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VALUING INJURY TO NATURAL RESOURCES: THE EFFECT OF RESOURCE QUALITY INFORMATION ON PERCEPTIONS AND CONTINGENT VALUES

John P. Hoehn and Alan Randall

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Department of Agricultural Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824

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John P. Hoehn and Alan Randall
hoehn@msu.edu

Abstract

Respondents are heterogeneous in their prior information about resource injury. The analysis derives an updating model of how heterogeneous respondents incorporate new information contained in resource injury descriptions. The analysis confirms that the sign of the information effect is determined by the difference between new and prior information. However, in the present analysis, respondents differ in prior information so that treatment information induces different perceptions and different values in different respondents. The empirical analysis confirms that identical treatments result in different injury perceptions. Across respondents, treatment induced changes in perceived injury vary not only in size, but also in sign. Both theory and empirical results show that willingness to pay varies directly with perceived injury.

(25 Total Pages)

Valuing Injury to Natural Resources: The Effect of Resource Quality Information on Perceptions and Contingent Values

1. Introduction

Stated preference valuation methods such as contingent valuation ask respondents to compare different descriptions of resource services. In the simplest form of contingent valuation, a valuation instrument provides information about a baseline set of resource services and an improved set of resource services. Preferences are elicited on the basis of the descriptions. Information contained in the resource quality descriptions is central to valuation. Mitchell and Carson identify this information as "among the most important and most problematic sources of error" (p. 247) in such preference experiments.

Understanding how information affects preferences and elicited values has been problematic. Some research finds that information about substitutes and budget constraints has a predictable effect on elicited values (Bergstrom, 1985; Bergstrom, et al, 1989, 1990; Whitehead and Blomquist, 1991, 1995). Other research finds that information has no effect on values (Loomis, 1994; Boyle, 1989; Boyle, et al, 1990). Boyle (1989) sheds some light on these contradictory results by making a distinction between major and minor differences in information. Boyle's experiment showed that minor differences in information had no statistically significant effect on mean values. Minor differences did affect the variance of value responses. While suggestive, the analysis did not offer a general means of distinguishing minor and major differences in information.

Blomquist and Whitehead (1998) build on Viscusi's (1989) suggestion that new information may be evaluated relative to respondents' prior familiarity with a resource. Blomquist and Whitehead construct a theoretical model where a representative respondent updates prior knowledge with the new information provided by a valuation instrument. The effect of new information depends on the difference between new and prior information. If new information presents a relatively higher level of resource services than indicated by prior knowledge, new information increases elicited values. If it presents a lower level of services, values decrease.

Tkac (1999) used an experiment with subjects from different college majors to test directly the effects of prior knowledge and new information. A knowledge quiz demonstrated that majors in wildlife had greater prior knowledge of an endangered species than did respondents majoring in economics. When given no new information, wildlife majors were willing to pay more for a program to protect the species than were economics majors. When given additional information, the values elicited from economics majors increased, but the values of wildlife majors remained the same. The result underscored the significant influence of prior information on elicited values. It also revealed the significant differences in prior information across respondents.

The present analysis extends updating model to incorporate differences in respondents' baseline information and multiple information treatments. The analysis confirms that the sign of the information effect is determined by the difference between new and prior information. However, in the present analysis, respondents differ in prior information. For instance, one set of respondents may view a mildly contaminated site as pristine. Another set may view it as terribly contaminated. New information that confirms the mild contamination has a different effect on each set of respondents. New information reduces site quality for those who previously viewed it as pristine. The same new information improves perceived resource quality for those who viewed it as terribly contaminated. The same information has a different effect due to the differences in prior information.

The empirical analysis uses multiple information treatments to test the effects of resource injury information. A injury severity index is used to measure the combined effect of information of respondents' prior and new information. Consistent with the hypothesis of different prior knowledge, identical information treatments result in injury perceptions that vary in sign and size across respondents. The same information treatment increases injury severity for one set of respondents while decreasing severity for another set. Paralleling Boyle's (1989) hypothesis regarding the effects of major and minor information treatments, the first few information treatments that define the major parameters of the injury result in the largest change in value. Further treatments fill in details about the injury and result in much smaller increments or decrements in the mean value of injury.

2. A Model of Information and Heterogeneous Respondents

The objective is to understand how new information about a resource injury affects respondents' preferences and willingness to pay. Consider a valuation experiment where respondents are given information about a resource injury and willingness to pay is elicited for a resource restoration plan. The information may be in the form of text, tables, pictures, verbal explanation or other form. The information treatment seeks to describe the various dimensions of injury. Respondents combine the treatment information with their baseline or prior information to formulate a post-treatment perception of the injury. Prior information summarizes what a respondent knows about the injury before the treatment. Prior information may be null. Different respondents may have different prior information.

