes. Consequently, paramount to successfully implement a mitigation plan is establishing current (baseline) and targeted hydrologic conditions. Probably, the best approach for achieving that goal is to identify and monitor a reference aquatic ecosystem that represents those targeted conditions and functions. The reference system can also be utilized to monitor seasonal variation and catastrophic effects (*force majeure)* that are outside the control of the restoration site and action. In addition, watershed considerations should be taken into account in the context of the landscape position of the restoration site and the restoration actions. Future mitigation plans should improve predictability of outcome, increased transparency, and improved performance. Federal and state agencies should develop guidance that is consistent, reproducible, and fair across regions and political boundaries.

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