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Wetland Mitigation in the United States:

Assessing the Success of Mitigation Policies

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Abstract

Over most of the past 200 years, wetlands were viewed as useless or worse and about 50% of the original wetlands in the United States were destroyed. Over the past few decades, as the ecological and economic values of wetland habitats have become increasingly recognized, a variety of laws and policies (most notably Section 404 of the Clean Water Act) have been adopted to protect wetland resources. *Mitigation* is a cornerstone of these policies, whereby wetland losses are compensated by wetland restoration, creation or enhancement. Recent surveys show that mitigation policies have reduced the rate of wetland losses, but they have not achieved the goal of "no net loss." Most of these surveys have relied on permit files or simple field visits. These studies show that the area of wetland proposed for mitigation often does not even meet the area impacted. In addition, few mitigation projects are in compliance with all of their permit conditions. The picture is even worse when one considers the ability of restored wetlands to replace natural wetland functions. Several qualitative assessments of wetland mitigation projects in California indicate that some projects produce high quality habitat, but most are moderate quality and some are very low quality. A quantitative functional assessment of riparian mitigation projects in Orange County, California showed that **none** of the mitigation projects were successful from a functional perspective. To prevent continued wetland losses, permit conditions must focus on wetland functions, mitigation ratios (the area of mitigation required compared to the area lost) must be larger, permit conditions must be enforced, and monitoring and remediation must be improved.

Introduction

Throughout most of history, wetlands have been viewed by most of society as undesirable, the source of mosquitoes and disease and noxious odors. Consequently, it is not surprising that a great deal of the original wetland habitat in the United States, as elsewhere, has been destroyed. A comprehensive analysis of wetlands in the United States provides a good estimate of wetland losses (but not degradation) by analyzing aerial photographs of a stratified random sample of 3,629 plots throughout the U.S., each 2,560 acres[1] in size (Dahl and Johnson 1991). In the 1780's, the conterminous United States contained 221 million acres of wetlands (Dahl 1990); by the 1980's, only 103 million acres remained (Dahl and Johnson 1991). Over the past 200 years, 22 states have lost more than 50% of their wetland habitat (Dahl 1990). California has the distinction of having lost the largest fraction of its wetlands, 91%.

Over the past few decades, the value of wetlands has become more apparent. Wetland functions have been catalogued, and wetland values identified (Sather and Smith 1984; Mitsch and Gosselink 1993; National Research Council 1995). For example, wetland functions can include control of surface water storage, maintenance of high water table, the transformation and cycling of elements, the retention and removal of dissolved substances, the maintenance of characteristic plant communities, and food chain support (National Research Council 1995). Wetlands provide important habitat for a variety of fish and wildlife populations, including habitat for about one-third of the plant and animal species federally listed as threatened or endangered and important habitat for migratory birds (Dahl and Johnson 1991). Wetlands also provide many services to humans, including flood control, water quality improvements, and opportunities for hunting, recreation, bird-watching, education and scientific research (Mitsch and Gosselink 1993).

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[1] Areas are reported in acres throughout this paper because that is unit used in permits and reports. To convert acres to hectares, multiply by 0.4047.

Development of Wetland Mitigation Policies

The past destruction of wetlands seems shortsighted in light of our current knowledge of wetland functions and values. As society's understanding of wetland values increased, a variety of policies were established to protect existing wetland habitats. Foremost among these policies has been the concept of wetland mitigation. In this paper, I discuss how wetland mitigation has been applied in the United States. My view is nation-wide, but with a focus on California and the western United States.

The protection of wetland resources has its roots in the concept of mitigation. Mitigation was developed as a way to allow necessary development while protecting natural resources. The concept of mitigation was introduced in the Fish and Wildlife Coordination Act of 1958 (Blomberg 1987). The use of mitigation in natural resource impacts did not become firmly established until the late 1960s, notably with the National Environmental Policy Act (NEPA), which applies to all federal agencies and all activities involving federal monies. NEPA established the procedure for incorporating mitigation analyses into Environmental Impact Statements. NEPA does not require that effective mitigation occurs, but it does require an explanation of mitigation decisions as part of the planning process (Ashe 1982).

One of the early problems with mitigation was inconsistent definitions and applications. If they used mitigation at all, individual agencies applied it according to their own mandates and political environment. The first step towards a consistent national definition came with the Council on Environmental Quality regulations for implementing NEPA, which defined mitigation as: (1) avoiding the impact; (2) minimizing the impact; (3) rectifying the impact; (4) reducing or eliminating the impact over time; and (5) compensating for impacts. This definition includes components of *avoidance* so that an impact does not occur, and *compensating* for impacts that do occur. In general use, and for the most part throughout this paper, "mitigation" usually refers to compensatory mitigation, though it is important to keep the full definition in mind.

At the same time mitigation policy was being developed, the U.S. government moved to restrict development of wetlands by passing the Federal Water Pollution Control Act of 1972 (later the Clean Water

Act). This legislation gave wetlands special protection not afforded other habitat types. Section 404 of the Clean Water Act regulates the placement of dredge and fill materials in the "Waters of the United States," which has been interpreted to include a broad range of wetlands. The U.S. Army Corps of Engineers, in cooperation with the U.S. Environmental Protection Agency, is responsible for implementing the Section 404 program (USACE (United States Army Corps of Engineers) 1986). Mitigation is an important part of the permitting process under Section 404 (Kruczynski 1990), not because it is explicitly required under the Clean Water Act but because the issuance of a Section 404 permit triggers NEPA and its mitigation requirement (Berry and Dennison 1993). The Corps administers a similar permitting program under Section 10 of the Rivers and Harbors Act of 1899.

During the 1980s, the concept of mitigation began to mature. The U.S. Fish and Wildlife Service (Federal Register, v. 46, No. 15 at 7644) adopted the first comprehensive mitigation policy in 1981. The Corps of Engineers adopted its own mitigation policies in 1985. In 1990, the U.S. Congress instructed the Corps to pursue the goal of "no overall net loss" of the nation's remaining wetlands (Section 307 of the Water Resources Development Act). President Bush's administration adopted this "no net loss" goal, as has President Clinton's administration. There is some issue about the interpretation of "no net loss." It is clear that there is a desire that there be no further loss of wetland acres. But if acres alone were the criteria, low-function mitigation wetlands could replace highly functioning natural wetlands, and this would be contrary to the overall goal of protection wetland functions and values. Therefore, the current interpretation is there should also be no net loss of wetland functions and values. This could mean a highly functioning mitigation wetland could replace a low-function natural wetland using a smaller area. On a case-by-case basis, this does occur, but if widely implemented it would mean an overall loss of wetland acreage. Some mitigation policies address these issues explicitly. For example, the U.S. Fish and Wildlife Service mitigation policy for wetlands in the western United States is no net loss of in-kind habitat value or acreage, whichever is greater (Habitat Resources II, Wetland Policy, Region 1, October 22, 1985, cited in DeWeese [1994]).

