COMPENSATING FOR WETLAND LOSS:
A CASE STUDY OF MICHIGAN RIPARIAN WETLANDS

by

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Abstract

State and federal laws regulate the use of wetlands in Michigan. Under the current regulatory system, the destruction of a wetland may require the creation or restoration of a wetland to compensate for the wetland destroyed. Wetland ecosystems vary in ecological quality and type. Determining the appropriate amount of compensatory wetland creation and restoration is difficult. The number of acres restored may not adequately account for the variations and quality of the ecoservices lost in the destroyed wetlands. This paper describes an economic approach for determining the adequacy of compensatory wetland creation and restoration. Coefficient estimates and data from previous studies are used to examine four hypothetical wetland restoration scenarios. The results indicate that the appropriate amount of compensatory creation and restoration (a) increases with the quality of the destroyed wetland and (b) declines with the quality of the created or restored wetland. The results of the economic model are compared with mitigation results obtained using the standard procedures in Michigan. The comparison indicates that standard wetland mitigation procedures may require too little compensation when the restoration accomplished is not of the highest quality. Relative to the economic model of compensatory mitigation, standard procedures seem to result in too little restoration when (a) the *destroyed* wetland is high quality habitat and (b) the *restored* wetland is poor quality habitat. Standard procedures also appear to require too much restoration relative to the economic model when (a) the *destroyed* wetland has poor quality and (b) the *restored* wetland is high quality.

Introduction

Mitigation in Michigan

The destruction of a wetland in Michigan usually requires a permit from the Michigan Department of Environmental Quality. Many of these permits require that the loss of the wetland be mitigated by the creation or restoration of another wetland. The amount of compensatory wetland creation and restoration is determined by application of a set of standardized mitigation ratios. A mitigation ratio states the number of wetland acres to be restored for each acre of the wetland converted or destroyed.

Michigan wetland regulations outline acceptable wetland replacement when there are not reasonable alternatives to the impairment or destruction of a wetland ("Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, PA 451," 1994). The minimum accepted mitigation ratio is 1.5 acres of replacement wetland for every acre of destroyed wetland. When the wetland is classified as forested, coastal, or bordering on an inland lake, the mitigation ratio increases to 2 acres created for every acre destroyed. If the wetland is categorized as rare or endangered statewide, the ratio increases to five or more acres of created wetland for every acre of restored wetland. It should be noted that wetlands containing rare or endangered species are not permitted to be destroyed.

The Department of Environmental Quality is authorized to make minor adjustments in the standardized mitigation ratios. The ratios may be adjusted by as much as 20% to account for site-specific factors such as special hydrological features. An additional adjustment, not limited to 20%, may also be made for differences in the type of wetland destroyed and the type created or restored ("Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, PA 451," 1994).

The Michigan mitigation ratios are based on wetland acreage but may not protect the economic value of wetlands. Economics suggests that the value of a good or service is a function of the good's features and qualities (Lancaster, 1966). As an economic good, a wetland area with higher quality ecological features should be more valuable to people than an equal amount of wetlands with lower quality ecological features. Proper valuation of a wetland requires looking at its specific ecological features and services. The variation in features and services among wetlands means equally sized wetlands should vary in value. As a result measuring wetland net loss solely in terms of acreage may not account for real variation in value. If replacement wetlands provide fewer services than the destroyed or damaged wetland, a net loss of value occurs even with a net gain in acreage.

Reported Research

This paper examines how wetland habitat qualities may affect the level of mitigation required to adequately offset wetland loss. The model used in this study is based on the economic idea of in-kind compensation. In-kind wetland compensation is the quantity and quality of a restored wetland that offsets the permitted wetland loss. The reported analysis develops a quality-adjusted model of mitigation that incorporates differences in habitat quality in restored wetlands and the destroyed wetlands. The results of the quality-adjusted economic model of wetland compensation (the "economic model") are compared with the standard mitigation ratios used in the State of Michigan (the "standard procedure").

The economic model and the standard procedure are compared using data for wetlands that vary in habitat quality and type. Habitat qualities varied as to the degree to which a wetland provides habitat for game species, non-game waterfowl and birds, and plants of interest to the public, such as wild flowers. Habitat quality levels for each wetland were measured categorically with each habitat quality category scored as 'excellent', 'good', or 'poor'.

Restoration Scenario

Two hypothetical restoration scenarios were considered for four base cases. The base cases for four wetlands were founded on ecological data collected in field studies of four riparian wetlands in Michigan by the Michigan Great Lakes Protection Fund (Goforth et al., 2001). The restoration scenarios varied in the quality of wetland used as mitigation for the wetland destroyed. The first restoration scenario used poor quality wetland to compensate for the destroyed wetland. A poor quality wetland was a wetland defined as having poor ratings in all of the habitat features. The second restoration scenario offset a wetland loss with good quality wetland. A good quality wetland was a wetland with good ratings in all of the habitat quality categories. The restoration scenarios for each of the four wetlands allowed the generation of mitigation ratios for eight hypothetical restoration scenarios using both the economic models and the standard procedure.

Mitigation Ratios

The economic model was applied to each of the eight restoration scenarios. The mean mitigation ratio for permits issued by the Michigan Department of Environmental Quality between 1980 and 1998 was used to represent the mitigation ratios resulting from standard procedures. A comparison of the mitigation requirements based on application of the standard procedures and those requirements based on the economic model shows that when restoration efforts result in poor quality wetlands, standard procedures appear to call for less mitigation than that needed to prevent an economic net loss of wetlands value. The level of mitigation needed under standard procedures may result in over compensation if (a) the initial wetland has poor habitat features and (b) the restoration wetland has good habitat features. However, the economic model indicates that the wetland loss is not adequately compensated by the standard procedure when (a) the initial wetland has excellent habitat features and (b) the restored wetland has good habitat features. The standard procedure's mitigation ratios are in line with to the economic model when (a) the initial wetland is a mixture of good and excellent features and (b) the restored wetland has good habitat features.

