Untying a Lancastrian Bundle: Ecosystem Valuation in Wetland Mitigation

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Abstract

A utility-theoretic model indicates that mitigation prices for wetland ecosystems depend on preferences *and* technical knowledge. Empirical analysis found gaps in respondents' knowledge about such ecosystems. Valuing wetland types requires dealing with respondents' possible misinformation, by developing tools for informing respondents or by combining service-based valuations with valid technical data.

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Wetlands 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. §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 is the "no net loss" of wetlands criterion (Gaddie and Regens 2000). To implement this principle, the wetland permit process encourages potential dischargers to minimize and avoid 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 1997). 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 (U.S.). Committee on Characterization of Wetlands. 1995; Mitsch and Gosselink 1993). Substantial effort has been made to define and measure wetland equivalencies using engineering principles and biophysical characteristics (Bartoldus 1999). However, the economic equivalency of wetland services has received less attention. Absent an understanding of the economic tradeoffs, wetland mitigation may leave economically important services unprotected and under provided.

In this paper, we report initial research results regarding the development and application of a framework for measuring the relative economic values of wetland ecosystems. We begin by reviewing the ecological characteristics of wetland ecosystems and past efforts to value wetlands. We then derive a model that leads to three approaches to estimating wetland ecosystem values in stated choice experiments. The relative performance of these valuation approaches depends on the distribution and extent of ecological knowledge among respondents. Knowledge of a particular form is an essential input into accurate ecosystem valuation.

The second part of the paper examines the knowledge base that residents of central Michigan might use in valuing wetland ecosystems. Residents were contacted using random digit dialing and were asked to participate in a group discussion about natural resource issues. Each group involved 6 to 8 residents. A moderator using a discussion guide specifically prepared to explore participants' knowledge, uses and perceptions of wetland ecosystems conducted each group interview.

Discussion participants demonstrated better than expected general knowledge of wetland ecosystems, but their detailed knowledge of wetland functions and services was uneven. Participants recognized habitat for plants and animals as a key wetland function. A smaller portion identified maintenance of water quality and water storage as important wetland functions. Misperceptions were also revealed. For example, several respondents thought that trees do not grow in wetlands. When asked to interpret and discuss photographs of wooded wetlands, some participants said that wetlands were killing the trees. This was especially interesting because wooded wetlands are common in Michigan.

Wetlands Ecosystems and Valuation Research

Wetlands are transitional types of ecosystems that occupy a spectrum between land and water ecosystems. Their exact definition has been controversial (National Research Council (U.S.). Committee on Characterization of Wetlands. 1995). The operational definition used in Federal wetlands permitting regulations builds on two essential wetland characteristics: (i) the land is composed of soils that are water-saturated during part of the vegetation growing season and (ii) the land supports plants that are typical of saturated soils (Smith et al. 1995). Using this definition, wetlands may have covered about 12 percent of the area of the continental United States during colonial times. Since that time, human activity in the United States has converted approximately 45 percent of wetlands area to other uses (Heimlich, Carey, and Brazee 1989).

Wetlands 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 types and 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. Maintenance of groundwater flows may contribute to stable sources of potable water. Wetland habitats may offer recreational opportunities, open space amenities in otherwise densely settled areas, and potential non-use services such as maintaining biodiversity.

The objective of wetland mitigation is to replace wetlands destroyed by permitted activities through the 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 a common type. When the destroyed acreage is a rare wetland type, 5 acres of mitigation are required for each acre lost (MCL §324.30319). 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 1996).

Wetland mitigation ratios are analogous to the 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 is satisfactory on engineering or biological grounds may not be acceptable in terms of preventing the loss of economic services and values. For instance, 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 wetlands. However, most studies shed little light on the relative value of different wetlands types, functions, and wetland services (Heimlich et al. 1998). A handful of studies do document commercial and recreational values associated with some wetlands (Loomis et al. 2000; Costanza et al. 1998; Bergstrom and Stoll 1993).

