Disentangling Preferences and Expectations in Stated Preference Analysis: The Case of Invasive Species Prevention

Bill Provencher
Dave Lewis
Katherine Anderson
University of Wisconsin-Madison

Abstract

Contingent valuation typically involves presenting the respondent with a choice to pay for a program intended to improve future outcomes, such as a program to place parcels into conservation easement, or a program to manage an invasive species. Deducing from these data the value of the good (or bad) at the core of the program—the welfare gain generated by a parcel of conserved land, for instance, or the loss incurred by a species invasion—often is not possible because respondent preferences are conflated with their expectations about future environmental outcomes in the absence of the program. This paper formally demonstrates this conundrum in the context of a standard contingent valuation survey, and examines the use additional survey data to resolve it. The application is to the prevention of lake invasions by Eurasian Milfoil (Myriophyllum spicatum), an invasive aquatic plant that is present in many lakes in the northern U.S. and Canada and a possible threat to many more. Respondents are shoreline property owners on lakes without Eurasian Milfoil. The estimated per-property welfare loss of a lake invasion is $30,550 for one model and $23,614 for another, both of which are close to estimates obtained from a recent hedonic analysis of Eurasian Milfoil invasions in the study area (Horsch and Lewis 2009), and from a companion contingent valuation survey of shoreline property owners on already-invaded lakes.

I. Introduction

Well-designed stated preference surveys often present respondents with a choice to pay for a program to avoid unfavorable events, or to induce favorable events. Asking respondents about their willingness to pay for a program to affect an event, rather than directly asking their willingness to pay for the outcome, is preferred as a matter of presenting a realistic valuation scenario, thereby minimizing so-called “hypothetical bias”. So, for instance, rather than asking respondents about their willingness to pay to prevent the extinction of a species, respondents are asked about their willingness to pay for a particular program intended to assure the species is preserved. Instances of such program-focused valuation studies abound in the contingent valuation literature, ranging from the reduction of old growth timber harvests to preserve northern spotted owls (Rubin et al.1991), to a phosphorus reduction program to improve water clarity in Lake Mendota, Wisconsin (Stumborg et al. 2001), to the preservation of horse farms in Kentucky (Ready et al. 1997).

Deducing from these data the value of the event that is the focus of the program can be problematic because respondent preferences are conflated with their expectations about future outcomes in the absence of the program. With reference to our species preservation example, respondents might place a low value on a preservation program not because they place a low
value on the species, but rather because they don’t believe the species will become extinct in the absence of the program. The analyst can account for this by explicitly stating in the survey the outcome in the absence of the program (“Without the program, species X will become extinct in the next 5 years”), but especially in cases where the respondent is familiar with the environmental good in question (such as preservation of a particular parcel of land, improving water quality in a lake, or preventing a species invasion) this can be problematic as it may conflict with the respondent’s own judgment about the likelihood of outcomes.

In many instances the analyst may find it perfectly acceptable to estimate only the net benefit of the program developed in the contingent valuation scenario, but we suspect that often the “core good” that is the focus of the program is the true subject of the valuation analysis, and extracting the value of this good from the valuation of the program—obtaining a “portable” value, in other words—is important in benefit transfer and understanding the implications of changes in environmental policies and programs.

Although we suspect that this issue is well understood by analysts engaged in nonmarket valuation, we know of no attempts to disentangle expectations and preferences. Boyle (2003) observes, “Physical descriptions of changes in resource conditions frequently are not available. In this case, contingent valuation questions often are framed to value the policy change. With vague or nonexistent information on the resource change, survey respondents are left to their own assumptions regarding what the policy change will accomplish” (p. 117). He concludes, “This issue really has not been directly and extensively addressed in the contingent valuation literature and deserves more consideration” (p. 118).

The next section formally examines the conflation of expectations and preferences in contingent valuation surveys, and argues that without additional information, separately identifying expectations and preferences requires strong assumptions and is unlikely to generate estimates that are robust to the specification of the willingness to pay (WTP) function. The analysis then makes the case that additional survey data can resolve the identification problem, and shows that for a particular class of events that are common in contingent valuation studies—binary events such as the extinction of a species, the preservation of a parcel of land, the invasion of a lake by a non-native species, and so forth—this resolution is especially clean and cheap (in terms of the data requirement), though it does require parametric assumptions about how the probability of an event evolves over time.