Blomquist and Whitehead (BW) develop a model describing how a representative respondent updates prior resource information on the basis of new information contained in a valuation instrument. In the derived model, information represented by a scalar and the representative respondent receives a single information treatment. There is a single unique prior. In the present model, information is vector-valued to represent the different dimensions of a resource such as its geographic extent, different land forms, local ecosystems, and the species that inhabit it. Information treatments address different dimensions of the resource. The representative respondent is dropped so that different respondents may have different prior information.

A resource has *T* different dimensions that are of interest to respondents. The *i*th respondent's prior information about the *t*th dimension of the resource is $\theta_{it}^{0} \in \mathbb{R}^1$, $i = (1,...,I)$ and $t = (1,...,T)$. On the basis of this *T* priors about the *T* resource dimensions, the *i*th respondent perceives an aggregate index of resource quality s_{i0},

(1) $$s_{i0} = \sum_{\tau=1}^{T} \lambda_t \theta_{it}^0$$

where $\lambda_t > 0$ maps the *t*th dimension of information into an index of resource service quality. The parameters λ_t converts units in one dimension to the units of a numeraire. The numeraire units are normalized so that $\lambda_1 = 1$. Baseline information, s_{i0}, may be null, but is likely to vary due to different respondent histories, demographic status, interests, and abilities.

Information treatments are sequential in time so that a respondent receives information about the first resource dimension first, the second after the first, and so on until all *T* information treatments are received. Each treatment, q_t, addresses a different dimension of a resource services. The *t*th treatment might provide information about the geographic extent of contamination while element t+1 might represent information on wildlife mortality.

The respondent combines prior information with each successive treatment of new information to formulate a post-treatment perception of the *t*th resource dimension,

(2) $$\theta_{it}^1 = \theta_{it}^0 \rho_{it} + q_t \delta_{it}$$

where ρ_{it} represents the relative confidence that the respondent's has in prior information and δ_{it} is a analogous weighting on the new information contained in a treatment. Following Viscusi and O'Connor (1984), $\rho_{it} \geq 0$, $\delta_{it} \geq 0$ and $\rho_{it} + \delta_{it} = 1$ so

(3) $$\theta_{it}^1 = \theta_{it}^0 (1 - \delta_{it}) + q_t \delta_{it}$$

Since δ_{it} represents relative confidence, a δ_{it} close to zero means the *i*th respondent has little confidence in new information *relative* to prior information. A respondent *j* with δ_{jt} close to one places more confidence in the treatment information relative to prior information.

As information is updated, the index of perceived resource quality is also updated. After the *t*th information treatment, the index of resource services is

(4)

$$\begin{aligned} s_{it} &= \sum_{\tau=1}^{t} \lambda_\tau \theta_{i\tau}^{1} + \sum_{\tau=t+1}^{T} \lambda_\tau \theta_{i\tau}^{0} \\ &= \sum_{\tau=1}^{t} [\lambda_t \theta_{it}^{0}(1-\delta_{it}) + \lambda_t q_{jt}\delta_{it}] + \sum_{\tau=t+1}^{T} \lambda_\tau \theta_{i\tau}^{0} \end{aligned}$$

The change in the index of resource services due to treatment *t* is computed by subtracting s_{it-1} from s_{it}. This change in resource quality is

(5)

$$\begin{aligned} ds_{it} &= s_{it} - s_{it-1} \\ &= \lambda_t \delta_{it}(q_{it} - \theta_{it}^{0}) \\ &= \lambda_t d_{it} \end{aligned}$$

where d_{it} is a confidence weighted change in information and ds_{it} is the change in perceived resource services resulting from the change in information.

The impact of new information on perceived resource services is transparent in equation (5). The sign of the change in information depends on the difference between treatment information and prior information. If treatment information suggests that the quality of the *t*th resource dimension is greater than that suggested by prior information, the change in quality is positive. If treatment information suggests quality is lower than prior information, the change in perceived quality is negative. The sign of the change in perceived quality depends on the treatment message relative to prior information rather than the absolute quality communicated by the treatment. Both the information effect, d_{it}, and the resource quality effect, ds_{it}, are proportional to the confidence that the *i*th respondent places in the *t*th treatment.

Different respondents may experience either a positive or negative impact on resource services. For instance, suppose q_t describes a resource service as mildly contaminated. This treatment reduces perceived resource injury for a respondent whose prior information indicated that the site was heavily contaminated. In contrast, the same message of mild contamination increases resource injury a respondent whose baseline information indicated that the site was pristine. Heterogeneous baseline information generates heterogeneous perceptions of resource injury even though the informational treatment is the same. Heterogeneous information, in turn, is likely to generate different responses in willingness to pay.

