Assessing wetland compensatory mitigation sites to aid in establishing mitigation ratios

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NOTE

ASSESSING WETLAND COMPENSATORY MITIGATION SITES TO AID IN ESTABLISHING MITIGATION RATIOS

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Abstract: Compensatory mitigation has been a keystone of state and federal programs for regulating wetland loss. This study reviewed mitigation performance in Indiana, USA to propose mitigation ratios (area to be mitigated/area permitted for fill) based on the rate of wetland establishment by type. Between 1986 and 1996, the Indiana Department of Environmental Management (IDEM) required 345 mitigation sites. Of these, applicants constructed 214 of the sites; another 70 were not completed. No attempt was made to construct the required mitigation on 49 of the sites. Measurements of both the total wetland area and the area of each vegetation community in the mitigation site were taken at 31 of the sites identified as ''constructed.'' IDEM required 34.33 ha to compensate for the 13.73 ha of state waters lost through the permit actions associated with these sites. The mapping effort found that a total of 15.21 ha of wetland and other waters had established, a net gain of 1.48 ha. Vegetation community mapping revealed that palustrine forested areas, which had a failure rate of 71%, and wet meadow areas (87% failure) were harder to establish than shallow marsh areas (17% failure) and open water areas (4% failure). These results suggest that federal and state regulatory agencies would have to require minimum mitigation ratios of 3.5:1 for palustrine forested, 7.6:1 for wet meadow, 1.2:1 for shallow marsh, and 1:1 for open water to compensate for the risk of failure. Additional mitigation may be needed to offset the effects of temporal loss of wetland function.

Key Words: Indiana, mitigation, ratio, area, GPS, GIS

INTRODUCTION

Mitigation begins with avoidance, then proceeds to minimization of the degradation, and finally reaches compensation for unavoidable loss (MOA between Army and USEPA dated 19 January 1989) by creating, restoring, enhancing, and sometimes preserving additional wetland areas. Many authors have expressed concern regarding compensatory mitigation. Studies have found that U.S. federal agencies often permitted a net loss of wetland area (Kunz et al. 1988, Kentula et al. 1992, Sifneos et al. 1992, Sibbing 1997), that the compensation was often not constructed (Eliot 1985, Erwin 1991, Redmond 1992, Race and Fonseca 1996, Mockler et al. 1998, Johnson et al. 2000) and that, when constructed, the mitigation often failed to compensate for what was lost (Eliot 1985, Race 1985, Storm and Stellini 1994, Gallihugh 1998, Mockler et al. 1998, Gwin et al. 1999, Magee et al. 1999).

According to the U.S. Army Corps of Engineers' data, the total area of compensation required from 1993 to 2000 exceeded the total area of permitted wetland loss by a ratio of 1.8:1 (National Research Council 2001). However, a recent National Research Council study found that there was insufficient information to determine if these mitigation sites had been constructed or if the area of wetland required had actually been established (National Research Council 2001). Commonly, a state or federal agency will require more compensation area than the area impacted to offset the risk of failure and the temporal loss of wetland function. This is referred to as the mitigation ratio. In the past, the magnitudes of these ratios were often a result of negotiations between the applicant and the regulatory agencies. Recently, Indiana, Florida, Ohio, New Hampshire, Maryland, Oregon, and North Carolina have attempted to standardize their mitigation ratios or the methods used to calculate these ratios. Few data exist on which to base these ratios, however, as few researchers have quantified the risk of failure and temporal loss of function during wetland reestablishment.

METHODS

Wetland compensatory mitigation sites in Indiana were used to calculate gross mitigation compliance and to estimate mitigation performance by comparing the area of wetland actually established through the mitigation process to the area of permitted loss. Indiana's mitigation sites were first inventoried and classified as constructed, incomplete, or no attempt. Area measurements were then taken at a randomly selected sample of the constructed mitigation sites to determine the area of wetland established.

