PROFILE

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Section 404 Wetland Mitigation and Permit Success Criteria in Pennsylvania, USA, 1986–1999

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ABSTRACT / Twenty-three Section 404 permits in central Pennsylvania (covering a wetland age range of 1–14 years) were examined to determine the type of mitigation wetland permitted, how the sites were built, and what success criteria were used for evaluation. Most permits allowed for mitigation out-of-kind, either vegetatively or through hydrogeomorphic class. The mitigation process has resulted in a shift from impacted wetlands dominated by woody species to less vegetated mitigation wetlands, a trend that appears to be occurring nationwide. An estimate of the percent cover of emergent vegetation was the only success criterion specified in the majority of permits. About 60% of the mitigation wetlands were judged as meeting their originally defined success criteria, some after more than 10 years. The permit process appears to have resulted in a net gain of almost 0.05 ha of wetlands per mitigation project. However, due to the replacement of emergent, scrub–shrub, and forested wetlands with open water ponds or uplands, mitigation practices probably led to a net loss of vegetated wetlands.

Wetland management in the United States is frequently considered a legal process more often than one based upon scientific principles (Mitsch and Gosselink 1993, NRC 1995). Wetlands are regulated through Section 404 of the Clean Water Act, with regulatory duties being assumed by the US Army Corps of Engineers (US ACE) and the US Environmental Protection Agency (US EPA). Permits are required for dredge and fill activities that negatively impact natural wetlands and often require the creation of wetlands as mitigation for damage done to those wetlands. The US EPA and US ACE, in a memorandum of agreement, agreed that mitigation was to focus on functional replacement rather than area or structure (US EPA 1990). Once these mitigation wetlands are built, they are assumed to eventually function as well as natural wetlands. Functions can include such processes as flood flow attenuation or nutrient transformation.

Regulatory authority for permit issuance rests with regional (district) offices of the US ACE. In Pennsylvania, located in the mid-Atlantic region of the United States, three US ACE districts hold some wetland jurisdiction (Pittsburgh, Baltimore, and Philadelphia). In addition, the Pennsylvania Department of Environmental Protection (PADEP) also holds state jurisdiction for wetland issues. Therefore, the US ACE and PADEP have developed a joint permit program within the state.

A number of previous studies have examined the effectiveness of the Section 404 wetland mitigation program in various regions (Kentula and others 1992, Holland and Kentula 1992, Sifneos and others 1992a,b). These studies have shown that, in some areas, a net loss of wetlands has occurred in spite of the Section 404 permit mitigation requirements (Kentula and others 1992, Holland and Kentula 1992, Sifneos and others 1992a,b). Moreover, impacts to different wetland types are not the same, and the required mitigation does not always result in the in-kind replacement of lost wetlands (Kentula and others 1992, Holland and Kentula 1992, Sifneos and others 1992a,b).

None of these studies, however, have attempted to evaluate the compliance of the projects with permit requirements. In order to determine whether the project was successful, some performance standards or success criteria are necessary; but there is a great deal of regional variation in permit conditions and requirements. For example, Streever (1999) lists seven different sets of mitigation guidelines from seven different Corps districts. Some permits are quite specific about mitigation requirements, although other permits are very general. Some permits may not list success criteria at all (Streever 1999). When such criteria are enumerated, they are often very simple and typically rely upon

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vegetation structural characteristics, such as percent cover.

The National Research Council (NRC 1995, p. 34) defined function as ". . . all processes and manifestation of processes that occur in wetlands." Research suggests that mitigation wetlands rarely resemble, or function, as natural wetlands (Race 1985, Langis and others 1991, Zedler and Langis 1991, Reinartz and Warne 1993, Mitsch and Wilson 1996, Cole and others 1998, Shaffer and Ernst 1999, Cole and Brooks 2000). Although wetland structure is commonly assessed in mitigation wetlands, function rarely is, due in large part to time and cost constraints. As a result of the difficulty in actually measuring most wetland functions, there is rarely any permit requirement for functional success, even though that was the intent of the memorandum between the US ACE and the US EPA (US EPA 1990).