In valuing a resource injury with contingent valuation, a questionnaire describes a resource injury and offers a restoration strategy to repair the injury [Ward and Duffield, 1992]. Willingness to pay for the restoration is modeled as a utility theoretic decision. To derive this utility theoretic model, we denote restored resource services as a simple scalar *r* and focus on how injury information affects willingness to pay.

The analysis examines two approaches to characterizing how injury information enters utility functions. The first approach rests on the assumption that the resource services index summarizes all the information that is relevant to valuing the resource. In this case, respondents derive utility from the aggregate index of resource services. The utility level after *T* information treatments is $u_{iT} = v(s_{iT}, m_i)$ where $v(\cdot)$ is an quasi-concave indirect utility function and m_i is the *i*th respondent's income.

The second approach recognizes that the utility derived from different dimensions of resource services may be different. Respondents may care about some attribute of dimension *t* that is not adequately represented once the conversion by λ_t is carried out. In this case, both the level of resource services *and* the dimension *t* are important in considering the welfare changes due to injury. To account for the possible importance of the resource dimension, injury is characterized as a vector of treatment specific effects, $\sigma_{iT} = (s_{i0}, ds_{i1}, ..., ds_{iT})$, and utility is denoted $u^{\sigma}_{iT} = v(\sigma_{iT}, m_i)$.

Resource services are characterized as injury in both the severity index and severity vector models of utility. Resource injury is assumed to increase as the resource services index, s_{iT}, and its components increase. As injury increases, utility declines so $\partial v / \partial ds_{it} < 0$.

Using the aggregate index form of the utility function, willingness to pay for restored services is

$$
\begin{aligned}
w_{iT} &= e(s_{iT}, u_{iT}) - e(r, u_{iT}) \\
&= m_i - e[r, v(s_{i0} + \sum_{t=1}^{T} ds_{it}, m_i)]
\end{aligned}
\tag{6}
$$

where $e(\cdot)$ is an expenditure function and $s_{iT} = s_{i0} + \sum_{t=1}^{T} ds_{it}$. The second line of equation (6) shows that injury information affects willingness to pay through the reference level of utility. Holding income constant, willingness to pay increases with decreases in the reference utility level brought about by increases in injury–e.g, $ds_{it} > 0$. Thus, willingness to pay increases with increases in injury. For instance, the change in willingness to pay as a result of the *T*th information treatment is

$$
\begin{aligned}
w_{iT} - w_{iT-1} &= e(r, u_{iT-1}) - e(r, u_{iT}) \\
&= e[r, v(s_{iT-1}, m_i)] - e[r, v(s_{iT-1} + ds_{iT}, m_i)]
\end{aligned}
\tag{7}
$$

The sign of the change in willingness to pay has the same sign as ds_{iT}. Injury increases if $ds_{iT} > 0$ and $u_{iT-1} > u_{iT}$. This, in turn, implies that $e(r, u_{iT-1}) > e(r, u_{iT})$. Willingness to pay therefore increases with a positive ds_{iT} and falls with a negative ds_{iT}.

The vector form of injury leads to a willingness to pay equation similar to equation (6),

$$
\begin{aligned}
w^{\sigma}_{iT} &= m_i - e[r, v(\sigma_{iT}, m_i)] \\
&= m_i - e[r, v(s_{i0}, ds_{i1}, ..., ds_{iT}, m_i)]
\end{aligned}
\tag{8}
$$

where the ds_{iT} now enter now enter as specific, individual arguments of the utility function rather than as components of a sum, s_{iT}. The effect of a change in ds_{it} on equation (8), however, is analogous to equation (6). Willingness to pay conditioned on the vector form of injury varies directly with ds_{it}.

Treatment information affects willingness to pay through the sign of ds_{it} as determined by equation (5). The change in resource services is positive if treatment information indicates that injury to *t*th dimension of resource services is greater than suggested by prior information. Such injury related treatment information increases perceived injury and reduces utility. The expenditure required to maintain the reduced level of utility declines and the increment in willingness to pay for restoration is positive. If treatment information indicates that injury to the resource is less than suggested by prior information, the reverse holds and the increment in willingness to pay is negative. Hence, the incremental change in willingness to pay varies directly with a respondent's perceived change in resource services. Of course, the change in resource services varies across respondents due to heterogenous baseline information. Thus, heterogenous baseline information generates heterogenous responses in willingness to pay for the *same* informational treatment.

3. **Econometric Model**

Tests involving the effects of information on willingness to pay require an econometric model of willingness to pay that accommodates heterogenous changes in resource quality perceptions. We derive such econometric models from equations (6) and (8) by Taylor series expansion about mean initial resource services, $\bar{s}_{i0}$, and a fixed restoration strategy, r. Since the restoration is constant across respondents, it remains implicit in the derived coefficients. The injury to resources services perceived by respondents does vary across respondents and treatments. Changes in perceived injury enter as explanatory variables as indicated in equations (6) and (8).

