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ANALYSIS

Contractual difficulties in environmental management: The case of wetland mitigation banking☆

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A R T I C L E I N F O

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A B S T R A C T

This paper offers a principal–agent model of private contracting in mitigation banking aimed at protection of wetland acreage and habitat, bio-diversity and physical functions of US wetlands. While it is straightforward to design an incentive contract, such a contract may be incapable of achieving the federally mandated objective of no net loss of wetland functions through wetland mitigation; there may be failure of contract design or execution. Also considered are several institutional mechanisms that may promote the convergence of private contracting and attainment mandated wetland protection. These include greater oversight by the government, payment of subsidies, greater accuracy in the identification of actual wetland quality by the principal, and use of several other incentive alignment mechanisms.

Wetlands perform valuable functions including shoreline anchoring and protection, reservoirs for flood control, nutrient and toxin filtering and wildlife habitat for plants, birds, fishes, mammals and other biota. However, over one-half of US wetland acreage has been lost (Dahl, 1990) to agricultural, urban and commercial uses — such as housing, highways, airports, harbors, marinas, and industrial parks (Dahl and Johnson, 1991). Very largely these functions cannot be commercialized — and so protected, by landowners, but legislation exists (see below) aimed at mitigating 'unavoidable' losses of wetlands through creation or restoration of wetland acreage elsewhere. However, loss of wetland acreage still occurs. This paper investigates why these losses persist in the important case of mitigation banking — a for-profit private-sector institutional arrangement run with some governmental oversight.

Mitigation of wetland functions lost to property development is through various avenues. In 2003, the most recent year for which information is available, credits purchased by property developers from for-profit mitigation banks accounted for about one-third of total mitigated wetland acreage in the United States (E.L.I., 2006). Of the remainder, over one-half was mitigated by property developers themselves; and a small amount of mitigation was by 'in-lieu fee' whereby a property developer pays a third-party to restore wetland rather than using either of the other two methods.

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There are four types of mitigation: 'creation', 'restoration' (including of abandoned industrial land, lands dominated by invasive species, and areas of wetland cut off from a contiguous productive environment by linear developments such as roads, bridges and railways), 'enhancement' of targeted functions of undisturbed wetland, and 'preservation' of existing wetland through legal actions such as land easement, or protection through the erection of fences (E.L.I., 2006).

1. Legislation

The relevant legislation is contained in Section 404 of the *Clean Water Act* (1972)[1], Section 10 of the *Rivers and Harbors Act* (1899)[2] and in the wetland conservation provisions of the *Food Security Act* (1985)[3]. The practice of mitigation banking is systematized in the *Federal Guidance for the Establishment, Use and Operation of Mitigation Banks* (1995).[4] While US laws require mitigation of impacts, growth of private (or, 'entrepreneurial') mitigation banking initially developed without legislation of details (see Sheahan, 2001). Contractual details developed 'on the go', important in this paper, are the definition of the 'commodity' unit traded as a mitigation credit, the time at which credits are awarded to a mitigation bank for wetland restoration, and how quality of wetland functions is measured. Institutional details of mitigation banking are described *inter alia* in Bonnie (1999), Castelle et al. (1992), E.L.I. (2006), Government Accounting Office (2005), Federal Register (1995), Sheahan (2001), and Weems and Canter (1995).

2. Mitigation banks

A typical mitigation bank is of a defined size, say, 70 acres, of which, perhaps, one-half is wetland acreage.[5] A mitigation contract is signed between a mitigation bank and a responsible government agent or agencies, the US Army Corps of Engineers, the US Environmental Protection Agency, the US Fish and Wildlife Service and, perhaps, a state agency such as California's Department of Fish and Game. These principals are responsible for setting targeted quality of wetland mitigation, and for awarding 'credits' to a mitigation bank in lieu of the quality and acreage rehabilitated.[6]

Credits become available for sale by a mitigation bank to property developers once specified mitigation work has been verified by the principal as completed. The 'service areas' of a mitigation bank are limited to nearby areas in order to mitigate like with like, and to maintain acreage in given localities.