An important aspect of the refinement of mitigation policy was the development of priorities for evaluating mitigation alternatives. Mitigation that avoids or minimizes impacts is the preferred approach; compensatory mitigation should be used only to mitigate for unavoidable impacts. These priorities are implemented in Section 404 permitting through a process of "sequencing," initiated through a 1990 Memorandum of Agreement between the Corps and EPA (Berry and Dennison 1993). First, an applicant must show that a project is "water dependent" and must therefore be completed in or near a wetland, and that the project is the least damaging, practicable alternative that meets the specific project purpose. The applicant is also required to attempt to avoid impacts, then minimize them. Finally, if the applicant can show that the proposed project has no alternative sites and the impacts have been minimized but there are remaining impacts to wetlands and "waters," the permitee may be required to provide compensatory mitigation, such as wetland creation or restoration.

These national efforts have been mirrored by a variety of state policies. For example, the California Coastal Act of 1976 regulates coastal development, with specific guidelines for impacts to wetland habitats. Unlike Section 404, where often an applicant is not required to notify the Corps for impacts less than 1/3 acre and the commonly applied Nationwide Permit 26 allows impacts up to 3 acres, there is no acreage threshold below which a proposed project is categorically exempt from Coastal Commission review. To permit a project, the Commission must find that (1) there is no feasible less environmentally damaging alternative, (2) feasible mitigation measures have been provided to minimize adverse environmental effects, and (3) the functional capacity of an existing wetland or estuary is maintained or enhanced. In evaluating feasible restoration alternatives, availability of potential restoration sites is considered but the sites do not need to be owned by the project proponent. The governor of California has also adopted a no-net loss policy for the state. The states of Oregon and Washington also have specific and complex mitigation policies (Blomberg 1987). Another example is the Freshwater Wetlands Protection Act (FWPA) adopted by New Jersey specifically for protection of freshwater wetlands, considered to be the strongest wetland law in the United States (Torok et al. 1996). The FWPA regulates more activities than Section 404 and requires permits for activities impacting one acre and less of man-made drainage ditches, natural swales or isolated wetlands.

Thus, the current attitude about wetland protection is vastly different from the attitudes of the past. Federal and state policies have been adopted that protect wetland habitats. Although these policies universally favor wetland conservation and protection, they also provide for mitigation of the wetland impacts that are inevitable with continuing public and private development. In the next section, I consider how well these policies are being implemented.

Implementation

There are many different ways to evaluate the implementation of wetland protection and mitigation policies. The simplest is to rely on information contained in permit files. Permit files contain information about the nature of the impacts to natural wetlands, including type of wetland and nature and size of the impact, and the type of compensatory mitigation required, including size and type of wetland to be created or restored. Permits also contain special conditions that establish the goals for the mitigation wetlands. Special conditions are established by regulatory personnel, though frequently with input from the permittee, on a project-by-project basis. As a result, there can be differences between regions and even individuals in what conditions are attached to a permit. On the other hand, there are some general policies that apply broadly. For example, the 1990 Memorandum of Agreement between the Corps and EPA (Berry and Dennison 1993) establishes policy for the location of a mitigation project: the highest priority is given to on-site mitigation, but if off-site, the mitigation should be in close proximity to the impact area, such in the same watershed.

Permit files provide insight into the intent of regulators when they issue permits for wetland projects. Of course, intentions are not always realized, so another approach for evaluating how mitigation policies are being implemented is to assess how well actual mitigation projects meet their permit conditions. From this perspective, compliance with permit conditions would mean successful implementation of permit objectives.

Successful achievement of permit conditions does not necessarily mean that wetland mitigation goals have been achieved, however, because the permit conditions may have been inadequate. Since an underlying goal of mitigation policy is to protect wetland functions and values, a final approach to evaluating the success of mitigation policy is to assess how well mitigation wetlands attain the functions of natural wetlands.

These three approaches are discussed in the following sections.

Acreage Required

When the US Army Corps of Engineers was required by the US Congress to report on its implementation of Section 404, it based its evaluation on the area of wetland impacted and required for mitigation. According to the Corps, Section 404 implementation is resulting in more acres of wetland being required as mitigation than are being allowed to be destroyed (Studt 1994). In 1993, 11,600 acres of wetlands were impacted under Section 404 permits with mitigation requirements for 15,200; in 1994, 17,200 acres were impacted with requirements for 38,000 acres of mitigation (Table 1). Thus, by the simple metric of acreage, overall the Section 404 program appears to be protecting wetland resources in the United States and, in fact, achieving the policy goal of “no net loss.”

The Corps data represent data aggregated across the entire United States. Several studies have focused on individual states or regions. Kentula and her colleagues have examined 404 permits for a number of southern and Pacific coast states (Kentula et al. 1992; Sifneos et al. 1992a; Sifneos et al. 1992b). In every case, fewer acres were required as compensatory mitigation than were allowed to be impacted under 404 permits (Table 1). In some cases, such as Arkansas, the number of permits was quite low (only 7) and the difference between impacts and compensatory mitigation was small (only 10.7 acres, or 1.5% of the impacts). In other cases, though, many acres were impacted or the difference between impacts and mitigation were substantial. For example, 2,945 acres were impacted in Texas, but 917 fewer acres were required as mitigation, for a loss of 31%. In Oregon, fewer acres were involved but the loss was 43%.

Several studies have assessed wetland mitigation in California (Table 1). Holland and Kentula (1992) summarized statistics for the entire state. In contrast to other states, there was a net gain of wetland acreage, although the gain was very small (0.06%). McEnespy and Hymanson (1997) reviewed 13 permits given by the California Coastal Commission for wetland mitigation in coastal California. The total acreage was small (12.7 acres of impacts), but acres of mitigation required exceeded impacts by 32%; most (13.0 acres) of the compensatory mitigation was enhancement of existing wetland rather than restoration or creation. This pattern of more acres of mitigation than impacts has also been found in studies of California subregions. (DeWeese 1994) examined Section 404 permits for the San Francisco Bay-Delta region issued between 1983 and 1993. A subset of 30 projects was evaluated from a total of 168 permits for the area. For these 30 projects, 415 acres of impacts were to be mitigated by the 599 acres of mitigation, for a gain of 184 acres (Table 1). Allen and Feddema (1996) reviewed 75 projects in southern California in which 276 acres of mitigation were required for 199 acres of impacts. Sudol (1996) examined Corps permits (both Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act) issued in Orange County from 1979 to 1993. The 70 permits requiring mitigation permitted 335 acres of impacts while requiring 376 acres of mitigation, for a gain of 41 acres (Table 1). In San Diego County, impacts to 253 acres of wetlands were compensated by requiring 382 acres of mitigation, a 51% increase in area (Fenner 1991). Thus, it appears that the imposition of compensatory mitigation requirements for wetland impacts in California may have been more in line with national mitigation policy than in other states, at least in terms of increasing acreage.

The preceding analyses focused on permits requiring compensatory mitigation. Only a subset of all Section 404 permits require compensatory mitigation. In Louisiana, 41% of the 404 permits required compensatory mitigation (Sifneos et al. 1992a), whereas only 3% of the permits in Oregon required mitigation (Kentula et al. 1992). By including only permits requiring compensatory mitigation, these studies may have overlooked some cases of uncompensated loss. For example, 13% of the 535 Corps permits for Orange County required compensatory mitigation (Sudol 1996). The remaining 465 permits allowed 54 acres of impact without compensatory mitigation. Most of these permits were issued under Section 10 for work in bays and harbors that was considered to have minimal impacts on the aquatic environment. Nonetheless, if the 54 acres of impacts is added to the 335 acres of impacts allowed by permits requiring compensatory mitigation, then overall Orange County has experienced a net loss of 13 acres (3.3%) rather than an increase of 41 acres.