Other research suggests that wetlands may provide open space amenities (Mahan, Polasky, and Adams 2000; Opaluch 2000). 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 2000). Especially interestingly in terms of mitigation ratios, Mullarkey (1997) estimates that an acre of naturally occurring wetland is 6 times more valuable to respondents than an acre of mitigated wetland.

Woodward and Wui (2001) conducted a meta-analysis to estimate the value of wetland services. The estimated values of services per wetland acre are shown in Figure 1. The estimates indicate that consumptive services such as bird hunting (Hunt Bird), commercial fishing (Com Fish), and recreational fishing (Rec Fish) created significant derived demand for wetland protection. Non-consumptive services were also highly valued (Habitat, Flood Cntrl, and Bird Watch). Bird watching (Bird Watch), for instance, had the highest value per acre of all the wetland services examined in the study.

Economic Features of Wetland Ecosystems

Wetlands mitigation, to varying degrees in different cases, attempts to account for differences in wetland types, functions, and services. In the context of mitigation, economic values are useful to the extent that they allow for differences across wetland ecosystem types, functions, and services. In an economic sense, a wetland is not a generic economic commodity. Rather, a wetland is a Lancastrian, multi-attribute bundle that may vary in three major dimensions: type, function, and service. A research design for wetland ecosystem valuation would vary these attributes and assess how value changes with changes in ecosystem type, function, or service.

A second feature of wetland ecosystems that bears on the economics of wetland values is that wetland attributes occur in specific patterns and types. Ecosystems share a general pattern of species relationships. At the foundation of an ecosystem food web are plants that convert energy and nutrients into food. Plant consumers and predator relationships are build upon the vegetative foundation. The specific pattern of species relationship varies with the type and scale of an ecosystem (Miller 1999). That is, a fen does not support the same species and relationships as a bog. Nor does a small wetland of a particular type support the higher order predators that a larger wetland of the same might (Osborn 1996). Since the species mix and interrelationships may vary with type and scale, it is possible that the economic value of wetland types may differ from individually valued sets of wetland functions and services.

A third feature of wetland ecosystems that impacts the economics of wetland values is the uncertainty associated with incomplete knowledge. Knowledge of wetland ecosystems, their functions and services is incomplete on the scientific level (Miller 1999). That is, science may not be able to characterize a full list of relevant wetland attributes nor may science be able to help restore these attributes once there are impaired. In turn, ordinary citizens have incomplete and possibly inconsistent knowledge of the science of wetland ecosystems and functions. Given the evolving nature of science, a useful economic research design for ecosystem valuation might describe how wetland values change with specific changes in respondents' baseline knowledge of wetland types, functions, and services.

A Research Design for Wetland Ecosystem Valuation

The research design outlined below takes an initial step toward a rigorous framework for valuing wetland ecosystems. This first step focuses on wetland types and services in stated preference experiments. The goal is a research design that shows the relationship between the value of wetlands as wetland types and the value of wetlands as Lancastrian service bundles. As our research program advances, we plan to extend the framework to describe the derived demand for wetland functions. Additionally, we seek a wetland valuation design that makes explicit the role of respondents' knowledge in valuation.

The framework for the valuation model considers two wetland types. Wetland acreage of type 1 is represented by $A1$. Wetland acreage of type 2 is represented by $A2$. Each wetland type yields different sets of wetland services. Wetland type 1 yields services of a single kind that we represent with the symbol $S1$. Wetland type 2 yields services of the first kind, $S1$, as well as services of a second kind, $S2$. The total amounts of services available from acreage of type 1 and 2 are:

$$(1) \qquad S1 = A1 + A2$$

$$S2 = K(A2)$$

where K(A2) is an increasing, concave function that maps the acreage of type 2 into a levels of services S2. Equation (1) might correspond to a situation where both wetlands provide open space amenities but only type 2 wetlands support habitat with significant biodiversity.