Section three presents the econometric model for an application to the prevention of lake invasions by Eurasian Milfoil (Myriophyllum spicatum; hereafter simply “Milfoil”), an exotic aquatic weed that is present in many northern lakes in the U.S. and Canada and a possible threat to many more. The model applies to households with shoreline property on lakes without Milfoil, and the elicitation format is a referendum on a program to prevent a Milfoil invasion. A significant feature of the format is that respondents are asked to report the probability that they would vote “yes” on the referendum were it to actually occur. The format accounts for recent

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1 Broadly understood, a “physical description” of an environmental change includes the time profile of the change. So, for instance, whereas the presence/absence of an aquatic species invasion is well-defined and easily described, the timing of an invasion typically is not.
evidence of “uncertainty bias” in stated preference surveys, and is examined at length in Provencher and Lewis (2009).

Section four provides details of the sampling strategy and survey instrument. The application is to shoreline property owners in Vilas County, Wisconsin. Section five presents results of the analysis. We find that the welfare loss from an invasion is about $25,000 per shoreline property (it varies across model specifications). Section six compares the estimated welfare loss to those of two other analyses. The first is a companion contingent valuation analysis concerning Milfoil control (as opposed to Milfoil prevention that is the focus of this paper), in which shoreline property owners on already-infested lakes were asked about their willingness to pay for a program to virtually eliminate Milfoil. The second is a recent hedonic analysis of Milfoil invasions in the study area conducted by Horsch and Lewis 2009. All estimates considered, the welfare loss from a Milfoil invasion appears to be in the range of $20,000 to $35,000 per shoreline property. The last section concludes with caveats and recommendations.

II. Model of Expectations and Preferences, and Implications for the Design of a Contingent Valuation Survey

In this section we develop a simple model of willingness to pay (WTP) for a program to create/maintain an environmental good for which WTP depends on the direct value of the good and the individual’s judgment about the probability of enjoying the good in the absence of the program intervention. The model applies to a binary provision problem and serves as the basis of the econometric model employed in our empirical analysis. For expositional reasons we focus on a Milfoil invasion of a lake, but the basic model applies to any binary provision problem (species preservation, conservation of a particular land parcel, etc.).

Let \( L(z) \) denoting the annual loss from a Milfoil invasion, where \( z \) denotes a vector of variables affecting household utility, including household characteristics, and let \( P(x) \) denote the probability of an invasion during the year, where \( x \) is a vector of lake characteristics affecting the probability of a successful invasion, such as public access to the lake and lake chemistry. The willingness to pay to assure no invasion in the initial year (year 0) is equal to the expected loss from an invasion in the initial year, \( P(x) \cdot L(z) \). Conditional on no invasion in year 0, the willingness to pay to assure no invasion in year 1 is equal to this same value discounted. The probability of no invasion in year 0 is simply \( P^0 \), and so the unconditional WTP to assure no invasion in year 1 is (where we suppress function arguments for clarity),

\[
\frac{1-P}{1+r} \cdot P \cdot L .
\]

By extension, the WTP for a program that prevents an invasion is:

\[
WTP(x, z, r) = P \cdot L + \frac{1-P}{1+r} \cdot P \cdot L \cdot \left(1 - P(1+r)^r \right) \cdot P \cdot L + \left(\frac{1-P}{1+r}\right)^2 \cdot P \cdot L + \left(\frac{1-P}{1+r}\right)^3 \cdot P \cdot L + ... \]

\[
= P(x) \cdot L(z) \cdot \sum_{t=0}^{T} \left(\frac{1-P(x)}{1+r}\right)^t = G(x, r) \cdot L(z) .
\]

(1)
Assuming that the discount rate is high enough that an infinite time horizon provides a good approximation of \( G(x) \), the expression in (1) simplifies to,

\[
WTP(x, z, r) = L(z) \cdot \frac{P(x)(1+r)}{r + P(x)}
\]  
(2)

The issue for the analyst is how to separately identify \( L(z) \) from data generating \( WTP(x, z, r) \); it is this loss function that is the economic basis for evaluating management policies. In principle at least, it would appear possible to identify \( L(z) \), even in the case where \( z \) and \( x \) share variables, in part because of the nonlinearity in (2) and also because of the nonlinearity implied by bounding \( P(x) \) between 0 and 1. But relying on such nonlinearities for identification would generate estimates of \( L(z) \) that are unlikely to be robust to alternative specifications of the functional forms of \( L(z) \) and \( P(x) \), and for some specifications of \( L(z) \) and \( P(x) \) identification is not possible. ²

This dilemma can be resolved by asking respondents in the survey one or several questions concerning their subjective probability for the environmental event in the absence of the program. Importantly, the response need not be correct in a predictive sense; for the purpose at hand—disentangling preferences and expectations—it is enough that the stated probability of the event merely accords with the respondent’s subjective probability.

