Western Regional Research Project W-133

Benefits and Costs in Natural Resource Planning

Fifth Interim Report

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Introduction

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This volume includes most, but not all, papers presented at the fifth and last annual meeting of regional research project W-133, Benefits and Costs in Natural Resource Planning. The fifth meeting was held in association with the annual meeting of the Western Regional Science Association at South Lake Tahoe, Nevada, February 23-27, 1992.

The papers in this volume were presented to a group of the most widely respected scholars working on the theory and application of nonmarket valuation techniques. After spirited discussions during the meetings and reflective conversations in the hotel, most authors took advantage of the opportunity to revise their papers. Thus, although the papers have not been peer reviewed in the traditional sense, they have met the test of careful scrutiny used at the annual W-133 meetings.

Regional research projects are organized around academic scientists working at land-grant universities. In addition to most of the states in the western region, W-133 includes representation from midwestern, southern, and eastern land-grant universities. Economists working for federal natural resource agencies are active cooperating members, often carrying methodological improvements directly back to their work responsibilities. Economists from nonland-grant universities also attend and present important information on work in progress. Finally, readers should notice references in papers to collaborative research projects that involve economists from more than one land-grant university. The annual W-133 meetings not only provided opportunities to report state-of-the-art methodological and empirical advances, they also provided opportunities for investigators to initiate and continue important work across state and agency boundaries.

The travel-cost method of estimating nonmarket values, while continuing to be a popular approach, presents many difficulties. The first two papers address some problems and suggest methods to reduce errors in estimating values. Houston, Bergstrom, and Dorfman examine trip demand for recreational activities in Louisiana wetlands using a Linear Approximate Almost Ideal Demand System. They estimated the demand system using a two-limit Tobit, seemingly unrelated regression procedure. Besides showing how modern economic theory and statistical procedures can be used to address problems of direct importance to resource managers, this study, which is based on a survey conducted by one author at the University of Georgia and another W-133 member at Texas A&M University, illustrates the value of regional collaboration. Although the paper is intended primarily to report methodological approaches, examples of policy-relevant conclusions that help resource managers, such as management practices that improve success in one recreational activity can affect the demand for other activities, are included.

One significant source of problems with travel-cost models is that the sample is drawn from recreationists at specific sites, but results are generalized to a larger population. Of that larger group, many do not recreate at a specific site for many reasons. How should one handle data sets with many zero observations? What are the implications of these corner solutions for appropriate quantitative procedures? Ozuna and Gomez contribute to this literature by applying hurdle and with-zeros count models to a Texas data set. After rejecting the basic geometric model, the authors concluded that "the hurdle model is preferred because it is less restrictive and it also permits the joint modelling of the decision to participate or not and the decision, if participating, of how much to participate. In essence, the hurdle model accounts for both the behavioral decisions of the individual and the statistical properties of the recreation data."

Methodological advances, many of them offered by W-133 members, have contributed to the growing popularity of contingent valuation as a process for estimating nonmarket values. Dichotomous-choice questions have become especially popular because they are easy for respondents to answer (primarily because they sound similar to the questions shoppers ask themselves every day), avoid the bias due to strategic behavior from the respondents, are easy to administer, take little time and energy from respondents, and are free from starting-point bias. Unfortunately, as Ready and Hu argue, the questionnaires create limited amounts of information and require great care in statistical analysis. The authors review issues of concern including discussion of the work of previous researchers, with particular attention to the problem of drawing inferences from the small number of observations at high values. To offset biases from assigning too much weight to the high values, many researchers truncate the data set. Ready and Hu show that the mean value of willingness to pay is highly sensitive to the choice of truncation point, and they propose a new approach that allows direct estimation of the truncation point.

Growing world-wide concern about the challenges in maintaining biodiversity and frustration growing out of legal and political disputes associated with the Endangered Species Act of 1973 (as amended and probably to soon be amended again) has triggered wide interest in estimating existence values. Stevens addresses these difficulties in interpreting contingent values for wildlife existence. Most of his paper addresses the challenges of handling zero bids. He discusses the tendency for zero bids to be protest bids, i.e., expressions of dissatisfaction with the survey rather than actual feelings that the resource has no value. He points out that the practice of eliminating zero bids from the analysis may bias aggregate value estimates upward. Finally, Stevens explores the interpretation of contingent valuation studies of existence values, emphasizing the problematic relationship between reported estimates of contributing the respondent's fair share toward a good cause on the one hand and the economic value of the resource itself on the other.

Existence values are an important part of nonuse values. Opaluch and Grigalunas explore the interrelationship between nonuse values and ethical values. They are particularly concerned with challenges posed in using contingent valuation methods to place dollar values on lost or diminished nonuse value caused by a dramatic environmental catastrophe such as a large oil spill. After exploring the strengths and weaknesses of measuring loss with monetary measure, they suggest asking people what level of actions "to replace, restore, rehabilitate or acquire the equivalent" natural resources is needed to compensate for the environmental catastrophe.

Boyle, McCollum, and Teisl develop a protocol for estimating option value and apply it to moose hunting data from Maine. After reviewing the received literature on the appropriate policy criterion for public investments under uncertainty, they conclude that option price (the willingness to pay now rather than foregoing the option of using a natural resource such as a recreational resource in the future) remains a criterion with substantial support. They also conclude that risk-averse people should tend to place a value on an uncertain supply of such a resource that exceeds the value they actually expect to receive (expected consumer surplus plus expected expenditures). The difference between these two magnitudes, option value, has been analyzed extensively but few attempts have been made to measure it. Boyle, McCollum, and Teisl conclude that their quantitative methods are appropriate but that their numerical results are inconclusive. They report plans to continue this research with an additional survey in 1992 and to report the results of a new regional research project aimed at developing protocols for transferring benefit estimates from one setting to another.

Although most people are willing to accept the idea of existence value and other nonuse values in the abstract, one challenge to the credibility of estimates of such values is that they are abstract and must be measured through contingent valuation techniques. The credibility of contingent valuation in the estimation of use values was enhanced and contingent valuation procedures were improved by comparison with actual market sales of hunting and fishing licenses. Duffield and Patterson report research that aims to validate and clarify contingent valuation of existence values by comparing this method with market experiments. They compare a hypothetical contingent valuation measure and a cash transaction-simulated market criterion for increased stream flows in two Montana streams. Duffield and Patterson found that there are not major differences in the willingness to pay for stream improvement between the individuals who responded to the three types of surveys they conducted. Although they report differences in willingness to participate in the real and hypothetical market experiments, part of the difference is attributed to the different treatment in one survey, which included additional mail contacts. The study thus offers both insights into the validity of contingent valuation of existence values and suggestions for developing protocols for future studies.

Bishop and Welsh argue that, rather than estimating option value and existence value and adding these nonuse values to use values, researchers should estimate the total economic value of environmental resources. In their paper, they use Grand Canyon resources as a case to explore economic and survey-design principles needed to measure total values of environmental resources. Their review of the theoretical basis of total economic valuation includes several specific recommendations for the development of valuation protocols and a detailed explanation of their reasons for choosing this approach.

Both Cooper and Kanninen address important experimental design questions related to contingent valuation. Cooper develops a model for optimal survey design for a dichotomous choice format that finds the bid amounts as well as the sample sizes corresponding to each bid. Kanninen derives the D-Optimal, C-Optimal, and Fiducial Method optimal designs for the double-bounded logit model.

Walsh and McKean argue that technological change, rising incomes, and evolving preferences are changing both the way that people recreate and the way that they plan for future recreational activities. Before recreating in a new area, people buy and watch videos, attend lectures, buy and read books, gather information about alternative outdoor equipment such as fishing tackle, and so on. Each of these activities is a costly transaction and takes time and money, but each provides pleasure in the anticipation of the planned recreation event. Walsh and McKean argue that valuation of option price and option value should take into account these preliminary activities that give rise to what they call indirect option value. The authors develop their arguments and report the results of a survey of college students. They conclude that their hypothesis of a significant source of value cannot be rejected based on their empirical work.

People find risk difficult to understand. Environmental policies, especially those that affect people in highly uncertain ways, must, however, respond to public attitudes toward these risks. Although contingent valuation can be used to summarize public preferences, respondents must first understand the issue they are asked to evaluate. Loomis and Duvair report their use of alternative risk communication devices in a study of hazardous wastes. They find that different devices make a major difference, and they conclude that the risk ladder (explained in their chapter) provides responses more consistent with consumer theory than pie charts. They also provide suggestions for improving risk communication in future contingent valuation surveys.

In his paper, Randall shares work in progress on a project that questions whether one can develop an ethical justification for considering benefits and costs in environmental policy decisions. He draws on his cooperating investigator, the philosopher Don Hubin, who defines "benefit cost moral theory" as: *Right action is whatever action would have benefits in excess* *of costs.* Hubin argues that no respectable modern school of moral philosophy would find this acceptable.

After much reflection, Randall concludes that one should maintain safe minimum standards unless costs are "intolerably high." With any luck this may be what the Endangered Species Act is all about. He explores three viewpoints: the consequentialist (someone who believes that benefits and costs are consequences of human actions and the potential Pareto-improvement framework is one way to decide whether the action is beneficial), the contractarian (someone who argues that arrangements are justified if they respect the rights of all affected parties), and the neo-Kantian or duty-based person (someone who believes that preserving the ecosystem and enhancing the life-prospects of the worst-off people are moral goods).

The consequentialist uses benefit-cost analysis because benefits are good and costs are bad. He or she might support the safe minimum standard, because the consequences of violating it are terrible. The contractarian uses the safe minimum standard because it would be chosen at the constitutional stage. Specifically, those who follow principles of the "veil of ignorance" popularized by John Rawls would choose this approach for fear of harming the worst-off person in society. The duty-based person uses the safe minimum standard because the duty of conservation is important (but not always overriding if there are conflicts with other duties).

All papers in this volume report research that will help improve the public management of environmental and natural resources. The research clearly shows the continuing value of close collaboration in exchange of research methodology and empirical findings. Increasingly, the work reported in this project involves investigators in more than one state and shares specific results from more than one site to allow for the accumulation of valuable applied information.

ESTIMATING BAG/CATCH ELASTICITIES FOR RECREATIONAL HUNTING AND FISHING USING A MULTIPLE ACTIVITY DEMAND SYSTEM APPROACH

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Abstract

Trip demand for waterfowl hunting, saltwater fishing, freshwater fishing, and recreational shrimping are examined in a Linear Approximate Almost Ideal Demand System (LA/AIDS). Socioeconomic and site quality factors are incorporated to determine their influence on respondents' decisions about recreational trips to Louisiana Wetlands. Bounded expenditure share observations required that the demand system be estimated using a two-limit Tobit, seemingly unrelated regression procedure. Own-price elasticities indicate that these activities are price inelastic. Compensated cross-price elasticities suggest that these activities are significant substitutes. The policy-related variables are significant and indicate that participation inthe recreation activities is strongly dependent on success rates. Own-success rates for waterfowl hunting were much more elastic than own-success rates for fishing activities. Cross-success elasticities suggest improvements in quality for one activity significantly affect demand for other activities. The own price elasticities suggest that trip demands for recreational fishing activities are price inelastic. Cross-price elasticities suggest that waterfowl hunting, freshwater fishing, saltwater fishing, and shrimp catch, at least in the wetlands area, are Hicks-Allen substitutes. Expenditure elasticities are practically unitary for these wetlands activities.

Based on survey designed and implemented by John R. Stoll, Texas A & M University and John C. Bergstrom, The University of Georgia. Support of the U.S. Army Corps of Engineers is gratefully acknowledged. Appreciation is expressed to John Titre, Jim Henderson, and Roger Hamilton of the Waterways Experiment Station, USCOE, for technical support, Mr. Richard Bush and Mr. Theodore Hokannen of the New Orleans District, USCOE, for coordination assistance and advice on data collection and comments on data collection, and Dr. David Moser of the Institute of Water Resources, USCOE, for interpretation assistance.

INTRODUCTION

Wetlands are considered a public good, and, as such, estimates of costs and benefits of wetlands recreational use have public welfare implications. Identification of personal characteristics of recreational users that significantly affect their choices of wetlands activities enables policy makers to better plan and manage those resources. An overriding interest lies in measuring changes in trip behavior with changes in hunting or fishing success. Demand responses relative to the success of various activities provide a measure of substitution among the recreational uses of the wetlands and the benefits, such as fish catch and waterfowl bag, accruing from such uses.

Hunting or fishing success may have a considerable effect on trip behavior, and that hunting or fishing success can be influenced by public policy, investment, and management. Appropriate policy measures can be taken by public authorities to develop and/or maintain the natural resources of the wetlands in a way that is most beneficial to the public. The study area of immediate interest here included 6,000,000 acres of Louisiana coastal wetlands (see Bergstrom et al. for descriptions of area and the survey of users).

The objectives of this paper are to estimate bag/catch success elasticities using travel cost demand functions estimated within the framework of neoclassical consumer demand theory. To achieve this objective, it is important to develop a procedure to estimate a linear approximate Almost Ideal Demand System (LA/AIDS) with (1) a truncated distribution incorporating two limit shares (0 and 1), and (2) contemporaneous correlation between activity demand equations.

THEORETICAL MODEL

Recreational uses of the wetlands area studied include waterfowl hunting, saltwater fishing, freshwater fishing, and recreational shrimping. A linear scaled version of an AIDS model (Deaton and Muellbauer 1980a, Teklu and Johnson, Heien and Wessels) is specified and estimated using survey data. An LA/AIDS model is chosen over other models because it is considered the most flexible of the currently available demand models, and it permits a wide range of tests on the structure of preferences (Teklu and Johnson). Moreover, it does not require additivity of preferences (Eales and Unnevehr).

The LA/AIDS model specification provides a flexible system to obtain estimates of price and expenditure elasticities and to consistently incorporate demographic and attribute variables which influence demand shares. Waterfowl hunting bag, saltwater fish catch, freshwater fish catch, and recreational shrimping catch are treated as site attribute quality (or trip success) variables that can be influenced by public control, management, and investment. Demographic and qualitative variables include age, education, and boat ownership.

Travel cost demand equations, as shares of total travel costs for all activities in the study area, are estimated within a multiple equation system (Burt and Brewer; Cicchetti, Fisher, and Smith). The demand equations were modeled using a two-limit Tobit model to correctly treat the significant frequency of observations at both zero and 100 percent expenditure shares.

The AIDS model is specified in a linear scaled version (Deaton and Muellbauer 1980a,b):

(1) $w_i = \alpha_i + \Sigma\, \gamma_{ij} \ln\, p_i + \beta_i \ln(Y/P^x)$

where the intercept, α_i, can be made a function of demographic (Heien and Wessels) and policy variables such that:

(2) $\alpha_i = \theta_{i0} + \theta_{i1}\,(\text{Boat}) + \theta_{i2}\ln(\text{Educ}) + \theta_{i3}\ln(\text{Age}) + \phi_{i1}\ln(\text{WFbag}) + \phi_{i2}\ln(\text{SFcat}) + \phi_{i3}\ln(\text{FFcat}) + \phi_{i4}\ln(\text{RScat})$

with

w_i = average expenditure share of the i<u>th</u> recreational activity,

p_i = cost per trip for waterfowl hunting, saltwater fishing, freshwater fishing, and recreational shrimping,

$\ln P^x$ = $\Sigma w_i \ln p_i$ is Stone's (geometric) price index,

Y = combined total expenditure on all single-purpose trips to the recreational area,

Wfbag = average number of waterfowl bagged per day when hunting on trips for main purpose of waterfowl hunting,

Sfcat = average number of fish caught per day when fishing on trips for main purpose of saltwater fishing,

Ffcat = average number of fish caught per day when fishing on trips for main purpose of freshwater fishing,

Rscat = average pounds of shrimp caught per day when fishing on trips for main purpose of recreational shrimping,

Boat = boat ownership (1 if boat owner, 0 otherwise),

Educ = respondent's educational level,

Age = respondent's age.

Consistency with consumer theory requires that the parameters be restricted as follows (Johnson, Hassan, and Green; Heien and Wessels):

Adding up: $\Sigma\theta_{i0} = 1;\quad \sum_{i=1}^{n} \gamma_{ij} = 0,\ j = 1,\ldots,n;\quad \sum_{i=1}^{n} \beta_i = 0,$

$\Sigma_i\theta_{ik} = 0,\ k = 1,\ldots,r$

$\Sigma_i\phi_{im} = 0,\ m = 1,\ldots,s$

Symmetry: $\gamma_{ij} = \gamma_{ji}$

Homogeneity: $\Sigma_i\gamma_{ij} = 0,\ i = 1,\ldots,n$

DATA SOURCES AND TRANSFORMS

During 1986-1987, a mail survey was conducted by the U.S. Army Corps of Engineers of people who use the study wetlands area for outdoor recreation. Data collected included recreation quantity (numbers of trips for each activity), quality of experience (i.e., the success rates measured in bag or catch), expenditures, and socioeconomic variables.

Implicit prices for recreational activities were measured as waterfowl hunting, saltwater fishing, freshwater fishing, and recreational shrimping trip costs. Resource economists have developed various methods of measuring costs and benefits of alternative uses of natural resources since the passing of the Flood Control Act of 1936 (Seller et al.). One widely used method, the travel cost method (TCM), was conceptualized by Hotelling. Over the years, TCM has been applied numerous times and has been modified considerably (Walsh; Ward and

Loomis). TCM trip costs for all activities accounted for the costs of operating a medium-sized motor vehicle and the opportunity cost of time for a two-way trip. The implicit price, or trip costs, for each activity times the number of trips made for the activity, was divided by the total expenditure on all activities to obtain expenditure shares for individual activities.

ECONOMETRIC ESTIMATION

The expenditure share equations constitute a system of four equations. Since the expenditure shares sum to unity, one of the equations is redundant. Therefore, the shrimping trip equation was deleted from the system of equations to be estimated, and its parameter estimates were derived from adding up, symmetry, and homogeneity restrictions.

Unobserved trip prices (for non-consumers) were predicted using regression models estimated using the observations for all the consumers of that type of recreational trip (Heien and Wessels). These price equations were specified for each activity as

(3) $p_i = f(S, H)$,

where S is a vector of substitutes including quantity (number of trips) and quality (bag/catch) and H is a vector of household characteristics including household income, proportion of lifetime spent recreating in the study area, and boat ownership. Predictive values of these equations using the S and H vectors for nonconsumers are used as prices for nonconsumers in the LA/AIDS model.

Because the errors from the expenditure share equations are likely to be contemporaneously correlated, some type of seemingly unrelated regression is the appropriate estimation technique (Zellner). Although all equations have the same set of independent variables, the presence of cross-equation restrictions causes the application of SUR techniques to result in a gain in efficiency (unlike the case with identical regressors and no cross-equation restrictions). Because the expenditure share equations are represented by two-limit Tobit models to account for the truncation of expenditure shares at both 0 and 1, the two-limit Tobit model was employed, accounting for the cross-equation correlation of the errors by transformation. Thus, the resulting estimates might be referred to as SUR-Tobit estimates.

RESULTS

Descriptive statistics for the variables used to estimate recreational demand are given in Table 1. The mean number of recreational trips ranged from 3.7 for recreational shrimping and 4.3 for waterfowl hunting to 13.7 and 13.9 for saltwater and freshwater fishing, respectively. Those figures provided for mean expenditure shares of 0.12 for waterfowl hunting, 0.13 for shrimping, 0.27 for freshwater fishing, and 0.48 for saltwater fishing. Mean total expenditures for all trips for these activities amounted to $863.75 per annum. To avoid selectivity bias, "outliers" were not eliminated.

Parameter estimates of the share equations, constrained to satisfy restrictions for symmetry, homogeneity, and adding up are presented in Table 2, with standard errors reported in parentheses. The system modelled has an R^2 of 0.51. Apart from the demographic variable parameters, 21 of 24 free parameter estimates were significant at the 0.05 level.

The signs of the demographic variables hypothesized to influence trip demand for each activity provide some intuition as to their impact on the recreational uses of the wetlands. Of the demographic variables included in the system -- age, education, and boat ownership -- only boat ownership and education are statistically significant in any equation. Hence, it is difficult to surmise what impact, if any, that these variables have on trip behavior. The estimates suggest that only higher education contributes to an increase in the number of trips taken, and then only for waterfowl hunting and saltwater fishing.

Implicit own and cross prices of recreational activities are statistically significant in the travel cost demand share equations. Also, total expenditures are significant in the waterfowl hunting, saltwater and freshwater fishing equations. Total expenditure for all wetlands recreational activities is constrained to be a constant share of total expenditures for all activities in the separability assumptions used to model LA/AIDS shares. Thus, the parameters represent reallocations only with respect to changes within the recreational activities and factors that influence those activities. The significance of the coefficients suggests that recreational uses of the wetlands are sensitive to changes in price levels and in total expenditures.

Of the site attribute (or success) variables, all catch or bag rates are statistically significant at the five percent level, with the single exception

Table 1. Descriptive Statistics of Variables.

Variable	Mean	Standard Deviation
Waterfowl Trips	4.2974	6.9535
Saltwater Trips	13.6579	15.5378
Freshwater Trips	13.8667	20.5555
Rec'n Shrimp Trips	3.7000	6.4271
Waterfowl Share	0.1220	0.1981
Saltwater Share	0.4796	0.3204
Freshwater Share	0.2715	0.3007
Rec'n Shrimp Share	0.1269	0.1936
Boat	0.8912	0.3115
Education	13.3605	3.0559
Age	39.0254	12.4558
Waterfowl Bag	2.2192	3.1080
Saltwater Fish	23.6282	18.9913
Freshwater Fish	12.9652	12.5971
Rec'n Shrimp	39.6197	53.6383
Waterfowl Price	27.3894	33.8392
Saltwater Fish Price	35.0606	59.8010
Freshwater Fish Price	36.1511	99.4162
Rec'n Shrimp Price	25.0981	125.7529
Total Expenditure	863.7528	2750.6513

1140 Observations

Table 2. Parameter Estimates of Share Equations.

Independent Variable	Waterfowl Hunting Share	Saltwater Fishing Share	Freshwater Fishing Share	Recreational Shrimp Share
	Expenditure Shares			
Intercept	0.0394 (0.1102)	-0.2257 (0.1458)	0.0923 (0.1404)	0.0941
Boat	-0.0113 (0.0222)	0.0463 (0.0298)	-0.0692* (0.0294)	0.0342
Education	0.1284* (0.0304)	0.0924* (0.0368)	-0.0156 (0.0365)	-0.2052
Age	-0.0135 (0.0210)	0.0460 (0.0284)	-0.0070 (0.0275)	-0.0255
Waterfowl Bag	0.1053* (0.0025)	-0.0172* (0.0022)	-0.0151* (0.0022)	-0.0731
Saltwater Fish Catch	-0.0426* (0.0022)	0.1217* (0.0037)	-0.0443* (0.0027)	-0.0348
Freshwater Fish Catch	-0.0101* (0.0019)	-0.0513* (0.0030)	0.0753* (0.0039)	-0.0139
Recreational Shrimp Catch	0.0038* (0.0014)	0.0007 (0.0019)	-0.0201* (0.0017)	0.0156
Waterfowl Price	0.0223* (0.0034)	-0.0026 (0.0027)	-0.0061* (0.0020)	-0.0135
Saltwater Fish Price	-0.0026 (0.0027)	0.0581* (0.0055)	-0.0465* (0.0044)	-0.0089
Freshwater Fish Price	-0.0061* (0.0020)	-0.0465* (0.0044)	0.0443* (0.0058)	0.0083
Rec'n Shrimp Price	-0.0135	-0.0089	0.0083	0.0141
Total Expenditure	-0.0263* (0.0086)	-0.0240* (0.0113)	0.0773* (0.0109)	-0.0269

Note: $R^2 = 0.5098$
Standard errors in parentheses; * indicates significant at 0.05 level
Shrimp catch share equation derived from restrictions for adding up, symmetry, and homogeneity.

of shrimping success failing to influence saltwater fishing demand. Both fishing success variables detract from hunting trip demand share, while recreational shrimping tends to increase that share. Generally, greater success in one activity would suggest lesser expenditures on competing activities.