Aside from the issue of inadequate acreage being required, other problems with the implementation of Section 404 have been uncovered by analyzing permit files. In Oregon and Washington, impacts and compensatory mitigation were not balanced for some types of wetlands (Kentula et al. 1992). In Oregon, freshwater marshes had the greatest loss, with additional uncompensated losses of forested wetlands and lower riverine bottom habitat. In contrast, 18 freshwater ponds constituting 19% of the area were created, even though no freshwater ponds were impacted. For estuarine wetlands, there was a large loss of subtidal flats but a gain in salt marsh. Similar patterns were seen in Washington. In southern California, riparian woodlands accounted for 20% of the impacts but 35% of the required mitigation, whereas freshwater wetlands accounted for 29% of the impacts but only 19% of the required mitigation (Allen and Feddema 1996). In addition, compensatory mitigation under Section 404 can include projects that do not create or restore wetland habitat. For example, the planned mitigation projects in Orange County included 24 acres of enhancement of existing wetlands and 31 acres of passive revegetation (Sudol 1996). Although enhancement can improve wetland functions, it does not increase wetland area, and including this acreage in mitigation summaries as if it is a “gain” in area (which must usually be done because of the nature of permit records) overestimates the actual gain in wetland area.

Analyses based on area of wetlands impacted and required as compensatory mitigation rely on reviews of permit files. Each of the studies cited above has noted the difficulties associated with such reviews because of poor data quality, incomplete files, and poor accessibility. In spite of these problems, file reviews provide a useful picture of the *intent* of regulators when they issue permits for wetland projects, an important aspect of the implementation of wetlands policy. However, permit reviews provide only a limited view of compensatory mitigation. On the one hand, they only consider the final permit actions, not the avoidance and minimization of impacts that result from the permitting process. Allen and Feddema (1996) report that 14 permits were withdrawn from 1987-89, and that withdrawn permits are sometimes resubmitted with reduced wetland impacts. On the other hand, permit reviews cannot determine whether the required mitigation was actually undertaken, whether it actually complied with the terms of the permit, and whether it fully compensated for the wetland functions and values lost by the permitted project. Actual implementation and compliance of mitigation projects are discussed in the next section, while the function of mitigation wetlands is discussed in the following section.

Compliance with Permit Conditions

An assessment of how well wetland mitigation projects actually meet their permit requirements cannot be based on an office review of permit files. In theory, permittees provide the Corps with a signed certificate of compliance after completion of the project stating that they fully complied with the permit's terms and conditions. In practice, the Corps cannot keep track of whether these certificates have been filed, and in any case it is unlikely that a permittee would certify that the permit conditions were <u>not</u> met! Thus, an assessment of permit compliance necessitates an on-site review of mitigation sites. During a site visit, the conditions at the mitigation site can be compared to the permit requirements. Surprisingly few assessments of actual permit compliance have been completed in the United States. Results of early surveys in San Francisco Bay ranged from a low of 3% success (Eliot 1985) to 33% (Demgen 1988) or 43% (BCDC (Bay Conservation and Development Commission) 1988) success. (Note that some of these early studies often confounded *compliance success*, how well the projects met their permit requirements, with *ecological success*, how well they replace the functions of natural wetlands.) Recently, three different studies were completed in California, and these examples are discussed below.

DeWeese (1994) reviewed 30 projects in the San Francisco Bay-Delta region given Section 404 permits by the Army Corps of Engineers. Each project was given a Compliance Rating from 0-10, with 10 indicating full compliance, 9 indicating 85-99% compliance, and so forth. Only 3 projects complied with 100% of their permit requirements (Figure 1A). Six projects complied with 85-99% of their permit conditions, and another six projects complied with 75-84%. Twelve projects complied with 45-74% of their permit conditions. Finally, one project complied with only 1-14% of its permit conditions, and two projects had zero compliance. In terms of compliance, then, there were a few projects that fully complied with their permits, a few more that were nearly in compliance, the majority in the middle range, being out of compliance for a substantial number of permit conditions, and a few with very poor compliance.

DeWeese's summary of mitigation compliance indicates a number of problem areas regarding permit conditions. For example, the notes for one project (PN 9957) indicate a number of problems with plant survival and concerns about adequate irrigation, in part because the planting sites were high on a levee and might be too far from the water table. There are also questions about the maintenance and removal of vegetation planted as mitigation. These problems raise serious questions about the long-term sustainability of this site. Nonetheless, the site was given a perfect score (10) for compliance. DeWeese notes "the permit does not require that the plants have vigorous growth, only that they be alive."

DeWeese's study also illustrates an additional problem with using permit file summaries to evaluate the implementation of mitigation policies. Although 599.4 acres of mitigation were required by the Section 404 permits, only 537.2 acres were actually created. This still exceeds the 415.3 acres of impacts allowed by the permits, but reduces the excess acreage from 184.1 acres to 121.9 acres.

McEnespy and Hymanson (1997) conducted a similar survey of wetland mitigation projects, this time based on compliance with conditions established in California Coastal Commission permits. Half of these projects met 90-100% of their permit conditions (Figure 1B; compliance was not reported with finer resolution). Four projects (22%) met fewer than 32% of their permit conditions.

Sudol (1996) evaluated permit compliance at the Section 404 and Section 10 permits issued in Orange County from 1979 to 1993. Thirty of the 70 sites (43%) met all of their permit conditions and were considered successful; these projects comprised 195 acres. Six sites (9%) comprising 52 acres did not meet any of their permit conditions and were considered failures. In addition to the six failures, mitigation was never attempted at two sites where it was required. Finally, the permitted project was never completed for some reason at 13 sites, and so no compensatory mitigation was needed, even though these permits are included in summaries based on permit files. Excluding these "no project" sites, there were 315 acres of impacts; only 195 acres of mitigation met all permit conditions, for a success rate of 62%. Looking just at riparian sites (discussed further below), there were 40 projects allowing 240 acres of impacts and requiring 256 acres of mitigation. Twenty of the projects covering 143 acres successfully met all of their permit conditions, for a success rate of 60% by acres; 7 projects covering 41 acres were failures (17% by acres).

Achievement of Mitigation Goals: Replacement of Wetland Functions

The assessments reviewed thus far have not assessed the ecological trade-offs in mitigation, yet these are the most controversial. The basic goal for mitigating impacts to natural wetlands is to replace wetland functions (and values). In Oregon and Washington, functional replacement was listed as the goal for >65% of Section 404 permits requiring compensatory mitigation (Kentula et al. 1992). Unfortunately, few studies have assessed whether this goal is being accomplished.

Shortly after wetland mitigation became widespread, questions about its appropriateness were raised (Race and Christie 1982; Quammen 1986). One of the first critiques of wetland mitigation concluded that few, if any, wetland restoration projects in San Francisco Bay were successful (Race 1985). A review of 14 wetland mitigation projects in San Francisco Bay found that 43% of the projects were successful, in that they met their permit conditions and created valuable Bay resources (BCDC (Bay Conservation and Development Commission) 1988). Zentner (1987) examined 63 coastal wetland restoration projects throughout California and found that 65% of them were successful (defined as exhibiting roughly typical wetland values as similar, unrestored wetlands and meeting the goals of the project).