In our empirical analysis we asked each respondent to state the probability of a Milfoil invasion sometime in the next 10 years, with available responses presented as categories in 10% increments: 0-10%, 10-20%, etc. Let \( p_j \) denote household j’s response to this question, where \( p \) is the midpoint of the probability category. Then assuming the annual probability of an invasion \( P(x) \) is constant, we have,

\[
p_j = P_j + (1-P) \cdot P + \cdots (1-P)^9 \cdot P
\]

\[
= 1 - (1-P)^9
\]  
(3)

where \( (1-P)^9 \) is the probability that an infestation does not occur in the first 10 years. Solving for \( P_j \) we find \( P_j = 1 - (1-p_j)^{10} \). So, for instance, if the respondent states that there is a 50% chance of an infection in the next 10 years, the seasonal chance is 7.4% \((P=.074)\), and if the respondent states there is a 5% chance in the next ten years, the seasonal chance is .57% \((P=.0057)\).

Using this reported value for \( P(x) \) in (2) yields,

² That \( x \) and \( z \) share variables is clearly the case with Milfoil invasions because many of the variables of \( x \) that make a lake vulnerable to an invasion—the state of eutrophication and availability of public access, for instance—also affect the respondent’s utility function, which is the basis of the loss function.
\[ WTP_j(x, z_j) = \frac{P_j(1+r)}{r+P_j} \cdot L(z_j). \]  

(4)

### III. Econometric Model

In the empirical analysis, a respondent is presented with a program to prevent a Milfoil invasion on his lake, and is then queried about his voting behavior on a referendum to apply the program at a cost to his household of \( t \) dollars per year. Details of the referendum scenario are presented in the next section. With respect to the econometric modeling, the important unique feature of the scenario is that, rather than the conventional approach of giving the respondent a binary Vote Yes/Vote No choice on the referendum, we asked the respondent about the probability that he would vote “yes” were the referendum to actually arise. A discussion of this presentation of the choice model, and its econometric representation, is discussed in Provencher and Lewis (2009) in the context of several other choice exercises. The interested reader is referred to this discussion for details. Because it is not the focus of the analysis, here we only briefly develop the logic of the econometric model.

To answer a referendum question, respondent \( j \) compares his willingness to pay (\( WTP_j \)) to \( t_j \). Under the typical scenario in the literature, he responds that he would vote “yes” if \( WTP_j > t_j \). Recent evidence, though, indicates that often the respondent is uncertain about how he would vote were the opportunity to actually arise, just as respondents in presidential polls often express uncertainty about how they would vote on election day; see, for instance, the recent set of papers discussing the use of an “uncertainty scale” in contingent valuation (Champ and Bishop 2001, Champ et al 2002). To address this uncertainty we cast \( WTP_j \) as a random variable with mean \( \bar{WTP}_j \),

\[ WTP_j = \bar{WTP}_j - \varepsilon_j, \]  

(5)

substituting (4) for \( \bar{WTP}_j \) yields

\[ WTP_j(z_j, r) = \frac{P_j(1+r)}{r+P_j} \cdot L(z_j) - \varepsilon_j \]  

(6)

The probability of voting “yes” on the referendum is then,

\[ \pi_j = \Pr(WTP_j > t_j) = \Pr(\frac{P_j(1+r)}{r+P_j} \cdot L(z_j) - t_j > \varepsilon_j) \]  

(7)

We assume that the error term is logistically distributed with scale parameter \( \sigma \), in which case we have,
\[
\pi_j = \frac{\frac{P_j (1+r) \cdot L(z_j)}{e^{r+P_j} \cdot \sigma}}{1 + e^{r+P_j} \cdot \sigma}, \tag{8}
\]

In the survey the respondent is presented with probability categories, such as 0-10\%, 10-20\%, etc. The respondent chooses the probability category that bounds his probability.