The estimated parameters of the AIDS model can be used directly to infer the nature of recreation demand. Demand elasticities with respect to the independent variables can be expressed (Green and Alston 1990, 1991):

Uncompensated price: $\eta_{ij} = - \delta_{ij} + (\gamma_{ij} - \beta_i w_j)/w_i - (\beta_i/w_i)[GA]$,

Expenditure: $\eta_{i,x} = 1 + (\beta_i/w_i)[1 - \Sigma_j w_j \ln P_j(\eta_{j,x} - 1)]$,

Compensated price: $\eta^*_{ij} = \eta_{ij} + w_j \eta_{i,x}$, and

Bag/catch: $\eta_{i,m} = (\theta_{im} - \beta_i)/w_i$,

where $[GA] = \Sigma_k w_k \ln P_k(\eta_{kj} + \delta_{kj})$ and δ_{ij} is the Kronecker delta. The formula used in Teklu and Johnson (1988) for calculating household size elasticity is used here for calculating elasticities with respect to the attribute/success variables, bag and catch.

Waterfowl hunting, saltwater fishing, and shrimping activities are expenditure inelastic ($\eta_{i,x}<1$), although saltwater fishing is practically unitary (Table 3). Freshwater fishing, on the other hand, is expenditure elastic ($\eta_{i,x}>1$). The uncompensated implicit own- and cross-price elasticities are also presented in Table 3. All own-price elasticities are negative, and, hence, consistent with theoretical expectations. All recreational trip demand activities are inelastic with respect to their own prices.

Table 4 shows compensated price elasticities for the wetlands recreational activities. All compensated own-price elasticities are negative and rather inelastic. In the Hicks-Allen, compensated demand system, the activities are direct substitutes for each other in that an increase in price for any one activity will, *ceteris paribus*, increase the number of trips taken for an alternate activity.

The attribute/success elasticities provide a measure of the impact that changes in bag or catch success would have on the number of trips for alternative recreational uses of wetlands (Table 5). These estimates can enable policymakers to better assess the effects of management directed towards one use versus others. With the exception of the own-catch elasticity of freshwater fish, all own-success elasticities are positive. The elasticities of demand for waterfowl hunting with respect to waterfowl bag, freshwater fish catch, and shrimp catch

Table 3. Estimated Uncompensated Price and Expenditure Elasticities.

Elasticity with Respect to	Activity			
	Waterfowl Hunting	Saltwater Fishing	Freshwater Fishing	Recreation Shrimping
Prices of--				
Waterfowl Hunting	-0.7876	0.0014	-0.0617	-0.0776
Saltwater Fishing	0.1051	-0.8495	-0.3384	0.0544
Freshwater Fishing	-0.0036	-0.0862	-0.8982	0.1116
Recreational Shrimping	-0.0865	-0.0129	-0.0016	-0.8648
Expenditure	0.7726	0.9472	1.2999	0.7765

Notes: Parameters for recreational shrimping are derived using restrictions.

Table 4. Estimated Compensated Price Elasticities.

Elasticity with Respect to Prices of--	Activity			
	Waterfowl Hunting	Saltwater Fishing	Freshwater Fishing	Recreation Shrimping
Waterfowl Hunting	-0.6934	0.1170	0.0969	0.0171
Saltwater Fishing	0.4757	-0.3952	0.2850	0.4268
Freshwater Fishing	0.2062	0.1710	-0.5453	0.3224
Recreational Shrimping	0.0115	0.1073	0.1634	-0.7663

Notes: Parameters for recreational shrimping are derived using restrictions.

Table 5. Estimated Attribute/Success Rate Elasticities.

	Activity			
Elasticity with Respect to	Waterfowl Hunting	Saltwater Fishing	Freshwater Fishing	Recreation Shrimp
Waterfowl Bag	1.0795	0.0143	-0.3401	-0.3641
Saltwater Catch	-0.1332	0.3038	-0.4476	-0.0624
Freshwater Catch	0.1335	-0.0568	-0.0075	0.1023
Shrimp Catch	0.2470	0.0516	-0.3586	0.3349

Notes: Parameters for shrimp catch share equation are derived using restrictions.

are 1.08, 0.13, and 0.25, respectively. These estimates indicate a strong own-success relationship and complementary relationships between activity successes in freshwater fishing and shrimping and trips for the main purpose of waterfowl hunting. The implication is that management action taken to improve freshwater fish or shrimp catch may increase demand for waterfowl hunting, in addition to increasing demand for freshwater fishing and shrimping.

Generally, however, success rates in alternate activities diminish trip demand for fishing activities. For example, the elasticities of trip demand for freshwater fishing with respect to waterfowl bag and saltwater fish catch are -0.34 and -0.45, respectively. These results suggest that management action taken to improve waterfowl bag or saltwater fish catch may increase demand for these activities, but decrease demand for freshwater fishing.

CONCLUSIONS

This study incorporated socioeconomic and site quality factors in an LA/AIDS model to determine their influence on respondents' decisions about recreational trips to coastal wetlands. Among the demographic variables, only boat ownership and higher education significantly affect the trip demand, and only for saltwater fishing. The policy-related variables are statistically significant, and, hence, more firm conclusions as to their impact on travel cost demands are possible. Waterfowl hunting depends importantly on success rates for the recreation activity relative to other activities, as determined by the sensitivity of the quantity of hunting or fishing trips demanded to success measured in terms of bag or catch. Own-success rates for waterfowl hunting were much more elastic than own-success rates for fishing activities. Cross-success elasticities suggest improvements in quality for one activity significantly affect demand for other fishing activities, but the relationships are somewhat mixed. The own-success elasticities provide resource managers with a means of assessing how management action taken to improve success (i.e., bag or catch) for an activity will impact demand (i.e., number of trips) for that activity. The cross-success elasticities provide a means for assessing how management action taken to improve success for one activity may impact the demand for other activities.

The own price elasticities suggest that trip demands for recreational activities are price inelastic. In the recreation economics literature, alternative recreational activities such as hunting and fishing are most often viewed as substitutes. The cross- price elasticities estimated in this study suggest that waterfowl hunting, freshwater fishing, saltwater fishing, and shrimping, at least in the coastal wetlands area, are Hicks-Allen substitutes. Expenditure elasticities are practically unitary for these wetlands activities, suggesting increased individual trip demands will match increases in total expenditures allocated to wetlands recreational activities.

The use of natural resources such as coastal wetlands for outdoor recreation is growing in the United States. Management of these resources requires greater knowledge of the determinants of outdoor recreation demand. In order to gain this knowledge, better data and improved modelling techniques are needed. Recreation demand systems, employing systems frameworks such as the LA/AIDS model and carefully considering the statistical properties of the data, can provide a useful means for analyzing recreation demand determinants. Appropriate policy measures, such as enhancing fish populations, could lead to greater use of the wetland resources by recreationists.

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HURDLE AND WITH-ZEROS COUNT MODELS FOR TRAVEL COST ANALYSIS

by

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Abstract

Hurdle and with-zeros count models are used to model recreation demand decisions. This models are more flexible than the more familiar count models and they represent the discrete regression analogue of continuous sample selection models. The results indicate that the estimation of recreation demand functions via modified count models is plausible. Based on the parameter estimates, the specification tests and the behavioral implications of the geometric hurdle model, it was chosen over the basic geometric, geometric with zeros, and Tobit models.

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HURDLE AND WITH-ZEROS COUNT MODELS FOR TRAVEL COST ANALYSIS

Recent extensions of the travel cost model address issues relating to: (1) the problem of corner-solution outcomes; (2) the nonnegative character of recreation trips; and (3) the count nature of trip demand. For example, Bockstael, Hanemann, and Strand and Bockstael *et al.* address corner-solution outcomes by jointly estimating recreation participation and quantity decisions using sample selection models based on continuous normal distributions. Additionally, other researchers have used count models to estimate the nonnegative count nature of trip demand (e. g., Creel and Loomis; Hellerstein; Gomez and Ozuna; Grogger and Carson; Shaw; Smith). Although count models are more appropriate for travel cost analysis than the sample selection models,[1] they are still restrictive.

Count models as currently employed for recreation demand analysis do not permit the modelling of the systematic differences between users and nonusers of a recreation site. Hence, in this paper, hurdle and with-zeros count models are presented as an alternative method of modelling individual recreation demand behavior subject to corner-solution outcomes. These modified count models are the discrete regression analogue of continuous sample selection models. The modified count models are more flexible than familiar count models because they permit the relative probabilities of zero and positive count realizations to differ from those implied by the parent distribution from which they are derived (Mullahy).

Additionally, specification tests for over or under-dispersion in the hurdle and with-zeros models are applied to aid in the choice of an appropriate model. The tests evaluate whether the relative probabilities of zero and positive count realizations implied by the parent distribution are supported by the data. Given that alternative models produce different parameter estimates and hence different consumer surplus estimates, it is important that an appropriate model be selected. The specification tests as well as the model's behavioral implications can thus aid the researcher in selecting an appropriate model (Bockstael *et al.*).

The rest of the paper is organized as follows. The next section discusses the modelling of corner-solution outcomes. The third section presents the hurdle and with-zeros models as well as specification tests for overdispersion. In the fourth section, the models and tests are applied to a travel cost analysis of recreational boating in East Texas. The final section concludes the paper.

Modelling Corner-Solution Outcomes

Data for travel cost analysis are sometimes collected through the use of population-wide surveys. These surveys generally reveal that a large number of individuals do not participate in the recreation activity of interest and thus demand zero recreation trips which result in corner solution outcomes. In such cases, the data is said to be censored (*i.e.*, the exogenous variable (number of trips) in the travel cost model contains a large number of zeros). Given censored data, the researcher's task is to jointly model the factors which determine whether or not an individual participates in the recreation activity (a participation decision) and the demand for recreation trips given a positive decision to participate (a frequency decision).

However, just because the data contains a large number of zeros for an exogenous variable does not necessarily mean that the researcher needs to use a censored model. The researcher must first ask why or how these zeros observations were generated. Three explanations are possible. First, an individual may make no trips to the site simply because the observation period is too short. For travel cost analysis this explanation seems unlikely because the surveys usually relate to a yearly or seasonal time frame. Second, the observed zeros are purely involuntary. In this case, there is some barrier to the exercise of free choice to visit a site (*e.g.*, congestion at the recreation site). Third, the observed zeros are the outcome of a completely free choice. In other words, at current prices and income, the individual will not visit a site, and is therefore at a corner solution to his or her utility maximization problem.[2] Of the three mechanisms explaining how the zeros are generated, the third explanation seems to be the most plausible for travel cost analysis.

The researcher, however, is now faced with the task of choosing an appropriate statistical model which is capable of modelling this type of decision behavior. A logical choice is to adopt a two-step estimation process where the participation decision is modelled in the first step and the frequency decision is modelled in the second step. Depending on the statistical model adopted, the factors and stochastic error structures affecting the participation and frequency decisions can be the same or different. For example, whereas the Tobit model assumes that the participation and frequency decisions are determined by the same factors and normal error structures, the Heckman and Cragg models allow different factors and different normal error structures to affect the participation and frequency decisions (Bockstael *et al.*).

An additional concern when modelling corner-solution outcomes in travel cost analysis relates to the fact that the exogenous variable in the model, the number of trips, is of a count nature. Hence, the Tobit, Heckman, and Cragg models are not appropriate for several reasons. First, these models are quite sensitive to distributional assumption misspecification. Assuming an incorrect distribution for the stochastic error structures will result in biased parameter estimates (Maddala). Second, as stated by Mullahy , "the use of a continuous distribution to model integer outcomes might have unwelcome consequences, including inconsistent parameter estimates." Third, the models may predict fractional trip demand, while the individual demanding integer quantities.

Consequently, several researchers (Smith and Gomez and Ozuna) have used using Poisson and negative binomial models to address the count nature of trip demand. These models, however, are limited in that they do not permit the joint modelling of the participation and frequency decisions. Additionally, these count models are not very flexible because they do not permit the relative probabilities of zero and positive count realizations to differ from those implied by the parent distribution from which they are derived. Hence, more flexible count models are called for.

The Hurdle and With-Zeros Count Models

The hurdle and with-zeros count models were developed by Mullahy in an effort to provide some flexibility in the specification of the stochastic component of count models. These modified count models were developed around the Poisson and the geometric version of the negative binomial distributions. However, given that the Poisson's stringent mean/variance equality property is seldom encountered in empirical applications (see Creel and Loomis; Hellerstein; Grogger and Carson; and Gomez and Ozuna) the models and subsequent application that follows will focus only on the geometric version of the hurdle and with-zeros count data models.

Thus, let the basic geometric distribution of count variate Y_i, which serves as the parent distribution for the modified count models, be defined as

$$(1) \qquad G(y,\lambda) = \lambda^{y}(1+\lambda)^{-(y+1)}, \qquad y \in \Gamma,$$
$$= 0, \qquad \text{otherwise},$$

where $E(Y_i) = \lambda$ and $var(Y_i) = \lambda(1 + \lambda)$. Since the geometric distribution is only defined for positive values of λ, λ_i is usually parameterized as $\exp(X_i\beta)$, where X_i is a vector of exogenous variables and β a conformable vector of parameters to be estimated.

The geometric distribution in equation (1) characterizes discrete decay phenomena such that its probabilities obey $Prob(y) > Prob(y + 1)$ for all $y \in \Gamma = \{0, 1, 2, \ldots\}$. Hence, this distribution is ideal for modelling recreation demand behavior given that the probabilities characterize the structure of the data available for travel cost analysis. To appreciate why this is so, note that in many cases the probability of taking a trip to a recreation site is greater than the probability of taking two trips and the probability of taking two trips is greater that the probability of taking three trips, etc.

The Hurdle Model

The hurdle model is formulated on the notion that the binary zero or positive realizations of the count variate are characterized by a binomial probability model. In this model, the probability of the positive realizations relative to the probability of the zero realizations are specified by the parent distribution (e.g., the geometric distribution). The "hurdle" is crossed whenever the realization is positive and these positive realizations are then assumed to originate from a truncated-at-zero geometric conditional distribution. Given certain parameter restrictions, Mullahy has shown that the general form of the likelihood function of the hurdle model resembles the likelihood function of the Tobit model.

The hurdle model can thus be written as

(3) $$Prob(y = 0) = 1/(1 + \lambda_1),$$

(4) $$[1 - Prob(y = 0)] = \sum Prob(y) = \lambda_1/(1 + \lambda_1),$$

and

$$(5) \qquad \text{Prob}(y \mid y > 0) = \lambda_2^{(y-1)} / [(1 + \lambda_2)^y], \qquad y \in \Gamma_+,$$
$$= 0, \qquad \text{otherwise.}$$

The summation in equation (4) is based on the set $y \in \Gamma_+$. By parameterizing λ_{ji} as $\exp(X_i\beta_j)$, the probabilities in (3) and (4) are in the form of a binomial logit model and the probabilities in (5) correspond to those of the truncated-at-zero geometric model.

The With-Zeros Model

Unlike the hurdle model, in the with-zeros models the probability of the positive realizations relative to the probability of the zero realizations are no longer as specified by the parent distribution. The probability of the zero realizations are now assumed to be additively augmented or reduced by an amount Ψ. The conditional distribution of the positive realizations are, however, properly characterized by the truncated-at-zero version of the parent distribution. In this case, the loglikelihood function of the with-zeros model can be written as

$$(7) \qquad L^{wz} = \Sigma \log [\Psi\exp(X_i\beta) + 1] - \log [1 + \exp(X_i\beta)] + \Sigma \log(1 - \Psi)$$
$$+ y_iX_i\beta - (1 + y_i) \log [1 + \exp(X_i\beta)].$$

where the first summation is over the set $y \in \Gamma_0$ and the second summation is over the set $y \in \Gamma_+$.

Specification Tests

An important feature of the modified count model specifications is that they provide a means for modeling overdispersion or underdispersion of the data. In this case, overdispersion and underdispersion is interpreted as arising from a misspecification of the maintained parent data generating process in which the relative probabilities of zero and positive realizations implied by the parent distribution are not supported by the data (Mullahy). For the geometric models, overdispersion occurs whenever var(Y)/E(Y) > 1 + E(Y) and underdispersion is defined by reversing the inequality.

Several tests are available to tests of overdispersion. The first is the Lagrange multiplier (score) test. This test is based on the work of Lin and Schmidt. In the hurdle model, the equality of the β's is tested and in the with-zeros model the hypothesis to be tested is Ho: $\Psi = 0$. The second test is a Hausman test which is applicable only to the hurdle model. The hypothesis of interest here is the equality of the β's in the geometric vs the logit and the truncated geometric. The third tests is the regular likelihood ratio test.

Model Specification and Data

The empirical application employed in this study is based on a study carried out by Sellar, Stoll, and Chavas, which looked at the value of recreational boating in East Texas. Sellar *et al.* studied four lakes in East Texas namely, Lakes Conroe, Livingston, Somerville, and Houston. Almost all of the freshwater-lake recreation undertaken in these area is provided by these lakes. However, to keep the present analysis simple, only the travel cost data for Lake Conroe will be employed.

Following Sellar *et al.*, the recreation demand function for Lake Conroe can be written as follows

$$V_i = \alpha + \sum_{k=1}^{3} \beta_k C_{ik} + \delta I_i + \gamma Z_i + \varepsilon_i , \tag{9}$$

where $i = 1, 2, \ldots, m$ observations (*i.e.*, recreational groups); $k = 1, 2, 3$, sites; V_i is the number of visits to Lake Conroe by the i^{th} recreation group; C_{ik} are the costs incurred by group i while at and travelling to the site k; Y_i is the household income of the head of group i; Z_i are preference and behavioral variables introduced in the model; α, β, δ, and γ are parameters to be estimated, and ε_i is a random disturbance term.[3]

The actual variables employed in this study are defined as follows. V1, the dependent variable, is the number of visits made to Lake Conroe in 1980. Travel costs to Lakes Conroe, Livingston, Somerville, and Houston are denoted, respectively, as Cost-LC, Cost-LL, Cost-LS, and Cost-LH. I denotes household income. Quality-LC and Quality-LL are quality rating score for Lakes Conroe and Livingston. Overnight is a dummy variable indicating whether or not the individual stayed overnight at the site.

Of the variables included in the analysis, the quality variables (Quality-LC and Quality-LL) are unlikely to influence whether or not the individual is a boater or not, but they may have an effect on the quantity decision. Consequently, the quality variables were omitted from the list of relevant variables which affect the participation decision in the geometric hurdle model. Since the basic geometric and geometric with-zeros models do not allow the separate modelling of the participation and frequency decisions, the quality variables were included in both models. Additionally, because the Tobit model does not allow different variables to affect the participation and quantity decisions, the quality variables were implicitly modelled as factors which affect both decisions.

The data employed in this study is a subset of that collected by Sellar *et al.* This data where collected through a survey which was administered to 2,000 registered leisure boat owners in a 23 county area of East Texas. This survey have a response rate of 62.4%. After removing ineligible and incomplete responses, 659 questionnaires remained for use in this application. Additionally, it should be noted that in this application, the population frame (registered boat owners) is treated as the universe. Hence, researchers should be cautious when extending the empirical results that follow to a more general population.

Estimation Results

Parameter estimates and associated t-values for the geometric, geometric with-zeros, geometric hurdle, and Tobit models are presented in Table 1. Note that whereas the hurdle and Tobit models specifically model the participation and quantity decisions, the geometric and with-zeros models do not. Except for the intercepts, the parameter estimates for the count models are not substantially different. It is also noteworthy that in almost all instances the parameter estimates for the basic geometric and the geometric with-zeros models are bounded by the logit and truncated geometric parameter estimates.

Among all these demand equations the own-cost coefficient (Cost-LC) has the correct sign and are significant. The signs on other Cost-LL and Cost-LS indicate that Lakes Livingston and Somerville are substitutes for Conroe. The Cost-LH coefficient for all the models is insignificant. The coefficient for Income is negative across all count models, while it is positive in the Tobit model. Note also that the only significant Income coefficients are for the hurdle model.

The results of the specification tests which test the restricted model (the geometric model) against the hurdle and with-zeros model are presented in Table 2. In all cases, rejection of the the parameter restrictions specified under the null hypothesis is indicated. The Ψ coefficient in the geometric model (Table 1) indicates the presences of overdispersion in the basic geometric model and hence rejection of the basic geometric model. Given that the basic geometric model is rejected in favor of the the hurdle and with-zeros models and that the hurdle

Table 1. Estimation Results.

Variable	Geometric	Geometric With-Zeros	Geometric Hurdle: Binary Logit	Geometric Hurdle: Truncated Geometric	Tobit: Normalized Coefficients	Tobit: Regression Coefficients
Intercept	0.424	1.276	-0.962	1.746	-0.809	-12.443
	(1.388)[a]	(3.217)	(4.033)	(4.233)	(2.753)	(2.753)
Cost-LC[b]	-0.182	-0.135	-0.197	-0.097	-0.104	-1.600
	(11.169)	(6.651)	(6.474)	(4.723)	(7.197)	(7.197)
Cost-LL	0.124	0.099	0.120	0.072	0.0619	0.9511
	(12.398)	(7.585)	(7.110)	(6.046)	(7.963)	(7.963)
Cost-LS	0.062	0.044	0.066	0.021	0.034	0.527
	(8.515)	(4.198)	(5.914)	(1.964)	(5.836)	(5.836)
Cost-LH	-0.014	-0.017	0.006	-0.008	0.005	0.078
	(1.477)	(1.475)	(0.407)	(0.629)	(0.619)	(0.619)
Income	-0.005	-0.046	0.104	-0.062	0.018	0.272
	(0.187)	(1.305)	(2.165)	(1.674)	(0.669)	(0.669)
Quality-LC	0.137	0.135		0.177	0.067	1.029
	(3.116)	(2.746)	---	(3.293)	(1.444)	(1.444)
Quality-LL	-0.002	-0.023		-0.055	0.017	0.261
	(0.034)	(0.275)	---	(0.616)	(0.299)	(0.299)
Overnight	-0.647	-0.525	-0.644	-0.417	-0.353	-5.427
	(4.872)	(3.021)	(3.034)	(2.207)	(3.091)	(3.091)
Ψ	---	0.397	---	---	---	---
		(13.895)				

[a] the absolute value of the t-statistics are in parentheses

[b] LC=Lake Conroe, LL=Lake Livingston, LS= Lake Somerville, LH= Lake Houston

Table 2. Hurdle and With-Zeros Model Specification Results.

Hurdle Model	
Likelihood ratio test	262.2
Hausman test: geometric vs. truncated geometric	168.9
Lagrange multiplier test	278.4
With-Zeros Model	
Likelihood ratio test	185.9
Lagrange multiplier test	77.7

model explicitly models the participation and quantity decisions, the hurdle model is the prefered model for this study.

For purposes of comparison, per trip average consumer surplus (CSPT) estimates for each of the estimated models were calculated. This measures was computed for the Tobit model as CSPT = $-\hat{v}/(2\hat{\beta})$, where $\hat{v}$ is the predicted value of V calculated at the mean of the independent variables and $\hat{\beta}$ is the estimated own- price coefficient. Consumer surplus measures for the count models were computed as CSPT = $-1/\hat{\beta}$ where $\hat{\beta}$ is the coefficient on the own price variable.

Hence, per trip average consumer surplus estimates for the geometric, geometric with-zeros, geometric hurdle, and the Tobit model were computed to be \$5.49, \$7.41, \$10.31, and \$1.15, respectively. As can be noticed, the difference between the consumer surplus estimate of the Tobit model and the count models is substantial. This result is similar to that found by Gomez and Ozuna and Hellerstein. Differences among the count models are also noticeable. In sum, the distributional assumption made with respect to estimating a recreation demand function does have considerable impact on consumer surplus.

Concluding Comments

Overall, the estimation of recreation demand functions via modified count models is plausible. In this study, the basic geometric model was rejected as an appropriate model for recreation demand estimation. With respect to the choice between the hurdle and with-zeros model, the hurdle model is prefered because it is less restrictive and it also permits the joint modelling of the decision to participate or not and the decision, if participating, of how much to participate. In essences, the hurdle model accounts for both the behavioral decisions of the individual and the statistical properties of the recreation data.

Footnotes

1. Mullahy states "that the use of continuous distributions to model integer outcomes might have unwelcome consequences, including inconsistent parameter estimates."
2. It should also be emphised that some individuals because of social, psychological, or ethical distinctions will never visit a site irrespective of the level of prices and income and are therefore at a "true" corner solution. These individuals simply are not of the outdoor recreation type.
3. For a detailed discussion of the computations that made up the costs variables see Sellar, *et al.*, page 160.

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Calculating Mean Willingness To Pay From

Dichotomous Choice Contingent Valuation Data

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ABSTRACT

Mean willingness to pay for a resource or amenity is estimated from dichotomous choice contingent valuation data by integrating an estimated cumulative density function (cdf). If that cdf has an unrealistically fat right hand tail, then the mean will be overestimated. A common response to the fat tails problem is to truncate the range of integration. Two issues arise: where should truncation occur, and what form should the truncated cdf take? With regards the first issue, several authors have chosen a truncation point equal to the largest bid used in the survey. This approach provides an underestimate of the true mean willingness to pay. With regards the second issue, two approaches have emerged, simple truncation and truncation with normalization. Both approaches result in truncated cdf's with unrealistic shapes. A new approach is proposed that allows direct estimation of the truncation point, and results in a cdf with a realistic shape.