The question then arises as to why mitigation wetlands do not often structurally resemble their natural counterparts. To answer that question, the Section 404 permit is the first place to look. The permit requirements will establish the baseline for what a mitigation wetland is expected to become. Although there have been some cases where the required mitigation wetlands were never built (e.g., Erwin 1991), and numerous examples where the mitigation wetland differed from the wetland type specified in the permit, mitigation wetlands are generally developed following the conditions outlined in the permit. One approach to improving wetland mitigation projects is to examine what is specified in the permit conditions.

Methods

Eighty-four wetland permits, issued between 1986 and 1999, were obtained from a field office of the Baltimore District of the US Army Corps of Engineers. Each of these permits required some form of on-the-ground mitigation activity. From the permits reviewed, 23 were selected by age class (0–5, 6–10, and >10 years). The selected mitigation wetlands were located in the Baltimore District of the Corps, throughout central Pennsylvania (Table 1). An equal number of sites per age class were initially selected, but a few sites could not be evaluated due to access limitations. There were 8 sites from 1–5 years of age, 11 from 6 to 10 years, and four more than 10 years old.

For each permit, the type of natural wetland impacted and type of mitigation wetland developed were classified (if possible) according to the Cowardin system (Cowardin and others 1979) and the hydrogeomorphic (HGM) classification (Cole and others 1997) (Table 2). The Cowardin classification is based on water depth, the type of vegetation present (e.g., palustrine emergent, palustrine forested), and the substrate, with additional modifiers for water chemistry, soils, and other parameters. The HGM wetland classification system is based on the landscape setting, water source, and hydrodynamics of the wetland (Brinson 1993). Since HGM classifications were not specified in the permit files, sites were placed into HGM classes based upon site descriptions, as well as from relevant information found on any maps that were included with the permit. It should be noted that a general lack of information in each file made classifications difficult.

The performance standards used for defining success of a mitigation wetland (e.g., percent cover of wetland plants after three years, evidence of hydrology, lack of exotics), the frequency of monitoring, and any other agencies involved in the permit review process were noted. These 23 permits were also evaluated to determine if performance standards had changed over the years.

Since the United States government has a policy of "no net loss" of wetlands (White House Office on Environmental Policy 1993, NRC 1995), the areas of the impacted and mitigation wetlands were compared to determine if this goal was being met (even though many sites predated this policy). The area of the impacted and mitigation wetlands were determined from information found in the permit file.

Once sites were identified from file information, a field inspection was conducted at each of the sites to determine:

(1) if the mitigation wetland had actually been constructed;
(2) the current wetland type under both the Cowardin (Cowardin and others 1979) and the HGM classification (Cole and others 1997);
(3) if the older sites had changed through time to a different Cowardin class or had become uplands; and
(4) if the site still met the original performance standards at the time of inspection.

At each site, wetland plant community structure, percent plant cover, and evidence of hydrology were visually evaluated. A comprehensive assessment of these three parameters occurred during a walk through the site; however, quantitative data were not taken during these visits. We relied on reported data in the permit for the size of the impacts to natural wetlands and the size of the mitigation wetlands.

Table 1. Classification of wetland mitigation sites in central Pennsylvania and estimated gains and losses of wetland area as a result of mitigation

