The Economic Equivalency of Drained and Restored Wetlands in Michigan

Frank Lupi, Michael D. Kaplowitz, and John P. Hoehn

Wetland ecosystems are valued for a range of ecological services. These services are protected by national, state, and local regulation. The primary federal wetland protection statute is Section 404 of the Clean Water Act (33 U.S.C. Section 1344). Under this statute, the U.S. Army Corps of Engineers, in conjunction with the U.S. Environmental Protection Agency (EPA), administers a review and permitting process for the “discharge of fill material” in “waters of the United States.” Since 1989, the guiding principle of federal wetland policy has been the “no net loss” of wetlands criterion (Gaddie and Regens). To implement this principle, the wetland permit process encourages potential dischargers to avoid and minimize wetland impacts wherever possible. Where wetlands are impaired or destroyed, wetland mitigation is required. Mitigation refers to actions taken to recreate, restore, or protect wetlands of an equivalent type and function to those being impaired or destroyed (Denison and Schmid).

Since wetlands vary by type, ecological functions, and the services they yield to humans, the means for judging the equivalency of destroyed and mitigated wetlands is both problematic and central to successful implementation of the “no net loss” policy (National Research Council, Mitsch and Gosselink). While wetland regulation and mitigation regimes seem to address concerns of changes in wetland acreage, they do not adequately address the equivalency of changes in wetland values (Environmental Law Institute). Though substantial effort has been made to define and measure wetland equivalencies using engineering principles and biophysical characteristics (Bartoldus), the economic equivalency of wetland services has received less attention. In the absence of an understanding of the economic trade-offs, wetland mitigation may leave economically important services unprotected and under-provided.

In this paper, we report the results of a pilot study on the public’s willingness-to-accept wetland mitigation as in-kind compensation for the loss of an existing wetland. A choice experiment was developed to relate the acceptance of mitigation projects to the characteristics of both the lost and mitigated wetland. The wetland characteristics describing the lost wetland and proposed mitigation include acreage and several indicators of habitat suitability.

Wetlands Valuation and Mitigation

Wetlands are transitional types of ecosystems that occupy a spectrum between land and water ecosystems. Their exact definition has been controversial (National Research Council). The operational definition used in Federal wetland regulations builds on two essential wetland characteristics: (a) the land is composed of soils that are water-saturated during part of the vegetation growing season and (b) the land supports plants that are typical of saturated soils (Smith et al.). Based on this definition, wetlands may have covered about 12% of the area of the continental United States during colonial times. Since that time, human

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activity in the United States has converted approximately 45% of wetland area to other uses (Heimlich, Carey, and Brazee).

As mentioned above, wetland ecosystems vary greatly in type, ecological function, and services to human beings. Wetland types include bottomland swamps, tidal marshes, cattail marshes, vernal ponds, fens, and bogs. Ecological functions of wetlands include water storage, maintenance of surface and groundwater flows, biochemical cycling, retention of water-suspended and dissolved materials, accumulation of peat, maintenance of characteristic biological energy flows, and maintenance of characteristic habitats.

Wetland ecosystems and their functions provide services that affect human well-being. The water storage function, for instance, may result in service to human beings by retaining flood waters. Some wetlands may help maintain groundwater flows and contribute to stable sources of potable water. Wetland habitats may offer recreational opportunities, open space amenities in otherwise densely settled areas, and potential nonuse services such as maintaining biodiversity.

The objective of wetland mitigation is the replacement of wetlands destroyed by permitted activities through creation, restoration, or protection of equivalent wetlands. The ratio of mitigated wetland area to impaired wetland area is called the mitigation ratio. Mitigation ratios typically vary by wetland type. For instance, in Michigan, recent rules require compensatory mitigation of 1.5 acres for each acre lost when the wetland being lost is of a common type. When the destroyed acreage is of a relatively “uncommon” wetland type, 5 acres of mitigation are required for each acre lost (MCL Section 324.303 19). It is important to note that wetlands that contain or support endangered species or that are of a very rare type are protected from permitted impairment or destruction. At the Federal level, the Army Corps of Engineers makes adjustments in the mitigation ratios to account for the type and duration of impacts, the rarity of the impacted wetlands, and the methods used in mitigation (U.S. Army Corps of Engineers-Charleston District).