Calculating Mean Willingness To Pay From Dichotomous Choice Contingent Valuation Data

Contingent valuation practitioners have in recent years increasingly shown preference for the dichotomous-choice (DC) question format over open-ended questions and iterative bidding formats. The DC format is implemented through a hypothetical purchase situation with a set price or through a hypothetical referendum situation. Compared to open ended questions, the DC format may be more familiar to respondents, since it closely resembles an actual purchase or voting decision, and therefore easier to answer (Sellar, Stoll and Chavas). Also, in contrast to open-ended questions, the DC format does not provide incentives to respond strategically (Hoehn and Randall). Compared to iterative approaches, the DC format is easier to administer, is less taxing on the respondents time and energies, and does not exhibit starting point effects (Boyle and Bishop).

The principle disadvantage of the DC format is that it elicits a limited amount of information from each respondent. Open ended and iterative bidding formats directly measure the maximum willingness to pay (minimum willingness to accept) of each respondent. The DC format only determines whether maximum willingness to pay is larger or smaller than a specified bid amount. From this limited information, we desire to estimate maximum willingness to pay, either for each individual or in the aggregate. Such estimation involves specification and estimation of a cumulative density function (cdf) for maximum willingness to pay. Specific estimators of maximum willingness to pay, such as the mean and the median of the distribution of maximum willingness to pay, are calculated from this estimated cdf.

A number of issues associated with this procedure have received recent attention in the literature. This paper will focus on the functional form of the estimated cdf. Specifically, three commonly used functional forms, the logit form with log transformed bid, the truncated logit (Bishop and Heberlein; Sellar, Stoll and Chavas; Duffield and Patterson), and the normalized truncated logit (Boyle, Welsh and Bishop; Park, Loomis, and Creel), will be examined to determine whether each is consistent with statistical theory, whether each has a shape that is consistent with economic theory, and how well each models DC data. Data from a contingent valuation survey on horse farm preservation will be used to illustrate problems with each of these forms, and a fourth functional form, the pinched logit, will be proposed that remedies these problems.

A Model of Dichotomous Choice Valuation

Two different models of how respondents answer DC valuation questions have been proposed (Duffield and Patterson). Hanemann (1984) used a utility-difference model, where respondents compare their utility with a proposed change to their utility without the change. If utility is greater with the change than without, the respondent answers yes to the DC question. In contrast, Cameron used a tolerance distribution approach, where respondents compare the bid amount attached to the proposed policy change to their own maximum willingness to pay for the change. If the bid amount is less than the individual's maximum willingness to pay for the change, the respondent answers yes to the DC question. McConnell has shown that these two models are dual to each other, and that neither model is clearly preferred. This paper will rely on the tolerance distribution model, which provides a more intuitive framework for understanding the issues that will be addressed.

We are interested in valuing a policy change that affects a population of individuals, $i=1...N$. Each individual has a utility function $U_i(Y_i,Q)$ where Y_i is individual i's income, and Q measures the level of the environmental amenity. A proposed policy change would change Q from Q^0 to Q^1, a change that makes at least some individuals better off, and makes no individual worse off[1]. Each individual would be willing to pay any amount of money less than or equal to his or her compensating variation, CV_i, defined by

$$U_i(Y_i-CV_i,Q^1) = U_i(Y_i,Q^0),$$

to obtain the policy change. Ideally, we would like to know CV_i for each individual in the population. Unfortunately, we do not get to observe CV_i for any member of the population. What we observe instead is a limited amount of information about a subsample of the population.

In particular, for $n<N$ individuals, we observe whether CV_i is greater than or less than some bid amount, b_i. We assume that if CV_i is greater than b_i, then the respondent answers "yes" to the DC question. If CV_i is less than b_i he or she answer "no". For any given individual in the sample, there is no variability in the answer. CV_i is a fixed amount, not a random variable. Among individuals, however, there is variability among the CV_i's. Among the individuals in the population, CV is a random variable, distributed according to a conditional probability density function (pdf) $\phi(CV|X_i)$, where X_i is a vector of observable characteristics of the respondent (income, age, etc.). The probability that CV is less than some bid amount b is given by the cumulative density function of CV, $\Phi(b|X_i)$.

$$\Phi(b|X_i) = \int_{-\infty}^{b} \phi(CV|X_i)\, dCV$$

The probability that respondent i with unknown CV_i and observed

[1] Extending the analysis to include the possibility of individuals being made worse off by the change is relatively straightforward.

characteristics X_i will say no to bid level b is then equal to $\Phi(b|X_i)$. It is this cdf that is estimated from the DC data. A functional form is specified for $\Phi(b|X_i)$, $F(b,X_i,\theta)$, where θ is a vector of unknown parameters. The parameter θ is typically estimated using maximum likelihood techniques, yielding an estimated cdf for CV, $F(b,X_i,\theta_{ML})$. From this cdf we can derive an estimated pdf for CV, $f(b,X_i,\theta_{ML})$.

Individual or aggregate welfare measures are then calculated from this estimated cdf. One common welfare measure is the mean of the estimated distribution, E(CV), defined as[2]

$$E(CV) = \int_{-\infty}^{\infty} b \cdot f(b,X_i,\theta_{ML})\,db$$

The mean has desirable properties both as an individual welfare measure estimate, and for aggregate welfare measure estimates. If the analyst is interested in predicting willingness to pay for an individual, E(CV) is the predictor that minimizes the expected squared prediction error. If an aggregate welfare measure is desired, then the sum of the means, $\sum_N E(CV)$, allows investigation of whether a policy change satisfies the potential Pareto improvement criterion (PPIC). The PPIC is satisfied if the sum of the true CV_i's is greater than the costs of the policy change. The sum of the individual means, $\sum_N E(CV)$, is a consistent estimator of $\sum_N CV_i$. For a large population, the individual estimation errors will tend to cancel each other out.

Hanemann has argued that the median, or some other quantile, of the estimated distribution may be preferred to the mean as a welfare measure for

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[2] Expected willingness to pay is conditioned on the observable characteristics, X_i, and is more correctly denoted as $E(CV|X_i)$. Throughout this paper, the simpler E(CV) will be used to represent the conditional expectation.

an individual. He argues that the individual median is less sensitive to changes in the shape of the cdf than is the mean. He further argues that, regardless of how individual WTP is estimated, aggregate WTP is best estimated by the median WTP among individuals. Use of the median (or some other quantile) to aggregate individual measures is consistent with use of a majority (or super-majority) voting rule for public policy decisions (Hanemann 1989).

This paper will focus on estimation of the mean, though the results will have some relevance to estimation of a median. In either case, the welfare measure is calculated from the estimated cdf, and the choice of a functional form for the cdf takes on critical importance. Different functional forms can yield quite different estimates of E(CV) (Boyle, Bowker and Stoll). Use of an inappropriate functional form will lead to inaccurate estimates of either the mean or the median.

How should we choose among alternative functional forms for the cdf? Hanemann (1984) argues that the cdf should be consistent with utility theory, which places some restrictions on the form of the cdf. In contrast, Bowker and Stoll found that a more ad hoc functional form outperformed utility theoretic forms in terms of goodness of fit to the data. Boyle and Bishop found that estimated parameters for utility theoretic forms can take on unrealistic values. We will not restrict ourselves to cdf's that can be motivated by specific utility functions. Rather, we will evaluate alternative functional forms based on how well they fit the data in the range where data is available, and on whether they have a realistic shape outside the data range. It will be assumed that a cdf that does a good job fitting the data, and has a realistic shape outside the data range, can be viewed as a close approximation to a utility theoretic cdf.

The performance of alternative functional forms will be evaluated using a portion of a data set from a larger study on the value of preserving horse farms in Kentucky (Ready). As part of that study, 151 respondents answered a DC contingent valuation question valuing a state program to avert a decline in the number of horse farms in Kentucky. Bid amounts took on 8 different values, ranging from $5 per year to $500 per year per household.

The Logit cdf

Any cdf must satisfy a few restrictions that arise out of statistical theory. First, the cdf must be bounded by 1 above and 0 below. Second, the cdf must everywhere be non-decreasing in the bid. Third, the limit of the cdf as bid approaches ∞ must be equal to 1. Fourth, the limit of the cdf as bid approaches -∞ must be equal to 0. As long as these three restrictions are satisfied, then the mean of the distribution described by the cdf is given by

$$E(CV) = -\int_{-\infty}^{0} F(b,X_i,\theta)\,db + \int_{0}^{\infty} 1-F(b,X_i,\theta)\,db$$

(Johansson, Kristrom and Maler).

Prior information about willingness to pay can also impose some restrictions on the cdf. If the policy change makes no one worse off, absent cost considerations, then every individual should have a non-negative CV_i. More precisely,

$$\lim_{b \to 0^-} F(b,X_i,\theta) = 0$$

Notice that it is not necessary that the limit as bid approaches zero from above be equal to zero. The cdf could jump up at zero to some positive value. The interpretation of such a jump is that there is some number of individuals whose CV_i is exactly equal to 0. In such a case, CV has a mixed distribution, with both continuous and discrete regions. The proportion of the sub-population with characteristics X_i that has zero CV_i would be equal to the difference between the limit from above and the limit from below. Such a discontinuity in the cdf would occur if there was some portion of the population that is completely unaffected by the policy change, and therefore has a $CV_i=0$. If no individual has a negative CV_i, then the formula for E(CV) simplifies to

$$E(CV) = \int_0^{\infty} 1 - F(b, X_i, \theta)\, db$$

(Hanemann 1989).

One attractive functional form for the cdf that satisfies these few restrictions is the logit cdf, with a log transformation of the bid amount,

$$F(b, X_i, \alpha, \beta) = \begin{cases} \dfrac{1}{1+e^{[\alpha X_i + \beta \ln(b)]}} & if\ b>0 \\ 0\ if\ b \leq 0. \end{cases}$$

This functional form assumes that CV_i is positive for all individuals, and approaches 1 asymptotically as bid increases. Because the pdf for this form is not symmetric, it generates a median different from the mean. In this case, the median will be less than the mean. Indeed, if β is between zero and -1, the mean of this distribution is undefined, or infinite (Hanemann 1984). This problem has been referred to as the "fat tails" problem (Boyle, Welsh and Bishop). Simply speaking, there is too much weight too far out in the right-hand tail of the distribution. Even if β is less than -1, the weight of that tail can dominate the value of the mean, making the mean unrealistically large, and very sensitive to small changes in the value of β. In contrast, the median is always defined and finite, as long as β is negative, and is much less sensitive to the shape of the right hand tail.

How well does the logit cdf model DC data? A logit cdf was estimated for the horse farm study data, using only an intercept and log of bid as explanatory variables. Parameter estimates for the logit model, with

Table 1. Parameter estimates for logit cdf.

INTERCEPT (α)	1.9506	(0.5647)
SLOPE (β)	-0.4449	(0.1297)
LOG-LIKELIHOOD	-97.912	
MODEL CHI-SQUARE	12.97 with 1 d.f.	
McFADDEN'S R-SQUARE	0.0621	

asymptotic standard errors, are presented in Table 1. This estimated cdf is shown graphically in Figure 1, along with the actual proportions of "no" responses observed for each of the eight bid levels. Visual inspection indicates that the logit functional form does a good job at modelling the data in the range that data is available. Still, with no independent regressors other than bid, scalar measures of goodness of fit such as McFadden's R-square will tend to be low[3].

Notice that the estimate of the slope parameter β is negative, as expected, but is larger than -1. This means that E(CV) calculated from this functional form is infinite. In contrast, the median for this functional form is $80.16. The horse farm study data provides an extreme example of the fat tails problem.

Because the tail of the logit distribution contributes so heavily to the mean of the estimated cdf, it is useful to consider how respondents would answer DC questions with very large bid amounts. Economic theory dictates

[3] With few regressors, it is difficult to achieve high values of McFadden's R-square. For this data, the highest McFadden's R-square value that can possibly be achieved using bid as the only regressor is 0.777.

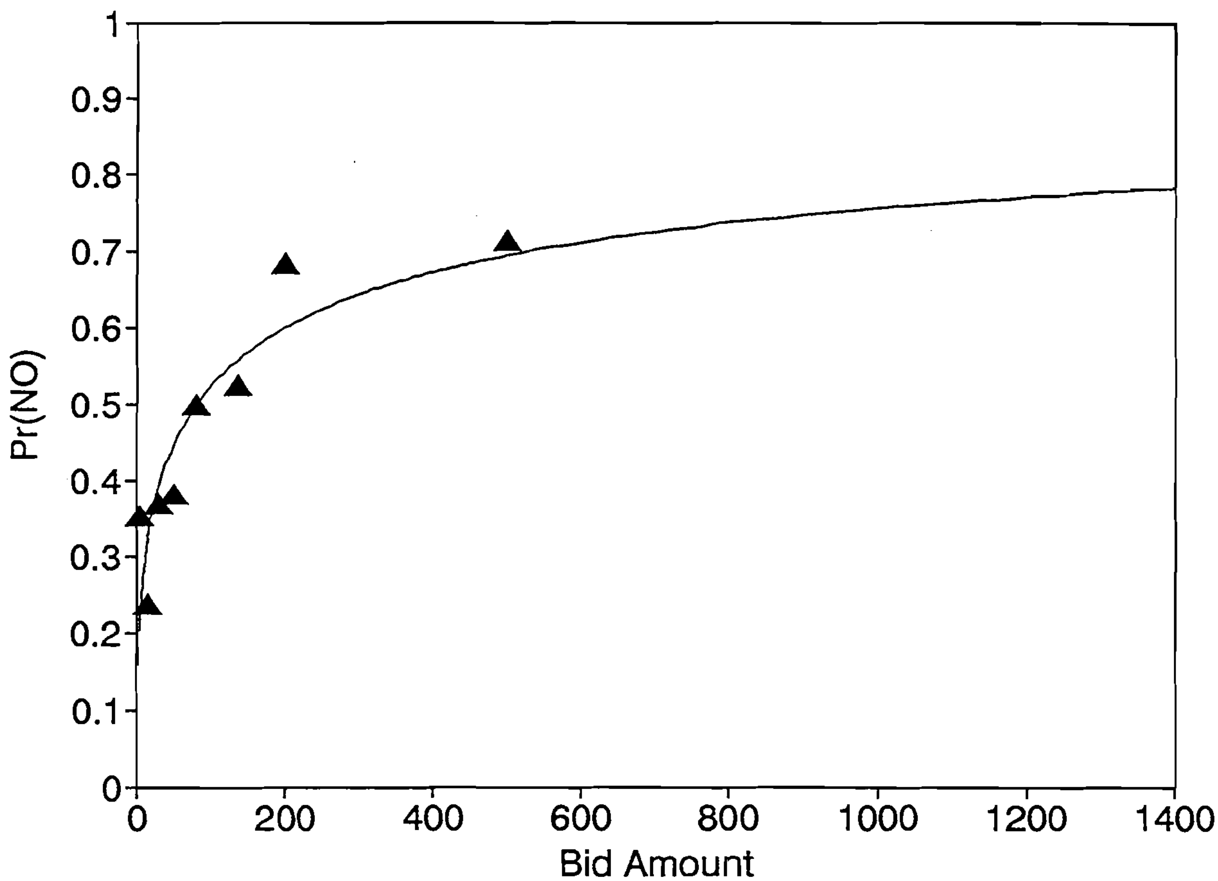

Figure 1. The logit cumulative density function. Triangles represent actual proportion of "no" responses for eight bid values.

that a respondent can never pay more than his or her total wealth in return for the policy change. A truthful respondent must say "no" to any bid amount larger than his or her ability to pay. Given some distribution of ability to pay among the population of potential respondents, there will be some bid amount above which no respondent is able to answer "yes." The heart of the fat tails problem lies in the fact that the logit cdf assumes that there is always some positive probability of a yes response, even for bid amounts larger than the ability to pay of the wealthiest member of the respondent population. For large bid amounts, therefore, the logit cdf overestimates the probability of a yes response, resulting in an overestimate of E(CV).

The Truncated Logit cdf

In response to the fat tails problem encountered with the logit cdf, several practitioners (Bishop and Heberlein; Sellar, Stoll and Chavas; Bowker and Stoll) calculated E(CV) have used a truncated logit cdf. Using the maximum likelihood values of θ from the logit estimation, they specified a new functional form for the cdf

$$F(b,X_i,\alpha,\beta) = \begin{cases} 1 \; if \; b>T \\ \dfrac{1}{1+e^{[\alpha X_i+\beta \ln(b)]}} \; if \; T\geq b>0 \\ 0 \; if \; b\leq 0. \end{cases}$$

This cdf is not everywhere differentiable. For bid values less than T, the truncated logit follows the logit cdf. At T, it jumps vertically to 1. Duffield and Patterson pointed out that the truncated logit cdf is motivated by a mixed distribution, where some discrete number of individuals have CV_i = T. Although the underlying pdf is not everywhere continuous, the mean CV is still given by the integral of the cdf, though now the limits of integration are 0 and T. The fat tails problem is avoided by cutting the tail off at some bid amount T.

Implementation of the truncation approach requires choosing a value for the truncation point, T. Bishop and Heberlein, Sellar, Stoll and Chavas, Bowker and Stoll, and Park, Loomis and Creel all chose to set T equal to the largest bid amount used in their contingent valuation surveys. The logic behind truncating at the highest bid amount used in the survey is that the analysis does not make inferences beyond the range of the data. This approach assumes that no one has a willingness to pay greater than the highest bid amount. Clearly, this approach underestimates the true value of E(CV). In the horse farm study, 29% said yes to a $500 bid, the highest bid amount included in the study. Surely, some of these respondents would have said yes to even higher bid amounts. Still, the estimated value of E(CV) arrived at by setting T equal to the highest bid amount can be defended as a lower bound estimate of the true E(CV)[4].

A second alternative approach to choosing T is to truncate the estimated cdf at a particular quantile, such as the 95% point or the 99% point (Boyle and Bishop). In other words, a given amount of weight is chopped off of the tail of the distribution. This approach is fairly arbitrary, as there is no guidance for choosing the quantile. This choice can be particularly important if β is close to 0. For example, for the logit cdf estimated from the horse farm study data, the 95% quantile occurs at a bid amount of $60,028. The 99% quantile occurs at $2,452,918. There is no reason why either of these quantiles would be a good estimate of the largest willingness to pay in the population.

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[4] Notice that it would never be appropriate to truncate the cdf at a bid less than the largest bid to which a respondent said yes. The estimated likelihood that a respondent would say yes to a bid greater than T is zero. The log-likelihood associated with such a truncated cdf would therefore be undefined.

A third alternative approach to setting T, and one that we prefer, is to use non-sample information on the distribution of maximum willingness to pay. For example, in the horse farm study, responses to open-ended valuation questions provide some insight into plausible values of T for truncation of the cdf. There, of 514 respondents asked an open-ended valuation question, the largest stated value was $1000 per year. This amount can serve as a reasonable estimate of the largest willingness to pay in the population. Truncating the logit cdf shown in Figure 1 at T=$1000 generates an estimated E(CV) of $340.90.

The truncated logit is superior to the untruncated logit in that it does a better job modelling responses to bid values larger than the respondent's ability to pay. Still, its shape is somewhat disturbing. While the truncated logit cdf fits the available data well and correctly sets the probability of a yes response at zero for bids greater than T, it overestimates the probability of a yes response to bids above the data range but below T. According to the estimated logit cdf for the horse farm study data, 24.6% of respondents would say yes to a bid of $1000. In contrast, of the 514 respondents asked an open-ended valuation question, the single $1000 response was the only response larger than $500. A better functional form for the cdf would increase smoothly between 0 and T, reach 1 at bid=T without any discontinuities.

The Normalized Truncated Logit cdf

Boyle, Welsh and Bishop proposed such a functional form, but arrived at it as the result of a mistaken argument. They did not recognize that the truncated logit cdf was motivated by a mixed distribution. Considering only the continuous portion of that distribution, they argued that the truncated logit cdf was not a valid cdf, because the underlying pdf did not integrate to

1[5]. They suggested a normalization procedure that transforms any untruncated cdf into a truncated cdf that is everywhere differentiable. This normalization procedure applied to the logit cdf results in a cdf of the form

$$F(b,X_i,\alpha,\beta) = \begin{cases} 1 \ \text{if} \ b>T \\ \dfrac{\dfrac{1}{1+e^{[\alpha X_i+\beta \ln(b)]}}}{\dfrac{1}{1+e^{[\alpha X_i+\beta \ln(T)]}}} = \dfrac{1+e^{[\alpha X_i+\beta \ln(T)]}}{1+e^{[\alpha X_i+\beta \ln(b)]}} \ \text{if} \ 0<b\leq T \\ 0 \ \text{if} \ b\leq 0. \end{cases}$$

This cdf starts at 0 for Bid=0, and increases smoothly to 1 at Bid=T. Park, Loomis and Creel use this functional form in their analysis of willingness to pay for elk hunting in Montana.

The normalized truncated logit satisfies all of our theoretical constraints, and has a shape that makes sense. Unfortunately, it is estimated in a way that guarantees that it will fit the data poorly. Using the same logit coefficients presented above, the normalized truncated logit cdf for the horse farm study data is shown in Figure 2. Notice that this functional form does a very poor job of fitting the data. Boyle, Welsh and Bishop's normalization procedure takes the weight contained in the tail of the untruncated cdf and distributes it across the range (0,T]. This additional weight increases the underlying pdf throughout that range, making the cdf increase more steeply and increasing the value of the cdf at all bid levels. This upward shift in the cdf has a dramatic effect on the estimated mean of CV. The normalized truncated logit cdf generates an estimate of E(CV) of \$126.47 and a median of \$25.98, substantially smaller than for the truncated logit. Park, Loomis and Creel found similar reductions in the estimated mean

[5] As Duffield and Patterson recognized, the underlying pdf of the truncated logit is a mixed pdf that does integrate to 1.

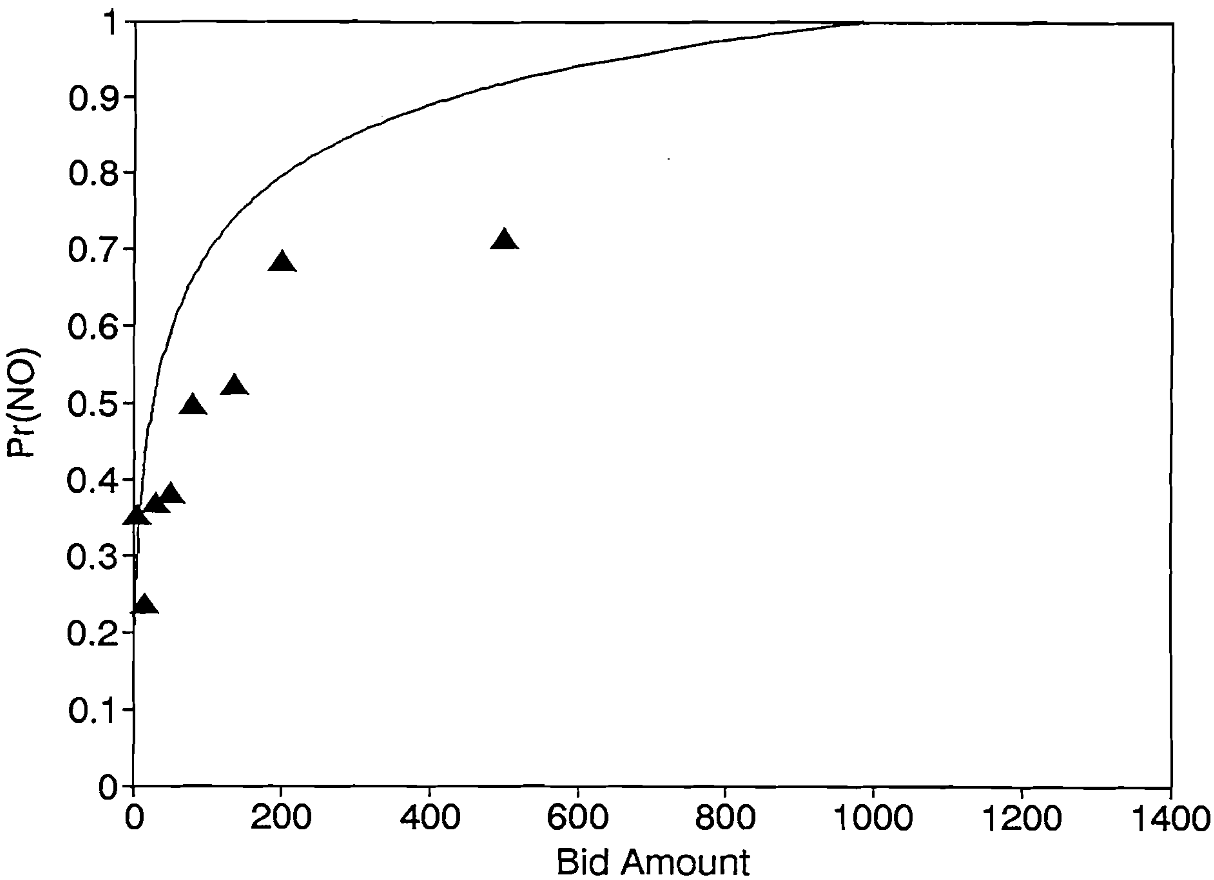

Figure 2. The normalized truncated logit cumulative density function. Triangles represent actual proportion of "no" responses for eight bid values.

of CV as a result of normalizing the cdf.