Site	Year constructed	Original Cowardin[a]	Mitigation Cowardin[b]	Original HGM[c]	Mitigation HGM[d]	Size of wetland before impact (ha)	Size of mitigation wetland (ha)	Difference (ha)
1	1999	PEM	PEM	D	D	0.10	0.15	0.05
2	1997	PFO, PEM	PEM	SL	D	0.74	1.02	0.28
3	1997	PEM, PSS	PEM, POW	D	D	0.05	0.81	0.76
4	1996	PFO, PSS, PEM, POW	PSS, PEM	SL	D	0.94	Multiple sites	
5	1996	PEM, PSS	PEM, POW	SL	Fr	0.14	0.14	0
6	1996	PEM, PSS	PEM, POW	SL	D	0.49	0.61	0.12
7	1995	PEM	PEM	SL	HWF	0.09	0.09	0
8	1995	PEM	PEM	HWF	SL	0.15	0.02[e]	−0.13
9	1994	PFO, PSS, PEM, POW	PEM	SL	D	0.94	Multiple sites	
10	1994	PEM	PEM	MSF	MSF	< 0.01	0.03	0.03
11	1994	PFO, PSS, PEM, POW	PEM, POW	HWF	Fr	1.21	1.82	0.61
12	1994	PEM	PEM, POW	D	D	0.12	0.40	0.28
13	1993	PFO, PSS, PEM	PEM, POW	SL	D	Multiple impacts	1.90	
14	1992	PSS, PEM	PEM, POW	HWF	D	0.03	0.03	0
15	1992	PEM	PEM, POW	D	D	unknown	1.0	
16	1992	PSS, PEM	PEM	MSF	MSF	0.07	0.11	0.04
17	1991	PEM	PEM	HWF	HWF	0.04	0.07	0.03
18	1990	PSS	PEM	D	D	0.05	0.10	0.05
19	1990	PFO, PSS	PEM	SL	D	0.27	0.28	0.01
20	1988	PFO, PSS, PEM	PEM	MSF	HWF	1.55	0.30	−1.24
21	1987	PFO	PEM, POW	D	D	1	1.0	0
22	1987	unknown	PEM	HWF	HWF	0.03	0.03	0
23	1986	PSS	PSS, PEM	HWF	SL	unknown	0.12	

[a]Original wetland type as classified according to Cowardin and others (1979). PFO (palustrine forested), PSS (palustrine scrub-shrub), PEM (palustrine emergent), and POW (palustrine open water).

[b]Mitigation wetland type as classified according to Cowardin and others (1979).

[c]Original hydrogeomorphic (HGM) classification (Cole and others 1997). Presumed based upon landscape position. D = depression, SL = slope, HWF = headwater floodplain, MSF = mainstem floodplain, Fr = fringe.

[d]Mitigation HGM classification based upon field visit.

[e]Little evidence that this wetland still remained. Classifications are presumptive based upon position in the landscape. Wetland area estimated at 0.02 ha.

Results

Permit Documentation

Locating examples of older mitigation wetlands (>10 years) proved to be difficult. In some instances, the permit files did not contain sufficient information to determine the actual age of the mitigation wetland. This was not necessarily due to a lack of such sites in the landscape, but rather to a lack of permit information on file. Many older sites were developed without formal documentation, thus making it difficult to determine impacts and success criteria. At two sites, the size of the impacted wetland was not recorded, making it impossible to determine a net gain or loss of wetland area. Few permit files included site monitoring reports, regardless of age.

Wetland Classification

In the permit files, the impacted wetland was sometimes described in only very general terms (e.g., marsh) rather than more detailed vegetation communities, making it difficult to determine the type of wetland that was originally impacted. Nonetheless, enough detail was typically found to infer the classification of the impacted site. Under the Cowardin system (Cowardin and others 1979), wetland types impacted included

Table 2. Description of Cowardin classification (Cowardin and others 1979) and hydrogeomorphic classification (Cole and others 1997)

Classification system	Description
Cowardin	
Palustrine emergent (PEM)	Nontidal freshwater wetland dominated by emergent plants.
Palustrine forested (PFO)	Nontidal freshwater wetland dominated by trees.
Palustrine scrub-shrub (PSS)	Nontidal freshwater wetland dominated by shrubs.
Palustrine open water (POW)	Nontidal freshwater system, not always a wetland.
Hydrogeomorphic	
Depression	Wetland formed within closed topographic contours. May be fed by groundwater or surface water.
Slope	Wetland located on a topographic gradient, receiving both groundwater and surface water.
Headwater floodplain	Wetlands found along streams of second order or less, receiving most of their water from overland flow during spring runoff or rainfall. Water moves through these sites across a broad face perpendicular to the stream.
Mainstem floodplain	Wetlands found along third or greater order streams, deriving most of its water from overbank flow. Most of their water flow occurs parallel to the stream.
Fringe	Wetland found along the edge of an impoundment. Adjacent to open and/or deep water.