Conceptual Framework

Michigan's wetland statute defines a wetland as "land characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation or aquatic life, and is commonly referred to as a bog, swamp, or marsh" ("Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, PA 451," 1994). However, not all wetlands are "bogs, swamps, or marshes," in fact; the State of Michigan recognizes 29 different wetland community types (Chapman, 1986). Each of these community types have a unique set of features and services associated with them, including vegetation, soil types, animal habitat and groundwater recharge capability. Even within a given wetland type, the amount of each service provided can range greatly depending on factors such as soil type or surrounding habitats.

Wetland compensation in monetary terms is complicated by the wide variety of wetlands and by the lack of open markets for wetland features. The services therefore do not have clear monetary values associated with them. Non-market valuation techniques, such as travel cost or contingent valuation, can help determine some of these values (Woodward, 2001). Woodward and Wui found in a meta-analysis of wetland valuation studies that, across studies, the statically significant economic variables when determining the value of a wetland were the wetland's size, the provision of bird hunting and bird watching opportunities and amenity values (Woodward, 2001).

The quality-adjusted economic model used in this paper allow for the generation of a mitigation ratio. Mitigation ratios can be viewed as an in-kind price for the wetland (Hoehn, Lupi, & Kaplowitz, 2003). In-kind tradeoffs are the amount of one quality feature that is required to offset the loss or decline of another quality feature. Some of the difficulties associated with determining the monetary value of wetland features are circumvented by using in-kind tradeoffs. However, the relative value of each quality level still needs to be determined. This can be accomplished by using a properly designed survey questionnaire to elicit the tradeoffs that the respondents are willing to make between different features (Lupi, Kaplowitz, & Hoehn, 2002).

Standard Procedures and the Economic Model

This section develops a model of the standard Michigan mitigation procedure and an economic model for determining mitigation ratios. The standard procedure model, as presented, adjusts the mitigation ratio for type of destroyed wetland, site-specific factors destroyed and changes in wetland type. The economic model changes the mitigation requirements based on the type, accessibility and habitat quality levels of the wetlands lost and created. The economic model is then used to determine how the mitigation ratio varies due to changes in the habitat quality features of the destroyed wetland and the restored wetlands.

Standard wetland mitigation procedures base mitigation ratios on three factors ("Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, PA 451," 1994). The first factor is the base ratio, γ, which accounts for differences in wetland type. The second factor, α, adjusts the base ratio for differences in wetland type between the destroyed and restored wetlands and is limited to between .8 and 1.2. The third factor, β, adjusts the base ratio to account for site-specific wetland features. The mitigation ratio, R_s, is then the product of the three different factors.

$$R_a = \alpha_a \beta_a \gamma_a \qquad (1)$$

where R is the required minimum mitigation ratio. The minimum mitigation ratio is the amount of wetland that needs to be created or restored for the loss of one acre of original wetland.

The development of a mitigation ratio using the economic value of wetlands requires determining the economic value of different wetland features. Summed, these values are the total economic value of a specific wetland. A valuation function for the good can be created where the total value of the good, V_a, is equal to marginal value of each feature times the amount of each feature present in the good (Hoehn et al., 2003). Equation (2) shows a valuation function for a single wetland *a*:

$$V_a = \beta_q Q_a + \beta_y Y_a \quad (2)$$

where V_a is the value of the wetland *a*, where Q_a is a vector of the wetlands features, including type, habitat quality levels, and accessibility, and Y_a is the acreage of the wetland. β_q is the marginal value of the features while β_y is the marginal value of each acre of wetland.

An economic net loss occurs unless the mitigation wetland has equal or greater economic value than the wetland destroyed. Equation (3) shows the change in value resulting from replacing wetland *a* with wetland *b*:

$$V_b - V_a = \beta_q (Q_b - Q_a) + \beta_y (Y_b - Y_a) \quad (3)$$

The left hand side of equation (3) shows the difference in value between wetland *a* and wetland *b*. The right hand side of equation (3) shows how much of the change in value results from a change in quality features, $\beta_q (Q_b - Q_a)$, and how much of the change comes from the change in acreage between the wetlands, $\beta_y (Y_b - Y_a)$.

A key goal of wetland mitigation is to avoid a net loss of wetlands, the so-called no-net-loss criterion (Sapp, 1994). In economic terms, no net loss may be interpreted as no net loss of wetland services and no net loss of wetland values. No net loss of wetland values means that the change in value described by the left-hand side of Equation (3) is equal to zero:

$$0 = \beta_q (Q_b - Q_a) + \beta_y (Y_b - Y_a) \quad (4)$$

Equation (4) may be rearranged to give the amount of restored wetland acreage, Y_b, that offsets the loss of wetland acreage, Y_a, adjusted for the quality differences between the two wetlands,

$$\beta_y (Y_b - Y_a) = - \beta_q (Q_b - Q_a) \quad (4)$$

Dividing both sides of equation (4) by β_y and adding Y_a to both sides isolate Y_b as shown:

$$Y_b = (-\beta_q / \beta_y)(Q_b - Q_a) + Y_a \tag{5}$$

Y_b is the minimum size of wetland *b* that compensates for the loss of wetland *a* given the characteristics of each wetland. $(-\beta_q / \beta_y)$ is the rate at which tradeoffs can be made of quality for acreage. When multiplied by the change in the quality features the result is the amount of acreage that has to be added to compensate for the decline in quality. If the restoration wetland has higher quality values then the result is the amount of restoration that does not need to occur in order for the value to be maintained.