One problem with these early studies is that they relied on non-quantitative, subjective evaluations. In recent years, many studies have provided a quantitative comparison between restored and natural wetlands (e.g., Craft et al. 1988; Moy and Levin 1991; Rulifson 1991; Chamberlain and Barnhart 1993; Sacco et al. 1994; Havens et al. 1995; Streever et al. 1996; Minello and Webb 1997; Zedler et al. 1997). However, few of these studies have taken a broad look at mitigation *per se*, and concerns about whether constructed or restored wetlands can successfully replace natural wetland functions remain. A recent special feature in the journal *Ecological Applications* highlighted some of the concerns (Zedler 1996).

After 10 years, Race notes that, in spite of progress in some areas, compensatory mitigation continues to have a poor record of performance (Race and Fonseca 1996).

In perhaps the most detailed study of the functional equivalence of a mitigation wetland, Zedler and her coworkers have developed an extensive body of information about two mitigation projects in San Diego, California (Pacific Estuarine Research Laboratory (PERL) 1990; Zedler 1996; Haltiner et al. 1997). The mitigation marshes were constructed on dredge spoils with substantially different sediment characteristics than natural marsh sediments, including coarser grain size and lower organic and nutrient contents. This fundamental difference has led to lower cordgrass (*Spartina foliosa*) heights than at a nearby reference natural wetland (Langis et al. 1991; Gibson et al. 1994; Boyer and Zedler 1999), and the consequent absence of the endangered species, the Light-Footed Clapper Rail, for which the mitigation was required (Zedler 1993). Five years after construction, the mitigation marsh did not reach the level of the natural marsh reference site for 10 of 11 ecosystem functions (Zedler and Langis 1991). Although the sediment may eventually become similar to the reference site, even after 12 years there is little evidence of a clear trajectory to convergence (Zedler and Callaway 1999). However, the mitigation site was not deficient in all functions: the fish assemblage was comparable to the reference site (Zedler et al. 1997).

Although Zedler's detailed studies of the San Diego mitigation salt marshes provide strong evidence that restored wetlands may not fully replace the functions of natural wetlands, they do not provide insight into the frequency and severity of this problem. Several recent studies that have surveyed a number of different mitigation projects can provide this broader perspective. Not surprisingly, there is a trade-off between the level of detailed information that can be obtained at one or two sites versus many different sites. As a result, these survey studies have less detailed information about each site, and frequently depend on qualitative assessments involving "best professional judgement." In spite of the limitations of this subjective approach, these surveys yield provide useful information about the general success of wetland mitigation projects.

DeWeese (1994)used a qualitative assessment of wetland value to evaluate the success of Section 404 projects in the San Francisco Bay-Delta region. Each project was given a Value Rating from 0-10, with

10 indicating extremely high value (among the best examples of this habitat type in the region) and 0 indicating no value; this rating system is similar to the ratings given for compliance (see above). The ratings were determined by each evaluator's best professional judgement. Most of the projects evaluated (53%) were more than five years old (the period most frequently specified in Corps permits for monitoring).

Of the 29 mitigation projects evaluated, only one was judged to have very high value (Figure 2A). Thirteen projects were judged average or slightly above or below average. Six projects were judged well below average, two were judged to have low value, and two projects were judged to have no habitat value. Although the goal of "no net loss of acreage" was being met in the Bay-Delta region, the mitigation projects were not replacing in-kind habitat values. The average value rating was only 4.66 for the 30 projects studied.

Compliance ratings were correlated with value ratings for different wetland types. For example, the two wetland types with the lowest compliance ratings, riparian and vernal pools, also had the lowest value ratings. This correlation also holds for all projects considered individually, with $r=0.69$ ($P<0.01$, $N=29$ because value was not rated at one site). These results suggest that mitigation projects that met their permit conditions were most likely to provide high habitat value.

DeWeese emphasized the importance of permit compliance for ensuring a successful project. One particular shortcoming highlighted was the frequent omission of monitoring reports. DeWeese considered the primary objective of the monitoring report to be requiring the permittee to evaluate interim project success and take remedial actions when necessary; absence of a monitoring report, therefore, may reflect a lack of attention to the mitigation site. DeWeese also noted that permits commonly included inadequate success criteria. Success criteria were stated as vague goals or a single criterion (e.g., percent vegetation survival) with no reference site designated as a control.

McEnespy and Hymanson (1997) examined sites permitted under the California Coastal Act. Using a methodology similar to DeWeese's, sites were evaluated during field visits and assigned a subjective score based on the perceived habitat quality. Six of the 23 projects were given the highest grade of "A," six were given B's, and six were given C's (Figure 2B). There were four projects given the barely passing score of D, and one project was given an F. Although the middle-to-lower distribution of scores appears similar to DeWeese's, relatively more projects were judged to have higher value. Because of the subjective nature of the assessments, it's not possible to know whether the Coastal Commission projects were actually resulting in higher habitat quality (perhaps because of better oversight or planning), or whether the apparent differences are due to differences in scoring.

Allen and Feddema (1996) used a different approach when they examined 75 southern California wetland sites. They used a subjective methodology that evaluated project completion/compliance and three condition criteria: vegetation status, ground cover, and invasion by weeds. They "discounted" mitigation acreage according to the status of the project. For example, for projects that were completed and generally complied with Corps permit requirements but exhibited significant problems in one of the three condition criteria, the project area was multiplied by 0.75; if two of the condition criteria were not met, the project area was multiplied by 0.50. If mitigation was incomplete or unsuccessful, the project area was multiplied by 0.0. Overall, Allen and Feddema found a 69% success rate, so that 191 acres served as mitigation for 199 acres of impacts. Successful mitigation was substantially lower than the 276 acres required by the permits, so that instead of the apparent 38.7% increase in acreage in the permits (Table 1), there was a slight decrease in acreage. Allen and Feddema found a difference in mitigation success between Orange County (75%) and Riverside County (40%), as well as a slightly higher success rate for large projects (>8.6 acres) compared to small (73% versus 66%).

Although not related to compensatory mitigation under Section 404, Josselyn et al. (1993) evaluated restoration projects conducted under the California State Coastal Conservancy's program. Twenty-two projects at 19 sites were selected for evaluation; as a result of these projects 1652 acres of coastal wetland were acquired or enhanced. The success of each project in enhancing specific wetland functions was evaluated subjectively using best professional judgement. At 36% of the sites, all of the evaluated wetland functions were improved by the restoration. At 48% of the sites, at least one wetland function was not improved by the restoration project, and one site (5%) failed in all functions evaluated.

Using criteria established by the National Research Council (1992) for judging project effectiveness, Josselyn et al. (1993) found that 59% of the projects were effective at achieving their goals, 45% were effective at producing a self-sustaining ecosystem, 61% were effective at restoring critical functions, and 55% were effective at producing habitat benefits. For each of these categories except producing a self-sustaining ecosystem, only 5% of the projects were ineffective. The majority of restoration projects did not produce a self-sustaining ecosystem, and 31% were judged ineffective in this category.