The next step in the valuation model is to link economic services with human well-being. Human well-being is represented by a utility function, U,

$$(2) \qquad U = U(S1,S2,M),$$

where the level of well-being depends on the levels of the two services and an economic measure of income, M. The link between wetland acreage and well-being comes from the combination of equations (1) and (2). Substituting equations (1) into (2) shows the relationship between economic well-being and wetland acreage,

$$(3) \qquad U = U[A1 + A2, K(A2), M] = u[A1, A2, M]$$

where u() is utility function defined on wetland acreage rather than services. This latter utility function leaves the relationship between acreage and services implicit.

In economic terms, a no-net loss policy would leave economic well-being unchanged by compensating for a reduction in type 2 acreage with an increase in type 1 acreage and visa versa. For small changes in acreage, the amount of compensatory mitigation required to offset the loss of type 2 acreage is derived by taking the total differential of the second line of equation (3) with respect to *U*, *A1*, and *A2*. To keep well-being constant, *dU* is set equal to zero and the differentials rearranged. By this method, the following economic mitigation ratio is derived,

$$(4) \qquad P_{A2\,A1} = \partial u/\partial A2 \,/\, \partial u/\partial A1$$

$P_{A2\,A1}$ is the utility-theoretic mitigation price of a small reduction in type 2 acreage, measured in terms of a compensating increase in type 1 acreage. In terms of the utility function, this mitigation price is the ratio of the marginal utility of type 2 acreage, $\partial U/\partial A2$, and the marginal utility of type 1 acreage, $\partial U/\partial A1$.

Each of the marginal utilities in equation (4) is potentially measurable in stated choice experiments. In a choice experiment, respondents would be presented with alternative policy choices involving wetland acreage of type 1 and type 2. The choice data for acreage could then be used to statistically estimate the marginal utilities. Similar experiments could be conducted for choices involving wetland services such as open space and biodiversity. The problem then becomes how to link the estimated marginal utilities of services to the mitigation choices characterized in terms of acreage.

The link between the mitigation price of acreage, $P_{A2\,A1}$, and the mitigation price for services of type 1 and 2, $P_{S2\,S1}$, may be derived by taking the total differential of the first line of equation (3) with respect to *U*, *S1*, and *S2*. Setting *dU* equal to zero leads

$$(5) \qquad P_{A2\,A1} = 1 + K' \, \partial u/\partial S2 \, / \, \partial u/\partial S1$$

$$= 1 + K' \, P_{S2\,S1}$$

$$\geq 1$$

where *K'* is the marginal productivity of acreage of type 2 in producing services of kind 2, as understood and known by choice experiment respondents.

Several features of the mitigation price as stated in equation (5) are notable. First, we can expect the mitigation price of acreage to be greater than one when the in-kind price of services is positive. Mitigation with a wetland type that offers fewer services than the wetland type lost requires an acreage premium. Thus, the mitigation ratio between a wetland that is more diverse in services and one that is less diverse in services is greater than one.

Second, the mitigation price is a function of preferences as represented by the marginal utilities and by the perceived technical relationship between acreage and the second kind of service. This technical relationship is represented by K' in equation (5). The marginal utilities of acreage estimated in stated preference experiments are conditioned on respondents' knowledge of K'. If respondents' knowledge is inconsistent with wetland science, the mitigation prices may be inconsistent with wetland science as well.

Respondents' knowledge plays a central role in accurate estimation of the marginal utilities of acreage. If this knowledge is inconsistent with wetland science, there seem to be two ways to bring the mitigation prices in line with the science. First, it may be possible to bring respondents' knowledge in line with scientific knowledge using educational tools such as carefully worded text, photographs, and diagrams. Whether such informational devices can be effective is an open hypothesis that warrants appropriate tests.

A second way to bring mitigation prices in line with the science is to design stated preference experiments to elicit the mitigation price of services, $P_{S2\,S1}$. The wetland service preference information, $P_{S2\,S1}$, may be combined with a scientific estimate of K' to calculate a facsimile acreage mitigation price based on scientific information,

$$(6) \qquad S_{A2\,A1} = 1 + k' P_{S2\,S1}$$

where k' is the scientific measure of the marginal productivity of type 2 acreage in producing services of the type 2 kind.