Equation (5) can be converted into a mitigation ratio by dividing both sides by Y_a. The resulting equation is:

$$R_a = (-\beta_q)(Q_b - Q_a) / (\beta_y Y_a) + 1 \tag{6}$$

R_a represents the minimum number of acres that need to be restored for every acre of wetland lost in order for of the wetland to be held constant. The one on the right-hand indicates that if no change in quality occurs between the two wetlands the mitigation ratio is 1 acre restored for every acre destroyed. The change in value that results from changes in Q_a divided by the value of the original acreage, $(\beta_y Y_a)$ represents the additional acreage needed per acre destroyed.

The tradeoffs between habitat qualities and acreage can be made clearer by defining β_y as the marginal value of a percentage change in acreage. If the percentage change in acreage is used instead of change in acreage when estimating β_i and β_y,, Equation 4 is rewritten as:

$$\beta_y((Y_b - Y_a)/Y_a) = -\beta_q(Q_b - Q_a) \tag{7}$$

The required mitigation ratio is now expressed as:

$$R_a = (-\beta_q \ / \ \beta_y)(Q_b - Q_a) + 1 \quad (8)$$

The rate at which tradeoffs can be made between quality features and acreage is shown by , $\beta_q \ / \beta_y$. The tradeoff no longer depends on the size of the original wetland. When multiplied by the change in quality features, it gives the amount of additional acreage that needs to be created per acre destroyed.

The final step in deriving the economic mitigation model is to explicitly denote each of the element-wise changes in the difference between vectors Q_a and Q_b. Denoting the element-wise changes as $\Delta q_i = Q_{ib} - Q_{ia}$, i =(1,...,K), the economic mitigation model is:

$$R_q = 1 - (\beta_1 / \beta_y)\Delta q_1 - \ldots - (\beta_2 / \beta_y)\Delta q_k - \ldots - (\beta_k / \beta_y)\Delta q_K \quad (9)$$

The economic mitigation ratio, R_q, in equation (9) depends on the quality changes between the destroyed and restored wetlands. If the quality level of q_i declines the mitigation ratio, R_q will increase. Likewise, if the quality level of q_i increases the mitigation ratio R_q will decrease. R_q can be held consent if another quality feature were to increase such that the increase in mitigation required by the decline of q_i was equal to the decrease in mitigation required by the increase in *q*.. Although *q* could represent a near infinite set of habitat features, for this paper the quality features considered are the type of the wetlands, the accessibility of the wetlands, and the quality of habitat provided to reptiles/amphibians, songbirds, wading birds and wildflowers.

Lupi et al. describes how the coefficients, α, β_y and β_1 to β_k, may be estimated using stated choice data and a logit estimation procedure (Lupi et al., 2002). Stated choice experiments may be designed to elicit respondents' preferences using pairs of, say, drained and restored wetlands. Respondents may be asked to state whether a restored wetland is sufficient to compensate for the loss of a drained wetland (Lupi et al., 2002). Given a set of such choice data, logit estimation may be used to estimate the sensitivity of choices to variations in the quality of wetland features across the different pairs. This choice sensitivity is summarized by estimated coefficients analogous to those described in equation (9) (Lupi et al., 2002).

Research Objective and Hypothesis

The reported research applies the economic mitigation model (equation (9)) and compares the mitigation ratios resulting from the quality- adjusted model with the mitigation ratios implied by standard procedures. The main hypothesis is that the amount of mitigation required to prevent a net loss of value will vary under the economic model. The results of the economic model will vary with quality levels of wetland destroyed and the quality of the wetland created or restored. A secondary hypothesis is the economic model will result in mitigation ratios that are greater than those suggested by standard procedures when the destroyed wetland is very high quality. Additionally it is hypothesized that when the restored wetland is of poor quality features the economic model will suggest a larger amount of mitigation than standard procedures.

The Case Study Data

This section describes the data needed to compare the standard procedures and the economic compensation model. A short explanation of the methodology used to gather the data and a discussion of other techniques for data collection are presented.

Value Coefficients

Hoehn, Kaplowitz, and Lupi (2003) estimate the coefficients for equation (9) using stated preference methods. The survey questionnaire was developed using a series of six focus groups, a science advisory panel, sixty one-on-one interviews and a small pilot survey (Lupi et al., 2002). Based on the feedback, the researchers selected nine wetland attributes to include in the questionnaire: type, acreage, access to the public, and habitat qualities for amphibians and reptiles, songbirds, wading birds, and wild flowers. Color-coded scorecards were developed that included a drained wetland and a restored wetland each of which had each of the nine features described. The questionnaire asked about the respondent's knowledge and experience with wetlands while providing basic information concerning wetland type and species commonly found in wetlands. The respondents were also given some information concerning wetland policy and how wetlands are restored. The respondents were then told they would take part in a citizen panel for five restoration scenarios. They were also told that the wetlands described were common wetland types that did not contain any rare or endangered wildlife species or wetland types before being asked if the restored wetland offset the loss of the drained wetland.

The study defined the habitat quality as either poor, good, or excellent based on the number of species supported and the visibility of these species. Excellent habitat is defined as “wetland habitat [which] supports these species in better than average numbers and variety; a casual observer is *very likely to see a variety* of these species”. Good habitat supported an average number of species, with visitors likely to see a few species as defined by the questionnaire. Finally the poor level supports species in “very small numbers or not at all” and “a trained observer is *unlikely to find any* of these species”.