Wetland mitigation ratios are analogous to in-kind prices of impaired wetlands. Such ratios represent an agency’s in-kind valuation of mitigation activities relative to the lost wetland type or function. A question then arises regarding the adequacy of such prices. For instance, a mitigation ratio that may be satisfactory on engineering or biological grounds may not be acceptable in terms of preventing the loss of economic services and values. That is, a particular wetland may be ecologically common in a region or state, but rare in terms of its recreational services and open space amenities by virtue of its location in an urban area. Hence, using Michigan’s rules to make the point, the statutory mitigation ratio for replacement of a particular cattail marsh might be set at 1.5 to 1 on statewide ecological grounds, whereas the particular wetland’s economic value to its urban area might warrant a rare wetland ratio of 5 to 1.

The economic literature suggests the importance of considering relative economic values in mitigation pricing. Many studies estimate the value of specific wetlands and thereby demonstrate the economic value of these specific wetlands and wetlands in general. However, most studies shed little light on the relative value of different wetlands types, functions, and wetland services (Heimlich et al.). A handful of studies document commercial and recreational values associated with some wetlands (Loomis et al., Costanza et al., Bergstrom and Stoll). Other research suggests that wetlands may provide open space amenities (Mahan, Polasky, and Adams; Opaluch). Some recent studies imply that the economic services of wetlands, including recreation, water quality, and flood control services are well recognized by ordinary citizens (Azevedo, Herriges, and Kling). Especially interestingly in terms of mitigation ratios, Mullarkey estimates that an acre of naturally occurring wetland is six times more valuable to respondents than an acre of mitigated wetland.

Recently, Woodward and Wui conducted a meta-analysis to estimate the value of wetland services. The estimated values of services per wetland acre indicate that the consumptive wetland services such as bird hunting, commercial fishing, and recreational fishing created significant derived demand for wetland protection. Nonconsumptive services including habitat values were also highly valued. For example, bird watching had the highest value per acre of all the wetland services examined in the Woodward and Wui study.

Method

This paper summarizes the design, implementation, and results of a survey on the wetland mitigation trade-offs that are acceptable to the
public. The reported research focuses on estimating the in-kind compensation for mitigation of wetland loss and aims to improve information about the public’s “price” for mitigated wetlands. The survey-based approach presents individuals with the characteristics of a drained wetland and a restored wetland. Individuals are asked if the restoration project compensates for the loss of the drained wetland. The data on the wetland choices are analyzed using Lancaster’s approach to consumer theory which holds that utility is determined by the attributes of the goods rather than the goods per se (Lancaster). Following this theory, the wetland restoration choices are analyzed using discrete choice methods based on a random utility model (RUM) (McFadden). Let the conditional indirect utility derived from the utility model (RUM) (McFadden). Let the conditional indirect utility derived from alternative 1 by individual \( i \) (\( 1 = 1, \ldots, N \)) be given by \( U_i^1 \). Faced with the wetland choice, if the respondent views \( U_i^1 > U_i^0 \) (i.e., the utility from the restored wetland exceeds that of the drained wetland) then individual \( i \) will accept (vote for) the restoration. Thus, the probability that restoration is acceptable can be modeled as a function of the utility difference, that is, restoration is acceptable if \( U_i^1 - U_i^0 = \Delta U_i > 0 \).

Using the familiar binary logit model (McFadden), if \( Y_i = 1 \) indicates that the restored wetland is acceptable, the choice probabilities take the following form:

\[
\text{Prob}(Y_i = 1) = \frac{1}{1 + \exp(-\alpha - \beta r^{1.0} - \gamma (x^1 - x^0) - \theta z_i)}
\]

where the vector \( x \) denotes wetland characteristics (e.g., type, habitat ratings), and the vector \( z_i \) denotes demographic factors. The percentage increase in acreage for the restored wetland relative to the drained wetland is given by \( r^{1.0} \) and can be interpreted as a wetland mitigation ratio.