Why does the normalized truncated logit fit the data so poorly? The parameters listed above were estimated under the assumption that $T=\infty$. The likelihood function that was maximized is that associated with the untruncated logit cdf. Normalization results in new cdf, with a new likelihood function. The parameters shown in Table 1 are not the maximum likelihood parameter estimates for this new likelihood function. The parameters must be re-estimated using the appropriate likelihood function.

It is relatively straightforward to construct a new likelihood function from the normalized cdf. Unfortunately, the normalized truncated cdf has a form that does not perform well in parameter estimation. In particular, because α appears in both the numerator and the denominator of the cdf, the likelihood function is very flat in α, making estimation difficult. The flatness of the likelihood function makes it particularly difficult to investigate the impact of observable characteristics of the respondent, X_i. Because large changes in α do not impact the likelihood function, the X_i matrix has little impact on the cdf, and therefore little impact on E(CV).

We need, then, a functional form for the cdf that increases smoothly, reaches 1 at some finite value, and has a well behaved likelihood function that allows identification of the impacts of X_i.

The Pinched Logit Cumulative Density Function

Consider the following functional form for the cdf of CV

This is simply a logit functional form with a log-bid specification, with a multiplicative term that we call the "pinching" function. The pinching function assures that the cdf reaches 1 at Bid=T, and does so smoothly. The pinched logit cdf generates a likelihood function that is well behaved, making

$$F(b,X_i,\alpha,\beta) = \begin{cases} 1 \ \mathit{if} \ b>T \\ 1 - \left(1 - \dfrac{1}{1 - e^{[\alpha X_i + \beta \ln(b)]}}\right)\left(1 - \dfrac{b}{T}\right) \ \mathit{if} \ 0<b\leq T \\ 0 \ \mathit{if} \ b\leq 0. \end{cases}$$

estimation of α and β relatively easy. Parameter estimates for the pinched logit cdf using the horse farm data are shown in Table 2[6]. This cdf is shown graphically in Figure 3. Here, the estimated cdf smoothly increases from 0 at Bid=0 to 1 at Bid=T, and does a good job at fitting the data. In fact, this cdf does a slightly better job fitting the data than does the original logit.

Table 2. Parameter estimates for pinched logit cdf.

INTERCEPT (α)	1.4166	(0.5887)
SLOPE (β)	-0.2468	(0.1449)
LOG-LIKELIHOOD	-97.709	
MODEL CHI-SQUARE	13.376 with 1 d.f.	
McFADDEN's R-SQUARE	0.0641	

Using this form, we get an estimate of E(CV) of 259.78, and a median of $111.71. This functional form tends to take the middle ground between the truncated logit and the normalized truncated logit, both in its shape and in its estimated mean. It follows very closely the truncated logit in the range of the data, and then angles more steeply upwards, to smoothly reach 1 at Bid=T. In doing so, it solves the problems that hamper both of the other functional forms. It does a better job of fitting the data in the data range than does the normalized truncated logit, because the parameters were estimated using the correct likelihood function. At bids above the range of

[6] Standard error estimates are generated by estimating the inverse Fisher information matrix using a technique suggested by Berndt et al called the "Fisher method of scoring".

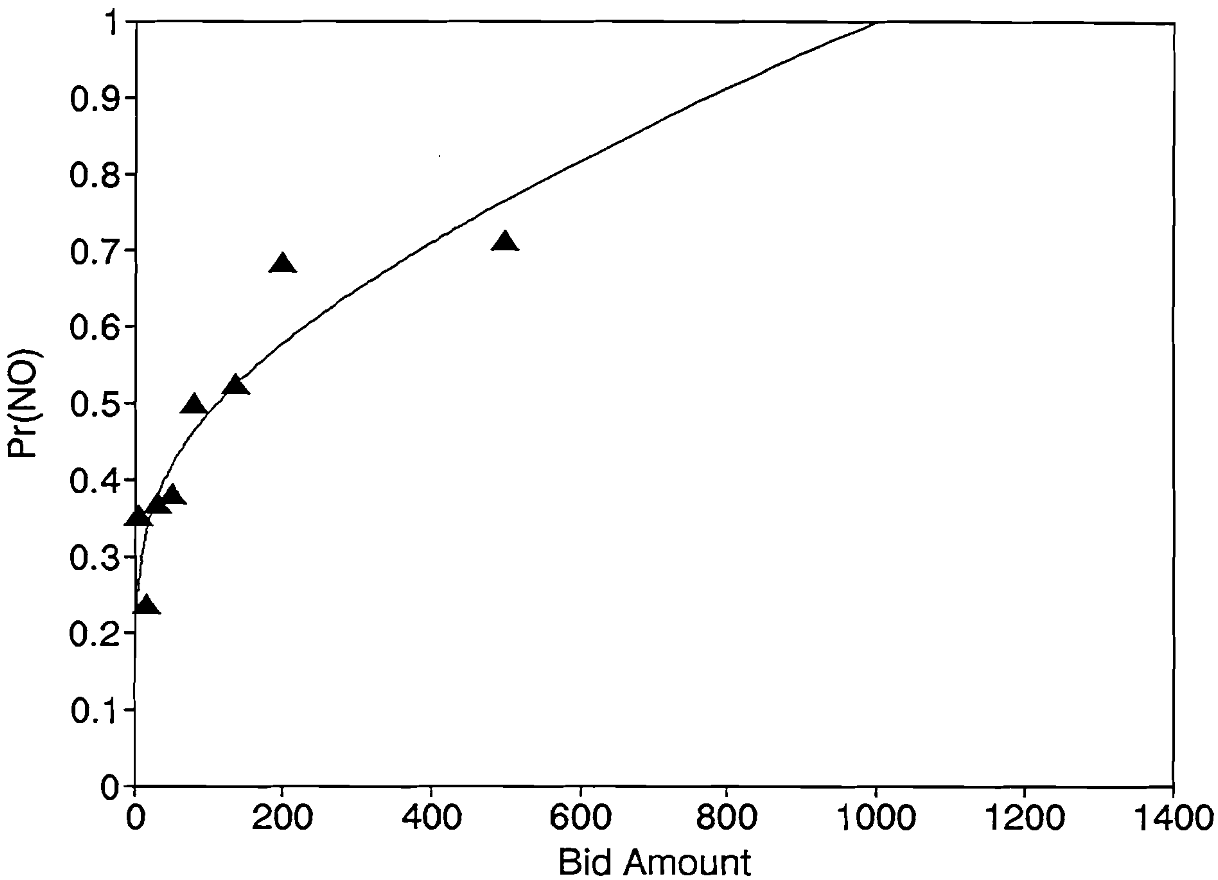

Figure 3. The pinched logit cumulative density function, with T=1000. Triangles represent actual proportion of "no" responses for eight bid values.

the data, but below T, the pinched logit cdf behaves more realistically than does the truncated logit, increasing smoothly to 1 at Bid=T rather than jumping up abruptly. The pinched logit form also has a well behaved likelihood function, making estimation easy.

Table 3. Parameter estimates for the pinched logit cdf with estimated T

INTERCEPT (α)	1.5661	(0.7280)
SLOPE (β)	-0.3021	(0.2236)
TRUNCATION POINT (T)	1296.93	(1299.38)
LOG_LIKELIHOOD	-97.651	
MODEL CHI-SQUARE	13.492 with 2 d.f.	
McFADDEN'S R-SQUARE	0.0646	

Using the pinched logit cdf gives the analyst another alternative for choosing the truncation point, T. Because the likelihood function for the pinched logit cdf is conditional on the value of T, T can be estimated from the data in the same way α and β are, rather than specified a priori. Maximum likelihood estimates of α, β, and T for the horse farm data set are shown in Table 3. The cdf associated with these parameter estimates is shown in Figure 4. The estimated truncation point lies slightly to the right of our largest open-ended value, \$1000. This makes sense, as it is unlikely that our sample would include the one individual in the population with the largest CV_i. The fact that the estimated T is not much larger than our specified T is encouraging. The standard error of the estimated T is quite large, however, and the standard errors on α and β are larger than for the estimation where T was fixed at 1000. These parameters generated an estimated E(CV) of \$300.53 and an estimated median CV of \$101.57.

Estimates of the median and mean CV for alternative functional forms of the cdf are consolidated in Table 4. To summarize, the logit cdf is unrealistic because it assumes that $T=\infty$. For very large bids, the logit cdf

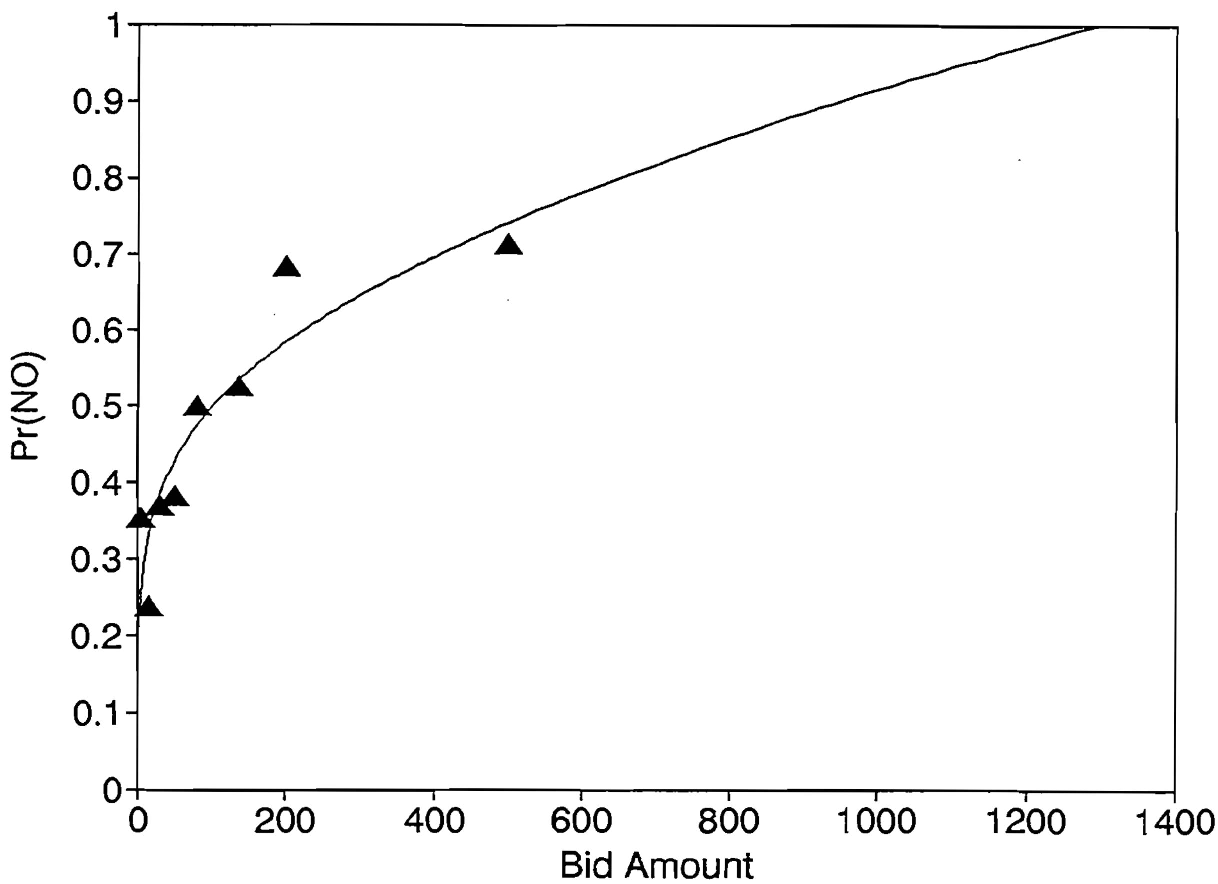

Figure 4. The pinched logit cumulative density function, with T estimated from data. Triangles represent actual proportion of "no" responses for eight bid values.

Table 4. Estimated Medians, Means and Confidence Intervals

	Truncated Logit	Normalized Truncated Logit	Pinched Logit	Pinched Logit
T	$1000.00	$1000.00	$1000.00	$1296.93
Median CV	$80.16	$25.98	$111.71	$101.57
E(CV)	$340.90	$126.47	$259.78	$300.53
Confidence Interval for E(CV)				
Upper Limit	$473.61	$156.37	$321.11	$507.96
Lower Limit	$238.49	$81.86	$188.93	$156.74
Width	$235.12	$74.51	$132.18	$351.22

overestimates the probability of a yes response, and therefore overestimates E(CV). The truncated logit cdf still overestimates the probability of a yes response for bid values above the range of the data, but below T. The normalized truncated logit overestimates the probability of a no response for bid values in the range of the data, and therefore underestimates E(CV). In contrast, the pinched logit cdf performs well both within and outside the range of the data, and has the added advantage that the truncation point can be estimated from the data.

The Impact of Functional Form on The Variability of The Estimated Mean

These results show that the choice of a functional form has an important impact on the estimated value of E(CV). That choice also has an important impact on the variability of the estimated mean. For each of the three truncated functional forms, confidence intervals around the estimated mean CV were estimated using the method outlined in Krinsky and Robb. For each model, the covariance matrix of the parameters was estimated using a technique suggested by Berndt et al. The Fisher information matrix, $I(\theta)$, was approximated by the Fisher method of scoring:

$$I(\theta_{ML}) = \sum_{i=1}^{n} \left[\frac{\partial L_i(\theta_{ML})}{\partial \theta}\right]\left[\frac{\partial L_i(\theta_{ML})}{\partial \theta}\right]^T$$

where $L_i(\theta_{ML})$ is the ith respondent's contribution to the log-likelihood function, evaluated at the maximum likelihood parameter values. The maximum likelihood estimates of θ are then asymptotically normally distributed, with a covariance matrix equal to the inverse of this approximated information matrix. From this multivariate normal distribution, a set of parameter vectors were generated. Parameter values that were out of bounds ($\beta>0$, $T<500$) were discarded. For each of 4000 valid parameter vectors, E(CV) was calculated by numerical integration, generating 4000 estimates of E(CV). These were ordered by size, and a 95% confidence interval around E(CV) was constructed by dropping the 100 largest and 100 smallest estimates of E(CV).

The results of this process are presented in Table 4 for four models: the truncated logit, the normalized truncated logit, the pinched logit with fixed T, and the pinched logit with estimated T. Of the three models with fixed T, the truncated logit model generates the widest confidence interval, and the normalized logit model generates the narrowest confidence interval. It is also noteworthy that the confidence intervals for the normalized logit model and the pinched logit with fixed T do not overlap. If we accept that the pinched logit is the more appropriate form, use of the normalized logit form would leave the analyst with a false sense of confidence in his or her results. These results serve to remind us to be careful when interpreting confidence intervals around estimated values of E(CV). Those confidence intervals are only as good as the assumptions that underlay the estimator.

A second interesting comparison is between the confidence interval for the pinched logit with fixed T and the pinched logit with estimated T. The mean estimate is higher for the latter model, simply because the estimated T is higher than the specified T. The confidence interval for the latter is wider than that for the former because less information was imposed on the estimation. Fixing T at some value imposes a great deal of information on the model, reducing uncertainty over the true shape of the cdf. When we admit that we do not know T with certainty, we introduce an important extra source of variability. Our estimate of T, $1296.93, had a standard error of 1299.38. This uncertainty over the true value of T increases our uncertainty over E(CV). This added uncertainty over E(CV) is not inappropriate, however. It seems fair to say that the confidence intervals for the three models with fixed T are too small, because they assume that T is known with certainty, when it is not.

Discussion

Boyle, Welsh and Bishop argued that truncation is a second-best approach to data analysis. The first-best approach is to get more data at higher bid levels. In the horse farm study, 29% of respondents said yes to the highest bid levels. Data on higher bid levels would help pin down the tail of the logit distribution, reducing the fat tails problem. However, even with more data, the logit model is unrealistic because it assumes a non-zero probability of a yes response for all bid levels. The logit cdf is constrained never to reach 1. A model whose predicted probability of a yes response reaches 0 at higher bid values, such as the pinched logit, is preferred. Still, use of a self-truncating model such as the pinched logit is not a substitute for good study design, particularly when T is to be estimated from the data. Data at higher bid levels is important to identify the true value of T. Absent that data, the pinched logit functional form is flexible enough that a wide range of T values can generate similar values of the likelihood function. For our data, the estimated value of T seems reasonable. However, that value has a large standard error. Absent data at high bid levels, the estimated T could take on unrealistic values.

The pinched logit cdf can be modified in a number of ways to be more flexible. First, we used a log transformation of the bid value in all of our functional forms. The pinched logit can easily accommodate a linear bid specification, or some other transformation. In such cases, the analyst must decide what to do about negative bids. If no individual will be made worse off by the change, then it is appropriate to ignore negative bids, calculating E(CV) as an integral of the cdf between 0 and T.

One particularly attractive bid transformation is the Box-Cox transformation

$$b' = (b^{\delta} - 1)/\delta.$$

When $\delta = 1$, this transformation is linear. As δ approaches 0, the transformation approaches a log transformation. Use of the Box-Cox transformation therefore imposes less information on the model, allowing the data a larger role in determining the shape of the estimated cdf. This loss of information has a cost, however. It increases the variability of our estimates of α and β, and particularly of T, reducing our confidence in the estimated value of E(CV). Again, this reduction in confidence may be appropriate.

A second possible extension of the pinched logit cdf is to include the information contained in X_i. One easy modification is to replace the scalar α in the pinched logit cdf with some function of X_i. Individuals with different values of X_i will then have cdf's with different shapes. A second modification is to allow the truncation point, T, to vary depending on X_i. For example, T could vary with the respondent's income. Taken together these modifications allow different individuals to have very different cdf's. The asymptotic properties of maximum likelihood estimators allow statistical tests of the significance of such differences.

The principle drawback of using the pinched logit cdf is a slight increase in the difficulty of estimation. Whereas the parameters of the logit cdf can be estimated using any of a number of commonly available, easy to use statistical packages, estimation of the parameters of the pinched logit requires some additional programming. Still, the likelihood function for the pinched logit is easy to construct, and is well behaved, making iterative maximization fairly straightforward. The advantages of the pinched logit cdf, a more realistic shape and an ability to estimate T from the data, make the extra programming effort worthwhile.

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Interpretation of Contingent Values For Wildlife Existence

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ABSTRACT

Existence values are playing an increasingly important role in wildlife preservation decisions, but existence value estimates may often be misinterpreted. Case study results suggest that many zero bids are protest zero bids motivated by ambivalence, and that the usual practice of eliminating protest zero bids may bias aggregate value estimates upward.

Many individuals who are willing-to-pay appear to be paying their "fair share" or for the satisfaction derived from contributing to a "good cause", as opposed to the value of the resource itself. Although payment of fair share may represent a lower bound estimate of resource value, payment for a "good cause" may have little or no relationship to the economic value of the resource itself.

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INTERPRETATION OF CONTINGENT VALUES FOR WILDLIFE EXISTENCE

Thomas H. Stevens

Introduction

Existence values are likely to play an increasingly important role in wildlife preservation decisions. One reason is budgetary; the cost of recovering all species listed as endangered or threatened under the 1973 Endangered Species Act is expected to be about $460 million per year. Yet, the total budget for recovery is less than $100 million per year (Mann and Plummer, 1992). Choices about which species to save are therefore inevitable, and proposed amendments to the Endangered Species Act would allow decisions to be based, in part, on benefit/cost analysis. This would facilitate decision making, but there may be several problems with using a benefit/cost approach.

One issue is that the contingent valuation method (CV) is the only technique capable of measuring wildlife existence values, but since little is known about how individuals interpret CV questions, existence value estimates might be misleading. Kahneman and Knetsch (1992), for example, suggest that CV responses often reflect the moral satisfaction or "warm glow" derived from contributing to public goods, not the economic values of those goods.

This paper examines the meaning and interpretation of CV bids for wildlife existence. We begin with a brief discussion of motives underlying CV responses. A case study of existence values for wildlife in New England is then presented.

Motives

Madariaga and McConnell (1987) reminds us that although motives usually don't matter in economic analysis, CV is often an exception. Motives matter in CV because they determine how the results should be interpreted and used in decision making. Consider, for example, the familiar problems which arise whenever CV respondents register zero bids. Zero bids are very common in CV, but in most cases only a portion of these represent zero economic valuation for the resource. Some zero bids are usually protest zero bids which occur whenever individuals motivated by ambivalence or opposition to some aspect of the survey place a zero value on a good which they actually value. Motives matter because if protest zero bids are not identified, they will be misinterpreted as indicating zero value for the resource itself.

Motives underlying positive CV bids also matter, but this issue is more controversial and has received much less attention. As expressed by Margolis (1982), if we are concerned only with private goods it is usually possible to bypass the question of motivation. However, this is generally not the case when analyzing individual decisions about the provision of public goods. Social choices about public goods are often not adequately explained by traditional neoclassical theory (Sen, 1979; Elster, 1989; Margolis, 1982). Perhaps the most familiar illustration is the inability of neoclassical theory to explain the fact that many people vote and make voluntary contributions. Why should individuals expend effort and money when there is really no chance that their actions will make any difference?

One possibility is that some individuals are motivated to do their "fair share" to promote the interests of society as a whole. Consequently, some responses to CV questions about the value of public goods may reflect individual judgement about the amount of money which constitutes their "fair share" as opposed to the economic value of the good itself.

Others may be motivated by "impure altruism." As summarized by Opaluch and

Grigalunas (1992),

> "Although impure altruism measures a form of personal benefit, it actually reflects the value of doing good, not the value derived from the good. Hence without taking care to identify the underlying motivation for responses, a CV survey can easily misinterpret the satisfaction obtained from contributing to a good cause as benefits associated with the specific commodity being described." (1992, p. 4).

Another example of altruistic motivation is given by Madariaga and McConnell (1987). Suppose that individual A is altruistic. His utility depends on his level of income Y_A, and the utility of individual B. B's utility is a function of income Y_B, and the consumption of a public good, R.

$$U_A = U_A\,(Y_A,\ U_B(Y_B,\ R))$$

$$U_B = U_B\,(Y_B,\ R)$$

where:

$$\left[\frac{\partial U_A}{\partial U_B}\right]\left[\frac{\partial U_B}{\partial R}\right] > 0$$

Following Madariaga and McConnell (1987), assume that individual A is asked how much he is WTP for a specified increase in R. In this case, A's WTP depends not only on R, but also on how much B is required to pay.

Very little is known about the process used by CV respondents in making choices about public goods. CV bids for wildlife existence might measure the value of existence, they might indicate the value of contributing to a "good cause", or they might reflect individual judgments about paying their "fair share". This is cause for concern about using benefit/cost analysis for making wildlife preservation decisions. The following case study provides one illustration.

Case Study

A CV survey about the value of bald eagles, wild turkeys, and coyotes in New England was mailed to 1500 randomly selected households in the spring of 1989. This sample was partitioned into five groups, each of which received an identical questionnaire except for the valuation question. Each group was asked to value a different species or management program: bald eagle, wild turkeys, bald eagles and turkeys combined, coyote protection and coyote control. Survey design and results are reported in Stevens, et. al. (1991).