Variables

Poor, good and excellent are not cardinal rankings so the marginal value of poor to good may be different from the marginal value of good to excellent. The compensation function developed views changes in habitat qualities in terms of incremental changes from poor to good and good to excellent. Two variables per species group show how the value of the habitat quality changes. If the habitat increases from the lower to the higher it receives a rating of one, if it declines, negative one, and if no change, zero.

Table 1 summarizes all the variables used in the economic model. For example, if the original wetland is poor reptile habitat and the replacement habitat is good quality, then the reptile rating is one for *reptiles-good* and zero for *reptiles-excellent*. This shows that the restored wetland was an improvement in terms of reptile quality compared to the destroyed wetland however the improvement was not enough to rate it excellent. If the quality level of the replacement habitat had increased to excellent quality, then both poor to good and good to excellent are +1. The marginal value of a good quality habitat feature compared to a poor habitat feature for a species group is given by the coefficient on the *(species-good)* variables. Where species represents one of the four species groups measured: reptiles, songbirds, wading birds, and wildflowers. The *(species-excellent)* variables' coefficients show the marginal utility that results from habitat quality to excellent compared to good. Therefore, the total increase in value resulting from an excellent habitat quality for a species group compared to poor habitat quality for that group is the sum of the coefficients for *(species-good)* and *(species)-excellent*.

Three other variables were also defined. *Chantype* is a dummy variable that is given a value of "1" if the ecological type of the restored wetland is different from the ecological type of wetland destroyed and "0" if the restored and destroyed wetlands are the same ecological type. *Access* was also a dummy variable based on whether the public access to the wetlands destroyed and restored differed. If the public gains access to the restored wetland and the destroyed had been closed to the public, *Access* is "1." If the restored wetland is closed but the destroyed was open *Access* is coded as "-1," if the restored and destroyed are both open or both closed access is coded as "0." The final variable was *chanacre*, which was defined as the percentage change in acres between the restored and created wetlands.

<u>Mail Survey Data</u>

A mail survey was conducted using a sample of 1500 random Michigan residents. Respondents were chosen from driver license records using a weighted sample of counties to ensure that the sample contained a mix of both urban and rural respondents. In order to maximize the response rate a Dillman "Total Design approach" was used with, each respondent received up to five letters (Dillman 2001). The first contact with perspective respondents was a one-page pre-notification letter that was mailed on October 19. On October 29, the first wave of the survey was mailed. On November 5, a follow-up postcard was mailed. The second wave of the survey mailed on November 13 to 1,184 residents. The third wave of the survey was conducted after the holiday season and mailed on January 4, 2002. 196 surveys were returned as undeliverable. 602 surveys were returned resulting in a response rate of 46.17%.

The responses to the mail survey were used to estimate preference equations. The preference equations estimated the probability that a person would approve a wetland restoration given the planned habitat features of both the restored and destroyed wetland. The preference equation coefficients are the marginal changes in acreage needed to offset small changes in the wetland habitat features (Lupi et al., 2002). The estimation allows for the creation of an economic model of mitigation similar to the one specified in equation (9). The only adjustment that needs to be made is for quality features not included in the survey. An intercept term, *α,* is added to represent the quality features not explicitly measured. The economic model as developed is shown in Equation (10):

$$R_q=1 + \alpha - (\beta_1 / \beta_y)\,\Delta q_1 - \ldots - (\beta_{10} / \beta_y)\,\Delta q_{10} \qquad (10)$$

Where q_i are the ten quality variables discussed above. Table 2 shows the coefficients and the standard errors for each habitat feature.

Representative Wetlands Data

The comparison of the results of the use of the standard procedure with the application of the economic models requires information about the habitat qualities and the ecological types of actual wetlands destroyed. Four actual wetland areas were chosen to serve as representative base cases for the destroyed wetlands in the hypothetical permitting and mitigation scenarios. The primary reason they were chosen was the existence of detailed data concerning the habitat qualities features for each area.

The base cases are wetlands located near four of southern Michigan's major rivers, the Grand, the Kalamazoo, the St. Joseph, and the Raisin Rivers. Detailed surveys of the riparian zones were conducted for part of each of these rivers and their tributaries (Goforth et al., 2001). The riparian zones included a variety of wetland types that ranged from boggy areas to wooded wetlands. Two small sections are wetland types that are rare in Michigan; however, these areas are excluded from the analysis as rare wetland cases were excluded from the economic survey (Lupi et al., 2002). Under standard procedures, the four base cases would probably receive a base mitigation ratio of either 1.5 acre restored per acre impacted or 2.0 restored per acre destroyed. The historical mean level of mitigation, that is used as a proxy for the standard procedure falls in this range at 1.73 acres restored per acre impacted.

The ecological data collected for this paper was originally used for a study of the biodiversity of riparian area (Goforth et al., 2001). The study collected a wide variety of wildlife statistics, including information on the four wildlife groups used in the stated preference survey. That study separated its results into four categories based on the proximity to the river. This analysis used only the first category, within 125 meters of the river, since the percentage of upland areas increased as the distance from the river increased. It should be noted that the economic model's survey neither specifically included nor excluded riparian wetlands.

Goforth et al. collected data concerning amphibians and reptiles in three ways: straight-line drift fences, visual surveys and frog calls. The two fifteen meter straight-line drift fences were set up between May 15, 2000 and May 27, 2000 at each site. Each fence had three pitfall traps and two funnel traps at the end that were opened for a period of 10 days and nights. A single two person-hour time constrained visual survey was conducted along 100 meter transects at each site between May 29, 2000 and June 7, 2000. Researchers also listened to frog calls between May 20, 2000 and June 6, 2000 following the Michigan Frog and Toad Protocols for determining the number of frogs involved (Sargent, 2002).