The analysis of the economic model of ecosystem values leads to three alterative valuation approaches shown in Table 1. Each approach varies in its information requirements regarding individuals' preferences and the ecological relationship between acreage and services. One approach sets up the choice experiments in terms of acreage tradeoffs for different wetland types. Such an approach mixes preference with ecological knowledge in the structure of the mitigation prices. All else equal, it results in a valid estimate of mitigation prices if respondents' knowledge is adequately complete and consistent with science.

The second approach sets up the wetland ecosystem choice experiments in terms of tradeoffs in ecosystem services. Such an approach would compliment the preference information from respondents with information on ecological relationships from science. It would yield a mitigation price based on science that the researcher deems appropriate and acceptable. The science portion of the valuation may also be modified as scientific information changes. A drawback to this approach is that the list of relevant services identified by the research and specified in the model may be incomplete resulting in a partial valuation. In addition, such an approach may not capture the value associated with the pattern of ecological relationships represented by wetland types.

A third approach to wetland ecosystem valuation is based on wetland types. This approach modifies the first approach by attempting to bring respondents' knowledge in line with scientific knowledge. This approach would try to assess respondents' baseline knowledge and to develop information tools that would alter the baseline so that respondent's knowledge was consistent with scientific knowledge. Respondents would engage in choice experiments once they received a systematic exposure to the information treatment. A key issue for the success of this method is whether respondents are sufficiently sensitive to the new information. If not, the new information may have little effect and the choice experiment results would mirror those of the first approach.

The availability of three different approaches to valuing wetland ecosystems offers the opportunity for cross-corroboration and hypothesis testing. For instance, the second approach based on scientific information might be used to set reasonable upper bounds on the valuation estimates derived from the first approach. Further, the second approach might be used to set up hypotheses regarding the effects of information treatments on the mitigation price.

Knowledge Base of Michigan Respondents

Qualitative research is helping us learn what it is that people value about wetland ecosystems. This step will be used to help the researchers determine the functions and services that should be the focus of the valuation effort. Furthermore, the qualitative research also gives insights into the general state of people's knowledge about wetland ecosystems, their functions, and types (Kaplowitz 2000). We have also been exploring ways of communicating to respondents about wetland functions, "what wetlands do."

To this point, the qualitative research has conducted three group discussions with participants recruited from the general population of adults in the Lansing, Michigan. Each discussion group involved 6 to 8 participants. Participants were initially contacted using random selected telephone numbers. Because of election year resistance to participate in political focus groups, participants were asked to participate in a group discussion of “natural resource issues in Michigan.” They were not told that we would be discussing wetlands.

Outline of group interviews

Each group interview lasted for roughly two hours. Sessions were held in a facility on the campus of Michigan State University. All of the sessions were conducted by the same moderator who used the same discussion guide for each session. The moderator used non-directive prompts to encourage participants to participate and elaborate their responses. The discussion guide and the sessions had five basic sections, with the first three taking roughly 45 minutes and the last two sections taking roughly 45 minutes. The balance of the time was used for breaking the ice, taking a “snack” break, or completing university paperwork.

The five substantive sections of the discussion guide and sessions were:

1. Introduce participants, identify each participant’s top three natural resource issues, and discussion of their natural resource issues.
2. General background questions about wetlands to explore what participants know about wetlands and to learn about their experiences with wetlands and the things that wetlands do.
3. Photographs of both wetland and non-wetland ecosystems projected on a screen to determine how people judge what is and is not a wetland, to see if people can distinguish wetland and non-wetland plant communities, and to see if people know about different types of wetlands.
4. Verbal, written, and graphic presentation of different wetland functions including flood control, wildlife habitat, and sediment retention. The functions and definitions for this section were taken from scientific literature on wetlands.