For the resource services index model, equation (6), the willingness to pay econometric model is

(9) $$w_i = \alpha + \sum_{t=0}^{T} \gamma\, ds_{it} + \epsilon_i$$

where $\alpha = \bar{w}_{i0}|_{\bar{s}_{i0},r}$, , $\gamma = -\frac{\partial e}{\partial u}\frac{\partial v}{\partial s_{iT}}|_{\bar{s}_{i0},r}$, $ds_{i0} = s_{i0} - \bar{s}_{i0}$, and ϵ_i is a white noise error term. The intercept is mean willingness to pay given only mean prior information, $\bar{s}_{i0}$, and the fixed restoration strategy, r. The coefficient, γ, describes how willingness to pay varies with treatment induced changes, ds_{it}, in the resource quality index, s_{iT}.

Equation (9) restricts the coefficient, γ, to be equal to the same constant for each dimension of injury. This restriction stems from using aggregate resource services index to summarize information about the injury. The aggregate index converts the units of a specific injury dimension into units of the numeraire using the exchange factor, λ_t. The assumption of such exchange factors allows the injury index to summarize the relevant injury information.

There may be attributes of the *t*th dimension of the resource injury that are not well represented by the resource services index. Respondents may care more about one dimension of the injury than another.

In this case, the vector form of the willingness to pay may model, equation (8), may be a better representation of the relationship between willingness to pay and injury information. The empirical model for the vector form of injury is

(10) $$w_i = \alpha + \sum_{t=0}^{T} \gamma_t ds_{it} + \epsilon_i$$

where $\gamma_t = -\frac{\partial e}{\partial u}\frac{\partial v}{\partial ds_{it}}|_{\bar{s}_{i0},r}$. The vector form of injury does not restrict different injury dimensions to have the same impact on willingness to pay.

Equations (9) and (10) provide two different ways of assessing the relationship between injury information and willingness to pay. Both are fixed coefficients models that may be estimated using standard maximum likelihood estimators. The restrictive form of equation (9) asserts that all the value-relevant injury information is captured by a single injury index. Equation (10) relaxes this assumption by introducing the vector injury form. The validity of the injury index approach may be empirically tested by testing the restriction that γ equals a constant, for all *t*. That is, by comparing the overall statistical performance performance of equation (9) relative to equation (10).

In contrast to equations (9) and (10), previous research tends to define willingness to pay as a function of the information treatments alone. Since Tkac (1999) showed that respondents differ in prior information and these differences had a significant impact on willingness to pay, ignoring prior information as an explanatory variable may result in econometric problems. The econometric consequences of using explanatory variables based only on treatment information are derived from equation (9) by substituting $\lambda_t\delta_{it}(q_t - \theta_{it})$ for the change in resource services, ds_{it}. By rearranging terms, the following model results from considering only the effect of treatments, q_t,

(11) $$w_i = \beta_i + \alpha_0 s_{i0} + \sum_{t=1}^{T} \beta_{it} q_t + \epsilon_i$$

where $\beta_i = \alpha + \gamma ds_{i0} - \sum_{t=1}^{T} \beta_{it}\theta_{it}^0$ and $\beta_{it} = \gamma\lambda_t\delta_{it}$. In equation (11), the intercept term is a function of a respondent's baseline information. The coefficients, β_{it}, are functions of an individual's confidence in information. This makes equation (11) a random coefficients model. The random coefficients model results from using explanatory variables that are constant across respondents who have heterogeneous perceptions. The heterogeneity of the respondents shows up as heterogeneity in the coefficients since the explanatory variables do not address the differences in prior information.

Previous research has tended to ignore the econometric issues induced by heterogeneous perceptions. It has tended to estimate fixed coefficients models when using variables that account only for information provided by the experimental treatments. Ignoring the resulting random coefficients structure may have resulted in inconsistent estimators and misleading hypothesis tests. In contrast, the empirical analysis below estimates versions of equation (9) and (10).

4. Data Collection and Estimation Procedures

We examine the effect of resource quality information with data from a natural resource damage assessment (NRDA). The resource injuries were sustained through more than a century of mining in the basin of the south fork of the Coeur d'Alene River. Biological and engineering studies showed the injury to be widespread. Sediments containing toxic materials were deposited throughout the basin. Abandoned mines, mine adits, and tailing basins were a continuing source of contaminated material and toxic leachates. Fish and migratory birds appeared most susceptible to the injury. The threat of exposure to toxic materials restricted human access to many areas, including those customarily used by a Native American Tribe.