Wading birds and songbirds in the baseline wetlands were both studied using standard point count methods using standard methods. (Ralph, Sauer, & Droege, 1995) (Ralph, Guepel, Pyle, Martin, & DeSante, 1993). Three stations per site at least 250 meters apart were monitored for 5 minutes between May 13, 2000 and May 15, 2000 and 10 minutes between June 23, 2000 and June 29, 2000. The dates were chosen to coincide with spring migration and breeding seasons. Any individuals spotted or heard within 50 meters were recorded. Individuals seen outside of 50 meters were noted as well.

Wildflower populations were measured to record both early and late flora. The first studies occurred between May 22, 2000 and June 15, 2000 and the second between August 17, 2000 and August 29, 2000. Timed meander searches were conducted as well through reconnaissance surveys. These surveys were used to identify representative transects for each site. Five transects per site were established and five one-square meter sample plots were studied. Any species within the sample plot were assigned a percent groundcover and the number of species was recorded. Species discovered during the timed meander searches and the reconnaissance surveys were recorded as well. Any species that could not be identified in the field were collected and identified by the University of Michigan Herbarium.

Analysis

Standard Procedure Estimation

As previously explained, statutory mitigation required by the State of Michigan are adjusted, depending on the judgment of the Department of Environmental Quality. The Department of Environmental Quality may adjust the base ratios for differences in wetland type and site-specific factors. As a result, the mean mitigation ratio for 1980-1998 was used an estimation of the mitigation ratios required by standard procedures for this paper. The mean mitigation ratio for this period was 1.73 acres restored per acre destroyed. (*Michigan Wetland Mitigation and Permit Compliance Study*, 2001)

Habitat Quality Determination

The ecological data collected by Goforth et al. needed reformatting before it could be used with the economic compensation function based on the work of HLK. These changes transformed the biological data into poor, good, and excellent categories, so it could be used with the economic model. Once the ecological data was transformed, the *(species)-good* and *(species)-excellent* variables could be determined.

The first of the four habitat quality levels determined for each base case was for the reptile and amphibian group. Three types of information were gathered by Goforth, et al. concerning reptile and amphibians: total number of species at a site, pitfall and trapping success rates, and number of individuals observed from a visual survey. As the economic model based its habitat quality levels on the visibility of the wildlife groups and the number of species present, the visual survey was the primary determinant in the assignment of habitat quality. The number of species also was a factor, as more species may increase the situations where sightings are possible. If the surveyors spotted at least three individuals per hour and at least five different species, the base case received a rating of excellent. If the surveyors spotted at least three individuals per hour or at least three different species the base case was rated good and if less then three individuals per hour were spotted and the total number of species was less then five the base case was rated poor. Table 3 shows how the biological data was correlated to the category levels for reptiles that were in the economics model.

The next habitat quality rating determined was for songbirds. Although Goforth et al. did not separate out songbirds; they did include a full survey of bird species. Of the 69 species of birds, 48 belong to the order Passeriformes. The Passeriformes make up the majority of songbirds although a few non-passerine birds do sing. (Van Tyne & Berger, 1971) The morning dove is the only non-Passiformes songbird found; making the total number of songbirds identified in the study forty-nine, although only thirty-six were within 125m of the rivers. In order to correlate this data with the visibility-based variables in the economic model, the ratings were based on number of species spotted. Base cases received an excellent rating if they had two-thirds of the species present, good if they had at least one-third, and poor otherwise.

The determination of wading birds habitat levels used a similar process to the process used for songbirds except that the data collectors observed only two species of wading birds (Great Blue Heron and Belted Kingfisher) in the study areas. The habitat quality variables in the economic model are based on the visibility of the species so a base case received an excellent rating if both were present, good if one was found and poor if none were present.

The final habitat quality level to be determined was for wildflowers. As the study did include some upland areas, the first step was the removal of plants that were either Facultative Upland or Upland Obligate. Species are Facultative Upland species if they occur 66-99% of the time in upland areas while species are Upland Obligate species if found over 99% of the time in upland areas, based on the National Wetland Indicator Categories as used by the State of Michigan (Herman et al., 2001; Reed, 1988). The inclusion of all plant species, including trees and shrubs, requires separating out the wildflowers. Newcomb's Wildflower guide provides a list of wildflower species (Newcomb, 1977). The final step removed the invasive non-native species from the list. The total number of wildflower species identified was 110 wildflower species, 77 of them in the under 125m areas. Wetlands received ratings of excellent if the data collectors found at least 38 species of wildflowers and wildflowers made up at least 40% of the plant species. Wetlands received good ratings if at least 26 species were present and they made up at least 30% of the total plant species.

The final feature needed for the economic model is the type of wetland created and destroyed. All four base cases contained a variety of different wetland types. The assumption made was that the type of wetland changes under each restoration scenario for all scenarios, since most of the successful actual mitigation projects have been cattail marshes, which represents a only small percentage of each base case. Table 4 shows a summary of the habitat quality data and ratings for the each base case.

<u>Mitigation Scenarios</u>

Each mitigation scenario consists of a base case and a wetland restoration. The base cases are taken from the four wetlands described by the field survey data (Goforth et al., 2001). Each base case is restored with a poor and good quality wetland. The two different restoration possibilities for each base case result in eight hypothetical mitigation scenarios, public access to the wetland were assumed to remain unchanged by restoration in each scenario.