Survey

A survey questionnaire to elicit wetland mitigation trade-offs was developed using a series of six focus groups, sessions with a science advisory panel, and extensive one-on-one pretest interviews. The survey questionnaire was then pilot tested with fifty-eight randomly selected mid-Michigan adults. This pilot survey is the source of data for the analysis reported here. As in other studies (Kaplowitz and Hoehn), the qualitative research in the form of focus groups and individual interviews, helped researchers learn what it is that people value about wetland ecosystems. Furthermore, the qualitative research provided important insights into the general state of people’s knowledge about wetland ecosystems, their functions, and types. The qualitative research with residents of mid-Michigan revealed that most people know something about wildlife habitat functions of wetlands. The participants rated the wildlife habitat functions highly in terms of their relative importance vis-à-vis other wetland ecosystem functions. This finding is consistent with other research on wetlands (Azevedo, Herriges, and Kling; Swallow et al.; Stevens, Benin, and Larson) as well as the meta-analysis results on nonmarket values reported by Woodward and Wui. The findings on the importance of wildlife and habitat was used, in conjunction with feedback from a science advisory panel that habitat quality is not well-represented in current mitigation policy, to focus the study on the effects habitat has on the economic equivalency of mitigation projects.

Based on feedback from the focus groups and interactions with the advisory groups, nine attributes were selected to describe the drained and restored wetlands. The attributes for the choice experiment were: the type of wetland (wooded, marsh, mixed); the size (acreage); whether the wetland had public access and, if so, whether it had trails; and five habitat ratings for amphibians/reptiles, mammals, songbirds, wading birds, and wildflowers. Each of the habitat ratings had three levels (excellent, good, and poor) and were described to respondents in common language. For example, a “good” habitat was defined as: “The wetland habitat supports these species in average numbers and variety; a casual observer is likely to see a few of these species.”

Survey respondents were presented with a choice between drained and restored wetlands with the above attributes described in tabular form. That is, the levels of each attribute were combined to describe the drained and restored wetlands. Given the modest number of anticipated pilot study interviews, the choice experiments were not designed to identify the specific contribution to utility of each of the five habitat rating categories. Rather, the experimental design ensured there would be sufficient variation across the choice pairs to identify the effect of the total number of habitat ratings within a level (e.g., number of categories rated as “good”). Consequently, the design consisted of five different booklets,
We need your opinion as a member of the citizens’ panel on five restoration cases. The cases represent the kind of decisions that are made everyday by wetland restorers. In each case, the project to drain a common type of wetland has already been approved. The only question is whether quality and quantity of a restored wetland is enough to make up for the loss of the drained wetland.

- If the restored wetland is approved, the restoration project goes forward.
- If the restored wetland is not approved, the restoration project goes back to the drawing board. A revised project will be reviewed by a different citizens’ panel.

Framing the question this way effectively dealt with the tendency encountered in earlier stages of survey development for individuals to vote against a mitigation project as a means of stopping development. In order to enhance the incentive properties of the restoration question, respondents were told that if the restoration project is not approved a revised project will be voted on by a different panel.

The information on the attributes of the drained and restored wetland was presented in a color coded table along with the definitions of the habitat ratings. In a section called “the fine print,” individuals were reminded that the comparison between the drained and restored wetlands involved common wetland types that do not contain any rare species or rare habitat and are the same in terms of features not mentioned in the scorecard. On a the page facing the wetland tables, individuals were asked to compare the two wetlands and were asked “In your opinion, is the restored wetland good enough to offset the loss of the drained wetland in Case #X?” The answer to the choice question serves as the dependent variable in the logit choice models.

After completing the survey questionnaire, individual one-on-one debriefing interviews were conducted to gage the performance and functioning of the survey instrument. The fifty-eight respondents in the pilot interviews were each asked to make five choices. Interviewers identified one respondent as being confused and possibly incompetent and this subject was dropped from the sample. An additional respondent completed only four out of the five choices. The result was a sample of 284 choice responses from fifty-seven respondents.