The NRDA design included the development of a valuation questionnaire to measure damages to the general public. The objective was to use a contingent referendum to elicit total damages from a sample of respondents drawn from the general population of the northwestern part of the United States. The survey instrument that administered this referendum contained five sections: (1) a introductory section that introduced the contingent referendum to sampled respondents, (2) an informational booklet that described the mining injury, (3) the contingent referendum, (4) a debriefing section, and (5) a section eliciting household demographic information.

The informational booklet provided respondents with an injury description based on the best available scientific evidence. The booklet contained an initial section that identified the site and eight subsequent sections describing different dimensions of the injury. Each injury description section was printed on facing pages of the booklet. The left hand page displayed an outline map of the Coeur d'Alene basin. The right hand page contained one to three paragraphs describing a specific injury dimension, such as the extent and toxicity of the injury.

Figure 1 shows the first two pages of the injury description booklet that contained the initial information about the site. This initial description gave the name of the area and a brief history of mining activity at the site. This initial section gave no specific injury information. The eight subsequent sections of the booklet described the different dimensions of the injury. These eight sections addressed:

1. type and extent of the injury,
2. toxicity of the mining residues,
3. wetlands and affected waterfowl habitat,
4. effects on swan mortality,
5. effects on fish and aquatic habitat,
6. nearby resort and the absence of human health effects, and
7. impacts on the traditional cultural practices of the Coeur d'Alene Tribe, and
8. a summary section that listed all the above information and elicited a last injury evaluation based on all the information considered as a whole.

Each section of the booklet contained a injury severity question. The injury severity question asked respondents to rate the injury on a 1 to 10 point scale. Respondents were asked to rate the injury given the cumulative evidence--the evidence contained in the present and previous sections. Figure 1 shows that exact wording of the injury evaluation question. The 1 to 10 point scale had been anchored in introductory section of the valuation questionnaire so that a 1 was the least serious environmental injury that the respondent could recall. A 10 was the most serious environmental injury that the respondent could recall.[1] The injury severity questions provided a cumulative severity index of injury severity after each section of the injury description. The change in the index measured how respondents' perceived severity changed with each section of the injury description.

Respondents votes on a program to contain and clean up the injury were elicited after each respondent finished the information booklet. The objectives of the clean up program were to contain the exposed mine wastes, close mine entrances, restore habits for waterfowl and fish, and restore public access, including access for traditional Tribal activities. After a brief narrative remind respondents of substitutes and their budget constraints, respondents were asked by an interviewer how they would respond to the following ballot to vote for or against the restoration plan:

> If an election were being held today and the total cost to your household would be a one-time, additional tax of $X, would you vote *for* the restoration plan or would you vote *against* it?

The tax cost threshold $X was replaced with a specific dollar amount. The dollar amounts used in the final survey were $60, $90, $140, and $220. These cost thresholds were randomly assigned to the households selected in the final sample.

Qualitative research was used to develop, refine, and test the booklet and valuation questionnaire. The initial draft of the booklet was evaluated in 7 focus groups in Seattle, Spokane, and Salt Lake City. Subsequent revisions to the booklet were reviewed for accuracy by NRDA biologists and other scientists. Draft questionnaire materials were refined through an additional 10 focus groups, 4 small group interviews, and 108 pretest interviews. Pretest interviews were conducted in Seattle and Spokane with interview subjects recruited from the general population. Pretests were conducted at central interview facilities where the interviews could be monitored and the questionnaires edited as pretesting continued.

The finalized questionnaires were administered in a pilot survey sample administered by the National Opinion Research Center. The drew from counties in Portland, OR, Spokane, WA, and Salt Lake City, UT, that had aggregate demographic characteristics similar to those of general population of the northwestern United States. Respondent households were drawn using an approximate probability sample. Population weights were based on data updated from the 1990 U.S. census. Interviews were conducted at respondents' homes by trained, professional interviewers.

The final sample contained 731 households and resulted in 520 completed questionnaires for a completion rate of 71 percent. Approximately 19 percent of the contacted households were unwilling to complete an interview and five percent were unavailable during the sampling period. The remaining five percent were not completed due to a language barrier or some other reason. Of the 520 completed questionnaires, 17 turned out to have missing values for one of the variables used in the empirical analysis. Hence, the results reported below correspond to a sample of 503 households.

The injury severity indexes elicited by the information booklet, the cost thresholds, and the referendum data were used to estimate equations (9) and (10) for respondents' willingness to pay for the restoration. The severity indexes elicited in each section of the booklet were hypothesized to be direct measures of s_{it}. Under this hypothesis, the injury severity index elicited in the initial section of the booklet was s_{i0}. This initial section of the booklet provided no direct description of the injury. Any natural resource injury information associated with the initial section would have to come from an individual's prior knowledge. The second section did provide information about the type and extent of injury so that its injury index provided a measure of s_{i1}. Each subsequent section provided a corresponding measure of s_{it}. The third section provided a measure of s_{i2}, the fourth section provided a measure of s_{i3}, and so on until the ninth section of the booklet that provided a measure of s_{i8}. The baseline difference in injury information was computed as $ds_{i0} = s_{i0} - \bar{s}_{i0}$. The treatment specific changes in information were computed as $ds_{it} = s_{it} - s_{it-1}$ for t = (1,...,8).