Under standard procedures, the base cases would likely receive either the base ratio of 2 acres or 1.5 acres restored per acre destroyed as they contain both forested areas (2 acres restored per acre destroyed) and common wetlands types (1.5 acres restored per acre destroyed). As previously stated, the mean mitigation ratio for the state is 1.73. Therefore, in order to compare the two models the mean level of 1.73 is used as the standard procedure mitigation ratio for all four wetland areas. This value falls within the base range and, unless site-specific features were used to adjust this ration, there are no obvious reasons to believe that these base cases would warrant the use of a mitigation that would vary greatly from this value if actual mitigation were to occur at these base sites.

Results

The mitigation results for the four base cases using the standard procedure and the economic model are presented in this section. The mitigation ratios for cases mitigated with poor quality restoration wetlands are examined first. The results of scenarios mitigated with good habitat restoration are presented second. The section concludes with comparisons of the results of the poor and good quality scenarios for each base case.

Mitigation with Poor Habitat Quality

The first four scenarios pair the four base cases with poor habitat quality restoration for each species category. Table 5 lists the mitigation ratios that result for each base case under poor quality restoration. These scenarios result in mitigation ratios that range from 3.77 for the St. Joseph base case to 5.18 for the Grand River base case. The mean economic mitigation ratio is 4.2, 142% greater than the standard procedure mitigation ratio of 1.73. The Grand River case would require 39% more mitigation than the St. Joseph River case because habitat quality at the Grand River base case is better than at the St. Joseph base case.

Mitigation with Good Habitat Quality Features

The second restoration scenario for each base case increased the quality of the restoration wetland's habitat features for the different species groups to good. The mean mitigation ratio returned by the economic model, under this scenario, is similar to the standard procedure estimation. Table 5 shows the results. The mean mitigation ratio of 1.81 is only 4.3% greater than the standard procedures estimate. The St. Joseph River base case would actually be overcompensated by about 29% if the restored scenario consisted of 1.73 acres of wetland with good habitat features. Under the same restoration scenario, the Grand River base case would experience a net loss of 60% of the value of the base case. The economic model suggests that the developer at the Raisin River and St. Joseph River sites can either carry out create smaller mitigation wetlands or create mitigation scenarios with lower habitat quality and still prevent a net loss of economic value from occurring. For example, at the Raisin River a replacement wetland that only provided poor habitat for wildflowers would prevent a net loss of value at a mitigation ratio of 1.73. The Grand River scenarios now need over double the mitigation per acre compared to the Raisin River scenarios for both to avoid a net loss.

The difference between the good and poor quality scenarios is notable. Figure 1 shows the amount of mitigation required by each model for each base case. Under poor conditions, the Grand River and the Kalamazoo River base cases require approximately double (186% and 239% respectively) the mitigation they require under good conditions. The St. Joseph River base case is even more extreme, requiring three times the mitigation in terms of acreage under good conditions than the economic model required for the same base case under poor conditions. The poor quality restoration needed 56% more acres restored per acre lost than the good quality restoration scenarios.

Conclusions

The paper applies ecological data to an economic mitigation model that adjusts for quality differences between a destroyed wetland and a restored wetland. The goal of the economic model is to maintain the economic value of wetlands by preventing a net loss of value from wetland restoration and mitigation. The economic model highlights the fact that not all wetlands are equally valuable as they contain a number of features that can vary in quality. One feature that can vary in quality is the habitat quality for a group of species. Some wetlands provide better habitat features than others. The economic model shows that the habitat quality, and not just acreage, matters when preventing a net loss of wetland value.

The economic model indicates that preventing a net loss of acreage does not necessarily prevent a net loss of value. Unlike standard mitigation procedures, the economic model allows for differences in quality levels between the original wetland and the mitigation wetland. The economic model shows that by increasing the quality of the mitigation wetland from poor to good habitat, the mitigation ratio needed to prevent a loss of value declines by an average of 56%.

The sensitivity of the economic mitigation ratios to the starting habitat quality is also significant. The Grand River base case required more acreage under both scenarios than the average level of state mitigation in order to prevent a net loss. However, for the Raisin and St. Joseph base cases, the standard procedures would result in less mitigation than the economic model for mitigation that resulted in wetlands with poor habitat features. However, the standard procedure ratio is greater than the economic mitigation ratio for restoration wetlands with good habitat features. In all of the cases examined, the results are dependant upon the characteristics of the existing wetland and how they are translated into the quality levels that are used in the economics model.

The scenarios suggest that wetland mitigation would occur quite differently in particular cases using an economic model than it would using the average mitigation ratio. Since the existing wetland mitigation system allows individual permits to take account of site-specific features of wetlands, there is potential for the actual mitigation ratios used by the state to more closely approximate those suggested by the economics model. The economic model provides some guidance on how to take these differences in features into account. Wetlands that provide high quality habitats, such as the Grand River base case, require significantly more or better mitigation scenarios than wetlands that provide less in terms of quality habitat. The economic model also opens up options for those carrying out mitigation projects. Those destroying wetlands could reduce the total amount of mitigation needed by sighting their original project on lower quality wetlands or by improving the quality of their mitigation projects. It also allows the wetland user to make tradeoffs in the quantity and quality of the mitigation wetland while still preventing a net loss of value.