Site Selection

Before an agency may issue a federal permit or license that affects a state's waters, that state must issue a Water Quality Certification (section 401 of the Clean Water Act). When a state conditions these certifications, the conditions must be incorporated into the permit or license (e.g., conditions of a Clean Water Act section 404 Dredge and Fill permit). Often, the state requires compensatory mitigation as a condition of the certification. Applicants have proposed a wide variety of compensation strategies, including in-lieu fee payments, enhancement, preservation, etc., which are not comparable to conventional restoration or creation type mitigation. These strategies may have merit, but they require different study parameters. I inventoried all 345 mitigation sites in Indiana that met the following criteria.

1) IDEM granted, or waived with conditions, Water Quality Certification on or before December 31, 1996. This gave the applicants approximately two years to construct the mitigation site and excluded unconditional waivers.

2) The Water Quality Certification file must have been found before July 1999 (the conclusion of the inventory).

3) The certification required a specific *area of wetland mitigation.*

4) The certification required wetland restoration or wetland creation as compensatory mitigation.

5) The water quality certification required the applicant to construct the required area of wetland mitigation.

6) The wetland impacts permitted by the water quality certification had begun by the time of the inventory inspections.

7) Impacts were not a result of surface coal mining. IDEM has few records of surface coal mining operations due to approval of US Army Corps of Engineers nationwide permit 21 (33 CFR 330.1).

8) Mitigation was not in the form of mine reclamation. Concurrent off-site mitigation or mitigation done concurrently on another part of the property was included, whereas mitigation sites that were to be constructed within the mined area, after the site had been mined, were excluded.

Inventory

During 1998 and the spring of 1999, I categorized each mitigation site as constructed, incomplete, or no attempt according to the criteria below. These criteria were designed to allow a single observer to inventory all of Indiana's mitigation sites in one year.

Constructed. I classified sites as constructed if the applicant had completed the earthwork as planned (if earthwork was required) and had planted the site (if planting was required). Earthwork included grading, breaking tiles, erecting berms, installing control structures, etc. in a manner similar to the plans. This criterion did not require the site to have exactly the same contours, size, or shape, but sites that were obviously not built as planned were considered incomplete. The term ''constructed'' is used here rather than ''complete,'' which implies compliance. Classification as constructed does not mean the site was complete or compliant.

Mortality of planted material complicated the planting determination. Interviews with applicants indicated that some sites had been planted but suffered extreme mortality. An interview with each of the applicants to determine the status of planting was not feasible, nor would it necessarily provide reliable information. Instead, I chose a fairly liberal criterion for determining if planting had occurred: the presence of at least one species from the planting list other than cattail (*Typha* spp.), the presence of protective netting, lines made with a seed drill, broadcast seed laying at the surface, plastic or other indicators of tree or container plantings, or the remnants of mulch or straw. Sites with any of these characteristics were considered planted, although they may not have been planted correctly or in compliance with the certification or federal permit.

Incomplete. I classified a site as incomplete if the mitigation had begun but had not been completed as of the observation date. Sites that had been graded but showed no signs of planting were most frequent. A few sites that had obviously not been constructed as planned also fell within this category. This category included sites that appeared to be in the process of construction as well as those that had been abandoned.

No Attempt. Sites that showed no signs of mitigation construction activity at the location indicated in the IDEM files fell into this category.

A location and photograph were recorded for each site. Locations were recorded with either a Trimble GeoExplorer II or a Trimble ProXR global positioning system (GPS).

Area Analyses

Using computer-generated random numbers, I selected sixteen certifications, requiring 31 mitigation sites, from all of the certifications that had at least one site classified as constructed. I then measured the extent of wetland area and the area of each general vegetation type established at each of these sites.

Wetland Delineation. The wetland line was drawn at the furthest extent that supported a prevalence of hydrophytic vegetation and wetland hydrology as defined by the 1987 U.S. Army Corps of Engineer Delineation Manual (Environmental Laboratory 1987). Normally, the 1987 Delineation Manual requires a site to meet three parameters: prevalence of hydrophytic vegetation, presence of one primary or two secondary indicators of wetland hydrology, and hydric soils. An exception was made for man-induced wetlands. Man-induced wetlands must meet only the hydrophytic vegetation and hydrology parameters. According to the 1987 manual, wetland soils are presumed to exist or to be forming if wetland hydrology exists on the man-induced wetland site. Soil information is not necessary in making a wetland determination on restoration or creation sites, which are by their very nature man-induced.