Different respondents facing the same annual cost \( t \) and possessing the same characteristics \( z \) are likely to choose different probability categories due to unobserved differences among them. To account for this we expand \( L(z_j) \) to the linear form,

\[
L(z_j) = \beta z_j + \nu_j, \tag{9}
\]

where \( \nu_j \) is an individual-specific constant known by the respondent, but unobserved by the analyst. Substituting (9) into (8) yields the form,

\[
\pi_j = \frac{\frac{P_j (1+r) \cdot L(z_j) + \nu_j}{e^{r+P_j} \cdot \sigma}}{1 + e^{r+P_j} \cdot \sigma}, \tag{10}
\]

The analyst does not observe \( \pi_j \), but does observe the probability category chosen by respondent \( j \). Defining the lower bound of this observed probability category by \( \pi_{jL} \) and the upper bound by \( \pi_{jH} \) we have,

\[
\pi_{jL} < \frac{\frac{P_j (1+r) \cdot L(z_j) + \nu_j}{e^{r+P_j} \cdot \sigma}}{1 + e^{r+P_j} \cdot \sigma} < \pi_{jH}. \tag{11}
\]

Note that the logit expression in (11) is monotonically increasing in the stochastic term \( \nu_j \). It follows that algebraically manipulating (11) identifies lower and upper bounds on \( \nu_j \):

\[
\frac{t - P_j (1+r)}{r + P_j} \cdot \beta z_j + \sigma \ln \left\lbrack \frac{\pi_{jL}}{1 - \pi_{jL}} \right\rbrack < \nu_j < \frac{t - P_j (1+r)}{r + P_j} \cdot \beta z_j + \sigma \ln \left\lbrack \frac{\pi_{jH}}{1 - \pi_{jH}} \right\rbrack. \tag{12}
\]

From the perspective of the analyst, \( \nu_j \) is a random variable, and so the probability that respondent \( j \) chooses the probability category \( X_j \) defined by probability bounds \( (\pi_{jL}, \pi_{jH}) \) in responding to the referendum question is implicitly defined by the inequalities in (12). In the case where \( \nu_j \) is distributed logistically with scale parameter \( \varphi \) this probability can be explicitly stated,
\[
\text{Pr}(X_j) = \frac{1}{1 + e^{\frac{-\log(1 + \pi_{jH})}{\phi}}} - \frac{1}{1 + e^{\frac{-\log(1 - \pi_{jL})}{\phi}}}.
\]

The sample likelihood function is the product of these probabilities.

In the survey conducted for the empirical application, respondents were asked at least one follow-up referendum question (this is discussed in detail in the next section). These follow-up questions complicate the econometric model. From (12) the analyst can bound the unobserved portion of WTP, \(\nu_j\), conditional on the estimated values of \(\beta\) and \(\sigma\). Quite likely the analyst will find that in at least several cases the bounds defining \(\nu_j\) on the first question do not overlap the bounds on the second question. To avoid this contradiction, we allow \(\nu_j\) to vary across the referendum questions, reflecting temporal variation in WTP, variation in cognition, and errors in the reduced-form approximation of complex behavior. Specifically, letting \(k\) denote the survey question, we specify,

\[
\nu_{jk} = \nu_j + \xi_{jk},
\]

where \(\xi\) is iid, and \(\nu_j\) is iid across respondents. This amendment establishes a random effects model in which survey responses are correlated via \(\nu_j\). Estimation of this model requires simulation of the likelihood function. In our estimation \(\nu_j\) remains logistically distributed and \(\xi_{jk}\) is normally distributed with standard error \(\phi\). Details are provided in Provencher and Lewis 2009.

IV. Empirical Analysis: The Issue and the Data

Milfoil is an aquatic invasive species that has become a major nuisance in the lake country of the northern U.S. and Canada. It is spread by boaters who inadvertently carry propagules attached to their boats, anchors and trailers from lake to lake. It is blamed for “clogging” infected lakes, interfering with a lake’s ecology, and creating bad odors as the “mats” of plant matter decompose in the summer heat. Milfoil entered Wisconsin waters in the 1960s and has spread to all major water bodies (Mississippi River, St. Croix River, Wisconsin River, Lake Michigan, Lake Superior) and over 500 lakes in the state. In the survey of northern Wisconsin shoreline property owners conducted in this study, 92% of respondents whose lakes were not yet colonized by Milfoil stated they were “somewhat” (50%) or “very” (42%) familiar with the issue of Milfoil invasions. 58% of respondents on uncolonized lakes believed that there was a greater than 20% chance that their lake would be invaded in the next 10 years, and 26% believed the percent chance was greater than 50%.