Tables and Figures

Table 1. Economic Model Variable List

Variable Name	Description	Values
CHANTYPE	Dummy for change in type between restored and destroyed wetlands	1 if wetland type changes between restored and destroyed, 0 otherwise.
CHANACRE	Percentage change in acreage	= (acres restored-acres drained)/acres drained
ACCESS	Dummy for change in access between restored and destroyed wetlands	1 is access increases, 0 if no change, -1 if access lost
Reptile- Good	Dummy for change in poor reptile habitat between restored and destroyed wetlands	1 if change from poor to good or excellent, -1 if change from good or excellent to poor, 0 otherwise
Reptile-Excellent	Dummy for change in poor songbird habitat between restored and destroyed wetlands	1 if change from poor to good or excellent, -1 if change from good or excellent to poor, 0 otherwise
Songbird- Good	Dummy for change in poor wading bird habitat between restored and destroyed wetlands	1 if change from poor to good or excellent, -1 if change from good or excellent to poor, 0 otherwise
Songbird-Excellent	Dummy for change in poor wild flower habitat between restored and destroyed wetlands	1 if change from poor to good or excellent, -1 if change from good or excellent to poor, 0 otherwise
Wading birds-Good	Dummy for change in excellent reptile habitat between restored and destroyed wetlands	-1 if change from excellent to poor or good, 1 if change from good or poor to excellent, 0 otherwise

Table 1. Economic Model Variable List

Variable Name	Description	Values
Wading birds-Excellent	Dummy for change in excellent songbird habitat between restored and destroyed wetlands	-1 if change from excellent to poor or good, 1 if change from good or poor to excellent, 0 otherwise
Wild Flowers-Good	Dummy for change in excellent wading bird habitat between restored and destroyed wetlands	-1 if change from excellent to poor or good, 1 if change from good or poor to excellent, 0 otherwise
Wild Flowers-Excellent	Dummy for change in excellent wild flower habitat between restored and destroyed wetlands	-1 if change from excellent to poor or good, 1 if change from good or poor to excellent, 0 otherwise

Table 2. Estimated Logit Coefficients for Acceptance of Restored Wetland

Variable	β_i	$\beta_i / \beta_{chanacre}$
Chanacre	0.5703 (0.125)*	1
Chantype	-0.1981 (0.0889)*	-0.3474 (0.1660)*
Access	0.2500 (.0664)*	0.438 (0.1460)*
Reptile – Good	0.4606 (.0755)*	0.8077 (0.1778)*
Reptile- Excellent	0.2421 (.0751)*	0.4245 (0.1855)*
Songbird- Good	0.3630 (.0718)*	0.6365 (0.1731)*
Songbird- Excellent	0.1138 (.0718)	0.1996 (0.1407)
Wading Birds- Good	0.3483 (.0703)*	0.6108 (0.1820)*
Wading Birds- Excellent	0.2431 (.0694)*	0.4263 (0.1527)*
Wild Flowers- Good	0.1938 (.0705)*	0.3399 (0.1430)*
Wild Flowers- Excellent	0.1030 (.0699)	0.1807 (0.1288)
Intercept	-0.1168 (0.0791)	-0.2048 (0.1245)

Note. Regression results from Hoehn, et al (2003). Standard errors in parenthesis.

* Coefficient significant at $p<.05$

Table 3. Reptile Habitat Quality Levels

Quality	Survey Description	Number of Species[1]	Visual Survey[2]
Poor	very small numbers or not at all" and "a trained observer is *unlikely to find any* of these species	0	0
Good	wetland habitat [which] supports these species in better than average numbers and variety; a casual observer is *very likely to see a few* of these species	3	1
Excellent	wetland habitat [which] supports these species in better than average numbers and variety; a casual observer is *very likely to see a variety* of these species	5	3

[1] Total number of different species spotted during observations

[2] Average number of reptiles spotted per hour per person

Table 4. Habitat Quality Data and Ratings for each Base case

Wetland Features	Habitat Base Case			
	Grand	Kalamazoo	Raisin	St. Joseph
Reptiles				
Number of Species	10	6	3	6
Visual Survey (individuals per man-hour)	4.5	1.5	3.5	3.5
Rating	Excellent	Good	Good	Excellent
Wild Flower				
Number of Species	42	59	31	27
Wildflower Species/Plant Species	0.483	0.431	0.337	0.375
Rating	Excellent	Excellent	Good	Good
Songbirds				
Number of Species	25	22	16	22
Rating	Excellent	Good	Good	Good
Wading birds				
Number of Species	2	1	2	0
Rating	Excellent	Good	Excellent	Poor