5. Some questions about wetland mitigation and about replacement of impaired wetlands. In the later two focus groups, additional questions about replacing wetlands lost due to a highway project were used

Knowledge of wetland functions

Participants evidenced knowledge of wildlife habitat functions of wetlands. The participants also rated the wildlife habitat functions highly in terms of their relative importance vis-à-vis other wetland ecosystem functions. Almost all participants rated wildlife habitat as extremely important, the highest category, on their function ranking worksheets. This finding is consistent with other research on wetlands (Azevedo, Herriges, and Kling 2000; Swallow et al. 1998; Stevens, Benin, and Larson 1995).

Participants had mixed knowledge of some of the other functions of wetland ecosystems such as water quality, groundwater recharge and flood control. Often there were a few respondents in each focus group that were aware of and knowledgeable about one or more of these "non-habitat" functions. However, every group had a majority of participants who seemed much less aware of these types of functions and who did not seem very knowledgeable about them.

Interestingly, several of the scientifically recognized wetland functions prompted negative feedback from participants. More than a few individuals rejected the importance of several wetland functions such as pollution interception and waste treatment. These individuals expressed strong opinions that wetlands should not be used for these functions. In several instances, participants voiced their concern that environmental laws are supposed to provide for pollution cleanup and waste treatment; wetlands need not perform such functions. Note that functions such as pollution interception and waste treatment appear prominently in much of the literature describing wetland functions. After further discussions, most of the participants felt that it would be all right to create new wetlands for purposes such as waste treatment. This feedback seems to illustrate the potential difficulty of relying solely on scientific descriptions of wetland ecosystems, functions, and services.

What do photographs communicate?

As a part of the group sessions, photographs of various wetlands were shown to the participants. This exercise was intended to probe participants' knowledge of wetland types, wetland vegetation, and general understanding of wetland ecosystems. The participants' discussions of the images yielded some interesting insights about what photographs can communicate to people. For example, at one point we showed a photograph of a fen (a particular wetland type) that did not have visible water and had grasses and vegetation that was browning. In response to this image, some respondents noted that it did not look healthy and that it was not supposed to be that way. One participant said the photograph showed an area that "I would say [was] scorched by fire." In reality, the photograph contained a moderate amount of shadow that was mistaken as evidence of fire. This photograph clearly communicated something other than what had been intended, and the cue that caused the misperception, the shadows, is unlikely to be absent in future photographs of fens and other ecosystems.

Another example of the power of photographs to (mis)communicate was found when the blurry background in a photograph of a non-wetland meadow was "seen" by a respondent to be water. It is important to note that the focus group participants were viewing these images on a large projection screen at levels of resolution that are likely quite higher than what would be feasible in a typical survey application. The conclusion that can be drawn from these experiences is that photographs do communicate information, both intended and unintended, and that they must be pre-tested along with other potential survey elements. This will hold for web-based surveys as well as other mediums.

Wetland mis-perceptions

As a part of the group interviews, participants were shown a variety of photographs that depicted different wetland types in different settings as well as photographs that did not show wetlands. Part of the group interview probed for whether or not each of the photographs depicted a wetland. In each of the groups, several respondents commented on the notion that trees do not grow in wetlands and that wetlands kill trees.

In fact, some participants used their perceived presence of dead trees in some of the photographs to distinguish wetlands from non-wetlands. Therein lies the source of the paper title. The so-called "dead tree" comments occurred in all three of the sessions and they occurred in relation to different photographs. It is interesting to point out that in Michigan where the participants live over two-thirds of the state's wetlands are forested.