Table 3. Distribution of presumed HGM subclasses in original impacted wetlands (rows) and mitigation wetlands that resulted (columns)[a]

Impacted wetlands	HGM subclass	Mitigation wetlands				
		D	SL	HWF	MSF	FR
	D	6	0	0	0	0
	SL	6	0	1	0	1
	HWF	1	2	2	0	1
	MSF	0	0	1	2	0
	FR	0	0	0	0	0

[a]Cells on the diagonal represent no change in HGM subclass from impact to mitigation. Impacted and mitigation wetlands are classified according to Cole and others (1997). D = depression, SL = slope, HWF = headwater floodplain, MSF = mainstem floodplain, FR = fringe.

palustrine emergent (PEM), palustrine scrub–shrub (PSS), palustrine forested (PFO), and palustrine open water (POW) (Table 2). Palustrine emergent wetlands were impacted most frequently (18 sites), and also seemed most amenable to mitigation (23 PEM wetlands were built as mitigation) (Table 1). Thirteen PSS wetlands were impacted, but only two were designed as mitigation. Although only three POW wetlands were impacted, nine were developed as mitigation (Table 1). Eight PFO wetlands were impacted, but none were built as mitigation (or proposed). There appeared to be a shift from impacted wetlands dominated by woody species (PFO, PSS) to more open mitigation wetland types (PEM, POW). Although 19 of the 22 mitigation wetlands created (86%) were the same wetland type as some portion of the impacted wetlands, these data may be somewhat misleading. At several sites, as many as four different wetland types were apparently impacted, whereas mitigation resulted in the replacement of only one or two wetland types.

Under the HGM wetland classification system, depressional wetlands were most frequently developed as mitigation. Thirteen depressional wetlands were built as mitigation, although only six were impacted (Table 1). Six slope wetlands were impacted but no slope wetlands were replaced in kind. Two slope wetlands were developed as mitigation for headwater floodplain wetlands. Only two of five headwater floodplain wetlands had headwater floodplain wetlands as mitigation. Two of three mainstem floodplain wetlands, however, were mitigated in kind. Two fringe wetlands were built, although none were impacted. Only 10 of 23 (43%) mitigation wetlands were of the same presumptive HGM type as the original impacted wetland (Table 3).

Project Success Criteria

Many of the permit files lacked sufficient information to determine whether the project was successful. This was either due to a lack of clarity in the permit requirements, and/or a lack of monitoring of the mitigation wetlands during and after construction. Very few (<10%) of the permit files contained the required

Table 4. Criteria required for assessment of success of wetland mitigation project[a]

Site	Age (yr)	Success criteria	Did the site still meet success criteria?
1	1+	85% coverage of hydrophytes after 5 years	Yes
2	3	85% coverage of hydrophytes after 3 years	Yes
3	3		
4	4	85% coverage of vegetation	Yes
5	4		
6	4	85% cover of proposed plant species after 2 years	No
7	5	85% survival of planted hydrophytes after 2 years	Yes
8	5	85% survival of planted species after 5 years	No
9	6	85% coverage of vegetation	Yes
10	6		
11	6	85% cover of hydrophytic vegetation after 2 years	No
12	6	85% cover of hydrophytic vegetation after 2 years	Yes
13	7		
14	8		
15	8	75% survival of planted species after 2 years	Yes
16	8		
17	9	Predominance of species adapted for life in saturated soils	Yes
18	10	80% survival rate of transplanted species	unknown
19	10		
20	12	85% cover of hydrophytes after 2 years	No
21	13		
22	13		
23	14		