Variables and Results

The variables used to model the acceptance of the restored wetland when compared to a drained wetland are presented in table 1. The acreage change was defined as the percent change in acres from the lost wetland to the restored wetland. With this definition, the parameter estimates are more readily interpretable as wetland mitigation ratios. Because wetland size and habitat qualities are expected to be amenities, we hypothesize that

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres%</td>
<td>Percentage change in acreage from drained to restored</td>
</tr>
<tr>
<td>Good</td>
<td>Change in the number of “good” habitat ratings</td>
</tr>
<tr>
<td>Excellent</td>
<td>Change in the number of “excellent” habitat ratings</td>
</tr>
<tr>
<td>Type</td>
<td>Indicates if there was a change in wetland type, 0 otherwise</td>
</tr>
<tr>
<td>Mix</td>
<td>Indicates if restored wetland changes to a mix of marsh and wooded</td>
</tr>
<tr>
<td>Open</td>
<td>Change in “whether the wetlands are open to the public”</td>
</tr>
<tr>
<td>Trail</td>
<td>Change in “whether the wetlands have trails and nature signs”</td>
</tr>
<tr>
<td>College</td>
<td>“1” if college degree, 0 otherwise</td>
</tr>
<tr>
<td>Age 50+</td>
<td>“1” if over 50 years old</td>
</tr>
<tr>
<td>Gender</td>
<td>“1” if female, 0 otherwise</td>
</tr>
<tr>
<td>Confused</td>
<td>Indicates respondent confusion was identified in debriefing interview</td>
</tr>
</tbody>
</table>
the parameters on the percentage increase in acreage (acres%) and both the habitat variables (good, excellent) will have positive signs, that is, they will increase the likelihood that respondents accept the restoration plans. We do not have a prior expectation on the signs for the other variable. The type of wetland (type) and whether the restoration plans have a mix of types (mix) are categorical effects that may or may not be viewed as desirable to respondents. For the public access (open) and trails (trail) variables, focus group respondents differed on the desirability of these features so they may or may not be perceived amenities overall.

Model estimation results are presented in table 2. From table 2, it can be seen that increases in the mitigation ratio, acres% (the percentage of additional acres associated with the mitigation project when compared to the drained wetland), have a significant effect on willingness-to-accept a mitigation project. In addition, the number of habitat categories with the good or the excellent rating (good and excellent) both have a significant effect on willingness-to-accept the restoration project (at the 10% and 5% levels, respectively). A change in the type of wetland (type) does not have a significant effect on acceptance of the restoration plan, although if the restoration plan changes to a mixed type that consists of both wooded and marsh wetland areas (mix) the plan is significantly less likely to be accepted at the 5% level.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>S.E.</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.448</td>
<td>0.461</td>
<td>-64.00</td>
</tr>
<tr>
<td>Acres%</td>
<td>0.007**</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>0.180*</td>
<td>0.108</td>
<td>25.71</td>
</tr>
<tr>
<td>Excellent</td>
<td>0.348**</td>
<td>0.153</td>
<td>49.71</td>
</tr>
<tr>
<td>Type</td>
<td>0.118</td>
<td>0.404</td>
<td></td>
</tr>
<tr>
<td>Mix</td>
<td>-0.459**</td>
<td>0.234</td>
<td>-65.57</td>
</tr>
<tr>
<td>Open</td>
<td>0.161</td>
<td>0.324</td>
<td></td>
</tr>
<tr>
<td>Trail</td>
<td>-0.211</td>
<td>0.373</td>
<td></td>
</tr>
<tr>
<td>College</td>
<td>-0.563**</td>
<td>0.258</td>
<td>-80.43</td>
</tr>
<tr>
<td>Age50+</td>
<td>0.438*</td>
<td>0.258</td>
<td>62.57</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.215</td>
<td>0.261</td>
<td></td>
</tr>
<tr>
<td>Confused</td>
<td>0.312</td>
<td>0.885</td>
<td></td>
</tr>
</tbody>
</table>

Notes: N = 284; LnL = 182.7; Percent predicted correctly: 63%; Percent “yes” predicted correctly: 43%; Percent “no” predicted correctly: 78%.

**parameter significant at the 5% level; *significant at the 10% level.

Ratio = parameter estimate/parameter for acres percent; indicates additional acres needed as in-kind compensation for this factor.

Individuals with a college degree (college) were significantly less likely to accept a restoration plan (at a 5% level) while individuals over fifty (age50+) were significantly more likely to accept a plan (at a 10% level). Gender was not significant at conventional levels. In addition, the confused variable, which indicated if there were any task comprehension problems that surfaced in the post-survey debriefing interview, did not have a significant effect on choices.