Some estimates put the cost of wetland restoration at between $25,000 and $130,000 per acre while credits have sold for as much as $250,000 per acre in New Jersey (*The Economist*, August 10th, 2000). More recent cost estimates by the Army Corps of Engineers indicate that lowest restoration costs range from about $3000 to $16,000 per acre plus land acquisition costs. High-end restoration costs are much higher, ranging from $100,000 to $350,000 per acre (E.L.I., 2006, page 28). Such is the array of these estimates that little can be inferred about the profitability of wetland mitigation banking. However, there is a suggestion that, as costs are by no means trivial in relation to revenues, mitigation bankers are likely to be cost-conscious investors in wetland restoration.

3. Social benefits

As property developers are unlikely to be specialists in wetland mitigation, their costs are likely to be higher than those of specialists in wetland creation or restoration. To some extent therefore the development of private-sector mitigation banking over the last twenty years or so is a response to cost differences between property developers and specialist mitigation bankers, with a potential social surplus derived from trading mitigation credits. As such, the social value of mitigation banking is derived in much the same way as other private institutions trading in, say, pollution permits: viz.: equation of the marginal costs of abatement between polluters (see for example, Baumol and Oates, 1988; Bohringer, 2002; Stavins and Whitehead, 1992). Other advantages of mitigation banking are consolidation of wetland restoration

[1] This act requires a permit for discharges of dredged or fill material into the waters, including wetlands, of the United States.

[2] Specifically, "it shall not be lawful to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of, any port, roadstead, haven, harbor, canal, lake, harbor of refuge, or inclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same" (33 U.S.C. 403).

[3] The 'swampbusters' provision of this act (Title XII, subtitle C) denies farmers federal benefits if they convert wetlands for food production. However, they may be let back into Federal support programs if they mitigate wetland losses.

[4] The latter was issued under the signatures of five assistant secretaries in the Departments of Agriculture, Interior and Commerce, the Army and the Environmental Protection Agency.

[5] For a description of several mitigation banks see Department of Fish and Game (2003).

[6] Quality of restored wetland functions can vary as is implied in the following statement by three biologists: "There is no recipe for restoration that will work at all sites. The success of tidal marsh restoration efforts depends heavily on the extent to which the designer understands the site and the materials being utilized during construction. Projects need well-defined objectives and attention paid to detail. Site morphology, substrate transmissivity, and porosity all have the potential to make or break a project, and should therefore be considered carefully in design development" (Montalto, Steenhuis and Parlange, 2002, page 46). Wetland habitat and biotic valuation by experts can use the Delphi method of scoring the many characteristics of a wetland on a scale of 0 to 1 and then combining the individual scores into a weighted average quality index. Mitsch and Gosselink (2000, pages 591–96) point out that several quality assessment methods exist including the Habitat Evaluation Procedure used by the US Fish and Wildlife Service, the Wetland Evaluation Technique used for a time by the US Army Corps of Engineers, and the recently developed hydrogeomorphic classification. These authors also observe that economic valuation of wetlands depends, *inter alia*, on the correct identification of habitat, biotic and other physical characteristics.

into large areas rather than being dispersed as on-site mitigation by property developers; that mitigation occurs before impact; and that mitigation banks can become centers of expertise in wetland mitigation (Department of Fish and Game, 2003, pp 3–5).