A modified dichotomous choice economic valuation question was used in which each individual was confronted with a specified amount of money, N (randomly selected within fixed intervals over a range of $5 to $150), which could be given to ensure the continued existence of wildlife in New England. Respondents were given an opportunity to bid an amount less or greater than the stated value, N. All respondents who would not pay were asked the following question about why they would not pay:

I would not support this program because (Please circle one):

a. The amount is too much. I would support it if it cost me $_____ per year. (Please write in the <u>maximum</u> dollar amount you would pay.)

b. The (species) is not worth anything to me.

c. The (species) is important to me, but the money should not come from taxes.

d. The (species) is important to me, but I refuse to put a dollar value on them.

e. Other (Please specify)____

____

Responses (n=305) were then assigned to one of four "bid categories":

1. Absolute zero bid--"species is not worth anything to me"--10% of all bids.
2. Conditional zero bid--"will not pay any amount of money because of income constraint, other financial commitments, etc"--26% of all bids.
3. Protest zero bid--32% of all bids.
4. Positive bid--would pay <u>some</u> amount of money--32% of all bids.

Conditional and protest zero bids were combined, and a multinomial probit analysis was used to examine the nature of the relationship between type of bid, type of wildlife or wildlife management program, individual attitudes, and respondents' socio-economic characteristics. The results in Table 1 are consistent with expectations; individuals who were asked to value bald eagles, who had made an actual donation for wildlife preservation during the previous year, who felt that bald eagles were "very important," and who had more education were more likely to give positive bids. For example, the probability that the average respondent would register a positive bid was .32. This probability increased to .48 for individuals with a college degree, who were asked to value bald eagles, who had donated $100 to wildlife organizations during the previous year, and who felt that bald eagles are "very important".

A potential problem, however, is that protest zero bids represented a significant percentage of total survey responses. Value estimates are therefore likely to be quite sensitive to how these protest zero bids are interpreted and used in the analysis. This problem is quite common. As shown in Table 2, protest zero bids were a large portion of all zero bids in several previous studies.

Table 1
Multinomial Probit: Type of Bid (1989 Survey)

Dependent Variable = 0 if Absolute 0
1 if "Other" 0
2 if Positive Bid

Variable	Estimated Coefficient	T-Ratio
Constant	1.48**	2.42
Bald eagle	.76**	3.15
Coyote control	-.16	.58
Bald eagle and turkey	.26	1.30
Coyote protection	.04	.14
Actual Donation ($)	.002*	1.66
Bald eagle very important	.28*	1.70
Society has more important problems	-.33**	2.02
Age	-.005	.89
Education	.18*	1.69
Income	-.04	.57
N $\leq$ 50	.03	.11
N $\geq$ 75	-.04	.15
MU1	2.58**	13.13

Likelihood Ratio = 40.41 (12 DF)
n = 305
** .05 level
* .10 level

Table 2
Protest Zero Bids in CV: Some Examples

Study	Protest Zero Bids
Desvousges, Smith and McGivney (1983) (Water quality)	50% of all 0 bids
Reiling, et al. (1989) (Black fly control)	24% of all 0 bids
Stevens, et al. (1991) (Wildlife existence; 1989 survey)	47% of all 0 bids
Ferguson (1990) (Nongame wildlife)	27% of all 0 bids
Musser, et al. (1990) (Farmland preservation)	84% of all 0 bids

Protest Zero Bids

There is considerable debate about whether zero protest bids should be included or excluded from the data set.[1] McGuirk, Taylor, and Stephenson (1989) argue that protest zero bids should be considered legitimate zero bids because respondents are assumed to value the proposed policy, not just the good in question. Randall (1986) takes a similar view, arguing that WTP estimates are based not only on the value of the commodity being offered but also on the means by which the good will be provided and the method of payment, so that the valuation of the good cannot be separated from the policy issues associated with its provision. However, since most protest zero bidders appear to actually value the resource, the estimated value of the resource itself will be biased downward if these zero bids are

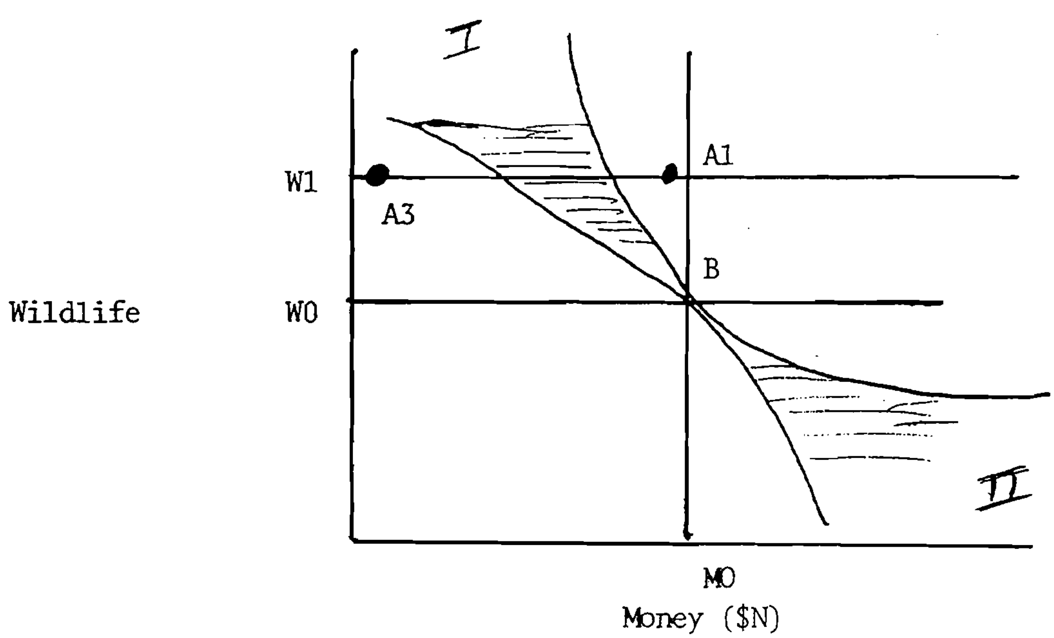
[1] Another problem is that not all protest zero bids may be identified. Some respondents who do not value the resource may be unwilling to state that the resource is actually worth nothing to them.

included in the data. Therefore, protest zero bids are often simply eliminated. This reduces the downward bias caused by including protest zero bids. However, some protest zero bids may be motivated by extreme interest in the resource, and consequently value estimates might also be biased downward if these bids are excluded.

Better information about factors motivating protest zero bids is therefore required. Reasons often cited for protest zero bids include disagreement with the proposed method of payment, ambivalence arising from ethical concerns (about making tradeoffs between money and moral principles), and lack of cognitive ability. Since most decisions about wildlife existence involve ethical considerations, the theory of ambivalence may be particularly relevant for understanding protest zero bids in wildlife existence value studies (Opaluch and Segerson, 1989; Opaluch, 1992; Ready, et.al. 1992).

Consider, for example, the individuals' preferences shown in Figure 1.

Figure 1
"Test" of Ambivalence Theory



Suppose that B represents the baseline condition in which this individual has M0 money and W0 wildlife. Quadrants I an II are of interest because they involve tradeoffs between money and wildlife. Quadrant I represents WTP scenarios while II represents WTA. When confronted with a move from B to A1 this individual prefers A1 because very little money is required for a large increase in wildlife. This individual prefers B to A3 because A3 involves a relatively large amount of money for a relatively small gain in wildlife.

If responding to a dichotomous choice CV, this individual will therefore answer yes to A1 and no to A3. The area between is the so called ambivalence region which arises when this individual is faced with tradeoffs that cannot be readily compared. She may be willing to make "easy" decisions, such as from B to A1 or A3, but when faced with more difficult tradeoffs, she is conflicted, and refuses to make tradeoffs. Even though she values wildlife, she registers a protest zero bid.

A test for ambivalence was conducted by estimating a logit model with the dependent variable equal to 1 if protest zero bid, and 0 otherwise. Independent variables included a set of dummy variables for species (bald eagle, eagle and turkey combined, coyote control, coyote protection), the respondents age, a dummy variable for whether or not the respondent had attended college, income category, a dummy variable for whether or not existence of Bald eagles in New England was "very important" to the individual, and a dummy variable for having made an actual donation for wildlife during the previous year. Two dummy variables were used for the amount of money, N, which had been specified in the contingent valuation question: $N \leq \$50$; $N \geq \$75$.

The results shown in Table 3 indicate presence of an ambivalence region. Individuals were less likely to give protest zero bids for values of N $\leq$ \$50 and for values of N $\geq$ \$75. This finding is important because it suggests that protest zero bids may be motivated by ambivalence about making tradeoffs between money and wildlife, as opposed to lack of interest in the resource.

Table 3
Logit Model: Dependent Variable: 1 if Protest Zero Bid; 0 Otherwise

Variable	Estimated Coefficient	Absolute Value of Asymptotic T-Ratio
Constant	-.04	.04
N $\leq$ \$50	-1.00*	2.42
N $\geq$ \$75	-.83*	2.09
Bald eagle	-.35	.87
Coyote control	-.44	1.09
Bald eagle and turkey combined	-.39	1.00
Coyote protection	-.37	.89
Age	.005	.57
Education (If college)	-.13	.76
Income	.30*	2.47
Bald eagle very important	-.33	1.25
Actual Donation (DV)	-.61*	2.06

Likelihood ratio test = 20.52 (11 df)
Maddala R Square = .07
% Right Prediction = .68
n = 305

Also, it is some interest to note that respondents with higher incomes were more likely to give protest zero bids. This result was not anticipated; previous studies suggest that protest bids are most often given by lower income respondents.[2]

In any case, the problem of what to do with protest zero bids remains. There are two basic choices:

1. Include protest zero bids as valid zero bids (valid zero bids within context of the specified market)
2. Delete protest zero bids.

The decision to include or exclude these protest zero bids is important because the resulting value estimates are quite sensitive to how these bids are treated. The final result depends, in part, on the functional form selected for the WTP function, and on whether the mean or median is used as the measure of economic value.

As shown in Figure 2, when protest zero bids were removed, and when a log form of the WTP function was employed (log of N and income), the median WTP <u>increased</u> from about $7.00 to about $9.00 <u>per person</u>, but the mean <u>decreased</u> from $20 to about $15 <u>per person</u>. If these values are to be aggregated over the population as a whole, the decision about whether protest zero bids should be included or excluded is obviously very important.

Some additional <u>indirect</u> evidence about the monetary value, if any, that protest zero bidders might have for the resource was obtained from an informal analysis of respondents attitudes and actual behavior. For example, as shown in Table 4, 11% of the individuals classified as absolute zero bidders had made an actual donation for wildlife management during the previous year. The average amount donated by this group was $1.67. By way of

[2] The likelihood ratio test (20.52) was significant at the 5% level, but not at the 1% level.

comparison, 49% of those who bid a positive amount had made actual donations, the average being $44. Protest zero bidders tended to fall between these extremes. A similar pattern was observed for the other categories in Table 4, and we therefore suspect that protest zero bidders value the resource, but less so than those WTP. Consequently, if protest zero bids are excluded, value estimates will likely be biased upward, but if they are included as zero bids, the estimated value of the resource itself, is biased downward.

Figure 2
Estimated Willingness To Pay Probability Function

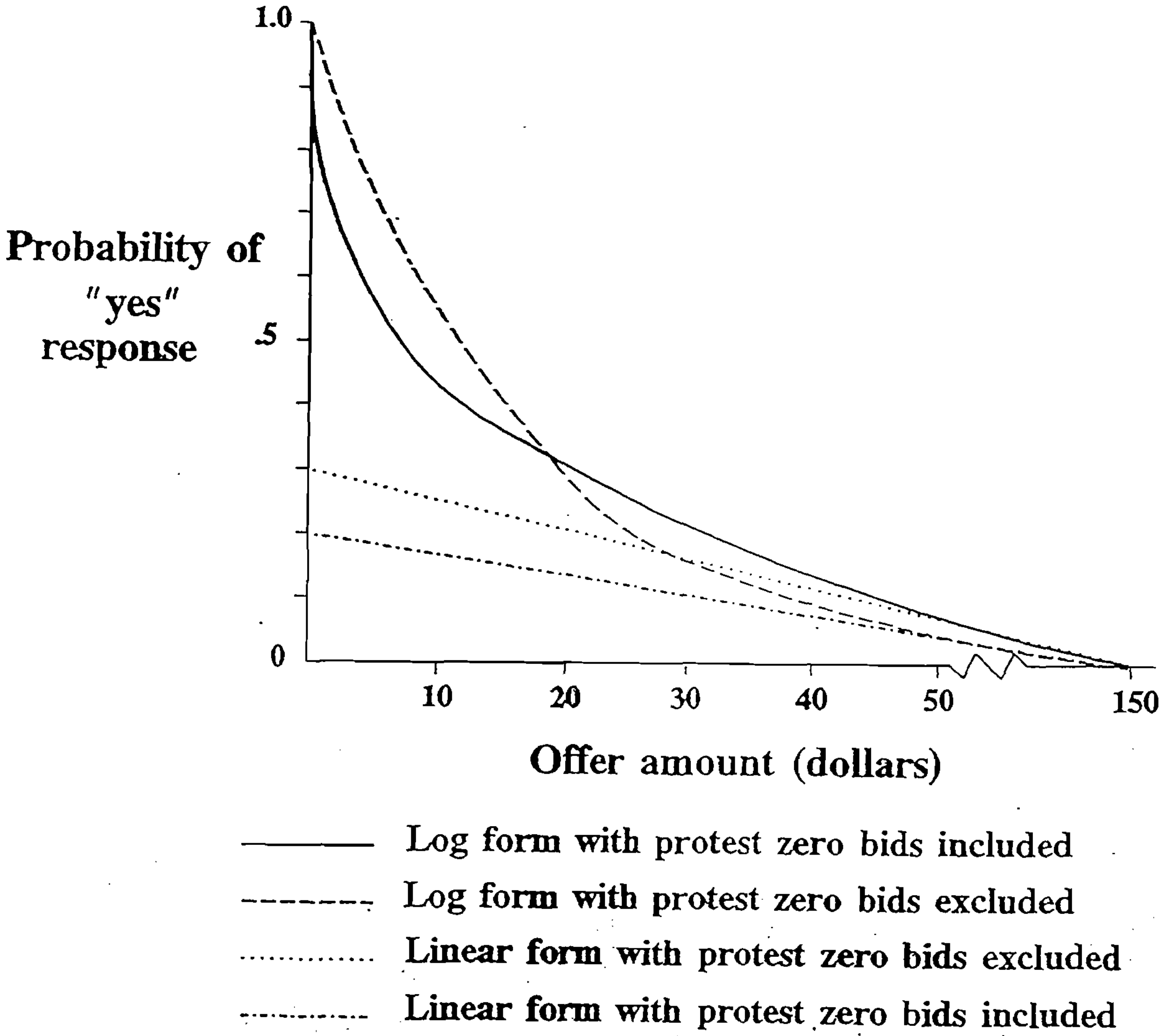


Table 4
Indirect Evidence: "Value" For Resource,
Protest Zero Bidders. 1989 Survey

	TYPE OF BID				
	Absolute Zero	Conditional Zero	Protest Vehicle	Protest Ethical/ Other	Positive Bids
Made Actual Donation Previous Year (%)	11	26	18	36	49
Average Amount Donated $	$1.67	19	5.23	23	44
Bald Eagle very Important (%)	22	53	47	47	63
Strongly agree that society has much more important problems (%)	78	32	44	47	25
Average hypothetical gift for wildlife preservation ($)	$15	78	43	24	79

Positive Bids

The economic theory of social choice suggests there may be several types of positive bids. Some people may be paying for the pleasure derived from existence of the resource itself, but others may be paying for the satisfaction derived from giving to a "good cause", and many may pay their "fair share" as opposed to the value of the resource. This issue was examined in a follow-up survey of all respondents to the 1989 bald eagle, and bald eagle/wild turkey combined valuation question (n=179). The follow-up survey was conducted in January, 1992. It was designed to gather more information about motivations underlying individual responses, and to test for whether or not the 1989 bald eagle results could be replicated.

Respondents to the 1992 follow-up survey (n=85) were asked the following questions about why they would pay to help ensure the existence of bald eagles in New England:

Interpretation of Positive Bids
(1992 Survey)

Q-10. Scientists disagree about how answers to "contingent valuation" questions (like Q-9) should be interpreted. Which of the following best describes why you would pay for bald eagle restoration. (Please circle all that apply.)

1. I WOULD GET PLEASURE FROM KNOWING THAT I HAD CONTRIBUTED TO A GOOD CAUSE.
2. I WOULD PAY BECAUSE I HAVE A DUTY TO DO MY SHARE TO PROTECT WILDLIFE.
3. I WOULD GET PLEASURE FROM KNOWING THAT BALD EAGLES WOULD CONTINUE TO EXIST IN NEW ENGLAND.
4. OTHER (Please specify) ____________________

____

Q-11. If you circled more than one answer to question 10, which one best describes why you would pay? (Please place the number from question 10 in the box below.)

☐

Q-12. Which of the following factors did you consider in deciding how much you would pay for bald eagle restoration. (Please circle all that apply.)

1. CONCERN ABOUT DOING MY "FAIR SHARE" TO HELP PRESERVE AND PROTECT WILDLIFE.

2. CONCERN ABOUT WHETHER OR NOT OTHER PEOPLE WOULD SUPPORT THIS PROGRAM.

3. HOUSEHOLD INCOME AND OTHER FINANCIAL COMMITMENTS.

4. UNCERTAINTY ABOUT WHETHER OR NOT THE RESTORATION PROGRAM WILL ACTUALLY WORK.

5. CONCERN ABOUT ENVIRONMENTAL QUALITY IN GENERAL.

6. UNCERTAINTY ABOUT FUTURE FINANCIAL SITUATION.

7. OTHER (Please specify) ______________________________

____

The total 1992 bid was $1993. The average bid was $23.45 per person which compares favorable with the average 1989 bid of $17.30 per person. Twelve percent of the 1992 total bid was classified as payment for contributing to a good cause, 40% was classified as payment to fulfill a duty to help protect wildlife, 40% was for the pleasure derived from knowledge that bald eagles would continue to exist in New England, and 8% was for other reasons.

Concern about doing "my fair share" was ranked by 11% of respondents as the most important factor considered in deciding how much to pay, but this 11% comprised 34% of the total bid. Concern about environmental quality in general was the most important factor considered by only 7% of respondents, but this 7% gave 22% of the total amount bid.

Positive bids must therefore be interpreted carefully. Payment of fair share might be interpreted as a lower bound estimate of resource value. However, payment for a "good cause" may provide little or no indication of the economic value of the resource itself. In fact, the "cause" itself may not really matter.

Conclusions

Our principle concern is that existence value bids may be misunderstood. Previous studies suggests that zero bids often represent something other than zero valuation. Protest zero bids to the case study reported here appear to be related to ambivalence, and indirect evidence suggests that these protest zero bidders actually value the resource, but that this value is generally less than that associated with individuals who are WTP. The usual practice of eliminating protest zero bids will therefore bias aggregate value estimates upward.

A more fundamental issue concerns interpretation of positive bids. The various theories of social choice indicate that respondents may be paying their fair share or for the satisfaction of contributing to a good cause, as opposed to the value of the resource itself. The evidence presented here tends to support this hypothesis. Although our results are for one case study only, we believe that unless motivations underlying CV response are identified, existence value estimates will often be misleading. Although payment of fair share may represent a lower bound estimate of resource value, payment for a good cause may have little or no relationship to the economic value of the resource being considered.

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Ethical Principles and Personal Preferences as Determinants of Nonuse Values: Implications for Natural Resource Damage Assessments

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Abstract

Nonuse values are frequently motivated by moral or ethical considerations, rather than personal benefits. To the extent that individuals reject the notion of making tradeoffs between ethical priniciples and personal benefits, the fundamental basis for economic value is violated. Thus, nonuse values may not be consistent with economic definitions of value, and it may not be possible to express nonuse values in monetary terms. Under these conditions we may do better by focussing policy on efforts to determine appropriate level of in kind compensation, through natural resource restoration, rather than attepting to derive monetary measures of compensation.

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Ethical Principles and Personal Preferences as Determinants of Nonuse Values: Implications for Natural Resource Damage Assessments

I. Introduction

Various social actions reveal values that transcend direct use values. Nonuse values are revealed, for example, in the Endangered Species Act, the Marine Mammals Protection Act, and the preservation of vast tracts of public land in National Wildlife Refuges, among many other social actions. Economists since Krutilla (1967) have recognized and explored nonuse values within the neoclassical paradigm. Krutilla's seminal contribution served as the intellectual catalyst for a vast literature dealing with nonuse value, as well as such topics as option value (e.g., Schmalensee, 1972; Graham, 1981; Bishop, 1982; Freeman, 1984) and quasi-option value (Arrow and Fisher, 1974; Conrad, 1979). This literature has played a valuable role in the public policy debate regarding preservation-development issues, and now it is a subject of major interest in *ex post* assessments of natural resource damages.

In recent years, the concept of nonuse value has been refined (e.g., McConnell, 1983; Randall and Stoll, 1983; Randall, 1987; Smith, 1987, 1990; Freeman, forthcoming). The recent conceptual literature provides an important contribution in that it attempts to more rigorously define nonuse value in the context of the neoclassical framework, while the efforts in the contingent valuation area have synthesized the state of the art for tools that attempt to measure value.

At the same time, a significant and growing literature disputes whether the utility-theoretic paradigm truly encompasses all dimensions of nonuse values (Sen, 1973; Kennett, 1980; Sagoff, 1981, 1988; Opaluch, 1984; Edwards, 1986, 1992; Brookshire, Eubanks and Sorg, 1987; Gregory and McDaniels, 1987; Opaluch and Segerson, 1989; Harris, Driver and McLaughlin, 1989; Stevens et al., 1991; Kahneman and Knetsch, 1992a, 1992b; Boyce et al., 1991). In aggregate, these criticisms have led some to question whether the neoclassical interpretation of nonuse value is conceptually appropriate for natural resource damage assessments.

This issue is critical for any analysis of the legal-economic foundation of natural resource damage assessments. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and the Oil Pollution Act of 1990 provide liability for damages which is compensatory, not punitive. The compensatory nature of damages readily lends itself to casting damages in terms of the standard Hicksian measures of welfare (McConnell, 1990). However, if motivations for nonuse values and/or responses to CV surveys are inconsistent with the neoclassical paradigm, then statements regarding hypothetical willingness to pay in response to a contingent valuation survey may be inconsistent with the notion of Hicksian compensation, so that neoclassical welfare theory may not be adequate for framing issues regarding compensation for natural resource damages.

These are fundamental issues posed by philosophers, psychologists, anthropologists, sociologists, public decision makers and economists. We believe it is a mistake to dismiss these fundamental issues out of hand without careful evaluation. Hence, this challenge should provoke a broad-minded appraisal of the neoclassical paradigm for nonuse values, rather than a narrow, defensive reaction. We as a profession have an obligation to carry out this kind of carefully considered evaluation prior to bringing nonuse values into the courtroom as evidence. This assessment must consider both the concept of nonuse value and the state of the art in its measurement. Research efforts in these directions may allow us to extend the neoclassical model in a fundamental dimension and may result in a forging of closer linkages with other social science disciplines (Peterson, Driver and Gregory, 1987; Harris, Driver, and McLaughlin, 1989).

Few fields of economics have been subject to the level of criticism and self evaluation as has welfare economics. Almost from its inception, the field has been questioned with respect to its theoretical basis or its practical relevance (Robbins, 1935; Little, 1950; Lipsey and Lancaster, 1956; Graaf, 1957; Samuelson, 1965). Yet, welfare economics has flourished despite, or perhaps because of, the controversy and nearly continuous fundamental challenges (Krutilla, 1981). This persistence is indicative of the critical importance of the field for analyses of major social policy issues and the difficulty of the challenges faced in measuring value. Only by questioning its fundamental basis have we been able to achieve essential advances within the welfare paradigm.

This paper follows an established tradition of self evaluation of welfare economics, in an attempt to contribute to debate regarding the concept and measurement of nonuse value and the appropriateness of monetary measures of nonuse value within the context of natural resource damage assessments. In practice, issues regarding nonuse values are not easily severed from issues regarding the Contingent Valuation Method (CVM) because CVM has been applied in attempts to measure nonuse values. Hence, we also place a major focus on issues regarding measurement of nonuse values with CVM.

We are mindful that some of the arguments made may apply to use value, in addition to nonuse value. However, the issues discussed in this paper are likely to be especially important for nonuse values, since these values are much more likely to be dominated by ethical concerns, while generally, use values are more likely to be dominated by personal benefits. Similarly, although the arguments may be appropriate for actual behavior, they are likely to be most significant for responses to hypothetical questions, such as those in CV surveys applied to nonuse values, since respondents are not required to face the consequences of their answers. Moreover, these types of surveys frequently present situations and/or commodities that are unfamiliar to the respondent and with which respondents often have had little or no prior decision making experience. Together these imply that the formation and measurement of crystallized nonuse values may be seriously hindered by an absence of repeated decision making and experience with the consequences of those decisions.