Soils are particularly misleading on mitigation sites. Commonly, mitigation has been. 1) constructed on previously drained hydric soils, 2) constructed by excavating upland down to the water table, or 3) constructed by over-digging an area and spreading a layer of wetland soil from another site. Finding hydric soil indicators does not necessarily reflect current hydrologic conditions. At least one pit was dug in each mitigation site to a depth of at least 46 cm to assess subsurface hydrology, except on sites that were entirely inundated.

A map polygon was determined to have wetland hydrology based on a pedestrian survey of the polygon and its boundary. Any one primary or two secondary indicators of surface hydrology (e.g., inundation, watermarks, FAC neutral test) were recorded and the boundary of the polygon adjusted to reflect the presence of wetland hydrology. I dug holes transecting the slope at regular intervals around a polygon's up-slope boundary in cases where surface hydrology was not present or insufficient (i.e., only one secondary indicator) and the vegetation was predominantly hydrophytic. The purpose of these holes was to observe any subsurface indicators of hydrology (e.g., oxidized root channels, saturation near the surface).

GPS Mapping and GIS Analysis. The wetland line and each vegetation cover type within the wetland area were mapped using a Trimble ProXR Global Positioning System (GPS) receiver with a differentially corrected accuracy of 0.75-meters root mean square. During the summer of 1999, I walked around the edge of each wetland polygon, recording one point every five seconds. A range finder attachment was used to map the extent of vegetation in deeper waters. All community types were determined qualitatively by visual estimation using the guidelines in Table 1.

Four sites were mapped during drought conditions according to the Palmer Drought Severity Index (PDSI) (National Climatic Data Center 2000). One of these sites had larger-than-planned open water areas. A second site had a large, deep, palustrine aquatic bed component. The mapping of these sites may depict more vegetation than occurs in normal years due to drought-induced draw down. The wetland line at the remaining two sites were drawn at the toe of the adjacent slope. An increase in water supply in these areas would result in higher water elevations but only a slight increase in inundated or saturated area.

All GPS data were analyzed using ArcView geographic information system software. The resulting GIS recorded the location of each site and the exact coordinates for future photographs of the site. The area of each wetland vegetation class polygon was calculated using the XTOOLS extension developed for ArcView by Mike DeLaune at the Oregon Department of Forestry.

RESULTS

Inventory

Of the 345 mitigation sites inventoried, 214 had been constructed, 70 more were incomplete, and 49 were not attempted (Figure 1). Another 12 of the Water Quality Certifications had too little information to evaluate. The mitigation sites were concentrated around Indianapolis, Fort Wayne, and the Lake Michigan area. The watersheds that feed Lake Michigan and Lake Erie contained nearly 37% of Indiana's mitigation sites. The Little Calumet-Galien basin (Lake, Porter, and LaPorte Counties), which covers approximately 1.5% of Indiana's surface area and directly abuts Lake Michigan, contains 20% of Indiana's compensatory mitigation sites.

Area Analyses

The certifications, associated with the 31 mitigation sites selected for area measurements, permitted impacts to 13.73 ha of wetland and other waters of the state. IDEM required 34.33 ha of wetland or other waters of the state in compensation, or approximately 2.5 ha of mitigation for every hectare of permitted impact.

Table 1. Classification criteria for area analysis plant community classes. Each GPS-mapped polygon was labeled with classes based on the listed characteristics.