Thirty-one states host mitigation banks, and, in 2005, there were 405 approved mitigation banks — a multiple of almost eight compared with 1992. A further 169 banks were seeking approval. In the case of approved banks, 70% were 'private commercial' with mitigation credits for sale on the open market; 4% were 'public commercial' sponsored by public agencies to mitigate for either public or private wetland development; and 25% were single client banks where the bank sponsor was the main purchasers of credits.[7]

4. Mitigation failures

As indicated earlier, mitigation efforts are often criticized for failing to protect US wetlands (see, e.g., General Accounting Office, 2005; Sheahan, 2001; Smoktonowicz, 2005). Castelle et al. (1992, page i) found that "follow-up studies indicate that the average rate of compliance with permit conditions was 50%. Common problems include inadequate design; failure to implement the design; lack of proper supervision; site infestation by exotic species; …failure to adequately maintain water levels; and failure to protect projects from on-site and off-site impacts such as sediments, toxics, and off-road vehicles". Harrison (1995) points out that mitigation banks often put little effort into restoration projects. Kukoy and Canter (1995) assert that non-compliance with Section 404 permit requirements was quite widespread. Redmond (1990) monitored 1262 permits issued by the Florida Department of Environmental Regulation. The key finding was that only about one-in-four projects were ecologically successful in the sense that they had or would probably become serviceable wetlands of the type permitted as a mitigation wetland. Instead mitigation banking has contributed to over-development by property developers of natural wetland habitats without adequate replacement through restoration of physical, chemical, biological or hydrological functions of mitigated wetlands.[8] Moreover, Sheahan (2001, page 22) offers evidence of a high failure rate of on-site mitigation by non-specialists.

5. Explaining mitigation failures

To explain mitigation failures we focus on mitigation contract design and execution in the presence of asymmetric information. The perspective of a principal–agent model would seem to be useful as a mitigation bank, the agent, works on a daily basis at a mitigation site, it will be more familiar than the principal with key characteristics of a site — such as the condition of the many determinants of its hydrology that are critical in the health of re-engineered wetlands (e.g. Montalto et al., 2002). Moreover, as oversight by the principal is not continuous, the agent has some scope to cut corners on amounts of mitigation investment, so reducing its costs.[9]

The focus here is on the award of mitigation credits by a governmental regulatory agency — the 'principal', to a mitigation bank, 'the agent', for the physical restoration work that it performs on a wetland site. For purposes of economic analysis the mitigation contract is characterized by: a) an agreed specification of inputs to be applied to improve the functioning of a defined acreage. Examples of inputs include construction work to establish a viable hydrology, plantings of desirable species and elimination of exotic species from the site. The vector X_N represents this set of pre-defined inputs; b) specification of the number of mitigation credits, F, that will be awarded for – c) creation of pre-defined wetland functions; and d) an understanding that if the target wetland functions are not achieved, wetland credits may not be released unless specified remedial work is performed – the additional input vector X_E.

6. Feasible contracts

A mitigation bank's net payoff for restoring a wetland depends on the number of credits awarded less the cost of creating those credits. Because it is difficult for the principal to observe investments being made, an agent, hoping that the principal will not notice, might reduce the level of investment below contractual limits — so lowering its costs.

A mitigation bank's expected payoff from "shirking" on the level of investment, $E(\Pi_S)$, measured in credits is:

$$E(\Pi_S) = F - [pWX_S + (1-p)W(X_S + X_E)] \quad (1)$$

where F is the number of mitigation credits awarded for restoration work, p is the probability of under-investment in mitigation not being detected, $(1-p)$ is the probability of under-investment being detected. W is a vector of the costs measured in credits of physical inputs.[10] X_N is a vector of government stipulated physical inputs, and X_S is a vector of a subset of government stipulated physical inputs. That is, X_S is the 'shirking' level of investment — chosen by a mitigation bank, if indeed it chooses to shirk. Both the amount and cost of investment with shirking are lower than without shirking. The level of X_S would be determined by the minimum set of "gardening" inputs that an agent reasons must be seen to be done, and the less thorough is governmental oversight the lower is X_S. If the agent thought that oversight was so thorough that any shirking would be spotted by the principal, then $X_S = X_N$. X_E is the additional cost imposed on a mitigation bank if it is caught under-investing in mitigation.[11] Thus,

[7] Data in this paragraph is drawn from E.L.I. (2006).