Data for the analysis is from a sample of lakeshore property owners in Vilas County, Wisconsin, the heart of northern Wisconsin’s lake district. Sample property owners were initially surveyed in the summer of 2005, with a follow-up survey—including the Milfoil CV questions—
administered in the early fall of 2008. The sample was drawn from waterfront property owners as identified from Vilas County tax rolls. The sampling of properties was not random, but instead favored properties on smaller lakes to assure adequate representation of such lakes, though we found no statistical effect of lake size on WTP.

The 2008 phase of the survey was piloted on a sample of 200 shoreline property owners during the late summer. In the full sample the survey protocol differed across sample households depending on whether the household responded to the original 2005 survey. Sample households that had responded to the 2005 survey received an initial contact letter requesting completion of the web-based survey, a follow-up postcard reminder, a follow-up hard copy of the survey instrument, a follow-up postcard reminder, and a final follow-up hard copy of the instrument. Sample households that had not responded to the 2005 survey received the initial contact letter and three follow-up reminder letters. Hard copies of the instrument were not sent to 2005 non-respondents to reduce survey costs.

Overall, 2955 households were contacted in the 2008 survey, with 1565 (53%) providing usable responses. In the analysis the sample size concerning willingness to pay for Milfoil prevention is considerably less than the response total of 1565, for two reasons. First, not all households received a Milfoil CV question because this question was part of a larger research effort concerning the value of freshwater lake ecosystem services, and some households received different contingent valuation questions concerning a lake’s green frog population and fishing quality. Second, the nature of the Milfoil valuation question posed to a household depended on the state of the invasion on the responding household’s lake. Households on a lake that was already invaded received a Milfoil control question, whereas households on an lake not yet invaded received the Milfoil prevention question.

The scenario for the Milfoil prevention question was a lake-wide referendum for a prevention program that would make it “highly unlikely” that Milfoil would invade the lake. For the most part the scenario design followed conventional protocols for contingent valuation. Respondents were told of the consequences of a Milfoil invasion, including the fact that in some lakes an invasion is barely noticeable while in others it is a major nuisance, and that Milfoil has been found in 20 lakes in Vilas County (about 1.5% of all lakes), and is spreading at an average of 1.6 lakes per year. The scenario used the best available science on Milfoil prevention, emphasizing the use of boat-washing stations at boat ramps, paid staff to inspect boats entering and leaving the most popular lakes, and educational literature. The scenario was presented after a short “cheap talk” script emphasized that although the scenario was hypothetical, it was important that respondents consider their behavior were the scenario to actually unfold.

As already discussed in section 2, and unlike the usual referendum scenario where the respondent is asked whether she would vote “yes” on the scenario if the annual cost to her was $X, we asked about the probability that the respondent would vote in the affirmative if the referendum were to actually arise. The referendum question was preceded by the following script:

Since you may not know for sure how you would vote on a real referendum, we are asking you to tell us the percent chance that you would vote YES. For example, if you check 0-10%, you are saying that you would
almost surely vote NO; if you check 70-80%, you are leaning strongly toward voting YES, but still have some doubts.

The question itself, with response categories, was:

What is the percent chance that you would vote “Yes” on the referendum to fund the Milfoil prevention program on your lake, if the annual cost to you was $____?

- □ 0-10%
- □ 10-20%
- □ 20-30%
- □ 30-40%
- □ 40-50%
- □ 50-60%
- □ 60-70%
- □ 70-80%
- □ 80-90%
- □ 90-100%

This question was repeated in a follow-up contingent valuation question. On the mail survey the amount of the annual cost on the follow-up was randomly assigned, whereas the web version took advantage of the opportunity to condition the follow-up question on the response to the initial question by lowering the annual cost if the respondent initially stated that the probability of a “yes” vote was less than 50%, and raising it if the probability was greater than 50%. An important point is that a follow-up question on the mail survey that would be trivial using the conventional approach—not to mention confusing to the respondent—such as asking a respondent who states “yes” for the case where the annual cost is $50 how he would vote if the annual cost were instead $20—provides good information in the current context because respondents are queried about the probability of their behavior. Finally, on the Internet survey respondents who indicated on both contingent valuation questions that their probability of a “yes” vote was 0-10%, or who indicated on both questions that their probability of a “yes” vote was 90-100%, were asked to state the amount that would leave their probability of voting “yes” at “about 50%”.