The paper is organized as follows. Section II provides a brief review of literature regarding ethical values and nonuse values. Section III discusses some implications of this literature for compensating for natural resource damages. Summary and concluding comments are presented in Section IV.

II. Ethical Values and Personal Preferences

Through most of its history, the notion of Hicksian compensation was applied to evaluate welfare effects of changes in market price or changes in quantities of market goods (Hicks, 1943; Currie, Murphy and Schmitz, 1971; Hausman, 1981). More recent applications of Hicksian compensation have extended the concept to measure values of nonmarket goods, including nonuse values (e.g., Brookshire, Eubanks and Randall, 1983; Stoll and Johnson, 1984; Boyle and Bishop, 1988).

Only in exceptional cases are ethical issues likely to be significant for evaluating welfare effects of changes in market prices or changes in quantities of market goods. Hence, for traditional welfare analyses, ethical values may not be a primary concern. However, ethical issues may be of paramount importance in motivations of nonuse values. Nevertheless, the application of Hicksian welfare measures to nonuse values has proceeded without a thorough examination of the potential significance of ethical concerns, with notable exceptions, some of which are discussed below.

Many have argued that utility theory may not be appropriate for framing issues with important ethical dimensions due to the fact that ethical values and personal preferences may be fundamentally incongruous (for example, Jeffrey, 1974; Sagoff, 1981, 1988; Opaluch, 1984; Brookshire, Eubanks and Sorg, 1987; Gregory and McDaniels, 1987; Opaluch and Segerson, 1989). In contrast, most economic analyses view social values as being merely an aggregation of the personal preferences of individuals, so that there is no fundamental distinction between an individual's ethical values, such as those concerning justice, and preferences for market goods, such as a hamburger or a shirt.

In practice, however, economic analyses focus almost exclusively upon decisions regarding commodities, and ignore ethical dimensions of behavior. Yet, ethical values can be important motivators of behavior in many instances, and in particular, for responses to hypothetical questions regarding natural resources subject to environmental damages.

The presence of an ethical motivation of behavior may have important implications for the interpretation of responses to CVM surveys that attempt to measure nonuse value. In particular, individuals frequently maintain that it is inappropriate to accept financial gain in exchange for compromising their moral principles. The fundamental basis for economic value is violated to the extent that individuals reject the notion of basing decisions trading off their moral principles for personal gain. When this is true, WTP responses to CVM surveys must represent something other than the monetary equivalent of an ethical value, as the notion of Hicksian surplus is inappropriate when individuals reject the implicit balancing of ethical values and personal preferences.

Individuals expressing a willingness to pay to prevent an environmental loss may be reflecting their personal preferences for the resource concerned, ethical considerations, or a combination of the two. If ethical values as motivations for behavior are not properly explained by the neoclassical model, then values that are revealed in CVM surveys may not be consistent with the neoclassical concept of value, defined in the standard terms of monetary compensation required to maintain indifference. Rather, there may be a fundamental divergence between certain social values, which may be ethically driven, and economic values, measured as Hicksian compensation, which are driven by personal preferences. In such cases, it may not be appropriate to interpret CVM results as a measure of economic value, congruent to personal preferences.

Increasingly, economists are questioning whether the neoclassical model fully explains all motivations for social value, and whether ethical values are fundamentally congruous with economic values, defined as Hicksian measures of compensation. Sen (1977), for example, extends economic definitions of value. His work distinguishes between the motivations of sympathy and commitment. Sympathy arises when an individual's utility depends upon the utility (or consumption) of another. This is consistent with the traditional neoclassical paradigm including external effects, whereby the utility of one individual enters the utility function of another. Sen's view of sympathy might be consistent with vicarious consumption and, perhaps, bequest value (Randall and Stoll, 1983; Brookshire Eubanks and Sorg, 1987).

Similarly, the concept is analogous to that of "impure altruism", where an individual is motivated to help others because of the utility obtained by doing so. This motivation may be related, in part, to the notion of the "warm glow of moral satisfaction" one gets from doing right, or giving to a good cause (Kahneman and Knetsch, 1992a, 1992b), but does not necessarily reflect personal benefits obtained from a specific commodity in question.

Although impure altruism measures a form of personal benefit, it actually reflects the value of *doing* good, not the value derived *from* the good. Hence, without taking great care to identify the underlying motivation for responses, a CV survey can easily misinterpret the satisfaction obtained from contributing to a good cause as benefits associated with the specific commodity being described. The former may reflect willingness to pay one's "fair share", or satisfaction obtained from helping out, while the latter must focus specifically on the use and nonuse benefits obtained from the commodity in question, and must not be related to the instrument used to obtain that commodity.

This problem may be magnified in the case of hypothetical surveys, as there is a danger that an individual might also obtain utility merely from making statements that affirm the importance of a cause. Thus, individuals may obtain utility directly from making the statement that they would sacrifice for a good cause. Since no actual sacrifice is required at the time a survey is administered, there is little incentive for discipline.

Furthermore, there is a danger that responses may not reflect actual or intended behavior, particularly when the survey focusses on a controversial subject, such as an oil spill or another dramatic environmental incident. Instead, respondents may view the survey as an opportunity to express their attitudes regarding the controversial subject, rather than the value ascribed to the specific commodity impacted. In this case their response may be a symbol reflecting the controversy, rather then an estimate of the actual willingness to pay for the specific commodity in question (see, for example, Mitchell and Carson, 1989, page 249-250).

Hence, the concept of sympathy may imply that responses to CV surveys reflect the value of "doing good", rather than the value of having the good. "Doing good" may even be a mere statement of support for something that is viewed as a good cause, with no *actual* sacrifice implied nor required. When this is an important motivation for statements regarding hypothetical WTP in a CV survey, it is inappropriate to interpret the results as a measure of Hicksian compensation associated with the good in question.

In contrast to Sen's definition of sympathy, commitment arises when one makes oneself unambiguously worse off because one feels committed to the issue in question. In this case, actions by an individual may be motivated not by self interest, but rather by this feeling of commitment to doing what is right, independent of its effect on the individual's utility. This is analogous to the concept of "pure altruism", whereby the individual is motivated to do right, independent of *any* personal benefit obtained, including the feeling of moral satisfaction. To the extent that individuals are motivated by doing what is right and not by personal preferences, WTP may be inconsistent with the notion of Hicksian compensation, in the sense of holding personal utility constant.

For example, an animal rights activist--and, indeed, many with far less extreme views--will reject the anthropocentric concept of value, and will argue that wildlife has a right to exist, independent of any value to humans, including human-determined nonuse values. Thus, from this viewpoint the levels of use and nonuse values held by humans for particular species may be irrelevant for determining WTP for wildlife preservation. Rather, humans may be viewed as having a moral obligation to avoid violating the rights of others, including nonhuman species.

In the context of preventing loss of wildlife, individuals may be willing to contribute to protection of wildlife stocks, not because they personally benefit, but rather because they feel a moral commitment towards protecting the wildlife, independent of any value to humans. In this case, the value is viewed as being truly intrinsic, and is not derived by humans. This implies that if wildlife populations are reduced, compensating humans is not an appropriate remedy, since humans were not injured. Rather, it is the wildlife themselves that are the victims. In this case, the hypothetical willingness to pay stated by CVM respondents includes their moral commitment to wildlife, and not only their personal benefit received from wildlife.

An important implication of this argument is that if ethical motivations are important, there may be a fundamental conceptual asymmetry between willingness to pay and willingness to accept compensation. It may be completely appropriate to make a personal sacrifice in order to protect wildlife stocks. However, it may be unethical and illegitimate to benefit personally in the form of compensatory payments in exchange for a reduction in wildlife stocks. For example, it is illegal for someone who knows of legal wrongdoing to accept payment in exchange for remaining silent. Yet in a real sense, this is exactly what happens under neoclassical definitions of compensation for injury to wildlife, if wildlife values are, in fact, driven by ethical values, rather than personal preferences. Indeed, this may provide a distinction between compensation and bribery. Compensation occurs when payment is made for a loss in personal preferences, while bribery occurs when payment is made for a violation of ethical values. Small wonder why decision makers and the public at large often view economic concepts of expressing environmental values in monetary terms as inappropriate and even immoral.

This implies that willingness to pay to avoid loss of wildlife may include both personal benefits foregone when wildlife populations are reduced, plus a personal sacrifice to maintain the rights of wildlife. However, willingness to accept may be ill behaved because respondents may view the question of how much they should be compensated for reductions in wildlife as being irrelevant and morally offensive. That is, if respondents view wildlife as being the "victim", then compensating people for remaining silent is akin to bribery, and will not be viewed as morally appropriate.

It could be argued that the ethical considerations described above could be addressed within the neoclassical framework simply by allowing a sufficiently broad definition of utility, whereby ethical values or moral commitments are included as a components in the individual's utility function. Hence, individuals may make tradeoffs between their ethics and their personal welfare, just as they do among ordinary market goods.

However, many would argue that most individuals do not, in fact, view the world in that way, since in the extreme, it implies that potential demand and reservation prices exist for all kinds of morally reprehensible and illegal behavior. Rather, it is frequently argued that individuals' view of justice or morality is incongruous with personal preferences and that this is reflected in their value systems and as well as their behavior (Opaluch, 1984; Opaluch and Segerson, 1989; Opaluch and Grigalunas, 1992). If we accept the notion of consumer sovereignty, then we must accept the commonly stated position that it is socially inappropriate to compromise one's moral principles for financial gain. This rejection of tradeoffs as the motivation for decision making reflects the common assertion of the incongruity of personal preferences and moral values, which violates the fundamental basis of economic value.

The distinction between bribery and compensation may provide important insights into the results of CVM surveys when an ethical dimension is present. The appropriate level of personal compensation to the individual is the amount required to return the individual to the initial level of personal welfare. However, WTP may include both the gain in personal welfare and the individual's ethical commitment to wildlife. If statements regarding hypothetical WTP reflect ethical values, in whole or in part, then CVM will overstate required personal compensation, as defined above. It may be inappropriate to compensate individuals for the ethical component, as this is akin to bribery. Hence, to the extent that stated WTP reflects an ethical commitment, it is not an appropriate measure of Hicksian surplus. However, the aggregate personal compensation may be insufficient to compensate society as a whole, as discussed below.

This distinction between compensation and bribery may also help to explain an observed divergence between WTP and WTA, as well as the frequently observed, ill-behaved nature of WTA. When asked WTP questions, respondents may provide an apparently well behaved response that reflects both the gains in personal welfare, and their ethical commitment wildlife, such as a commitment to avoiding human caused harms. WTP, while not a measure of Hicksian surplus, may be viewed as "legitimate" since it is perfectly appropriate, and even noble, to sacrifice personal benefits for carrying out moral actions. However, when asked WTA, respondents are likely to protest or give very large, perhaps infinite values, since they are being asked, in effect, how much they would have to be bribed to violate their moral principles. This again reflects the notion that monetary compensation to the individual is viewed as an inappropriate remedy for damages, because the individual was not personally injured. Instead, wildlife is the "victim" and accepting payment for an injury to others may be viewed as morally inappropriate.

If individuals are motivated simultaneously by ethical values and personal preferences, and if individuals view these as incongruous, there may be very important implications for attempts to measure nonuse value as part of natural resource damage assessments. The traditional framework may be inappropriate for both normative and positive purposes, as the incongruous nature of ethical values and personal preferences will be revealed both in behavior and in underlying value systems.

Commitment may also arise from a holistic view of systems, and a perceived moral obligation to maintaining the larger system. For example, environmentalists may believe that everything is interconnected, so that one cannot predict the ultimate consequences of an incident. This may lead the individual to reject even a carefully specified damage scenario in favor of more extensive, but only vaguely defined impact to the larger environmental system. In such a case, one may justify an extraordinary commitment to apparently minor environmental commodities, because they are viewed as integral parts of a greater whole that will suffer in some unknown, perhaps catastrophic way from an accumulation of impacts.

Here, the individual does not carry out an internal benefit-cost analysis for each incremental action, since the ultimate consequences are viewed as a completely unpredictable result of an accumulation of effects. Rather, the individual makes a commitment to protect each component, perhaps well beyond any apparent incremental value. This reflects a rejection of the reductionism that is implicit in the notion that one can value changes in individual environmental commodities, with "all else held fixed". In contrast, this model considers everything as being interconnected, and uncertainty of the ultimate consequences of an action is viewed by the respondent as so pervasive that the individual rejects the scenario of changing the level of specific environmental commodities without other effects. In the extreme, this may lead to the expression of the lexicographic attitude that each component of the environment must be preserved "at all costs", as a form of decision heuristic to deal with what is viewed as overwhelming uncertainty.

Within the context of natural resource damage assessments, this rejection of reductionism implies that respondents may state that they hypothetically would pay substantial sums of money to avoid even minor injuries to natural resources, because they believe that the ultimate injury to the environmental system as a whole is more far reaching than that described in the scenario, which respondents may view as considering only the readily identifiable injury to individual part(s). This is a form of inconsistent interpretation of the scenario, whereby the researcher provides a specific description of injury, but the respondent rejects the scenario in the belief that there are other, more extensive damages that cannot be precisely determined. It is critical to identify whether respondents accept that impacts are restricted to only those items specifically described in the scenario, as a preliminary step towards evaluating the meaning of the results of a CV survey.

III. Implications for Natural Resource Damage Assessments

The arguments presented above suggest that considerable caution must be given to the interpretation of the results of CVM studies of nonuse value in natural resource damage assessments. At a minimum, what is called for is a systematic probing of individuals' motivations for decisions when providing WTP responses. Responses cannot be interpreted as a measure of Hicksian compensation to the extent responses to open-ended questions reveal, for example, that the respondent has important ethical motivations, rejects the reductionist framework or otherwise makes decisions that are not based on tradeoffs, which are fundamental to the economic definition of value (See, for example, Schkade and Payne, 1992).

When these issues are important, monetary compensation may not be an appropriate remedy for losses with respect to ethical values; yet losses with respect to personal preferences only may be appropriate compensation for individuals, but may be insufficient from a larger social perspective. Hence, it may not be possible, even in theory, to measure appropriate levels of monetary compensation for natural resource injury when ethical values are important.

Thus, developing pure monetary measures of compensation may not be the best focus for natural resource damage assessments. Instead, our efforts at determining appropriate remedies for environmental impacts may better be focussed on determining appropriate actions to restore or enhance environmental amenities in order to maintain a portfolio of environmental assets (Smith, 1992b). Restoration of amenities directly addresses the ethical concerns, rather then attempting to translate the ethical components into monetary equivalents. This is likely to be a framework that individuals find more natural and ethically acceptable (Gregory and McDaniel, 1988; Opaluch et al., 1991), as opposed to attempting to identify monetary measures of compensation. Measuring monetary compensation is difficult or perhaps even impossible if ethical values and personal preferences are truly incongruous, such that the economic notion of tradeoffs between moral values and financial gain are viewed by the public as inappropriate.

This is also consistent with the Ohio Decision in its interpretation of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), that places primacy on restoration and with the damage assessment provisions of the Oil Pollution Act of 1990 (OPA '90), that focuses primarily on replacement, restoration, rehabilitation or acquisition of the equivalent, rather than providing monetary compensation. Furthermore, this is consistent with the requirement that *all* monetary compensation collected under CERCLA or OPA '90, including compensation for interim lost values, be used to "replace, restore, rehabilitate or acquire the equivalent" natural resources.

However, determining appropriate restoration is not at all straightforward. A naive view of restoration reduces the issue to a technical one of determining the actions that are necessary to return the environment to the pre-spill state. However, this view is not appropriate for several reasons. First, natural resource systems are not static, deterministic systems, but rather dynamic and stochastic. With few exceptions, random variations in wildlife populations are orders of magnitude larger than spill mortality, so it may be difficult or impossible to determine precisely how much restoration to undertake or when the system is restored.

Secondly, in many cases, artificial actions to enhance restoration of the environment will not be effective, technically feasible or desirable (see, for example, National Academy of Sciences, 1992). Natural restoration processes are often far more effective than artificial attempts at restoration. For example, when oil impacts wetlands, it is generally accepted that more harm is done by clean up efforts than is done by allowing the oil to degrade naturally. Also, wildlife enhancement beyond natural recovery may not be desirable, since food supplies, nesting habitat, etc. may not be sufficient to support wildlife populations beyond natural recovery. In many cases the most effective means of using available funds is to protect habitat, rather than attempting to replace lost wildlife populations. However, it is not straightforward to determine the appropriate amount of habitat to protect, since the relationship between habitat and populations are not generally known with any precision. Furthermore, habitat protection will generally provide a suite of services, beyond support for the specific population(s) of immediate concern for restoration; substitute and complementary relationships may be at work; and so forth.

Thus, we are in a circumstance where the importance of ethical values in many situations points towards actions to restore natural resources, rather than providing monetary compensation for lost values to humans. However, in most cases it is impractical or even undesirable to define restoration as returning the precise resources to the "without spill" level.

To date, there is little specific guidance for appropriate restoration actions or for the correct levels of those actions. For example, the April 29 Notice of Proposed Rulemaking (NPR) from US Department of the Interior (Federal Register, 1991) provides no explicit standard to be met by trustees in making restoration action decisions. Trustees are required to consider multiple factors--ten are listed in the NPR. Moreover, these are minimum factors to be considered "among other things", and the various restoration alternatives may balance these factors in different ways. According to the NPR:

> "In practice, the [restoration] alternative suggested by the trustee as the most appropriate might not satisfy all of the considerations, yet still be 'correct' for the purposes of the assessment. The trustee, after considering all the relevant factors, may make a selection that gives greater weight to some factors over others. The trustee is required to explain .... the reasoning for giving greater weight to certain factors than others." (p.19757)

The NPR specifically does not ask that Trustees do a straight benefit-cost analysis to assess whether restoration actions are grossly disproportionate, as suggested in the Ohio Decision. Rather, they are to consider various factors, which "...when considered together, would encompass the 'grossly disproportionate' determination suggested by the court" (p. 19758). Thus, the NPR provides scant guidance concerning when restoration is appropriate, what are appropriate restoration actions, and what are the appropriate levels of the actions.

Once we recognize that restoration actions are not generally defined in terms of replacing the exact resources injured, we need to develop methods to determine the type and level of restoration activities that are most appropriate. For example, restoration actions frequently substitute one vector of environmental amenities for another. In cases where impacts on fish are significant, proposed restoration may take the form of stabilizing river banks or protecting nursery grounds, such as wetlands. However, given that wetlands provide a suite of environmental services, it is unclear what is the appropriate level of wetlands protection to compensate for a given level of mortality to fish.

Part of this issue is clearly a scientific relationship concerning the level of wildlife population supported by a given size habitat. However, wetlands also provide other environmental services, such as recreation opportunities, open space and habitat for other species that may not have been impacted by the spill. Thus, the choice among alternative restoration options needs to extend beyond purely scientific judgement concerning the biological effects of various restoration options. Rather, we must consider the entire suite of services provided by that habitat when determining the appropriate level of habitat that compensates for a given biological injury. The appropriate level of habitat restoration must consider tradeoffs between the various services provided.

IV. Summary and Conclusions

The purpose of this paper is to contribute to the ongoing debate concerning the meaning and measurement of nonuse value in natural resource damage assessments. For the purposes of this paper, personal preferences are defined as self interest regarding how the individual benefits from alternative states of the world. In contrast, ethical values are defined as how the individual thinks the world "ought" to be, independent of whether the individual benefits personally.

We argue that for applications where nonuse issues are of primary importance, values are far more likely to be motivated by ethical concerns, as compared to applications where use value is the sole issue. Also, when hypothetical surveys are used to attempt to measure values, individuals may provide symbolic responses of how the world "ought" to be, particularly when surveys focus on controversial subjects (Mitchell and Carson, 1989), like oil spills or other dramatic events. Hence, our paper is primarily concerned with the concept of nonuse value and its measurement in monetary terms with CVM. We argue that it may not be possible to quantify nonuse values in monetary terms under certain circumstances, even in theory.

It is often argued that individuals view ethical values and personal preferences as fundamentally incongruous, so that individuals may be unwilling or unable to make tradeoffs between personal benefits and moral obligations. This may be true because these values are truly incongruous, as in the case when individuals reject the notion of trading moral principles for personal gain as a basis for decision making. Alternatively, individuals may be unable to make tradeoffs merely because they have not had sufficient decision making experience, so that individuals would make economic tradeoffs if only they had enough experience and feedback. However, individuals are unlikely to obtain sufficient experience with making these sorts of decisions and facing their consequences. Hence, either case implies that responses may not be based on tradeoffs, which are the fundamental basis of economic values, such as Hicksian surplus. Since acceptable tradeoffs may not exist or may not be crystallized, attempts to measure well defined nonuse values in monetary terms are likely to be frustrated. If this is true, economists may need to rethink the concepts and measurement of nonuse values.

These issues have important implications for natural resource damage assessments regarding nonuse values. Incongruity of ethical values and personal preferences may result in inherent deviations between willingness to pay (WTP) and appropriate levels of monetary compensation. If individuals' responses to WTP questions on CVM surveys include both personal preferences and ethical values, then WTP may reflect both personal welfare and personal sacrifice in order to do what is right.

Financial compensation for losses in ethical values may be viewed as improper if individuals deem it inappropriate to accept personal benefits in exchange for violations of moral principles, since the losses in ethical values are not personal losses to the individual, but rather represent a deviation from how the world "ought" to be. Under these circumstances, WTP may overstate the appropriate level of personal compensation, since monetary compensation will not be an appropriate remedy for losses in ethical values. Rather, other means may be required to compensate for losses in ethical values, as discussed below.

Furthermore, incongruity of ethical values and personal preferences may imply a fundamental asymmetry between willingness to pay (WTP) and willingness to accept (WTA). WTP will tend to comprise personal gains plus an acceptable sacrifice of personal benefits for moral commitments. In contrast, WTA is akin to asking the individual how much they would have to be paid to violate their moral principles--a bribe--and thus will not be ethically symmetric to WTP. That is, it is morally acceptable--even noble--to make a personal sacrifice to do right. However, it is immoral, illegitimate, and often illegal to obtain personal benefits in exchange for a violation of moral principles.

This fundamental asymmetry is consistent with frequently observed empirical findings of large disparities between WTP and WTA, with the commonly observed phenomenon of widespread protests to WTA questions and with explicit statements made by the public. Together, this suggests that neither WTP nor WTA is an appropriate measure of compensation in natural resource damage assessments if nonuse values are ethically motivated and if ethical values and personal preferences are incongruous.

A clear implication of the line of argument presented in this paper is that researchers attempting to estimate nonuse values using CVM should probe motivations for responses, using open-ended questions among other means. We have suggested that, at a minimum, such probing should be directed at the importance of an ethical or moral motivation, the extent to which respondents reject reductionism and the degree to which they are unwilling to make tradeoffs that are fundamental to economic decision making that is implicitly assumed by CVM.

To the extent that personal benefits are not an appropriate remedy for nonuse losses, economists must place a greater emphasis on determining appropriate actions "to replace, restore, rehabilitate or acquire the equivalent" natural resources. This provides a basis for compensation to the overall environmental system which may directly address the issues of moral standards and obligations.

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EMPIRICAL EVIDENCE ON THE SIGN AND SIZE OF OPTION VALUE

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The concept of option value, defined as the difference between option price and expected consumer surplus, has experienced a nearly continuous barrage of theoretical propositions, refutations of these propositions, and summary statements since the seminal article by Weisbrod (1964). In 1984 Freeman noted that "a lot of ink has been spilled on the option value question" (p.1), and we propose that this statement also holds for the subsequent eight years. This burgeoning theoretical literature has contributed substantially to the conceptual notion of option value.