Table 5. Required Mitigation Ratios for each Scenario

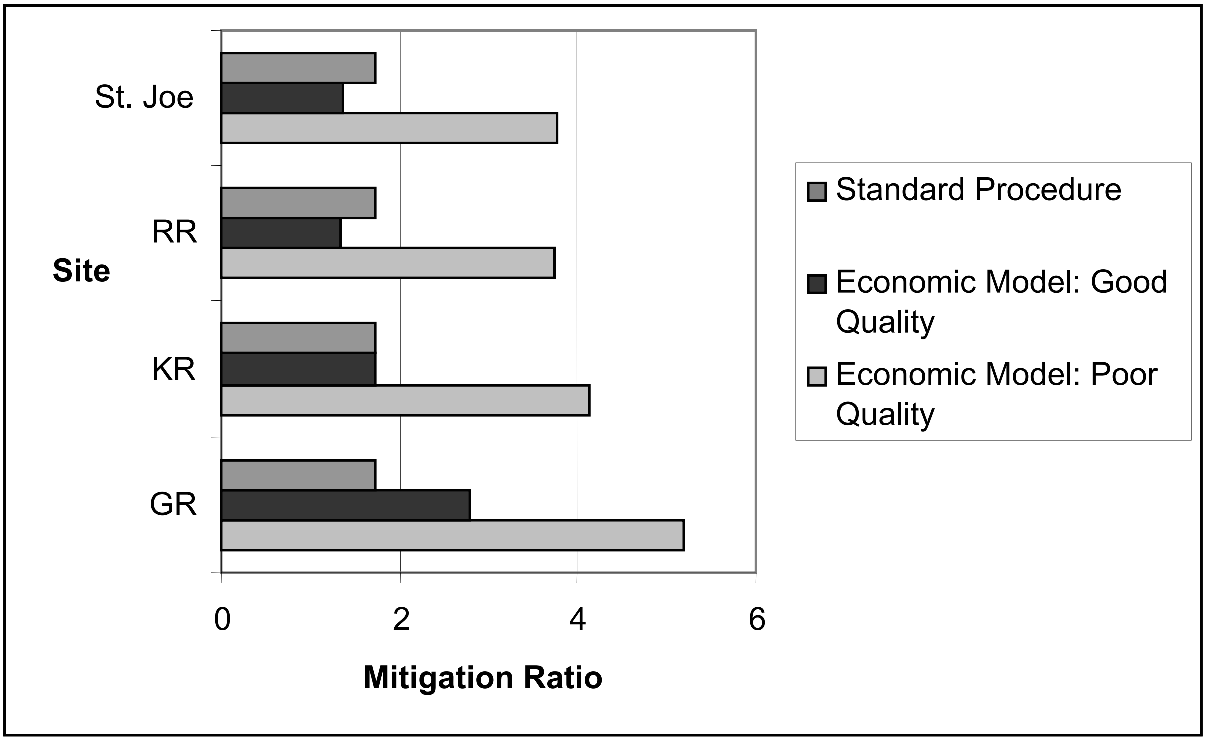
Base Case by Restoration Quality	Mitigation Ratio[1]	Difference[2]	Percentage Difference [3]
Restoration with Poor Quality Habitat			
Grand River	5.18	3.45	199
Kalamazoo River	4.13	2.40	139
Raisin River	3.98	2.25	130
St. Joseph	3.77	2.04	118
Mean	4.27	2.54	147
Restoration with Good Quality Habitat			
Grand River	2.78	1.05	61
Kalamazoo River	1.73	0	0
Raisin River	1.58	-.15	-9
St. Joseph River	1.37	-.36	-21
Mean	1.87	.14	8

[1] Mitigation Ratio returned by economic model in terms of acres restored per acre destroyed

[2] Difference between the economic mitigation ratio and the state procedure estimate

[3] Economic model minus standard procedure estimate divided by the standard procedure estimate

Figure 1. Mitigation Ratios by Base Case



References

Chapman, K. (1986). *Michigan Natural Community Types*. Michigan Natural Features Inventory.

Goforth, R., Stagliano, D., Cohen, J., Penskar, M., Lee, Y., & Cooper. , J. (2001). *Biodiversity Analysis of Selected Riparian Ecosystems within a Fragmented Landscape.* (2001-06). Lansing, MI: Michigan Great Lakes Protection Fund Michigan Dept. of Environmental Quality, Office of the Great Lakes. Michigan Natural Features Inventory.

Herman, K., Masters, L., Penskar, M., Reznicek, A., Bilhelm, G., Brodovich, W., & Gardiner, K. (2001). *Floristic Quality Assessment with Wetland Categories and Examples of Computer Applications for the State of Michigan*.: Michigan Department of Natural Resource, Wildlife Division, Natural Heritage Program.

Hoehn, J., Lupi, F., & Kaplowitz, M. (2003). Untying Lancastrian Bundles: Ecosystem Valuation in Wetland Mitigation. *Journal of Environmental Management, 68*(3), 263-277.

Hoehn, J., Kaplowitz, M., and Lupi, F. (2003) Initial Estimates of the In-kind Mitigation Coefficients for Common Michigan Wetlands, working paper. Department of Agricultural Economics, Michigan State University. East Lansing, MI

Lancaster, K. (1966). A New Approach to Consumer Theory. *Journal of Political Economics, 74*(2), 132-157.

Lupi, F., Kaplowitz, M., & Hoehn, J. (2002). The Economic Equivalency of Drained and Restored Wetlands in Michigan. *American Journal of Agricultural Economics, 84*(5), 1355-1361.

Michigan Wetland Mitigation and Permit Compliance Study (2001). Lansing, Mi: Land and Water Division Michigan Department of Environmental Quality.

Newcomb, L. (1977). *Newcomb's Wildflower Guide*. Boston: Little, Brown and Company.

Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, PA 451, 324.303 19 (1994).

Ralph, C. J., Guepel, G. R., Pyle, P., Martin, T. E., & DeSante, D. F. (1993). *Handbook of Field methods for monitoring land birds* (Vol. PSW-GTR-144). Pacific Southwest Experiment Station, Albany, CA: USDA Gen. Tech. Rep.

Ralph, C. J., Sauer, J. R., & Droege, S. (1995). Managing and Monitoring birds using point counts: Standards and Applications. In C. J. Ralph & J. R. Sauer & S. Droege (Eds.), *Monitoring Bird Populations by point counts* (Vol. PSW-GTR-149, pp. 161-168). Pacific Southwest Experiment Station, Albany CA: USDA Gen. Tech. Rep.

Reed, P. (1988). *National list of plant species that occur in wetlands: Michigan* (NERC-88/18.22.23): U.S. Fish and Wildlife Service.

Sapp, W. (1994). Mitigation Banking: Panacea or Poison for Wetlands Protection.

Van Tyne, J., & Berger, A. (1971). *Fundamentals of Ornithology*. New York: Dover Publishing Inc.

Sargent, L. (2002). *Michigan Frog and Toad Survey*. Michigan Department of Natural Resources, Wildlife Division - Heritage Program.

Woodward, R. Y.-S., W. (2001). The Economic Value of Wetland Services: A Meta Analysis. *Ecological Economics, 37*(2).