One of the images shown to participants included some prominent trees that had been attacked by Dutch Elm disease. To explore whether this image may have played a role in the perception that wetlands kill trees, the order of wetland photographs to be shown at the following two group sessions was changed. However, in both of the subsequent sessions participants raised comments about wetlands and dead trees in conjunction with photographs of forested and non-forested wetlands shown before the image of the wetland with the diseased trees. Thus, the photograph with the dead elms did not cause the perception, though it may have amplified the perception for some individuals. One conclusion that emerges from these examples is that it seems vital to the design of an accurate valuation instrument that researchers be aware of respondents' perceptions (and mis-perceptions) about the good being valued. Establishing such information is a key step in the development of methods of communicating with respondents about the good to be valued and the context of the valuation.

Understanding of mitigation

In all three of the group sessions, some questions were asked to about wetland mitigation and about the replacement of impaired wetlands. These questions were aimed at revealing peoples' understanding and acceptance of wetland mitigation. In the later two sessions, additional questions were asked in the context of a scenario in which the government would be replacing wetlands impaired by a highway project. This scenario was developed to force people to consider, to add realism, and reinforce the idea of trade-offs. The scenario was also used to learn more about one possible context for stated preference wetland valuation. The comments and discussion surrounding these portions of the group sessions revealed a general skepticism that wetland mitigation could adequately replace what might be lost due to a wetland impairment. This skepticism is related to the unique challenges posed by ecosystems as well as the role of knowledge as an input in ecosystem valuation efforts.

Another finding from this section of the group interviews was that there was some confusion over the meaning of wetland mitigation, especially wetland replacement. Some individuals took the concept quite literally and inferred that it would mean transferring plants and animals from one site to the mitigation site. For example, one participant asked, "How are they going to transfer all those frogs?" Again, this serves as another example of how indispensable to survey design it is for researchers to have a grasp of respondents' baseline knowledge and understanding.

Perhaps the main finding from what was learned about peoples' knowledge of mitigation relates to the general skepticism about replacing all functions of a specific wetland. The following are examples of the kinds of comments we received in discussions on wetland mitigation:

"I don't know if you can come out equal."

"Really replacing or just duplicating parts you see?"

"Like substituting oleo for butter."

"Could they truly get back all that was lost?"

It appears that such skepticism consists of two elements. The first related to a disbelief that certain functions, or services, of wetlands could actually be replaced. The second related to a feeling by several individuals that wetland replacement would not adequately compensate for impairments because wetlands are complex. That is people acknowledge that even though many functions might be replaced, there is more to the wetland than the specific functions that get replaced. Both elements of peoples' skepticism raise issues that are fundamental to ecosystem valuation. The former element raises questions about whether we want to elicit people's beliefs in the underlying production relationship, K(.), at the same time we elicit economic choices and values. As illustrated above in the table, this can lead to a co-mingling of values and knowledge about how final services are derived from the "replacement" wetland ecosystem. The second element speaks to the notion that an ecosystem is more than a bundle of listed functions or services.

Conclusions

The valuation framework outlined above identifies three approaches to valuing wetland ecosystems and wetland mitigation. The three approaches illustrate how the economic value of wetlands is derived from the value of wetland services; wetlands are valued when they provide services of value to individuals. Some of these services (like biodiversity) are independent of wetland use, others (like flood control) may be considered ecosystem uses, while still other services (like hunting) are extractive use values. The linkages between wetlands and wetland services have an important implication for stated choice experiments. If respondents' knowledge is inconsistent with wetland science, stated choice experiments may yield incomplete or inaccurate valuations.

Knowledge of the linkage between wetlands and wetland services plays a slightly different role in each of the three valuation approaches derived above. The first valuation approach takes respondents' knowledge as given. It elicits a valuation conditioned on respondents' baseline knowledge. The second approach elicits a valuation of wetland services and then uses scientific knowledge to compute a wetland valuation from the estimated value of services. The third approach attempts to bring respondents' knowledge in line with scientific knowledge using systematic information treatments. It elicits wetlands values conditioned on respondents' updated knowledge base.