Qualitative assessment approaches such as those just described are used because they are quick and easy to implement, but they have many significant shortcomings. For example, comparisons among studies are complicated by the subjective nature of the assessments, as mentioned above. Qualitative assessments also have tended to focus on vegetation and other easily reviewed aspects of a site, overlooking important wetland functions. As an alternative to qualitative assessments, the Hydrogeomorphic (HGM) assessment methodology has been developed to provide a function-based assessment approach appropriate for regional wetland types (Smith et al. 1995; Brinson et al. 1997). HGM is appropriate for planning and assessment of wetlands in a regulatory context. It is particularly well suited for questions concerning the mitigation of wetland impacts from the standpoint of the replacement of wetland functions (Rheinhardt et al. 1997; Hauer and Smith 1998), and has recently been used for impact assessment and mitigation planning (Ainslie and Sparks 1999). HGM classifies wetlands by hydrologic and geomorphic properties and uses information on other wetland sites from the region in the same HGM class to develop and calibrate standards for assessment. The number of functions included in the assessment depends on the wetland class, but are included in the general functional categories of hydrology, biogeochemistry, and maintenance of characteristic plant and animal communities. HGM models are developed for specific wetland classes (e.g., estuarine fringe wetlands), which allows them to be tailored to the specific functions performed by that wetland class in a specific region, but precludes comparison between different types of wetlands. HGM results provide an indication of the potential for a wetland to perform various functions, but does not directly measure the functions or the actual “value” of the site.

As part of his evaluation of all mitigation projects required by the Corps of Engineers in Orange County, CA as compensation for impacts to riparian habitats under Section 404, Sudol (1996) used HGM to provide a quantitative indication of wetland functions at a variety of mitigation sites. I have already discussed Sudol's survey of permit compliance at 70 mitigation sites in Orange County. The HGM assessment was conducted at all of those sites classified as lower perennial riverine habitat. Forty projects were included, representing 240 acres of impacts with 256 acres of proposed mitigation. The 15 habitat functions included in the HGM model were assessed for all 40 projects, and compared to the values at 7 reference sites representing the best attainable conditions in the region. The functions were combined into three subgroup scores, for hydrology, biogeochemistry, and habitat. Criteria for success were based on the functional capacity scores of the reference sites. Since none of the reference sites had subgroup functional capacity scores less than 83% (most were much higher, with a mean of 95%), the criterion for successful achievement of a subgroup function at a mitigation site was set at 80%. This criterion is quite low compared to the functioning at the reference sites in order to avoid judging the mitigation sites too harshly. Any site that scored less than 50% on two of the three function subgroups was judged a failure.

The results are striking. Not a single mitigation site was found to be successful. Five sites (16.5 acres of impacts and 24.0 acres of mitigation) were complete failures without applying an HGM assessment based on a lack of vegetation and hydrology. The remaining 35 projects were located at 20 sites. Of these, only two sites were judged successful for even one subgroup (hydrology) (Figure 2C), and many of the sites achieved less than 50% functional capacity in all three subgroups. Except for the two hydrology subgroup scores, the functional capacities of the mitigation sites were not even in the range of the reference sites. The distribution of the mitigation site subgroup functional capacities seemed to be bimodal, with one mode at 60% functional capacity and the other at 20%. These results indicate that most of the functions were being performed at a low level at most of the mitigation sites.

The major reason for the failure of these sites was the lack of proper hydrology, specifically stream channels. Most of the mitigation sites were planted and irrigated upland sites. There is no overbank flooding at these sites, so hydrological functions such as dynamic surface water storage and energy dissipation are low. The habitat scores were higher because of the ease of establishing vegetation on irrigated sites. However, even HGM does not measure an aspect of habitat function that is undoubtedly lacking at these sites: sustainability. Without the proper hydrologic regime, the riparian vegetation cannot be sustained at these sites even if irrigation can support planted riparian vegetation.

Sudol's results demonstrate the importance of judging the success of mitigation based on quantitative assessment of wetland functions. Comparing only acres of impacts with acres of mitigation, the riparian habitat losses caused by 40 projects in Orange County were more than compensated for, with 256 acres of mitigation required for 240 acres of impacts. Based on acres alone, all 256 acres of required mitigation are considered successful (Figure 2). Based on permit conditions, only 143 acres successfully met their permit conditions, and 41 acres failed to comply with any of the permit conditions. The HGM assessment, however, shows that even the sites that achieved compliance success did not attain ecological success. From a functional perspective, 0 acres were successful, 15 acres were partially successful, and 241 acres were a failure.

Sudol's results also highlight the difference between qualitative and quantitative assessments of ecological success, because he made independent assessments using each approach. Sudol's qualitative assessment, based on the type of field review using best professional judgement, indicated that 9 projects, accounting for 104 acres of impacts and 63 acres of mitigation, were successful, and 14 projects accounting for 51 acres of impacts and 84 acres of mitigation were failures. As with most qualitative assessments, Sudol's assessment was heavily influenced by the vegetation at the site. For example, success was defined as habitat with "similar spatial and species diversity as minimally disturbed habitat," while failure was assigned to sites with mostly upland plant species or less that 10% cover of vegetation. The HGM assessment provided a much broader framework for assessing functions. Ultimately, this broader framework was responsible for identifying fundamental flaws in the functioning of the mitigation sites. The difference in conclusions is dramatic: from 63 acres of successful mitigation and 84 acres of failed mitigation to 0 acres of success and 241 acres of failure. Thus, Sudol's work suggests that the ecological success rate found in other studies using "best professional judgement" may, in fact, be higher than warranted by a broader view of wetland functions.

Conclusion

The United States has some powerful laws and policies aimed at conserving wetland habitats. They are the result of the relatively recent realization of the magnitude of wetland loss in the United States coupled with a recent recognition of the ecological importance of wetland functions and the societal value of wetland habitats. However, there are problems with nearly every aspect of the implementation of these policies. As a result, wetland losses continue, albeit at a lower rate.

The problems described here do not mean that there is no value to mitigation policies. The policies have been evolving to protect wetlands better, and some of the studies discussed here have only recently identified remaining problem areas. In the United States, there is little point in considering the elimination of mitigation; outlawing any development in any wetland would raise serious issues of private property rights and legal "takings." Instead, we must focus on ways to improve the actual practice of mitigation. Several other authors have offered recommendations for ways to improve the success of wetland mitigation (BCDC (Bay Conservation and Development Commission) 1988; National Research Council 1992; Allen and Feddema 1996; Race and Fonseca 1996).

One reason for continued wetland losses is that too many wetland impacts are allowed to go unmitigated. Some of these losses occur because the regulatory protection of wetlands is not broad enough. For example, one of the largest sources of wetland loss, conversion of wetlands to agriculture, is not even regulated under Section 404 of the Clean Water Act (Holland and Kentula 1992). Even for impacts that are regulated, substantial losses still occur. Some 404 permits allow wetland losses without requiring mitigation; in Orange County, this amounted to 16% of the permitted impacts (Sudol 1996). Some are the result of nationwide permits, which allow impacts that are presumed to be non-significant. It is clear, however, that the cumulative effect of hundreds or thousands of small impacts can be significant (Stein and

Ambrose 1998). Finally, an unknown number of acres are impacted due to illegal activities; I will come back to enforcement issues later.

Even for those wetland impacts for which mitigation is required under a permitting program such as Section 10 or Section 404, implementation of the mitigation policy is insufficient. For most states that have been studied, even based on acreage the wetland impacts are not fully compensated. And too much emphasis has been placed on acreage. From both a compliance standpoint and a function standpoint, many (or sometimes all) wetland mitigation projects are not fully successful.

Several steps could be taken to improve the record of wetland protection under existing regulatory programs.