Equations (9) and (10) were both estimated using censored probit estimators (Cameron and James, 1987) and maximum likelihood procedures. The restriction that s_{iT} summarizes all the information relevant to valuation was tested by comparing the statistical performance of the model that restricts the injury coefficients to be equal, equation (9), relative to the unrestricted model equation (10) that allows the coefficient to vary across the different dimensions of injury. Relative performance of the two models was assessed using a likelihood ratio test.

5. Results

The results address how perceived resource injury changed with changes in treatment information and the perceived injuries affected the valuation of the restoration plan. The computed changes in the severity index are used to examine the effect of new information on respondents' perception of the resource injury. Estimates of equation (9) and (10) are used to assess the impact of the injury on respondents' valuations of the restoration.

Table 1 lists the sample data for the injury severity index. The table shows that the sample mean severity rating was 5.74 based on respondents' prior information evoked by the initial section (section 0 in Table 1) of the booklet. Describing the extent of the injury and the toxicity of mining residues increased the mean severity index by 0.69 and 0.89, respectively. Consistent with the hypothesis of heterogeneous priors, the increases in the mean index did not imply that all respondents increased their ratings in response to information on the extent and toxicity of the injury. Nine percent of respondents reduced their severity rating in response to information on extent. Seven percent reduced their rating in response to the toxicity information.

Section 3 described a wetland serving as habit for migratory waterfowl as one of the core areas affected by the mining residues. In response to this information, 29 percent of respondents reduced their severity ratings and the mean severity index fell by 0.36 units to 6.96. This reduction in severity arose despite the fact that section 3 contained no obvious information that would reduce the severity of injury. The reduction seems to be the result of how the treatment information compared to respondents' prior information.

The next two sections addressed two specific aspects of the wetland impacts, swan mortality and fish impacts. These dimensions of the injury resulted in mean increases in the severity index. Once again, however, the increase in the mean did not imply that all respondents experienced the same increase in the severity of injury. Notably, 7 and 13 percent of the sample, respectively, reduced their injury severity ratings in response to the section describing swan mortality and fish impacts.

The description of the resort and the absence of measurable health risks reduced the severity index by the largest amount of all the sections of the booklet. Almost 50 percent of the sample reduced their severity rating in response to this section of the booklet.

Section 7 described the impacts on traditional Tribal activities and section 8 asked the respondent to review all the information. Both of these sections results in mean increases in the mean severity rating. However, as in each of the other steps, respondents were not unanimous in their assessment. More than 15 percent of respondents reduced their severity ratings due to the information contained in each of these sections. The same information can affects different respondents differently depending on their prior information and perceptions.

The mean severity index increased by 1.7 units due the cumulative effect new information contained in section 1 through 8. More than 92 percent of the overall change in severity could be obtained from sections 1 and 2 alone. These two sections provided a description of the geographic extent and toxicity of the injury. Presumably, after receiving only sections 1 and 2, respondents had filled in other details of the injury with expectations based on prior information. As specific details were provided by the booklet, the mean severity index rose or fell in response to respondents' evaluation of how these details compared relative to respondents' expectations based on prior information. Differences in prior information across respondents resulted in markedly different incremental changes in injury severity for the same treatment information.

Table 2 lists the censored probit estimates. Results for the severity index model, equation (9), are listed in the third column. Results for the severity vector model, equation (10), are listed under in the fourth column.

The severity index model has two coefficients and both estimates were statistically different from zero at conventional confidence levels. The intercept estimate was statistically different from zero at the 90 percent level. It indicates that respondents would be willingness to pay about $42 per household for the restoration based only on prior information. The coefficient for changes in the severity index was statistically different from zero at the 95 percent level. Differences in the severity index due to differences in respondents' prior information and treatment information increase willingness to pay by $44.9 per household per severity unit. The likelihood ratio of the estimated model relative to a model with no explanatory variables is more than 74 with 2 degrees of freedom, a value that is statistically significant at any conventional critical value.

The severity vector model has coefficient estimates for the intercept, prior information, and each of the dimensions of injury described in the booklet. The intercept estimate for the vector model was not statistically different from zero. In contrast to the severity index model, this intercept estimate suggests that respondents would not be willing to pay a statistically significant amount for restoration based only on prior information.

Each of the treatment specific coefficients is statistically different from zero at at least the 90 percent level. The smallest coefficient is that for the resort dimension and the largest is for the treatment describing the toxicity of the mining residue. All of the treatment specific coefficients are positive, indicating that an increase in a respondent's severity rating increases a respondent's willingness to pay.