	Plant Community Classes
Palustrine Forest	Live tree species moderately dense (≥540 per hectare). Where neither tree or shrub species meet the density requirement alone, a moderately dense combination of tree and shrub species was called palustrine forest.
Palustrine Scrub-Shrub	Did not meet the forested criteria. Live shrub species moderately dense (≥540 per hectare).
Palustrine Emergent	Did not meet the criteria for palustrine forest or scrub-shrub. Three subcategories: wet meadow, shallow marsh, deep marsh.
Wet Meadow	Plants tolerant of saturation but not prolonged inundation: *Carex* spp., *Solidago* spp., *Euthamia* spp., *Panicum virgatum* L., *Eupatorium perfoliatum* L., *Mimulus ringens* L., *Aster simplex* Willd., *Phalaris arundinacea* L., *Cyperus* spp., *Juncus dudleyi* Wiegand, *Asclepias* spp., *Agrostis alba* L., *Lycopus* spp., and *Verbena hastata* L.
Shallow Marsh	Plants tolerant of shallow (<15-cm) inundation: *Typha* spp., *Sagitaria* spp., *Alisma* spp., *Scirpus validus* Vahl, *Juncus effusus* L., *Leersia oryzoides* Sw., *Iris virginica* L., *Ludwigia palustris* L., *Polygonum* spp., *Sparganium* spp., and *Eleocharis* spp.
Deep Marsh	Rooted plants that produce parts at or above the waterline, tolerant of permanent inundation >15-cm: *Potamogeton* spp., *Nelumbo lutea* Pers., *Nymphaea tuberosa* Paine, *Nuphar* spp., and *Polygonum amphibium* L.
Palustrine Aquatic Bed	Species living completely (or nearly completely) submerged, and species that float in the water column or at the surface without attachment to the substrate: *Chara* spp., *Lemna* spp., *Myriophyllum* spp., and *Ceratophyllum demersum* L.
Open water/Bare ground	<10% foliar coverage
Upland	Failed to meet the hydrophytic vegetation requirements or the indicators of hydrology listed in the 1987 US Army Corps of Engineers Delineation Manual (Environmental Laboratory 1987).

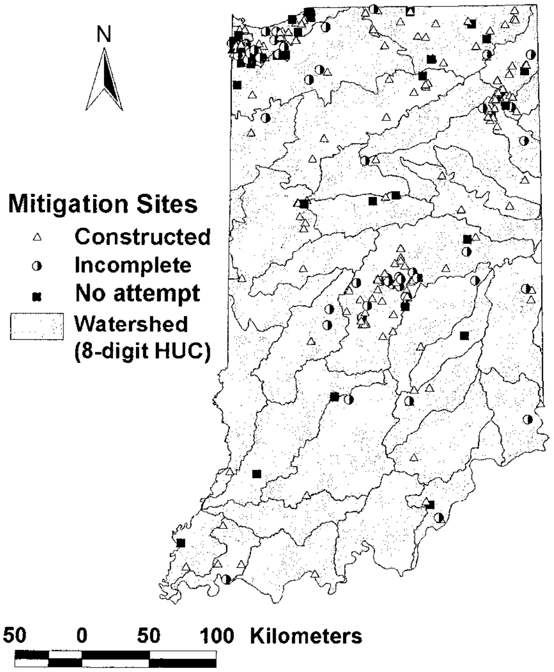

Figure 1. Distribution and construction status of mitigation sites in Indiana. Sites are clustered around the Lake Michigan, Fort Wayne, and Indianapolis areas where there are both more wetlands and greater development pressure.

The GPS measurements recorded 15.21 ha of wetland and other waters that had actually established. This is a total net increase of 1.48 ha over the total area lost but only 7% of the additional area required for mitigation. The overall area established was greater than the area lost in all vegetation types except for palustrine forested, yet for most types was far short of the mitigation targets (Table 2). IDEM permitted the loss of 7.98 ha of palustrine forested wetland and required 13.18 ha in palustrine forested mitigation, but only 3.82 ha had been established. The area established was less than the area required for all but deep marsh and palustrine aquatic bed types.

The palustrine forested type lost area through the certification process, but all other types gained area. This has the effect of trading palustrine forested wetland for the three biggest gainers: shallow marsh, open water, and to a lesser extent, palustrine aquatic bed wetland. From these results, one might infer that some wetland types are more difficult to mitigate than others. This difference in difficulty of establishment (i.e., failure rate) can be expressed by subtracting from 1.0 the area actually established (e) divided by the area required (r). For example, IDEM required 13.18 ha of palustrine forested compensation but received only 3.82 ha. The failure rate (f) is calculated as follows.

$$f = 1.0 - (e \div r)$$

Table 2. Hectares by Type. Regulators required a greater area of each community type as compensation than was lost through the regulatory process. Much less of each wetland community was established than was required. With the exception of the palustrine forested type, a greater area was established at each site than was lost.