[a]Sites with no data had none found in the permit file.

monitoring reports. Performance standards for the determination of success were found in only 13 of 23 files (57%). No success criteria apparently existed for some older sites that were built as a result of enforcement activities (T. Pluto, Baltimore District, US Army Corps of Engineers, personal communication). For the remaining sites, success criteria may have originally existed, but were no longer found in the permit records examined. Of the 13 for which success criteria were found, every permit relied upon the presence of herbaceous plant cover after a certain period of time for the determination of success of the mitigation project (Table 4). The required coverage was relatively high, with eleven permits requiring >80% cover. The period of monitoring for this cover varied from two to five years. There was no evidence that requirements for the determination of success had changed over the fourteen-year period covered by these permits.

For the 13 sites that had listed success criteria, eight were judged to meet those criteria (62%) at the time of inspection. One site could not be assessed since its success criteria related to the success of transplanted species and it was not clear what those species were. The other four sites clearly did not meet criteria, either through failure of wetland site conditions to form (e.g., lack of hydrology, hydric soils, hydrophytic plants) or through too much open water (i.e., the formation of open and unvegetated pools).

No Net Loss

Eighteen of the permit files contained sufficient data to determine if this goal was achieved through mitigation (Table 1). Based on the sizes of the impacted and mitigation wetlands recorded in the permit files, there was a presumptive gain of 0.89 ha in wetland area for those 18 sites, an average gain of 0.05 ha per permitted activity, even though many of those sites predated the no-net-loss policy. If only those sites constructed after implementation of this policy are considered, the net gain in wetland area per permitted activity increased to 0.2 ha. This suggests that implementation of the "no-net-loss" policy has had a positive effect on the wetland mitigation process in central Pennsylvania. In some cases, however, these apparent gains may be overstated and should be viewed with caution. Some sites were claimed as wetland but were mostly open water with a vegetated fringe. There was also a site that claimed almost 1 ha of wetland, but was actually upland comprised primarily of stone and gravel substrate, with little evidence of wetland plants, soils, or hydrology. Due to the replacement of emergent, scrub–shrub, and forested wetlands with open water ponds or uplands, there was likely a functional net loss of wetlands (if not an areal net loss) as a result of mitigation.

Discussion and Conclusions

Changes in Distribution of Wetland Types as a Result of Mitigation

According to the information provided in the permit files, it would appear that mitigation wetlands are replacing lost natural wetlands in central Pennsylvania, in agreement with recent governmental policy of no net loss of wetlands. However, in many of the mitigation wetlands examined, there was no in-kind replacement, within either Cowardin type or HGM subclass. Mitigation activities have resulted in a shift from wetlands dominated by woody vegetation (PSS and PFO) to wetlands dominated by emergent vegetation (PEM) and open water (POW). Similar increases in the relative abundance of POW wetlands as a result of mitigation activities have also been reported in Oregon (Gwin and others 1999), California (Holland and Kentula 1992), Washington (Kentula and others 1992), and throughout the Southeast (Sifneos and others 1992a, b). This trend appears to be nationwide (Tiner 1984; Dahl and Johnson 1991). If this pattern continues, changes in regional biodiversity are likely to occur (Gwin and others 1999). In addition, increases in the amount of open water ponds at the expense of other wetland types could increase the potential problems with exotic and nuisance species associated with these habitats (Holland and others 1995, Sibbing 1997).

If impacted wetlands are replaced with mitigation wetlands of the same HGM subclasses (i.e., same landscape setting and hydrology), this would likely increase the probability that the appropriate wetland functions were replicated. Mitigation wetlands certainly will not perform the intended functions if the landscape position is incorrect and the proper physical structure and characteristic hydrology are lacking. In this study, less than 45% of the mitigation wetlands were the same HGM subclass as the impacted wetland. The majority of wetlands made for mitigation were basin-shaped depressional wetlands. These wetlands, typically shallow ponds fringed with a robust emergent plants [e.g., cattail (*Typha* spp.)], are relatively simple and cost-effective to develop and can often be established within a short regulatory time frame. Ponds also tend to attract waterfowl and these sites then become locally popular. The presence of surface water also provides the regulatory community with an easy measurement of hydrology, even if such hydrology is not appropriate to a site (Cole and Brooks 2000).