However, as discussed above, the mean effect of information on the severity rating may be either positive or negative. Hence, the effect of an information treatment on willingness to pay must be determined by multiplying the estimated coefficient by multiplying the estimated coefficient by the change in the severity index.

The severity index model requires that the treatment specific coefficients to be statistically identical to one another. This restriction was tested by a likelihood ratio comparison of the severity index model with the severity vector model. The likelihood value for the severity index model was -312.5 and that of the ad hoc model was 306.8. This difference yields a likelihood ratio statistic of 11.7 with 8 degrees of freedom. The restriction is not statistically significant at any conventional critical value. The test fails to reject the restrictions imposed by the severity index model. The likelihood ratio test indicates that the severity index captures the information that statistically relevant to valuation. The performance of the two models appears to be statistically equivalent.

The statistical equivalence of the two models not mean that the two models have equivalent economic consequences. The severity vector model may capture more information about the relative economic value of restoring different dimensions of the resource. For instance, the coefficient on toxicity is more than twice the dollar size of the coefficient on fish impacts. These differences may be important to evaluating actual injuries and restoration alternatives. In addition, the difference in the size and significance of the intercept terms across the two models suggests that the severity index model fails to capture some constant effect associated with the different treatments. This constant effect is absorbed by other coefficients when they are allowed to vary in the severity vector. Hence, the vector model raises doubts about attributing it to prior information. Its size and significance may be due to variables that are left out of the index model.

Overall, both models seem important in interpreting the willingness to pay estimates. The statistical performance of the severity index model lends support to the conceptual validity of the severity index. The severity vector model may detect differences in the coefficients that are important to both statistical and economic interpretation such as the interpretation of the intercept term and the relative damage associated with different dimensions of the resource.

The last two columns of Table 2 use estimates from the severity index model to illustrate how changes in perceived injury affect mean willingness to pay. The second to the last column give incremental willingness to pay by information treatment. Incremental willingness to pay is the treatment coefficient times the mean change in the severity index as a result of treatment *t*. Since the treatment coefficient is constant in the severity index model, differences in incremental willingness to pay are due only to differences in the mean, treatment induced changes in the severity index. While mean changes are used in the example in Table 2, analogous value differences could be computed across respondents. Differences across respondents would be due solely to differences in prior information.

The incremental willingness to pay values listed in Table 2 vary in both size and sign due to the mean changes in the severity index. Incremental mean willingness to pay due to the extent of injury was $33.2. Information on the toxicity of injury increased willingness to pay by $42.8.   The wetlands treatment information reduced willingness to pay by $17.3.   Swan mortality, fish impact, and Tribal impacts lead to positive increments in willingness to pay. The resort and the absence of health effects information reduce willingness to pay by $46.7.

The last column of Table 2 shows the cumulative effects the information treatments on mean willingness to pay. With only the first two treatments, mean willingness to pay is $118.4, fully 95 percent of the final value of $124.1. Wetlands reduce total willingness to pay but it rises to $124.2 after the swan mortality section and $129.0 after the fish impact section. It then falls by more than a third to $82.3 after the resort and no health effects section. It rises again with the Tribal impact information and again with the summary review.

The last column illustrates the difficulty of detecting the impact of information through experiments with mean willingness to pay. Had the research merely compared two information booklets, one with sections 0 through 4 and the other with section 0 through 8, no difference in mean willingness to pay would have been detected. From a comparison of mean values, respondents would appear insensitive to information contained in the booklets. In contrast, the utility-theoretic model and experimental design described above lead to quite different conclusions.

6. Conclusions

The effect of new information depends on the resource quality it conveys relative to the quality that a respondent perceives on the basis of prior information. However, respondents in stated preference experiments are heterogenous in their prior knowledge and information.

The theoretical analysis showed that the effect of new information evokes different perceptions and value responses from different respondents due to differences in prior information. New information can cause one respondent to revise resource quality upward while another respondent, with different prior information, revises perceived quality downward. The same information has different value consequences for different respondents.

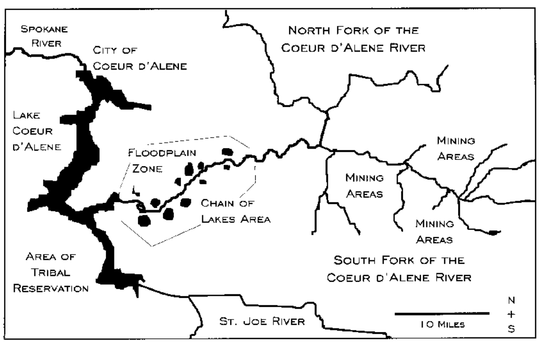
The empirical analysis confirmed that respondents' posterior injury assessments varied in size and sign. Changes in the perceived injury were correlated with elicited values in precisely the manner suggested by theory. A decomposition of the total valuation showed how a restoration valuation might vary given the extent of new information provided to respondents. The first two information treatments induced a total valuation that was more than 90 percent of the final value. Additional injury detail did not cause the cumulative to tail off slowly toward the final valuation. Rather, the cumulative valuation rose or fell by increments that approached 40 percent in the case of telling respondents that no there were no detectable health effects. A simple comparison of means between two information treatment could fail to detect the underlying changes in perceived injury and values.