V. Analysis Results

We estimate two models. In the first the systematic portion of the loss function $\beta z$ is reduced to the constant $\beta_0$ (Model 1), and in the second this expression takes the form $\beta_0 + \beta_1 Income_j$, where $Income_j$ is the annual income of household $j$ (Model 2). We keep the specifications simple because our focus is on identifying the average household loss $L_j$ rather than identifying the covariates that condition this loss. Overall, the estimated model parameters include the constant $\beta_0 / \sigma$, the income coefficient $\beta_1 / \sigma$, the bid coefficient $1 / \sigma$, the discount rate $r$, the scale ratio $\sigma / \phi$, and the random effects standard error $\phi$.

Tables 1 and 2 provide estimation results for Models 1 and 2, respectively. The estimate of mean annual loss from a Milfoil invasion is the sample average value of $\beta_0 z_j$. The mean present value of the loss is the calculated mean annual loss multiplied by $\frac{1+r}{r}$. Annual willingness to pay for the prevention program accounts for household expectations about the

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3 Estimation generates $\frac{\beta z}{\sigma}$. Dividing through by the bid coefficient $\frac{1}{\sigma}$ generates $\beta z$. 

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probability of an invasion in the absence of the program, and, following the modeling of section 2, takes the form,

\[
WTP_j = \frac{P_j (1 + r)}{r + P_j} \beta z_j .
\]

(15)

Confidence intervals are calculated using the delta method.

Table 1. Estimation Results for Model 1 (Household income not included; N=900)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Rate ((r))</td>
<td>0.09794</td>
<td>0.048428</td>
<td>2.02239</td>
</tr>
<tr>
<td>Bid coefficient ((1/\sigma))</td>
<td>0.792874</td>
<td>0.116477</td>
<td>6.807137</td>
</tr>
<tr>
<td>Scale ratio ((\sigma/\phi))</td>
<td>0.668516</td>
<td>0.021072</td>
<td>31.72496</td>
</tr>
<tr>
<td>Constant ((\beta_0/\sigma))</td>
<td>1.670136</td>
<td>0.409422</td>
<td>4.07925</td>
</tr>
<tr>
<td>Random effects standard deviation ((\phi))</td>
<td>1.782366</td>
<td>0.385117</td>
<td>4.628117</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean 95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample mean estimated <strong>annual loss</strong> from a Milfoil invasion ($)</td>
</tr>
<tr>
<td>Sample mean estimated <strong>present value of loss</strong> from a Milfoil invasion ($)</td>
</tr>
<tr>
<td>Sample mean estimated annual WTP for the prevention program ($)</td>
</tr>
</tbody>
</table>

Table 2. Estimation Results for Model 2 (Household income included; N=762)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Rate ((r))</td>
<td>0.047068</td>
<td>0.029036</td>
<td>1.62105</td>
</tr>
<tr>
<td>Bid coefficient ((1/\sigma))</td>
<td>1.057141</td>
<td>0.16556</td>
<td>6.385257</td>
</tr>
<tr>
<td>Scale ratio ((\sigma/\phi))</td>
<td>0.704104</td>
<td>0.029378</td>
<td>23.96727</td>
</tr>
<tr>
<td>Constant ((\beta_0/\sigma))</td>
<td>0.881238</td>
<td>0.28053</td>
<td>3.141336</td>
</tr>
<tr>
<td>Income coefficient ((\beta_i/\sigma))</td>
<td>3.827698</td>
<td>0.932467</td>
<td>4.104916</td>
</tr>
<tr>
<td>Random effects standard error ((\phi))</td>
<td>1.519658</td>
<td>0.264226</td>
<td>5.751367</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Sample mean estimated <strong>annual loss</strong> from a Milfoil invasion ($)</td>
</tr>
<tr>
<td>Sample mean estimated <strong>present value of loss</strong> from a Milfoil invasion ($)</td>
</tr>
<tr>
<td>Sample mean estimated annual WTP for the prevention program ($)</td>
</tr>
</tbody>
</table>
The results support several conclusions. First, all parameters have the expected sign, and in particular respondents with a higher household income are willing to pay more for a Milfoil prevention program. Second, the estimated mean welfare loss from a Milfoil invasion is considerably greater than the estimated mean WTP for the prevention program because most respondents believe the annual probability of an invasion is fairly low (the median annual probability is .0315). Third, although the models generate very similar values for the mean annual WTP for the prevention program (about $570), they generate very different values for the mean annual loss of an invasion. This is clearly due to differences in the estimated discount rate (9.7% versus 4.7%), as indicated in equation (6) and confirmed by a comparison of the present values of the mean welfare loss from the two models, with Model 2 generating a higher present value even though it generates a lower annual loss.