The reported qualitative research was intended to explore the knowledge base of likely respondents in order to assess the feasibility of the three valuation approaches. Initial findings show that Michigan residents are more cognizant of wetlands than expected, but that their knowledge is uneven. Most respondents had some prior knowledge of wetlands functions such as provision of wildlife habitat, maintenance of groundwater flows, and flood water retention. However, some functions identified by wetland science, such as retention of polluted run-off and waste treatment, were rejected as illegitimate by some respondents. A portion of these respondents thought that pollution retention would harm the ability of a wetland to support wildlife and other functions. Others thought that current environmental laws, not wetlands, should lead to cleanup of pollution.

The qualitative research also underscored the difficulties of using photographs to communicate wetland information. The initial hypothesis was that photographs might be an effective means of communicating differences in wetlands types and functions. Photographs, however, seemed to be an inaccurate communication device. When shown a photograph of a fen, some respondents correctly interpreted dark areas as shadows, while others interpreted the same dark areas as evidence of impairment and, perhaps, fire. When shown photographs of wooded wetlands, some respondents concluded that the wetlands were killing the trees, even though healthy wooded wetlands are a common wetland type in Michigan.

The evidence thus far underscores the role of knowledge as an input in valuing wetland ecosystems. The empirical results show that respondents have some baseline knowledge of wetlands, but that this baseline knowledge may be incomplete or inaccurate in certain dimensions. In this context, each of the three valuations approaches may be useful in posing and testing hypotheses about wetlands values and the effect of knowledge. For instance, if respondents' baseline knowledge is incomplete, values estimated via the second approach may be larger than values estimated via the first approach. Thus, the three valuation approaches may offer the means of testing and corroborating wetland values.

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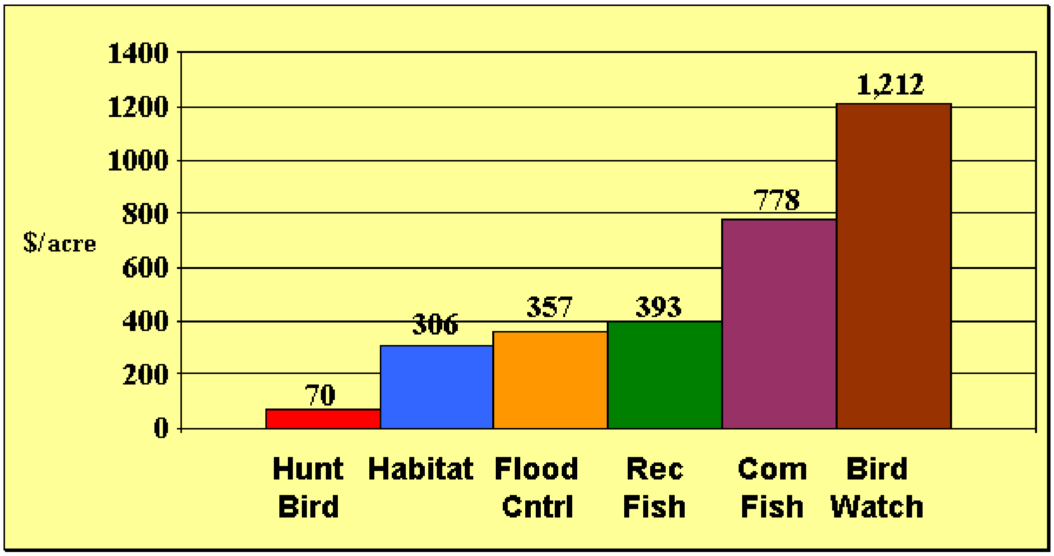
Figure 1. Value of Wetland Services



Woodward and Wui, 2001

Table 1. Valuation Approaches

	Choice Experiment Design	Limitations
1.	Tradeoffs in terms of acreage of different wetland types	Confounds preferences and ecological knowledge; Biased if respondents' knowledge is incomplete or inconsistent
2.	Tradeoffs in terms of final wetland services	Incomplete service list; miss value of whole
3.	Tradeoffs by acreage type, but make systematic effort to provide scientific information	Perceptions may not be sensitive to scientific information