[8] See also Choi (2004).

[9] In the model of Fernandez and Karp (1998) a mitigation bank tries to maximize the option value of a wetland tract assuming that finished quality is perfectly observable by the principal. However, this model does not take account of possible principal–agent problems.

[10] The cost of investment in a tract measured in credits is simply the dollar cost divided by market price of a credit.

[11] In practice the principal may require the agent to increase expenditure on inputs as work progresses. Hey and Philippe (1999) have a good description of this in the case of wetland mitigation in the Florida Keys.

Eq. (1) says that a mitigation bank's expected profit measured in net credits when shirking occurs equals the difference between the number of mitigation credits awarded and the probability weighted average production cost; the larger is p, the lower is probability weighted cost and the greater is $E(\Pi_S)$.

The expected payoff from not shirking, $E(\Pi_N)$, is:

$$E(\Pi_N) = F - [(1-q)WX_N + qW(X_N + X_E)] \quad (2)$$

Here q is the probability that the government thinks that low investment in mitigation has occurred when in fact a mitigation bank has met its contractual obligations. This would be an unfortunate situation for a mitigation bank, but it is possible since the government does not continuously observe investment, and the quality of rehabilitated wetland is subject to random variation in the state of nature. Thus, observed low quality of a completed restoration project might be taken as a signal that under-investment occurred, rather than, for example, the site's hydrology turned out less favorable than anticipated. X_N is again a vector of government stipulated physical inputs; and, even though X_N has been invested, extra investment, X_E, is required.

The, incentive compatibility condition, whereby the mitigation bank chooses not to shirk and to invest in inputs as laid out in the mitigation contract, is found by equating Eqs. (1) and (2). On rearrangement this yields

$$X_E \geq (X_N - X_S)/[1-(p+q)] \equiv X_0 \quad (3)$$

where X_0 is the minimum X_E consistent with incentive compatibility.

If the principal wants an agent to invest in a mitigation project it must set $E(\Pi_N) = U$, where U is reservation profit — the return on investment in a comparable risk class outside of mitigation banking. Subtracting U from the right hand side of Eq. (2) and rearranging yields the participation constraint:

$$X_1 \equiv (F - WX_N - U)/(qW) \geq X_E \quad (4)$$

where X_1 is the maximum X_E that can be imposed by the government while still inducing a mitigation bank to invest in mitigation.

Assuming that the vectors X_E, X_N and X_S each contain only one input, Fig. 1 can be drawn. Both the participation and incentive constraints are simultaneously fulfilled at X^*_N and X^*_E in Fig. 1. If the contract between the principal and the agent states X^*_N and X^*_E, the agent will want both to participate and to aim to fulfill its contractual investment obligations.[12]

A problem with actual mitigation contracts becomes immediately apparent. In practice, if shirking is detected, the agent is required to invest just enough to put the problem in the field right. However, X^*_E in Eq. (3) implies a penalty if caught shirking. For example, suppose that $(p+q)=0.2$; from Eq. (3) this implies $X^*_E = 1.25(X_N - X_S)$. The implication is that the agent should make good the investment short-fall, $(X_N - X_S)$, *and* pay what amounts to a fine, in this case, equal in value to 25% of the investment short-fall. While, as is mentioned below, mitigation bank contracts can allow for administrative penalties, according to GAO (2005) they are not enforced.

7. Another possible cause of contract failure

Given poor physical or biological conditions at a potential mitigation site, the government may have to stipulate a required level of investment X_{N1}. In Fig. 2, as X_{N1} is to the right of X^*_N and no feasible contract can be written that fulfills both the incentive and participation constraints at this level of investment.[13]

If the government were to set X_E consistent with the participation constraint — point B, X_E will be too low to fulfill the incentive alignment constraint. Recalling that X_E is a sort of 'punishment' for not fulfilling contractual obligations, low X_E will induce the agent to 'shirk' on the level of investment; to invest X_S rather than X_N. Alternatively, if the government reduces required investment to say X^*_N per mitigation credit awarded, knowing that X_{N1} is required, quality of restored wetland will be impaired.