Noticeably missing from the option value literature are empirical studies which provide tangible evidence as to whether the theoretical propositions are, in fact, appropriate descriptions of a real world phenomena. To our knowledge, there are only a handful of studies, in peer reviewed journals, that attempt to estimate option value (Greenley, Walsh and Young, 1981; Sanders, Walsh and Loomis, 1990; Smith, Desvousges and Fisher, 1983; Sutherland and Walsh, 1985; and Walsh, Loomis and Gilliam, 1984). The reasons for this deficiency are two fold. As was clearly demonstrated in the lucid review articles by Bishop (1982) and Smith (1983), option value is a theoretical construct representing the difference between <u>ex ante</u> and <u>ex post</u> measures of Hicksian surplus. Option value does not represent a held value arising from arguments in an individuals utility function. Given this definition and the fact that the primary impetus for the option-value literature has been to consider the role of option value when estimating nonmarket values, intuition clearly suggests that the estimation of option value may be difficult at best. Given this intuition, the second reason for not estimating option value directly is the proposition that the relevant empirical concept is option price (Bishop, 1982; Brookshire, Eubanks and Randall, 1983; and Randall, 1988). In turn, the trend has been to simply estimate option prices and avoid the messy theoretical and empirical issues associated with option value (Desvousges, Smith and Fisher, 1987; and Edwards, 1988).

Despite the focus of the theoretical and empirical literature, we paraphrase Freeman (1984a) to assert that "the question of (option value) is still of some interest" (p.1). For example, the most recent debate in the literature is whether option price is the appropriate welfare estimator for benefit-cost analyses under conditions of uncertainty (Graham, 1981 and 1984; Cory and Saliba, 1987; Freeman, 1991; Mendelsohn and Strang, 1984; Ready, 1991; and Smith, 1990). In a recent contribution to this debate, Meier and Randall (1991) proposed that the appropriate welfare estimator is "option price where compensation is limited to state-independent payments and insurance is unavailable" (p.379). Under these conditions it is reasonable to assume that for some valuation issues the only value estimates available may be ex post, from a travel-cost model perhaps. If the probabilities of potential states of the world are known, it is possible to compute expected consumer surplus. In the absence of information regarding the size and sign of option value, it is impossible to know the magnitude by which expected consumer surplus has overstated or understated option price.

Furthermore, the topical issue of conducting credible benefit transfers, where existing value estimates are transferred (used) to a new policy application, suggest another motivation for learning more about the sign and size of option value (Boyle and Bergstrom, 1992; Smith, 1992).[1] The logical question for conducting benefit-transfer studies is whether relevant value estimates exist in the "library" of existing studies. In the absence of a perfect match, the practical question is whether the existing estimates can be appropriately modified to fit the current need. It is quite reasonable to expect that knowledge of the sign and size of option value under selected conditions would facilitate the transfer of existing value estimates to the new study site.

The objective of the research reported is to estimate option value under conditions of supply uncertainty and demand certainty. This is done in the

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[1]A specific transfer application is the U.S. Forest Service's development of "RPA" values (Anonymous, 1990).

context of moose hunting in Maine where hunting permits are rationed by a lottery and the hunters we surveyed, those participating in the lottery, have certain demands for moose hunting. The results demonstrate a defensible procedure for estimating option value via contingent valuation, and extend the empirical literature on the sign and size of option value.

PREVIOUS RESEARCH

In this section we will not reiterate all of the findings from the extensive literature on option value. Rather our objective is simply to characterize the general theme of the literature to establish the context of our research. Given the empirical focus of our work, we will go into a little more detail when reviewing the empirical studies than we will for the numerous theoretical contributions.

Theoretical Contributions

The theoretical literature on option value can reasonably be divided into three chapters. The first chapter, as one might expect, opens with Weisbrod's (1964) initial conception of option value and closes with the summary articles by Bishop (1982) and Smith (1983). The focus of the literature over these 20 years was to establish the theoretical definition of option value and to begin to draw implications as to its policy relevance (See, for example: Arrow and Fisher, 1974; Byerlee, 1971; Cicchetti and Freeman, 1971; Henry, 1974; Lindsay, 1969; Long, 1967; and Schmalensee 1972 and 1975).

Following this literature, the definition of option value to be estimated in the current research arises from the following definition

$$V(Y\text{-}OP;\ H=1) = \pi V(Y;\ H=0) + (1-\pi)V(Y;H=1) \tag{1}$$

where $V(\cdot)$ is an indirect utility function, Y is income, OP is option value price, H=1 indicates the individual is allowed to hunt (H=0 otherwise), and $(1-\pi)$ is the probability of being selected in the lottery. Option price is a state independent payment that insures the individual will be able to hunt with certainty. The certainty equivalent measure of Hicksian surplus (CS) is defined as:

$$V(Y\text{-}CS;\ H=1) = V(Y;\ H=0) \tag{2}$$

Following procedures established in the literature, option value (OV) is defined as:

$$OV = OP - (1-\pi)CS \tag{3}$$

where $(1-\pi)CS$ is expected consumer surplus.

The second chapter is a theoretical exploration of the sign and size of option value. That is, is OP greater than or less than expected consumer surplus, and how large is the difference? The literature review in this chapter is primarily composed of a discourse in between Freeman (1984a and 1985a,b) and Plummer 1985 and 1986, and a single contribution by Smith (1984a). The outcome of the Freeman and Plummer debate is that under specific conditions option value can be signed and for other conditions the sign is indeterminate. For supply uncertainty and demand certainty, the case examined in the current research, they and others have shown that option value is positive for risk averse individuals (Bishop, 1982; Brookshire, Eubanks and Randall, 1983; and Smith, 1983). Relaxing the assumption of demand certainty results in the theoretical sign of option value becoming indeterminant. In fact, for most cases it appears that the sign of option value is indeterminant and option value can only be signed under very specific assumptions.

Freeman (1985a) also explored the size of option value relative to expected consumer surplus by positing specifications for the indirect utility function and conducting experimental simulations. Plummer (1986) contends that although Freeman's simulations are an interesting academic exercise, they are of little empirical significance due to underlying assumptions of the utility functions employed which limit the generalizability of the findings.

Smith (1984), following the work of Schmalensee (1972) and Cook and Graham (1977), develops a theoretical bound for the size of option value. Using the Cook-Graham index of uniqueness (R), he demonstrates that:

$$\frac{OV}{(1-\pi)CS} \leq \frac{\pi R}{1-\pi R} \tag{4}$$

This definition is modified to be consistent with the definition of option value defined in this manuscript.

Thus, option value, as a proportion of expected consumer surplus, is bounded by a function of the Cook-Graham index of uniqueness. When $R=0$ a replaceable good or service, option value is bounded by zero and is negative. For $R>0$, a normal good with some degree of uniqueness, both the degree of uniqueness and the degree of uncertainty set the upper bound and option value can be positive. The key to operationalizing this bound is knowledge of the marginal utility of income, the information from which R is derived. To our knowledge, no one has employed Smith's bound in an empirical study. However, such an effort could contribute substantially to the empirical understanding of option value.

The practical implications of the theoretical literature on the sign and size of option value are that conditions exist where option value can be signed. These occurrences appear to be exceptions rather that broad rules, and under very reasonable assumptions the sign of option value is indeterminate. The absolute magnitude of option value, as either a proportion of option price or expected consumer surplus, remains largely unknown.

The third chapter, which the profession currently has the book open to, deals with the appropriate welfare estimator for benefit-cost analyses under conditions of uncertainty. Graham (1981) was the first to question whether option price or, what he terms, the willingness to pay locus, is appropriate for cost-benefit analyses under uncertainty (see also: Freeman, 1991; Ready, 1991; and Smith, 1990).[2] More recently, Cory and Saliba (1987) question whether the intuitive appeal of simply estimating option price missed the point of whether it was the appropriate welfare estimator and argue that the appropriate welfare estimator is the expected value of the fair bet point. Recent contributions to the literature, as noted earlier, indicate that option price may actually be the appropriate welfare estimator under specific

[2]Cameron and Englin (1992) have attempted to estimate Graham's willingness to pay locus.

conditions and it may not be appropriate under other conditions (Meier and Randall, 1991). The alternative welfare estimators they propose to be appropriate under specific conditions are the "WTP locus," "expected value of the fair bet point," and "the greater of expected consumer surplus or option price."

Ready (1991) proposed a new welfare estimator, "maximum agreeable payment vector (MAP)," as a generally appropriate welfare estimator. He notes special cases where MAP and option price are equivalent, and even if the conditions are not met exactly, he suggests that option price may serve as a reasonable approximation to MAP.

Our interpretation of this theoretical literature is that option price is the appropriate welfare estimator in many circumstances and there is still a role for empirical studies of option value. As noted earlier, where option price is acceptable, it is impossible to guarantee that estimates of option price are available and original estimates of option price can be quite costly to derive. Thus, when ex post value estimates are available and probabilities of states of the world are known, knowledge of the sign and size of option value can play an important role in determining if benefits or costs, as the case may be, are over estimated or underestimated. Furthermore, the theoretical work on the sign and size of option value, rather than providing clear insights, appears to be progressing toward greater ambiguity.

Empirical Contributions

The first, and perhaps most widely cited study of option value, is the work by Greenley, Walsh and Young (1981) where they estimated values for protecting water quality in the South Platte River Basin in Colorado. This study used contingent valuation to estimate option value and the wording of their question is as follows:

> In the near future, one of two alternatives is likely to occur in the South Platte River Basin The *first alternative* is that a large expansion in mining development will soon take place, creating jobs and income for the region. As a consequence, however, many lakes and streams would become severely polluted. It is highly unlikely, as is shown in Situation C, that these waterways could ever be returned to their

> natural condition. They could not be used for recreation. Growing demand could cause all other waterways in the area to be crowded with other recreationist.
>
> The *second possible alternative* is to postpone any decision to expand mining activities which would irreversibly pollute these waterways. During this time, they would be preserved at level A for your recreational use. Furthermore, information would become available enabling you to make a decision with near certainty in the future, as to whether it is more beneficial to you to preserve the waterways at level A for your recreational use or to permit mining development. Of course, if the first alternative takes place, you could not make this future choice since the waterways would be irreversibly polluted.
>
> Given your chances of future recreational use, would you be willing to pay an additional _____cents on the dollar in present sales taxes every year to postpone mining development? This postponement would permit information to become available enabling you to make a decision with near certainty in the future as to which option (recreational use or mining development) would be most beneficial to you. Would it be reasonable to add ____to your water bill every month for this postponement? (p.665-6)

Our reading of this question is that the authors estimated option price, rather than option value, for removing uncertainty regarding the quality of future water supplies.

As you can see in the first paragraph of their question, they imply that there is a high probability of permanent deterioration in water quality if the mining project proceeds and a low probability of restoration. This is similar to the right-hand side of our equation (1). In the second paragraph, the condition for which values are elicited, water quality is preserved indefinitely. This is akin to the left-had side of equation (1). Although the exact probabilities and time frame are left unspecified, we believe that the authors actually estimated option price with this question.

The reasons for this difference in interpretation may be that Greenley, Walsh and Young based their study on the theoretical work by Henry (1974). Bishop (1982) noted that Henry's paper actually discussed quasi-option value and, in turn, served to confuse the option-value literature. The distinction between option value and quasi-option value only became clear during the

1980's, after the Greenley, Walsh and Young (1981) study was published (Conrad, 1980; Fisher and Hanemann, 1987; Freeman, 1984b; and Hanemann, 1989).

An additional concern with the study arises from the definition of option value; the difference between ex ante and ex post measures of Hicksian surplus. Option value does not arise from arguments in an individuals utility function, and it seems rather odd to ask respondents to directly answer an option value question, i.e., such a question appears to be incongruous with the theoretical definition of this concept.

The second study attempting to estimate option value, also using contingent valuation, is the study by Desvousges, Smith and McGivney (1982) of water quality in the Monongahela River. This work was based on the specification of option value as proposed in the review articles by Bishop (1982) and Smith (1983). In turn, respondents were not directly asked to answer an option value question. Rather, they were asked to answer two valuation questions. That is,

> "each respondent was asked to provide an annual bid that represented his (or her) valuation of each of three quality changes for the Monongahela River. In these bids each respondent was instructed to include values based on direct use and potential use... These bids are estimates of each individuals option price. To estimate option value, each respondent was asked to identify how much of their initial bid (i.e., the option price) was associated with their anticipated use. The difference between these two responses provides our estimate of option value" (p.83, 84) (Smith, Desvousges and Fisher, 1983).

Thus, the first question elicited option price and the second question elicited expected consumer surplus. This approach, has theoretical appeal since it recognizes that option value is the difference between ex ante (option price) and ex post (expected consumer surplus) measures of Hicksian surplus.

One concern does arise in that we question whether survey respondents can answer a contingent-valuation question designed to elicit expected consumer surplus. This approach requires respondents to assess the values that they place on potential outcomes, assign probabilities to each outcome and then to calculate their expected value. Not only is this a sophisticated task, the researchers did not provide directions to their respondents that this type of calculation was required.

Another concern with this study is that the same respondents answered both the option price and expected consumer surplus questions. It may have been more appropriate to apply each question to independent samples. In turn, valuation responses to the second question would not be conditioned on the first valuation question. The final, and somewhat minor concern, is that the sample sizes within experimental cells, especially for users of the Monongahela River (n<20), were quite small.

Our concerns aside, it is still useful to briefly consider the option value estimates from this study. Option values were derived for three changes in the level of water quality and four different contingent-valuation questioning formats, resulting in 12 experimental estimates. This was done for recreational users and nonusers of the Monongahela River. Across all experimental treatments, option values are positive and are generally significantly different from zero. Option value estimates, for users, ranged from 14 to 78 percent of the comparable option price estimates (see also Desvousges, Smith and Fisher, 1987). Making the same comparison for nonusers, option values are approximately 100 percent of the comparable option price estimates for all experimental treatments. This result appears to be due to a very small probability of future use making expected consumer surplus approximately zero.

The relative magnitudes of these option value estimates seem to be surprisingly large. That is the marginal utility of income [$\partial V(\cdot)/\partial Y$] would need to be substantial to obtain option-value estimates of the magnitude reported on by Desvousges, Smith and McGivney (1982). To illustrate this problem, let us consider the case of supply uncertainty evaluated. Respondents were told that:

> "If the water pollution laws were relaxed to the point that the water quality would decrease to Level E and the area would be closed 1/4 of the weekends of the year for activities on or in the water but would

> remain open for activities near the water, how much would you change this (<u>READ TOTAL $ AMOUNT</u>) to keep the area open all weekends for all activities?" (p.5-24)

Assuming demand certainty, we can formalize this valuation of supply uncertainty as:

$$V(Y\text{-}OP;D) = 0.25V(Y;E) + 0.75V(Y;D) \tag{5}$$

where D is boatable water quality and E is water quality below boatable. In a world of certainty, the following relationship holds:

$$V(Y\text{-}CS;D) = V(Y;E) \tag{6}$$

where CS is the Hicksian surplus to prevent a deterioration in water quality from D to E. Using equation (6) we can rewrite equation (5) as:

$$V(Y\text{-}OP;D) = 0.25V(Y\text{-}CS;D) + 0.75V(Y;D). \tag{7}$$

Note that all indirect utility functions in equation (7) are conditioned on water quality being at level D and the differences in utility are explained by subtractions from income (OP and CS).

Given the nonnegative estimates of option value, we assume the average respondent is risk averse and $\partial V(\cdot)/\partial Y > 0$. Using equation (7) and the risk aversion assumption, we can see in Figure 1 that the marginal utility of income must be substantial in order for option value [OP-0.75CS] to be large, e.g., 78 percent of option price. That is, for a given consumer surplus, both option price and option value increase as the curvature of the utility function, in income space, increases. Our experience in most recreation studies is that coefficients on income are generally insignificant or very small. In turn, our intuition suggests that the Desvousges <u>et al</u>. estimates of option value may be overstated. Of course, in this analysis we have assumed that demand is certain. Relaxing this assumption complicates the analysis, but does not clearly allow for large estimates of option value.

The third study, also using contingent valuation, estimated option values for wilderness preservation in Colorado (Walsh, Loomis and Gilliam, 1984) (See also: Sutherland and Walsh, 1985; Loomis, 1987; and Sanders, Walsh and Loomis, 1990). In this study the authors asked respondents to answer an

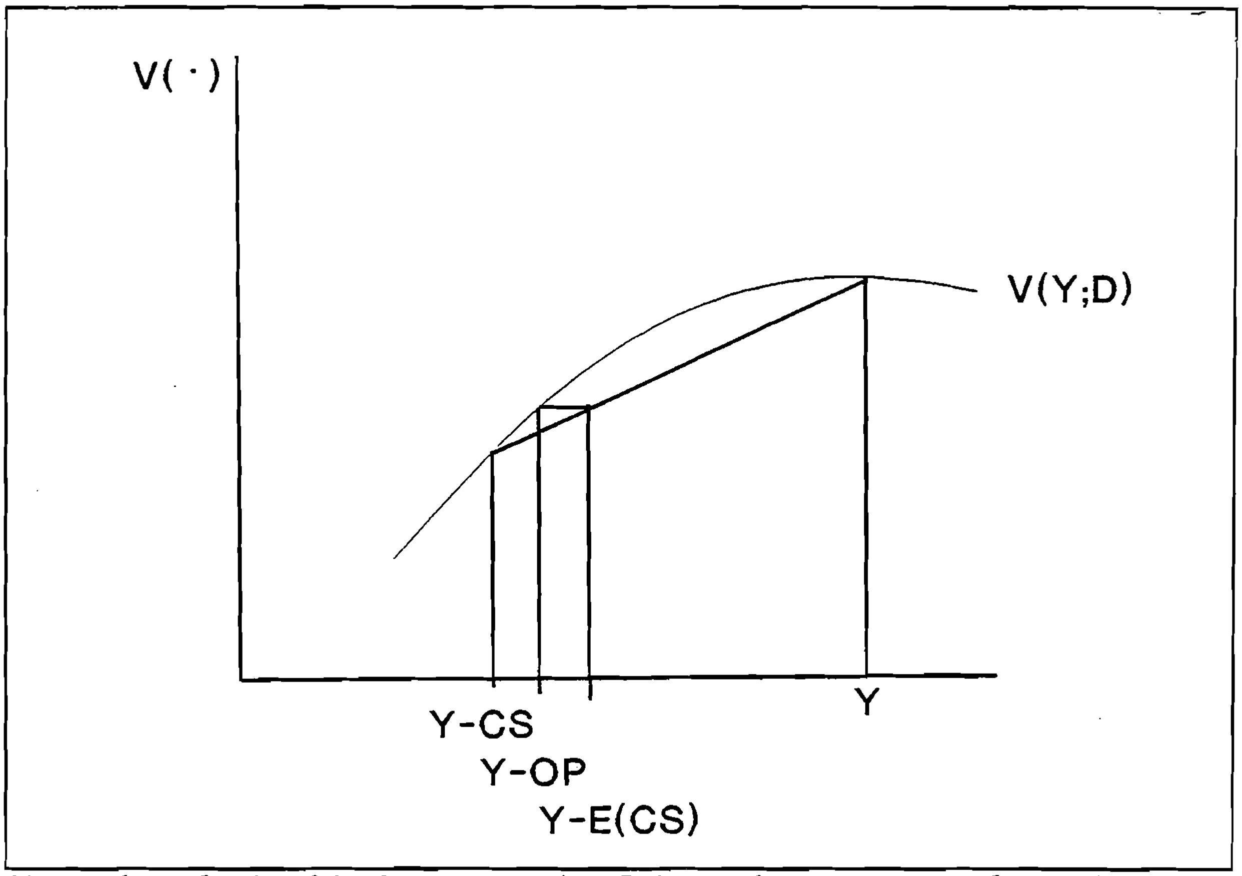

Figure 1 Relationship Between Option Price and Consumer Surplus Under Conditions of Supply Uncertainty and Demand Certainty

option price question and then to allocate their valuation responses across four categories: recreation use, option, existence and bequest. This study, although novel in its approach, may not have estimated option value. That is, the question format, as we suggested for the Greenley et al. study, is incongruous with the theoretical definition of option value. Option value is not a component of option price, rather, it is the difference between option price and the expected value of consumer surplus. The allocation process seems to include the implicit assumption that option value arises from arguments in individuals utility functions.

Although allocating option prices did yield option value estimates ranging from $4 to $9, we can not infer that respondents were indeed providing responses that reflect option values. Perhaps respondents provided option values because they felt that it was the way they were supposed to answer the survey. Alternatively, respondents may have accepted the question framework as being the only way to express their values, even if the approach was not consistent with their preference.

Finally, the most recent study to estimate option values used a travel-cost model for recreation in old growth forests (Larson, 1991). Larson modified travel cost estimates using the density functions of variables that are assumed to be random, ex ante, to the recreation event (travel cost and travel time). In contrast to the Smith et al. (1983) study, Larson's estimates of option value are less than $1, are not significantly different from $0, and are less than one percent of option price estimates. This result seems to be more in line with our expectation regarding the marginal utility of income and recreational activities. This approach can also, when used in conjunction with a comparable contingent-valuation study, offer the potential to establish convergent validity of option-value estimates.

Of the four studies reviewed, we propose that only two have a framework capable of estimating option values, the Smith, Desvousges and Fisher (1983) and Larson (1991) studies. However, each of these studies represent initial, tentative steps toward estimating option values. They provide empirical credence to the notion of option value, but certainly are not sufficient to clarify the debate on the sign and size of option value.

Proposed Protocol for Estimating Option Value

Given the theoretical literature on option value and the results of the empirical studies attempting to estimate option value, we propose the following protocol for estimating option value via contingent valuation:

1. Estimate option price;
2. Estimate consumer surplus for all potential states of the world (potential outcomes);
3. Use independent samples to obtain each of the estimates required in (1) and (2); and
4. Compute expected consumer surplus and derive option value.

This approach avoids asking respondents to directly answer an option-value question directly, and also avoids asking respondents to make internal computations of expected surplus. Furthermore, this approach explicitly recognizes that option value arise from the difference between ex ante and ex post evaluations, and is not a result of arguments in individuals preference functions. In the research reported here, we apply this protocol. We also designed the experiment to test the necessity of employing independent samples.

Experimental Design

The current study involves estimating ex ante option price and ex post consumer surplus for moose hunting in Maine using compensating variation measures of Hicksian surplus. This application provides a unique opportunity to examine supply-side option value where the probabilities of potential outcomes are known and demand is certain. Furthermore, the probabilities of potential outcomes are known to both the researchers and respondents. The fact that demand is certain is an advantage in the sense that the theoretical literature indicates that in the case of supply uncertainty option value is positive if moose hunters are risk averse. Consequently, the current study provides an opportunity to draw clear inferences regarding option value.

The advantages of the current experimental also have a downside. Many instances where option prices are estimated do involve demand uncertainty. We would argue, however, that our clean experimental design, involving only supply uncertainty, is the desirable starting point for estimating option values. Furthermore, as demand for many environmental services grows in the face of limited supplies, use opportunities are being rationed. Recreation, of which moose hunting is a specific example, often involves rationing of use opportunities. Rivalness in consumption of these activities due to crowding and/or deterioration in the recreational environment leads to the rationing of supply. Thus, although demand uncertainty can be pervasive, supply uncertainty is not a trivial issue.

For the moose hunting case study, the State of Maine issues 1,000 permits (900 to residents and 100 to nonresidents) each year to hunt moose.[3] The focus of our study is moose hunting by Maine residents during 1989; where 66,171 residents applied for the 900 permits. Thus, the odds of being selected in the lottery were 1.4 percent. This likelihood of being selected in the lottery for residents permits is relatively constant from year to year.

Demand is certain in the following sense. Assuming the lottery allocation of permits is fair, each applicant has an equal probability of selection, and the permit and no permit samples represent random draws from the same population. Nearly everyone who receives a permit, with one or two exceptions each year, hunts. Thus, we expect that individuals in the no permit sample, if given the opportunity, would hunt.[4]

The study was conducted by surveying the 900 residents who did receive a permit and a random sample of 600 residents who applied for, but did not receive a permit. Both groups were asked to answer two contingent-valuation questions, an actual trip question and an option price question. Individuals in the permit sample were surveyed immediately after their hunts and were initially asked to answer a valuation question for their hunts. Subsequently we asked them to assume that they did not receive a permit, and asked them an option price question to estimate the maximum they would pay to be able to hunt moose with certainty. (The valuation questions for the permit sample are presented in Appendix A.)

A similar protocol, with modifications, was followed for the no permit sample. We first provided respondents with the high, low and mean expenses

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[3]The moose hunt is an annual six day hunt, starting on a Monday and ending on Saturday. Hunters are assigned to specific geographic zones and are allowed to take one moose. Over 90 percent of hunters take a moose.