All studies that reviewed permit files have noted substantial problems with record-keeping. Holland and Kentula (1992) note that acreage data were lacking for 40% of impacted and compensatory wetlands. There have also been problems with permit follow-up. For example, Holland and Kentula (1992) found completion dates specified in only 2.2% of compensatory wetlands in California. Holland and Kentula (1992) recommend improved documentation, regular reporting, and increased monitoring.

Although improved record-keeping is essential for evaluating the effectiveness of the 404 Program, in itself it does not ensure that the appropriate compensatory mitigation is completed. Race and Fonseca (1996) have argued that the key to improving the effectiveness of mitigation is "getting to compliance." They recommend a stronger emphasis on compliance and enforcement. Moreover, they contend that noncompliance will likely continue as the norm unless enforcement and monitoring are emphasized. Although recognizing the importance of improved scientific understanding of restoration and creation efforts, they argue that additional scientific information will not be sufficient to resolve the current problems with compensatory mitigation.

One of the most important steps towards improving mitigation would be to improve the special conditions attached to permits requiring mitigation. To a large degree, permit conditions will determine how well compensatory mitigation replaces natural wetland functions and values – at least they establish what is expected. A major shortcoming of most permits is the failure to require replacement of wetland functions and processes; instead, performance standards are based on simple measures such as plant survivorship or cover. Part of the reason that mitigation wetlands do not replace natural wetland functions is undoubtedly the difficulty of reproducing natural functions and processes. But part of the problem is also the non-rigorous expectations established in permit conditions. Permittees and their consultants can be very good at providing the conditions required in permits. In Orange County, for example, permit conditions generally focused on survival of planted riparian trees, so consultants became quite good at producing "tree farms." Because the permits did not require the replacement of natural hydrologic or biogeochemical functions, it is perhaps not surprising that these functions were not present at mitigation sites. Requiring that these functions be replaced, as a permit condition, will challenge the consultants to find methods for replacing them.

Monitoring requirements must also be improved for mitigation projects. Lax monitoring requirements may send the wrong message to a permittee, suggesting that there is little interest in whether or not a mitigation project is successful. For example, monitoring by even one follow-up visit was required for less than one-third of compensatory mitigation sites in California (Holland and Kentula 1992), and for only 10% of the projects in Louisiana (Sifneos et al. 1992a). Most monitoring requirements are too short. The longest monitoring period typically required in Section 404 permits is five years, although monitoring can be longer if the mitigation involves a unique habitat type or is not successful. Recent studies have indicated that the long-term functioning and sustainability of a restoration site may not be apparent until 10 to 40 years after the project is completed. Finally, the permittee is responsible for monitoring. Although the permit conditions can specify what needs to be monitored and the permittee may be required to hire a biological monitor (i.e., someone trained to do this work), this does not remove the potential conflict of interest in which a permittee decides whether they have complied with permit conditions. Independent monitoring, where the monitor answers to the permitting agency rather than the permittee, might provide a more accurate accounting of restoration success.

Monitoring is also necessary to evaluate whether or not remediation is needed. Typically, there is no explicit provision for remediation if ecological functions are not replaced by a mitigation wetland. A permittee's responsibilities end with the satisfaction of permit conditions, but the simple, non-function basis and short time frame for most performance standards (3-5 years) means that there is little assurance that natural wetland functions will be produced and sustained. To compensate fully for impacts to a wetland, a mitigation wetland must provide the same wetland functions for as long as the impacted wetland would have provided those functions. Success in the short term (3-5 years) does not mean that the mitigation wetland will be as resilient to environmental perturbations as a natural wetland. Thus, mitigation wetlands must be monitored for an extended period of time, and appropriate remediation undertaken if the wetland ceases to provide replacement of the lost wetland functions.

Good mitigation policies do little good if there is no enforcement. The present lack of enforcement allows inadequate efforts to be considered successful, and illegal actions (e.g., failing to construct a required mitigation project) go undetected. Although there is widespread concern about the lack of enforcement, Sudol (1996) found relatively few cases where wetland impacts were permitted but the required mitigation was not undertaken. Still, there is little question that unpermitted activities are illegally impacted wetlands (although the magnitude of the impacts are not well known), and increased enforcement could help stem these losses.

Finally, it is clear that even the best implementation of mitigation policies, with appropriate permit conditions and monitoring, will not ensure successful mitigation. Experience to date suggests that even projects that have been carefully designed to replace natural wetland functions do not always do so. There is just too much we still don't know about how to restore or create wetland habitats. The history of mitigation failures argues for extreme caution. The greatest precaution is to avoid destruction of natural wetlands whenever possible. If this is not possible, we need to take the precautions mentioned above, and in addition higher mitigation ratios may be necessary in order to end up with no net loss of wetland functions in a region. We need to consider wetland restoration or creation as experimental. Adaptive management (see Zedler 1996) provides a framework to improving our understanding of wetland mitigation over the long term, so that eventually we may actually be able to realize the goal of no net loss of wetland functions.

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Table 1. Summary of wetland losses and required mitigation. Except for McEnespy and Hymanson (1997), all projects summarize Section 404 permits; permits not requiring mitigation were excluded from the analyses.

Location	Date	No. of permits	Impacts (acres)	Mitigation (acres)	Change (acres)	Change (%)	Comments	Reference
United States	1993 1994	NA NA	11,600 17,200	15,200 38,000	+3,600 +20,800	+31.0 +120.9		Studt 1994
Louisiana	1982-87	93	2909.6	2191.0	-718.6	-24.7	Permits req. mitigation 41% of total, 8% of imp. area compensated	Sifneos et al. 1992a
Alabama	1982-87	18	112.9	267.6	+154.7	+137.0	All permits req. mitigation	Sifneos et al. 1992a

Table 1. (continued)

Location	Date	No. of permits	Impacts (acres)	Mitigation (acres)	Change (acres)	Change (%)	Comments	Reference
Mississippi	1982-87	5	1,006.7	1,006.9	+0.2	+0.0002	Permits req. mitigation 50% of total, 37% of imp. area compensated	Sifneos et al. 1992a
Texas	1982-86	46	2,944.5	2,027.2	-917.3	-31.2		Sifneos et al. 1992b
Arkansas	1982-86	7	703.3	692.6	-10.7	-1.5		Sifneos et al. 1992b
Oregon	1977-87	58	182.8	103.7	-79.1	-43.3	Permits requiring mitigation 3% of total	Kentula et al. 1992b
Washington	1980-86	35	150.7	111.2	-39.5	-26.2		Kentula et al. 1992

Table 1. (continued)

Location	Date	No. of permits	Impacts (acres)	Mitigation (acres)	Change (acres)	Change (%)	Comments	Reference
California	1971-87	324	2,906.6	3,103.3	+196.7	+0.06		Holland & Kentula 1992
California	1976-90	13	12.7	16.8	+4.1	+32.2	Calif. Coastal Comm. permits req. mitigation	McEnespy and Hymanson 1997
Southern California	1987-89	75	198.8	275.8	+77	+38.7		Allen and Feddema 1996
SF Bay-Delta, CA	1983-93	30	415.3	599.4	+184.4	+44.3	Randomly selected from 168 projects	DeWeese 1994
Orange Co., CA	1978-93	70	335	376	+41	+12.2	Permits req. mitigation 13% of total	Sudol 1996

Table 1. (continued)