Contractual difficulties also arise if X_S is low, shirking as a way of life as it were, as this shifts the incentive compatibility constraint to the left, reducing the area of feasible contracting. There is no direct evidence on X_S but there is some indirect evidence. In an extensive study by the Government Accounting Office it was concluded that "because many projects that we reviewed did not receive oversight, the [Army Corps of Engineers] districts cannot definitively assess whether compensatory mitigation has been performed on thousands of acres" (G.A.O., 2005, page 9). Thus, if a mitigation bank anticipates that a principal may not verify its work, the incentive to shirk, with a low level of X_S, is all the greater. An un-enforced contract is not worth the paper it is written on.

8. Improving contract design and execution

Given that wetland restoration costs may be high — X_{N1} in Fig. 2, the frequency of the undesirable outcome of poor quality restoration may be reduced by finding ways to shift the participation constraint outward so that it passes through point A; or, to shift the incentive compatibility constraint downward so that it passes through point B.

Perhaps the most important action that principals can take is to enforce mitigation contracts through careful inspection of finished work. The effect would be to reduce the incentive to shirk, so shifting X_S and the incentive compatibility constraint to the right.

[12] If X_E is set lower than X^*_E down the incentive compatibility constraint, an agent's expected profit would increase above the minimum level required to engage in mitigation banking. This would be an unnecessary extra return to the agent, and it could be construed as government favoritism.

[13] Evidence in the field comparing restored wetland with undisturbed control wetlands suggests that restoration outcomes are uncertain and may take between 20 and 50 years to recreate (Coats et al., 1989, Pfadenhauer, and Grootjans, 1999, Zedler, 1996). Cumulative investment cost would likely increase substantially if mitigation banks were required to continue investing in restoration projects for such extended periods.

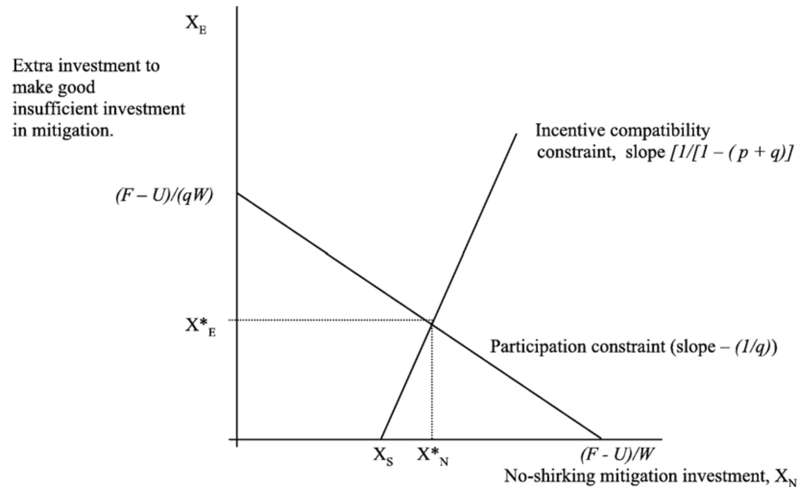

Fig. 1 – Feasible mitigation contracts.

The matter of inspection has recently been the subject of a withering GAO investigation. According to the US Government Accountability Office (2005),

> "Overall, the Corps districts we visited have performed limited oversight to determine the status of required compensatory mitigation…we found little evidence that required monitoring reports were submitted or that the Corps conducted compliance inspections" (G.A.O., 2005, page 5).