In interpreting the effects of the models variables, a positive sign indicates a factor that would decrease the mitigation ratio while a negative sign indicates a factor that will increase the mitigation ratio that provides equivalent in-kind compensation for the lost wetland. The final column of table 2, labeled “ratio,” presents the equivalent percentage increase in acreage that compensates for the effect of the variable which is computed by dividing the parameter for the variable by the parameter on acreage percentage. If the model had included a monetary effect as in a valuation study, then the parameter would be the marginal value (sometimes referred to as the marginal implicit price) for that attribute. In the present case, the ratios represent the percentage increase in acreage that provides in-kind compensation for the change in the variable in question.

The results indicate that for two wetlands with the same characteristics, an acreage premium of about 64% is required to leave the median individual indifferent between the drained and restored wetland. This translates into a baseline mitigation ratio of 1.64, holding all other characteristics constant. This ratio is computed by solving for the percentage increase in acres that results in the estimated change in utility associated with the restoration being equal to zero. Note, however, that in this version of the model with several demographic variables interacted with the constant and a small sample size, the constant term was not statistically significant. Thus, the baseline mitigation ratio should be interpreted cautiously. For the habitat variable indicating the number of habitat categories rated as good (good), the ratio indicates that if a restoration project results in a wetland with one fewer habitat category being rated as good, then the acreage must be 26% larger to leave people indifferent between the drained and restored wetlands. This premium is in addition to the baseline mitigation ratio of 1.64 that was mentioned earlier. Similarly, if a restored wetland has one fewer of
the habitat categories rated as excellent (excellent), then the ratio indicates that the acreage needs to be about 50% larger to leave people indifferent between the drained and restored wetlands. Therefore, the results suggest a mitigation ratio of 2.14 would be required to adequately compensate people in a situation where the proposed wetland mitigation involves the net reduction in one wildlife habitat attribute rated as excellent.

For the demographic variables, the results suggest that individuals with college degrees require an additional 80% in additional acreage to leave them indifferent between drained and restored wetlands when compared to individuals without college degrees. Alternatively, all else equal, individuals over 50 years of age do not require an acreage premium for mitigation (their premium is negative and of the same magnitude as the constant resulting in little net effect on acreage).

Conclusions

Wetlands vary by type, ecological functions, and the services they yield to humans. Because of this complexity, quantity-based protection policies such as “no net loss” risk protecting acres without preserving the quality of wetlands. This paper reports on a pilot study on the public’s willingness-to-accept wetland mitigation as in-kind compensation for the loss of an existing wetland. A choice experiment was developed to relate acceptance of mitigation projects to the characteristics of a drained wetland and a restored wetland. The results demonstrate that the public cares about the attributes of wetlands. Consequently, for wetland mitigation to adequately compensate for wetland losses, restoration activities need to account for quality differences. In particular, habitat quality clearly mattered to the public. Put differently, individuals will accept reductions in wetland acreage if accompanied by substantial improvements in habitat quality. Moreover, as determined in the fifty-eight individual debriefing interviews, the study demonstrated that ordinary citizens were quite capable of making the wetland mitigation choices which involved trade-offs between alternative mixes of wetland attributes.

While the study provides estimates of how to adjust mitigation ratios to account for the differences in habitat quality, it should be considered a first step. The wetlands considered here were of common types which are regularly subject to permit actions in Michigan. The study results do not apply to rare wetlands, rare habitats, or rare species. Likewise, in the wetland choices studied here, respondents were explicitly asked to hold other functions of wetlands constant. Future research may wish to address the effect that wetland functions, beyond habitat, have on mitigation ratios that will provide in-kind compensation for the loss of an existing wetland. Another fruitful area for policy research involves investigation of in lieu fee programs. In lieu fee approaches, where monetary compensation for wetland impairment is paid into a centralized fund directed at restoring wetlands, have the potential to address the mitigation quality issues raised here. However, in lieu fees programs have met resistance, in part due to concern that funds will not result in adequate resource protection. Choice models could be developed to improve understanding of the factors that influence the public’s (and managers) acceptability of an in lieu fee program, and results could be used to design in lieu fees programs that ensure that the public is adequately compensated for resource impairments.

References