San Diego Co., CA	1985-89	ND	252.6	381.8	+129.2	+51.1		Fenner 1991

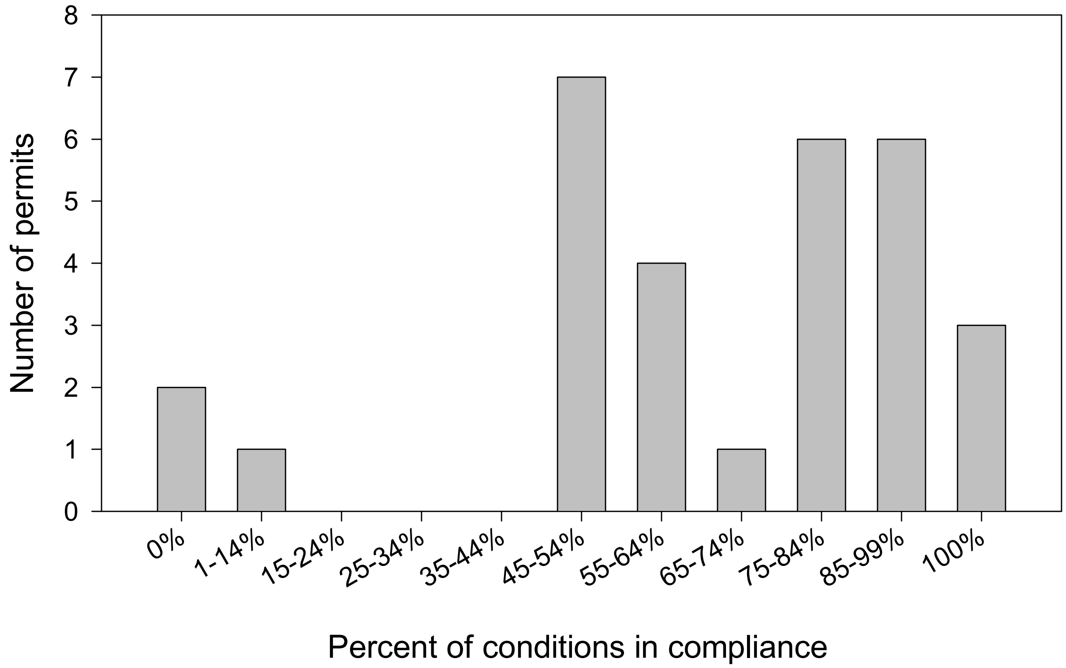
Figure Legends

Figure 1 Compliance of mitigation projects. (A) Compliance of mitigation projects in the San Francisco Bay-Delta region, California, with Section 404 permit conditions (data from (DeWeese 1994). (B) Compliance of coastal mitigation projects in California with conditions established in California Coastal Commission permits (data from (McEnespy and Hymanson 1997).

Figure 2 Habitat value of mitigation projects. (A) Qualitative ranking of 29 mitigation projects in San Francisco Bay-Delta region, California, based on best professional judgement (data from (DeWeese 1994). (B) Subjective ranking of mitigation projects permitted by the California Coastal Commission (data from (McEnespy and Hymanson 1997)). (C) Functional subgroup scores from Hydrogeomorphic (HGM) assessment of 20 riparian mitigation sites in Orange County, California (data from (Sudol 1996). Each project was scored for three functional subgroups (hydrology, biogeochemistry and habitat). Also shown are subgroup scores for 7 reference sites.

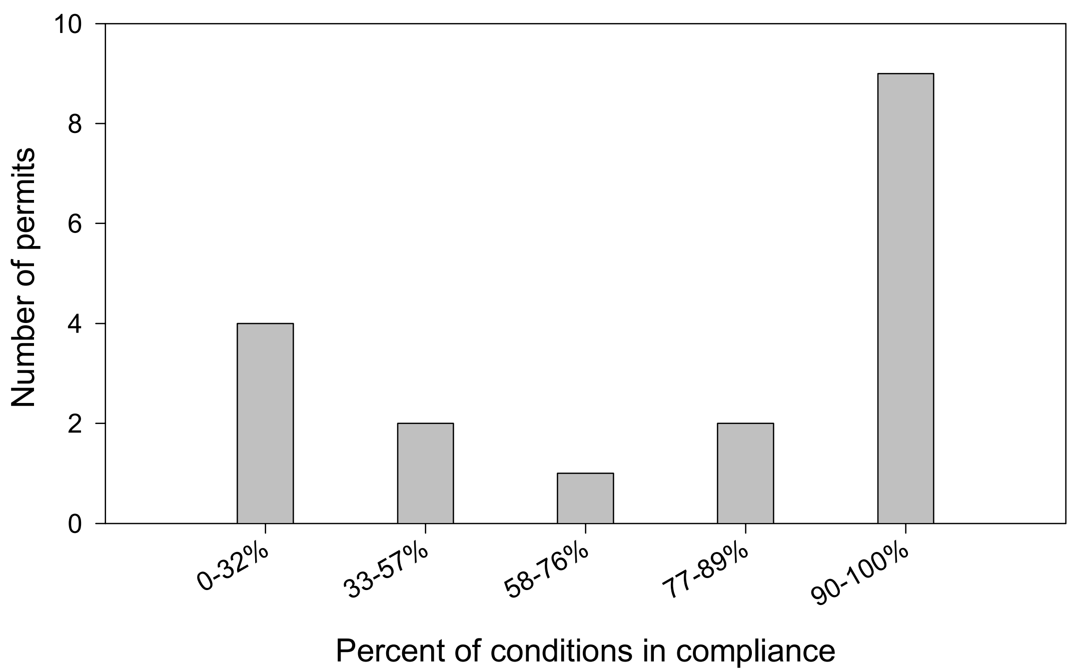
Figure 3 Success of riparian mitigation in Orange County using different criteria. "Planned mitigation" compares the required mitigation area to the area of impacted riparian habitat (97 ha or 240 acres). "Permit conditions" bases success on the degree to which a project met the special conditions established in its permit. "HGM Evaluation" bases success on the functional capacity of a mitigation site compared to reference sites.

A.