Section VI. Convergent Validity of the Estimated Welfare Loss

We assessed the convergent validity of the estimated welfare loss from a Milfoil invasion using two alternative analyses. The first used a contingent valuation question posed to households with shoreline property on Vilas County lakes already invaded by Milfoil. The question was presented as a referendum to control the Milfoil invasion to the point where it would be “highly unlikely” that Milfoil would cause any recreational, aesthetic, or ecological problems on the respondent’s lake.4 The elicitation format was the same as for the Milfoil prevention question; in particular, we elicited the probability of a “yes” vote on the referendum. For this question there is no issue of the conflation of expectations and preferences—the welfare loss from the Milfoil invasion is immediate and certain—and so in estimation the term $P_j(1 + r)/(r + P_j)$ in (13) is eliminated, and otherwise the estimation proceeds as with the Milfoil prevention case. The sample size is smaller than for the Milfoil prevention question, simply because fewer households in the sample reside on lakes already invaded by Milfoil, with N=233 when household annual income is excluded as a covariate, and N=198 when it is included.

The second analysis is the recently published hedonic study of Horsch and Lewis (2008). Using market sale data for shoreline properties in Vilas County, the authors used a difference-in-difference approach to account for the possibility that unobservables correlated with a lake’s vulnerability to a Milfoil invasion might also affect the market value of its shoreline properties. The analysis examined over 1800 shoreline property sales on 172 lakes in Vilas County over the 10-year horizon 1997-2006.

Table 3 presents results of the comparison. Our presumption in the table is that the present value of Milfoil loss is capitalized in shoreline property values. The Milfoil control analysis did not include estimation of the discount rate, and so for this analysis we present results for a range of discount rates.

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4 It is generally understood that once present in a lake Milfoil cannot be completely eradicated.
Table 3. Comparison of Estimated Present Value of Welfare Loss from a Milfoil Invasoin

<table>
<thead>
<tr>
<th>Analysis:</th>
<th>Present Value ($)</th>
<th>95% Confidence Interval ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milfoil Prevention Contingent Valuation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With income (estimated annual loss=$1373)</td>
<td>30,550</td>
<td>{17,283, 47,884}</td>
</tr>
<tr>
<td>Without income (estimated annual loss=$2106)</td>
<td>23,614</td>
<td>{14,709, 39,145}</td>
</tr>
<tr>
<td>Milfoil Control Contingent Valuation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With income (estimated annual loss=$1521):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r=.03</td>
<td>52,221</td>
<td>{40,445, 79,588}</td>
</tr>
<tr>
<td>r=.06</td>
<td>26,871</td>
<td>{20,811, 41,375}</td>
</tr>
<tr>
<td>r=.09</td>
<td>18,421</td>
<td>{14,267, 28,364}</td>
</tr>
<tr>
<td>r=.12</td>
<td>14,196</td>
<td>{10,995, 21,859}</td>
</tr>
<tr>
<td>Without income (estimated annual loss=$1226):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r=.03</td>
<td>42,092</td>
<td>{33,303, 53,633}</td>
</tr>
<tr>
<td>r=.06</td>
<td>21,659</td>
<td>{17,137, 28,426}</td>
</tr>
<tr>
<td>r=.09</td>
<td>14,848</td>
<td>{10,778, 19,487}</td>
</tr>
<tr>
<td>r=.12</td>
<td>11,443</td>
<td>{9,053, 15,017}</td>
</tr>
<tr>
<td>Horsch and Lewis Hedonic Study (2009):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear fixed effects</td>
<td>28,294</td>
<td>{9,656, 46,933}</td>
</tr>
<tr>
<td>Nonlinear fixed effects</td>
<td>32,087</td>
<td>{4,382, 59,792}</td>
</tr>
</tbody>
</table>

The obvious conclusions to be drawn from this comparison are that the cost to shoreline property owners of a Milfoil invasion are considerable, that contingent valuation questions do a reasonable job of estimating the welfare loss from an invasion, and (most tentatively) that it is possible to separately identify preferences and expectations in a contingent valuation survey.