Reasons for this were found to be that:

> "the Corps [had] conflicting guidance, which notes that compliance inspections are crucial yet makes them a low priority, as well as limited resources contribute to their low level of oversight of compensatory mitigation" (G.A.O., 2005, page 5).

And,

> "We found that, sometimes, district officials wanting to pursue enforcement actions after detecting instances of noncompliance may be unable to do so because they have limited their enforcement capabilities by not specifying the requirements for compensatory mitigation in permits…" (G.A.O., 2005, page 6).

Other tools that principals can use to enforce compliance – effectively increasing X_S, is to report serious violators to the local US attorney to file civil or criminal actions – but the G.A.O. (2005, page 5) found no evidence that this had happened. Nor was it found that principals had used their powers to assess administrative penalties of up to $27,500, nor to suspend or to revoke permits. Moreover, mitigation bank contracts usually include two other incentive alignment mechanisms: posting of bonds that may be forfeited in the case of inadequate work, and sequenced released of credits as quality in the field is verified. However, the effectiveness of these is greatly reduced if principals do not properly inspect finished work.

The participation constraint can be shifted outwards from the origin through payment of a subsidy to a mitigation bank. The subsidy reduces costs, so lowering W. However, new legislation would be needed for this and given that the system

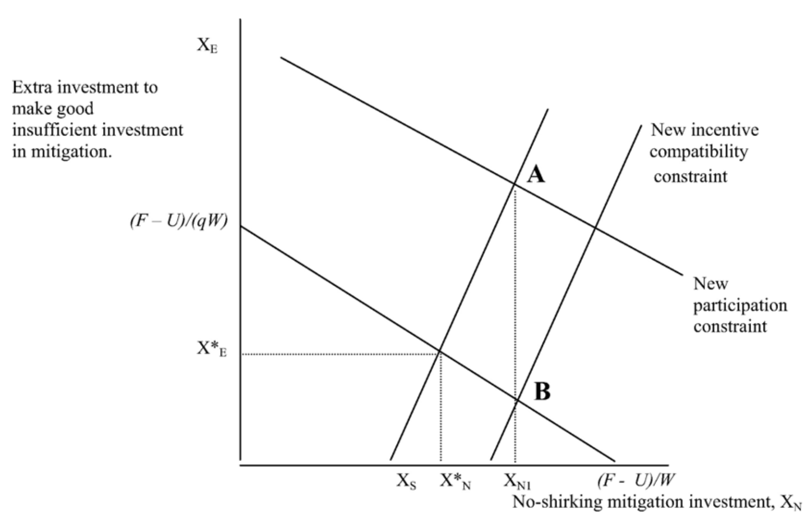

Fig. 2 – Creating a feasible mitigation contract.

is already under-funded to the extent that money is not available for thorough inspections, one wonders whether the use of subsidies is likely. The area of feasible contracting can also be increased by reducing q, the possibility that the principal will incorrectly judge that work that was properly completed was not done so. Lower q swings the participation constraint outwards from the origin.

9. Conclusions

This paper has argued that widespread failure to mitigate wetland losses through the practice of private-sector mitigation banking is tied up with problems of contract design and execution. In the first place, it may not be possible to write an efficient incentive contract if investment in restoration is too expensive (i.e., X_{N1} is to the right of X^*_N in Fig. 2). Nor is it likely that a contract will be efficient if it does not include penalties (over and above the cost of necessary extra investment in mitigation) for shirking, or, it does, but it is known that they are almost never enforced. Moreover, even when an efficient mitigation contract can be written, the amount of money that the federal government is willing to allocate to contract enforcement appears to be insufficient — at least this is the implication of the G.A.O. (2005) study. Moreover, high costs of proper contract enforcement could be so great as to negate any social surplus created through trading in mitigation credits. At the very least legislatures and principals have an urgent need to discover and apply low-cost methods of contract enforcement; and/or to look for places where mitigation is a relatively easy technical exercise and is, therefore, less costly.

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