Type	# of sites requiring	Lost to project construction	Required as mitigation	Established by mitigation	Difference between lost and established	Difference between required and established
Forest	15	7.98	13.18	3.82	−4.16	−9.36
Shrub	9	0.20	0.70	0.40*	0.20	−0.30
Meadow	6	0.65	6.24	0.82*	0.17	−5.42
Shallow marsh	24	3.26	6.19	5.16*	1.90	−1.03
Deep marsh	9	0.02	0.84	0.92*	0.90	0.08
Aquatic bed	1	0.20	0.21	1.15*	0.95	0.94
Open water/Bare Ground	3	0.69	3.08	2.94*	2.25	−0.14
Mixed	4	0.73	2.81	N/A	N/A	N/A
Unspecified	4	0.00	1.08	N/A	N/A	N/A

* Greater than actual loss.

$$f = 1.0 - (3.82 \div 13.18) = 0.71$$

The ratio (m) that regulators would need to require to overcome this failure rate can be calculated by dividing the area of compensation required (r) by the area actually established (e).

$$m = r \div e$$

Regulators would have needed to require 3.5 ha to receive one hectare of palustrine forested wetland through mitigation to overcome the 71% failure rate observed (Table 3). The area of palustrine aquatic bed, palustrine scrub-shrub, or deep marsh types included in the study was not sufficient to produce valid failure rates.

CONCLUSION

Mitigation ratios are meant to compensate for two factors: the temporal loss of wetland function from the time the impacts are made to the time the mitigation site is mature and the risk of mitigation failure. From a purely quantitative area standpoint, the average ratio of 2.5:1 documented in this study does appear to compensate or nearly compensate for the risk of failure when applicants actually construct the mitigation. This study, however, does not consider the loss of wetlands left uncompensated due to applicant failure to complete or even attempt construction of the mitigation, losses for which no mitigation was required, losses that were not regulated by IDEM, nor violations that IDEM knows nothing about. This study also did not consider the ‘‘quality’’ of the compensation received nor the capacity of those compensatory sites to replace lost functions. Factoring in these unmitigated losses and the temporal loss of function suggests that no-net-loss goals have not been achieved.

Table 3. Comparing the area required to the area established results in the mitigation ratio regulators would need to require to overcome the failure rates measured here. Different community types experienced different failure rates indicating that some types were harder to establish.

Type	Failure rate	Ratio to overcome failure rate
Forest	71%	3.5:1
Shrub†	43%	1.8:1
Meadow	87%	7.6:1
Shallow	17%	1.2:1
Deep†	<0%	N/A
Aquatic bed†	<0%	N/A
Open	5%	1:1

† Too little of this type was included in the study to reach a reliable conclusion.

Although this and previous studies indicate that mitigation, in general, is risky, King and Bohlen (1994) made a compelling case that the poor performance reported may be more a function of applicant motivation and agencies’ failure to enforce mitigation requirements than the status of restoration science. The high number of incomplete and undersized mitigation sites documented suggests that the limited follow-up and enforcement action of the past was not effective. Constructing mitigation properly is costly. Infrequent enforcement encourages applicants to cut corners rather than implement high quality restoration, if they mitigate at all (King and Bohlen 1994).

RECOMMENDATIONS

1) Enforcement could be used to provide a tool to switch applicant incentives, thereby promoting applicant interest in high quality wetland restoration over

applicant desire for lower construction costs (King and Bohlen 1994).

2) Like enforcement, the applicant could be required to guarantee construction of a mitigation site through a performance bond that provides an economic incentive. Releasing the bond contingent on the performance of the site shifts the applicant's priorities from low cost mitigation to site performance in an effort to achieve a release from the bond and its associated costs. Bonding will only produce the desired effect if the bond and its associated costs are large enough.

3) In the absence of up-front mitigation, the agencies should bear the procedural and financial burden of compliance and enforcement. Up-front mitigation shifts this responsibility from the agency to the individual applicants.

4) Even if perfect compliance were achieved, the risk of failure will always exist. Quantification of this risk from past performance, as done here, is key to calculating appropriate mitigation ratios. Regulatory agencies should adjust their ratios to reflect this risk.

5) In addition to policy changes, there is a need for more scientific research and experimentation to identify the variables involved in wetland creation and restoration, as well as ways of improving the performance of wetland compensatory mitigation.

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