On this last point it is instructive to consider the consequence of overlooking or ignoring the issue of respondent expectations of a Milfoil invasion in the absence of a prevention program, and simply asserting that the estimated WTP for the Milfoil prevention program is a measure of the welfare loss from an invasion. Econometrically the approach is the same as for estimation of WTP for the Milfoil control program; implicitly the analyst assumes that in the absence of the prevention program the lake is sure to be immediately colonized. Estimation of this model generates a program WTP of $426 per year when income is included as a regressor (N=762) and $410 when income is excluded (N=900). Present values at a discount rate of 6% are $7526 and $7243; the (incorrectly) estimated welfare loss would be far lower than found in the Milfoil control CV analysis and the hedonic analysis.

Section VII. Conclusion

Concerning the use of surveys to measure expectations, Manski (2004. pg. 42) concluded,

“Economists have long been hostile to subjective data. Caution is prudent, but hostility is not warranted…We have learned enough for me to recommend, with some confidence, that economists should abandon their antipathy to measurement of expectations. The unattractive alternative to measurement is to make unsubstantiated assumptions”.

This analysis extends this perspective to identifying the value of an environmental good in contingent valuation. To minimize complications from so-called “hypothetical bias”, contingent
valuation often involves the presentation of a valuation scenario in which the respondent is asked to pay or donate to a program of environmental improvement. The WTP calculated from this scenario is often a conflation of preferences over the environmental improvement and expectations concerning the state of the environmental good in the absence of the program. So, for instance, WTP to improve the habitat of an endangered species reflects both the utility from the existence of the species and the expectation that the species will become extinct in the absence of the habitat improvement. To the extent that interest lies primarily in the welfare gain from the environmental improvement per se, it is incumbent to separate preferences and expectations. One way to do this involves surveying households about their expectations, and our analysis provides theoretical and methodological particulars for the case where the environmental improvement is binary.

We are cautiously optimistic about the potential for survey questions to parse expectations and preferences, albeit with the following caveats/recommendations. First, in hindsight we believe that for binary environmental events such as exotic species invasions it would be well worth the effort and questionnaire space to ask respondents more than one question about the probability of the event in the absence of a change in management or policy. This allows relaxing the assumption that respondents believe the annual probability of the environmental event is constant. For instance, respondents could be queried about the probability of the event over 1-year, 3-year, and 10-year horizons.

A second and related point is that if the environmental improvement is not binary then the issue of identifying expectations becomes more complex because the issue is no longer when an event occurs, but the evolution of the environmental change. For instance, it is easier to estimate a reasonable model of respondent expectations about the binary state of development of a particular shoreline parcel over a 10 year horizon than it is to estimate a model of expectations about the rate of development of the entire shoreline.

Finally, we suspect that the greater the respondent’s familiarity with the environmental good in question, the more likely it is that the respondent can articulate expectations about future changes in the good, and the more important it is to allow respondents to express their subjective expectations about future changes in the good. This is consistent with Manski’s view that subjective expectations of future behavior are good predictors of actual behavior in cases where the behavior is substantial, such as changing jobs, retiring, moving, and so on. The evidence from this study and Horsch and Lewis (2009) is that a Milfoil invasion is very costly to shoreline property owners. In stated preference surveys concerning environmental changes for which the welfare loss is considerably lower, it is probably reasonable to simply assert in the survey the environmental outcome in the absence of intervention (“species X will become extinct in 10 years in the absence of the program”) without too much concern that the assertion conflicts with the subjective probabilities of the respondents. That said, there is the cart-and-horse question of judging a priori whether an environmental good has a high value; the contingent valuation analysis presented here was initiated in large part because one of the co-authors was convinced that the welfare loss from a Milfoil invasion was far less than estimated by Horsch and Lewis.
References