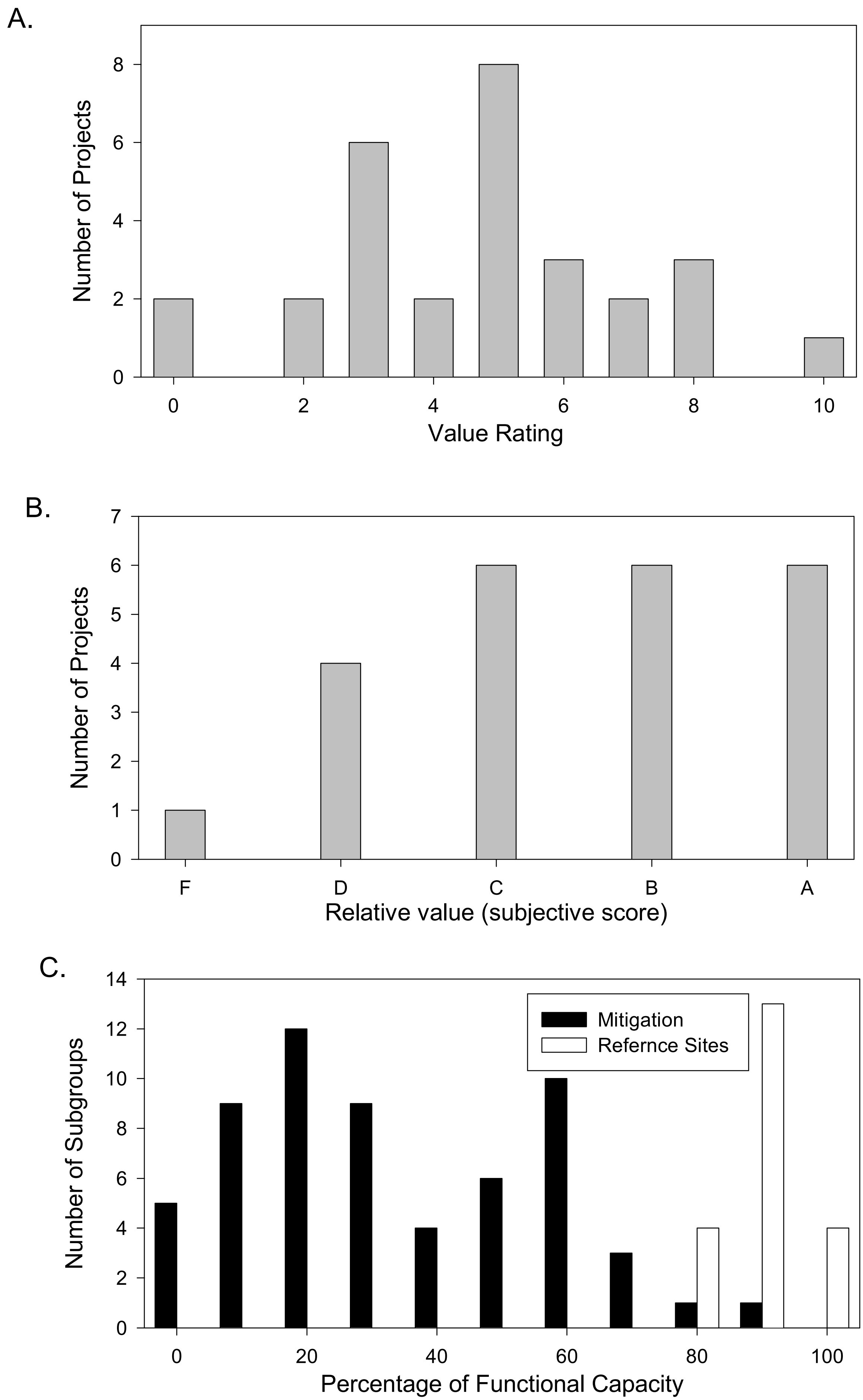


8
7
6
5
4
3
2
1
0
Number of permits
0%
1-14%
15-24%
25-34%
35-44%
45-54%
55-64%
65-74%
75-84%
85-99%
100%
Percent of conditions in compliance

B.



10
8
6
4
2
0
Number of permits
0-32%
33-57%
58-76%
77-89%
90-100%
Percent of conditions in compliance


A.
Number of Projects
0
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0
2
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8
10
Value Rating
B.
Number of Projects
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1
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3
4
5
6
7
F
D
C
B
A
Relative value (subjective score)
C.
Number of Subgroups
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4
6
8
10
12
14
Mitigation
Refernce Sites
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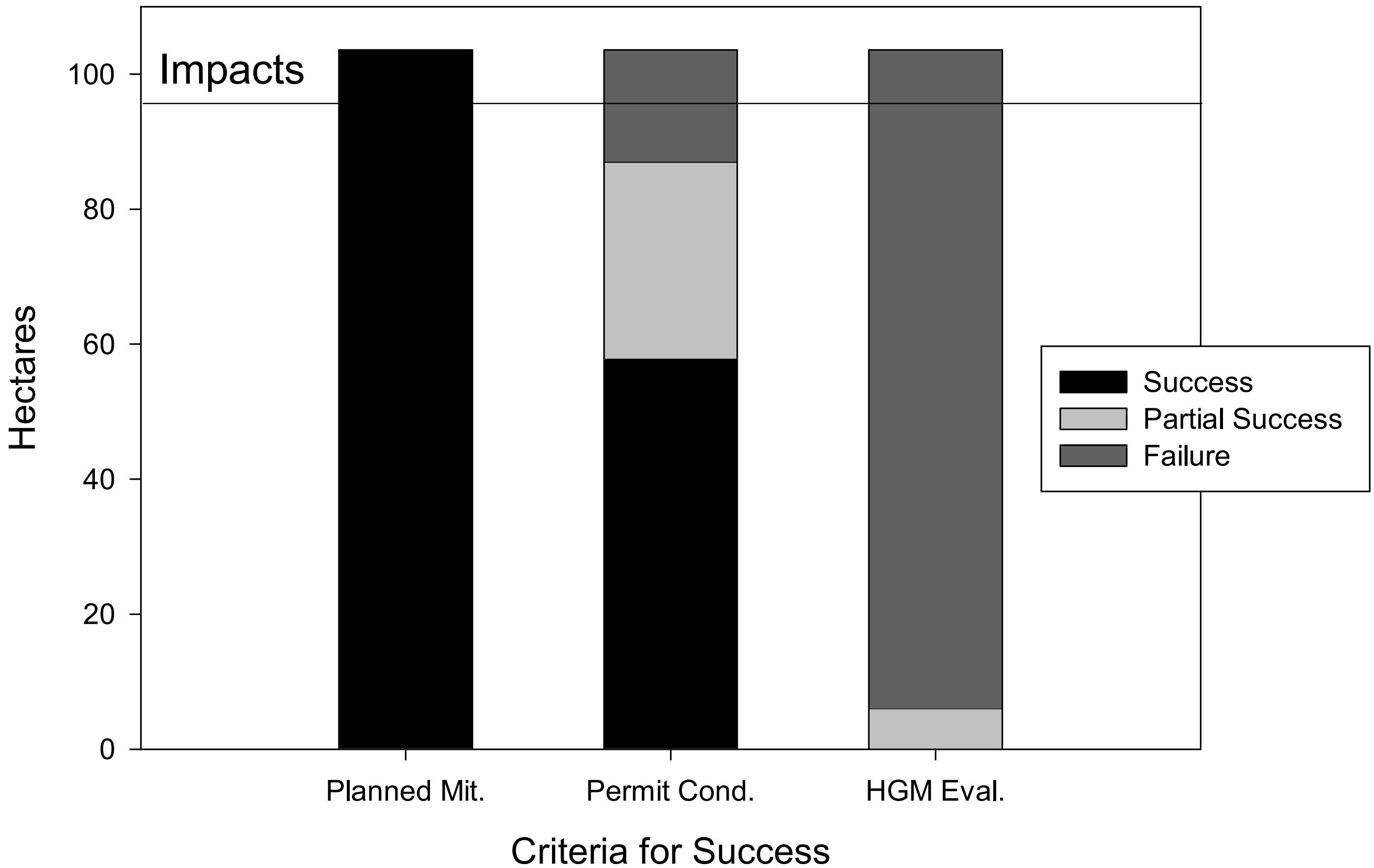
20
40
60
80
100
Percentage of Functional Capacity


Impacts
Hectares
0
20
40
60
80
100
Planned Mit.
Permit Cond.
HGM Eval.
Criteria for Success
Success
Partial Success
Failure