Success Criteria

Although measurement of plant percent cover is a convenient method for assessing mitigation wetlands, just what it assesses is subject to considerable debate. So why does the measurement of percent herbaceous plant cover after a certain period of time continue to be the preferred means of assessing the success of mitigation wetlands? Ecologists have long assumed that structure is a good indicator of function. For example, the presence of large woody debris in streams is a good indicator of habitat for salmonids (Cedarholm and others 1997), as well as a source of organic carbon for the stream. The correlation between percent herbaceous plant cover and most wetland functions is not as clear.

Having more than 80% plant cover (as is frequently required in a permit) is not necessarily desirable. Does a wetland with 80% cover of the exotic purple loosestrife (*Lythrum salicaria*) perform the same functions as a diverse wet meadow with a total of 80% cover from 30 native wetland species? Even high percent cover by a native species [e.g., cattail (*Typha latifolia*)] can be a problem. Somewhere in the transition from diverse to monotypic plant communities, there is a loss in the suite of available functions, but it is difficult to pin down exactly where that loss occurs. One of the more richly debated concepts in ecology has been the role of species diversity in the development of ecosystem function. The concept of biodiversity has arisen from this debate as a result of concerns over loss of ecosystem function with loss of species. A recent series of papers (Grime 1997, Hooper and Vitousek 1997, Tilman and others 1997, Wardle and others 1997) illustrates the debate that continues over the role of diversity in the maintenance of ecosystem function. Most of the biodiversity attention appears to be focused upon the consequences of a loss of function (i.e., species) when native ecosystems are damaged or destroyed.

Improving Wetland Mitigation Process

Regulatory personnel often have had difficulty in monitoring mitigation projects, both for compliance (i.e., was it built?) and for assessment of desired results (Sifneos and others 1992a, b). The district offices of the US ACE are faced with increasing caseloads of wetland permits as changes are made to the regulatory framework nationwide. It is this overload that contributes to documented cases of mitigation never having occurred (e.g., Erwin 1991). To continue the process of improvement in wetland mitigation, it is imperative that adequate resources are placed into monitoring mitigation projects both during the construction phase, and after they are built. Resources could go to the US ACE or to some independent agency that could track wetland mitigation projects and issue an annual report on compliance and success. Noncompliant projects could then be reported back to the US ACE, the US EPA, and the responsible state agency for further action. In Pennsylvania, the PADEP has increased resources to its wetland program for better tracking permits. However, there are still only a handful of DEP wetland biologists for the caseload.

Permit applications should include sufficient information about the wetland to be damaged to allow a mitigation wetland to be designed appropriately for development of function. Cole and others (1998) suggest using local reference wetlands to develop a series of performance criteria matrices (PCM's), essentially the median values of what constitutes the abiotic and biotic characteristics of a wetland in a certain HGM subclass. If an appropriate location cannot be found (i.e., in kind HGM mitigation is not possible), then the appropriate wetland should be built given the available site conditions. In these situations, PCM's developed from local reference wetlands could be used (Cole and others 1998).

It is reasonably clear that the use of percent herbaceous plant cover as a surrogate for function in mitigation permits was a compromise decision driven by a lack of time and resources. There has been little support for intensive assessment of wetland mitigation projects from either the regulatory community (which has the motivation, but not enough time or funds) or the regulated community (which would rather not deal with permits at all). A comprehensive research effort that looks at the relationships between structure and function in mitigation wetlands at the national level is needed if significant advances toward the goal of replacement of wetland functions are to be made. We need to improve our understanding of the relationships between percent plant cover and wetland functions, or develop alternative indicators.

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