Footnotes

1. Examples of the least serious environmental injuries were items such as littering. The Chernobyl reactor accident and the *Exxon Valdez* oil spill were mentioned often as the most serious environmental injuries.

Figure 1. The Initial Section of the Injury Description Booklet

The Coeur d'Alene River Basin



A Case of Mining Pollution: Your Opinion

We seek your opinion on a case of mining pollution. The facts of this case are described in eight steps. We would like your evaluation of the case at each step.

Step 1.

The mining area is located in the Coeur d'Alene River basin in northern Idaho. The Coeur d'Alene River is a tributary of the Spokane River in eastern Washington.

The primary mining areas were in the mountainous basin of the South Fork of the Coeur d'Alene River. Lead, silver, and other metals were mined there. Mining operations began in this area during the 1870s. Mining continued for more than 100 years. There were a number of mines of different sizes in the area. Most mining operations had closed by the mid-1980s.

Mining resulted in large amounts of mine wastes. These wastes included broken rocks, gravels, powdery sands, and chemicals. Waste deposits were piled and left around the mining sites and on the banks of the South Fork and its tributaries.

1. Please circle a number below to show how serious this case seems to you. Use the ten point scale we have talked about. A ten means "the most serious case of pollution I can think of". A 1 means "a case that's not serious at all".

Not serious at all									**Most serious case of pollution**
1	2	3	4	5	6	7	8	9	10

Table 1. Injury Severity Index

Booklet Section t	Severity Index Content	Sample Mean	Mean change from t-1 to t, ds_{it}	Percent of ds_{it} less than zero	$\sum_{\tau=1}^{t} ds_{it}$
0.	Prior information, s_{i0}	5.74	--	0.0%	--
1.	Extent of injury, s_{i1}	6.43	0.69	9.0%	0.69
2.	Toxicity, s_{i2}	7.32	0.89	7.0%	1.58
3.	Wetlands, s_{i3}	6.96	-0.36	29.0%	1.22
4.	Swan mortality, s_{i4}	7.44	0.48	7.2%	1.70
5.	Fish, s_{i5}	7.54	0.10	13.1%	1.80
6.	Resort and no health impact, s_{i6}	6.57	-0.97	47.9%	0.83
7.	Tribal, s_{i7}	7.03	0.46	16.1%	1.29
8.	All steps taken together s_{i8}	7.44	0.41	15.5%	1.70

Table 2. Censored Probit Estimates of Subjective Information Model

Estimated Parameter	Explanatory Variables	Estimates for Severity Index Model (standard error)	Estimates for Severity Vector Model (standard error)	$ Mean Willingness to Pay: $\gamma \bar{ds}_{i}$ and $\gamma \bar{ds}_{it}$	$ Mean Willingness to Pay: $\sum_{\tau=1}^{t} \gamma \bar{ds}_{it}$
α	Intercept	42.4* (24.2)	13.6 (31.6)	42.4	42.4
γ	All treatments, ds_{it}	44.9** (11,6)			
γ_0	Prior information, ds_{i0}		45.1* (11.9)		
γ_1	Extent, ds_{i1}		58.9** (17.0)	33.2	75.6
γ_2	Toxicity, ds_{i1}		64.2** (18.0)	42.8	118.4
γ_3	Wetlands, ds_{i3}		42.7** (16.4)	-17.3	101.1
γ_4	Swan mortality, ds_{i4}		30.2* (15.8)	23.1	124.2
γ_5	Fish, ds_{i5}		27.7* (15.6)	4.8	129.0
γ_6	Resort and no health impact, ds_{i6}		27.6** (14.6)	-46.7	82.3
γ_7	Tribal, ds_{i7}		41.6** (16.8)	22.1	104.4
γ_8	Summary, ds_{i8}		31.5** (15.0)	19.7	124.1
	Log-likelihood value for Censored Probit	-312.5 versus 348.7 with no variables (df 2)	-306.8 versus 348.7 with no variables (df 10)		
	Percent Correct Yes and No Predictions	68% Yes 64% No	67% Yes 70% No		

A "*" indicates significantly different from zero at the 90% level. A "**" indicates significantly different from zero at the 95% level

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