[4]Our study was conducted after the 1989 permits were allocated. Thus, individuals in the no permit sample knew they would not be able to hunt during the 1989 hunt. We could not survey applicants prior to the lottery because the deadline for applications is only a few days before the lottery is held. However, we do not believe this constraint is a significant problem for the study in that lottery records indicate that most applicants apply every year until selected. After being selected, an individual can not apply for a permit for five years.

for individuals who participated in the 1988 hunt. Mean costs were itemized. We then asked them to assume that they had received a permit, and asked them to estimate the cost of their hunt. Using this starting point, we asked the same valuation question for a hunt that was administered to individuals in the permit sample. Individuals in this no permit sample were also subsequently asked to answer the option price question administered to the permit sample. Unlike in the permit sample, we did not have to preface the option price question by asking respondents to assume that they did not receive a permit to hunt. (The valuation questions for the no permit sample are presented in Appendix B.)

This 2x2 experimental design yields four valuation estimates and three avenues of computing option value (Figure 1). The approach that we believe is the most desirable for calculating option value is to use OP_{np} and CS_p. These estimates are derived from independent samples, and each estimate, respectively, is based on responses of individuals who did not hunt and who did hunt. Thus, neither estimate is derived from a scenario of a condition that the respondents did not experience. This approach avoids the problems that we noted in the Smith, Desvousges and Fisher (1983) study where all respondents were asked to report expected consumer surplus and were also asked to answer the option price question.

Definitions of option price and consumer surplus to be estimated are presented in equations (1) and (2), respectively. If, moose hunters are risk averse, their marginal utility of income is greater than zero and we would expect that option value would be nonnegative. However, given the low probability of being selected in the lottery, consumer surplus and expected consumer surplus are nearly identical. Thus, we hypothesize that option value should be small and, perhaps, not significantly different from zero.

Alternatively, for a risk neutral person $[\partial V(\cdot)/\partial Y=0]$ option value should be zero. For a risk lover, option value will be negative, but we once again expect the magnitude of the estimate to be small.

Our experimental design also allows us to develop within sample estimates of option value for users and nonusers as was done by Smith, Desvousges and Fisher (1983). User option value is derived from the permit sample using OP_p and CS_p. Likewise, nonuser option value OP_{np} and CS_{np}. These within sample estimates allow us to learn whether our proposition of using independent samples is necessary.

Nonusers in our study, however, differ from non users in the Smith study. Our nonusers have a certain demand, but are classified as nonusers by the fact that they were not selected in the lottery. Thus, characteristics of individuals in the permit and no permit sample should be identical. Aside from instrument effects, therefore, we would expect option price, consumer surplus, and option value estimates to be statistically indistinguishable across the two samples.

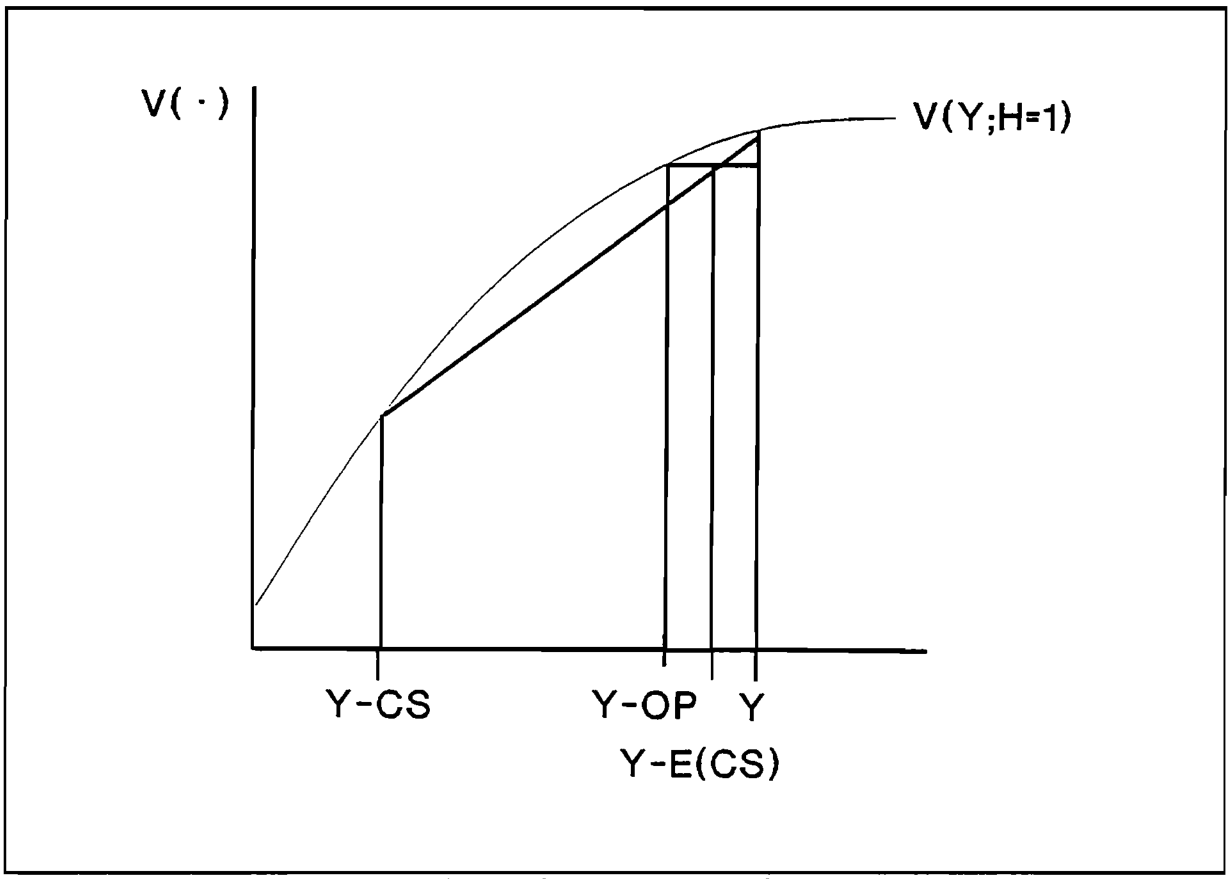

Figure 2 Moose Hunting Option Value Under Supply Uncertainty

Figure 1. Experimental Design.

Type of Respondent	Type of Valuation Question	
	Option Price	Actual Trip
No Permit	Based on Not Hunting (OP_{np})	Scenario (CS_{np})
Permit	Scenario (OP_p)	Based on Actual Hunting Experience (CS_p)

In contrast, nonusers in the Smith study were selfselected in the sense that they choose not to recreate on the Monongahela River and their potential for future use was quite low. Thus, demand uncertainty was also present. In turn, there was no reason to assume that the characteristics of individuals in the user and nonuser samples would be identical, nor was there any reason to assume that option price, consumer surplus and option value estimates are statistically indistinguishable. Indeed, as noted above, Smith found that option value, on average, was 52 percent of option price for users and the comparable figure for nonusers was 100 percent. We did not expect to replicate this finding in our study. In fact, our distinction of nonusers would be more appropriate for the Smith study if recreational use on the Monongahela was rationed.

The last point regarding the experimental design is that we used two questioning formats to ask the valuation questions. Seven hundred of the individuals in the permit sample and 500 in the no permit sample answered dichotomous-choice valuation questions, as shown in Appendices A and B. In addition, 200 permit holders and 100 in the no permit sample answered an open-ended question. The open-ended sequences of questions were the same as the dichotomous-choice sequences presented in Appendices A and B, except the open-ended questions replaced the dichotomous-choice questions.

Results

Ninety two percent of those in the permit sample responded to the survey and the comparable figure for the no permit sample was 84 percent. Item response rates to all valuation questions was about 90 percent.

Dichotomous-Choice Estimates

Option price, consumer surplus and option value estimates from the dichotomous-choice questions are presented in Table 1. The estimated probit equations from which these estimates are derived are reported in Appendix C. Option value, as shown in equation (3), is computed as :

$$OV = OP - 0.014CS \quad (8)$$

where 0.986CS is expected consumer surplus. As we stated earlier, the desirable procedure for computing option value is to use the option price estimate from the no permit sample and the consumer surplus from the permit sample. This estimate of option value is presented in the lower right corner of Table 1, $165. The within sample estimates of option value are $167 for the no permit sample and $185 for the permit sample, and are significantly different from zero at the 10 percent level. The null hypothesis that these

Table 1. Dichotomous-Choice Estimates of Option Price, Consumer Surplus and Option Value

Type of Respondents		Valuation Estimates		
		Option Price	Consumer Surplus	Option Value
No Permit	$\bar{x}$	$180	$903	$167
	s	$90[a]	$71	$90[b]
	n	359	359	---
Permit	$\bar{x}$	$200	$1,048	$185
	s	$24	$72	$26
	n	560	560	---
Permit/ No Permit	$\bar{x}$	NA	NA	$165

[a]Standard errors for option price and consumer surplus are derived using 1,000 boot strap iterations

[b]Standard errors for option value are derived from the following equation:

$$V(OV) = V(OP) + (0.014)^2 V(CS)$$

where V(·) indicates variance (Hogg and Craig, 1970, p.168).

within-sample estimates are statistically identical can not be rejected. This finding suggests that option value may be positive, implying risk aversion among moose hunters. Furthermore, it may be reasonable to have the same respondents answer both the option price and consumer surplus questions.

Open-Ended Estimates

Option price, consumer surplus and option value estimates derived from the open-ended questions are presented in Table 2. The preferred estimate of option value, the across sample estimate, is $140. Comparing this estimate to the dichotomous-choice across sample estimate, we see that the dichotomous-choice estimate is only slightly larger ($165 versus $140, respectively). The within sample estimates of option value are $141 for the no permit sample and $191 for the permit sample, and these estimates are not significantly different at the 10 percent level. These results, once again, indicate that option value may be positive, indicating risk aversion. Furthermore, the within sample estimates are not significantly different. These open-ended results also suggest that it may be possible to have respondents answer both option price and consumer surplus questions.

Table 2. Open-Ended Estimates of Option Price, Consumer Surplus and Option Value

Type of Respondents		Valuation Estimates		
		Option Price	Consumer Surplus	Option Value
No Permit	$\bar{x}$	$144	$204	$141
	s	$27	$21	$27[a]
	n	69	69	---
Permit	$\bar{x}$	$195	$257	$191
	s	$39[a]	$31	$39
	n	139	139	---
Permit/ No Permit	$\bar{x}$	NA	NA	$140

[a]Standard errors for option value are derived from the following equation:

$$V(OV) = V(OP) + (0.014)^2\, V(CS)$$

where $V(\cdot)$ indicates variance (Hogg and Craig, 1970, p.168).

Discussion

We have demonstrated a procedure for deriving option value from estimates of option price and consumer surplus when probabilities of potential outcomes are known. The option value estimates are positive and large in the sense that the estimates are significantly different from zero. This finding of positive option value is consistent with the theoretical literature of supply uncertainty for risk averse individuals. This outcome holds for both the dichotomous-choice and open-ended data. The size of these option value estimates do seem to be surprisingly large given the theoretical definition of option value we presented in Figure 2.

For both the dichotomous-choice and open-ended applications we found that within sample estimates are comparable to the across sample estimates. These results suggest that individuals in the permit sample, who had hunted moose, were able to put themselves in the position of not having received a permit when answering the option price assumption. Likewise, individuals in the no permit sample were able to assume that they had received a permit and answered the consumer surplus question as if they had hunted. This result, however, may not be replicated as one moves toward evaluating option values where the parameters of the choice problem are not well known by respondents and where nonuse values enter the valuation exercise.

As suggested in the reference operating conditions proposed by Cummings, Brookshire and Schulze (1986), respondents are better able to answer contingent-valuation questions for which they have experience with the object of valuation. An empirical study by Boyle, Welsh and Bishop (1992), of white-water boating in the Grand Canyon, indicates that contingent-valuation estimates are more defensible (robust) when respondents have extensive white-water boating experience. For the current study, moose hunters in the permit sample had participated in one or more lotteries prior to being selected. Individuals in the no permit sample, although they did not have the opportunity to hunt, have access to significant information regarding moose hunting in Maine. In turn, in applications where respondents may have limited experience with, or knowledge of, the object of valuation, it may not be possible to accurately estimate a within sample option value. This concern can only be addressed by future research.

Finally, the dichotomous-choice and open-ended questions provided similar estimates of option value, despite large differences in the consumer surplus estimates (see third columns in Tables 1 and 2). Interestingly, comparable estimates of option price were not significantly across the dichotomous-choice and open-ended data. The similarity of the option-value estimates, therefore, is due to the low probability of being selected in the lottery and expected consumer surplus being a very small proportion of option price regardless of the absolute magnitude of the respective consumer surplus estimates.

Summing up, our results indicate that option value, under conditions of supply uncertainty and demand certainty, can be positive and substantial, suggesting risk aversion. However, the similar dichotomous-choice and open-ended estimates may only be artifacts of the low probability of selection in the lottery. Furthermore, the option value estimates are larger than expected, regardless of whether it is positive or negative. Given these questions and concerns, we are using our current results to redesign the experiment and conduct a revised experiment inconjunction with the 1992 moose hunt.

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Appendix A:
Dichotomous-Choice Valuation Question
Applied in Permit Survey

Moose hunting requires a number of expenses. As near as you can recall, about how much were your total expenses for your 1989 moose hunt? (Only report your share of expenses and do not report equipment purchases. If you did not purchase an item, please enter a zero.) (FILL IN ALL BLANKS)

Scouting expenses prior to moose hunt (Gas, Oil, Tolls, Food, Lodging, etc.)............	$_______
Moose Hunting Permit Only (Do not include the cost of a hunting license)............	$_______
Gas, Oil and Tolls for Transportation............	$_______
Public Transportation (Airline, Car Rental, etc.)............	$_______
Food and Beverages (Include Restaurants, Ice, Propane)............	$_______
Lodging............	$_______
Guide Fees............	$_______
Ammunition............	$_______
Carcass Handling............	$_______
Meat Cutting, Cold Storage............	$_______
Taxidermy............	$_______
Land Access Fees............	$_______
Other Moose Hunting Expenses (Not Equipment), Please List ______________________________	$_______
TOTAL AMOUNT I SPENT FOR MY 1989 MAINE HUNT............	$_______

Hunting expenses often go up or down. For example, gas prices rose substantially in the 1970's, fell somewhat in the early 1980's, and have recently risen again. Would you still have gone moose hunting **in Maine** during 1989 if your total expenses had been $_____ more than the total you just calculated? (CIRCLE ONE NUMBER)

1 YES
2 NO

A total of 66,171 **Maine** residents applied for a **1989 Maine** moose hunting permit, and 900 of these people received a permit. This means that 1.4 percent of the applicants received a permit for the **1989 Maine** moose hunt. In other words, less than 2 out of every 100 hunters, who applied for a permit, actually received a permit for the **1989** hunt. You were one of the hunters who did receive a permit for the **1989 Maine** moose hunt.

We would now like you to assume that instead of having a lottery to distribute moose hunting permits, the 900 moose hunting permits issued to Maine residents would be sold to the highest bidders. The permits would be given to the 900 Maine residents making the highest bids. These 900 successful bidders would be required to pay the amount of their bid and would be guaranteed of receiving a moose hunting permit.

Recalling the amount that you spent on your 1989 Maine moose hunt, if you did not receive a permit for the **1989** moose hunt, would you bid and pay $_____ in an auction where the top 900 bidders would receive a permit to hunt moose in Maine? (CIRCLE ONE NUMBER)

1 YES
2 NO

Appendix B: Dichotomous-Choice Valuation Questions Applied in No Permit Survey

Right after the 1988 Maine moose hunt, all Maine resident permit holders who participated in the 1988 moose hunt were surveyed. The average expenditures reported by these Maine resident permit holders for the 1988 moose hunt are listed below:

Scouting expenses prior to moose hunt (Gas, Oil, Tolls, Food, Lodging, etc.)	$ 43
Moose Hunting Permit Only (Do not include the cost of a hunting license)	$ 24
Gas, Oil and Tolls for Transportation	$ 54
Public Transportation (Airline, Car Rental, etc)	$ 2
Food and Beverages	$ 63
Lodging	$ 31
Guide Fees	$ 6
Ammunition	$ 9
Carcass Handling	$ 12
Meat Cutting, Cold Storage	$ 83
Taxidermy	$ 53
Land Access Fees	$ 8
Other Miscellaneous Moose Hunting Expenses (Not Equipment)	$ 5
AVERAGE TOTAL AMOUNT SPENT PER RESIDENT MOOSE HUNTER FOR THE 1988 HUNT	$393

The expenses reported above are averages for all resident hunters who participated in the 1988 moose hunt. Most hunters' total expenses were between $80 and $706. Your expenses might have been higher or lower than $393 if you had hunted moose in 1989. For example, if you cut your own meat your total expenses may have been lower than $393. Alternatively, if you received a permit for a hunting zone that is a long distance from your camp or home, you may have had to pay to stay at a sporting camp and your total expenses probably would have been more than $393.

If you had hunted moose **in Maine** during **1989**, how much do you think your moose hunt would have cost? (Please give us your best estimate.) (FILL IN THE BLANK)

$_____ WOULD HAVE BEEN THE COST OF MY MOOSE HUNT

Hunting expenses often go up or down. For example, gas prices rose substantially in the 1970's, fell somewhat in the early 1980's, and have recently risen again. Would you have gone moose hunting **in Maine** during 1989, if you had received a permit for the 1989 moose hunt and your total expenses had been $_____more than the total cost you just estimated?
(CIRCLE ONE NUMBER)

1 YES
2 NO

A total of 66,171 Maine residents applied for a 1989 Maine moose hunting permit, and 900 of these people received a permit. This means that 1.4 percent of the applicants received a permit for the 1989 Maine moose hunt. In other words, less than 2 out of every 100 hunters, who applied for a permit, actually received a permit for the 1989 hunt. You were one of the 98 out of 100 hunters applying for a moose hunt who did not receive a permit for the 1989 Maine moose hunt.

We would now like you to assume that instead of having a lottery to distribute moose hunting permits, the 900 moose hunting permits issued to Maine residents would be sold to the highest bidders. The permits would be given to the 900 Maine residents making the highest bids. These 900 successful bidders would be required to pay the amount of their bid and would be guaranteed of receiving a moose hunting permit.

Considering <u>your</u> estimated cost for a moose hunt, would you bid and pay $_____ in an auction where the top 900 bidders would receive a permit to hunt moose in Maine? (CIRCLE ONE NUMBER)

1 YES
2 NO

Field Testing Existence Values: Comparison of Hypothetical and Cash Transaction Values

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ABSTRACT

This paper describes a theoretical framework for the comparison of individual responses in a hypothetical contingent valuation setting and a simulated market (or actual cash transaction setting). The total valuation framework includes both direct use as well as existence services. The model is applied to valuation of several instream flow resources for which the existence motive is anticipated to be significant. The payment vehicle is a trust fund that was set up through the cooperation of The Montana Nature Conservancy. To our knowledge, this is the first time a field test has been implemented to examine the validity of contingent valuation for measuring primarily nonuse values. The basic finding was that among contributors, the average contribution amounts were surprisingly similar across surveys. What differed greatly among the three surveys was the participation rate.

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INTRODUCTION

In this introductory section, we provide an overview of the policy setting and issues. Also in this section we define the concept of validation and provide a brief overview of our application. Following sections describe the theoretical model, survey methods and instruments, and some preliminary results.

Contingent valuation is a tool that is increasingly important for public policy applications. In addition to being endorsed by the U.S. Water Resources Council (1983) for use in federal water and land implementation studies, this approach is an approved method for use in natural resource damage assessments under current Department of Interior (DOI) rules (U.S. Department of Interior 1986). Contingent valuation has recently been upheld in court rulings challenging the validity of this approach in "superfund" applications.[1] While there has been considerable interest in the validation of the contingent valuation method in the past, most previous work on validation has focused on applications involving direct (in situ) use of a given resource, such as outdoor recreation. However, it is apparent that for some resources the primary service derived is of the nonuse or existence variety. This has been shown, for example, with regard to protection of bald eagles and striped shiners in Wisconsin (Boyle and Bishop 1987), for wolf recovery in Yellowstone National Park (Duffield 1991) and for protection of the Mono Lake resource in California (Loomis 1987) as well as many other wildlife resources and unique natural environments. One can speculate that recent natural resource damage assessments such as the those related to the Exxon Valdez oil spill also have a substantial existence component.

Existence values, as first articulated by Krutilla (1967), are the values associated with knowing that a resource exists. Existence services have the attributes of being both nonrival and nonexcludable. These services are nonrival because there are zero marginal costs associated with additional individuals knowing that the given resource exists in a healthy viable state. This is the attribute generally used to define a pure public good or commodity (Samuelson 1954). Because existence services are also nonexcludable it is very costly or impossible to establish property rights or entitlements to these services and thereby create viable markets. The absence of observable market or even market-related behavior for these services means that revealed preference measures can not be used to measure value. In fact the only approach available for measuring existence or nonuse values is contingent valuation. This fact has been recognized by DOI in the original 1986 CERCLA regulations as well as in a more recent set of proposed revisions released in a Notice of Proposed Rulemaking (NOPR) in April, 1991.[2] However, DOI's emerging guidelines for use of contingent valuation for nonuse values are somewhat controversial. Because there is no research "comparing nonuse values to values based on revealed preference approaches", DOI has characterized contingent valuation when used to measure nonuse values "as the least reliable method".[3] As noted by Carson, Hanemann and Kopp (1991), because revealed preference methods fail (by definition) to measure nonuse values they are an unlikely criterion for assessing the reliability of contingent valuation for these types of values.[4]

This brief characterization of the larger policy setting begs the question of what is meant by "reliability" or "validity". Mitchell and Carson (1989) provide a good overview of these concepts. Very briefly, reliability generally refers to the extent to which the variance of an estimate, such as mean willingness to pay, is due to random sources or "noise".[5] Reliability can be examined from the perspective of either the classical test-retest approach (Loomis 1987 provides an example) or sample theory. In short, reliability is closely related to the issue of precision and is a function of survey design elements such as sample size. Only recently have these issues begun to be addressed for nonmarket valuation measures (Kealy, Dovidio and Rockell 1988; Adamowicz, Fletcher and Graham-Tomasi; Park, Loomis and Creel 1991; Duffield and Patterson 1991). By contrast, validity measures the extent to which an instrument measures the concept under investigation.[6] From a statistical standpoint validity is the absence of systematic error or the extent to which a measure is unbiased. This is likely to be a more serious concern for contingent valuation measures.

There are actually several different types of validity. Mitchell and Carson (1989) reference the taxonomy suggested by the American Psychological Association (1974), which includes content, criterion and construct validity.[7] Content validity or face validity is the issue of whether the measure adequately covers the construct's domain. The basic theoretical construct at hand is the maximum amount of money respondents would actually pay for the given resource service if an appropriate market for the service existed. Content validity can only be evaluated subjectively, for example by examining the wording of questions. Criterion validity is evaluated by comparing the measure of the construct (eg. a contingent valuation estimate of willingness to pay) to another measure that can be regarded as criteria. The obvious problem for evaluating nonmarket measures is that substantive criteria, such as market prices, are unlikely to be available. However, some very interesting work has been done in creating actual markets for some resource services in side-by-side experimental applications with contingent valuation. In these cases the cash transaction prices can provide a criteria for evaluating the nonmarket measure. The first such study was Bohm's (1972) study of willingness to pay to see a television program. In another well-known study, a simulated market was developed for goose hunting permits for access to the Horicon area in Wisconsin (Bishop and Heberlein 1979). Bishop, Heberlein, Welsh and Baumgartner (1984) also conducted a series of experiments regarding deer hunting permits for the Sandhill Wildlife Demonstration area in Wisconsin. Dickie, Fisher and Gerking (1987) in 1984 conducted experiments regarding purchases of pints of strawberries. In general, these studies show a good correspondence between the hypothetical and simulated markets, particularly for willingness to pay measures.

The third concept of validity, construct validity, involves the extent to which a given measure is related to other measures predicted by theory.[8] The comparison of contingent valuation estimates to revealed preference measures, such as those from travel cost or hedonic models, falls in this category. In this case, neither of the measures is sufficiently similar to the construct to be a criteria.[9]

Within the Mitchell and Carson taxonomy, our study addresses criterion validity for contingent valuation. We compare a hypothetical contingent valuation measure and a cash transaction-simulated market criteria. The specific resource services we examine are increased stream flows in two Montana streams, Swamp Creek and Big Creek, which are small tributaries of the Big Hole and Yellowstone Rivers respectively. The streams are currently badly dewatered but are potentially important spawning tributaries for two important endangered fisheries: the only fluvial population of Arctic grayling in the lower 48 states and the population of Yellowstone cutthroat trout. It is anticipated that the existence services of these resources are much more important than direct use. However, unlike the previous hypothetical-simulated market experiments, such as Bishop and Heberlein (1979), the services at issue are not excludable in the way that goose hunting or deer hunting permits are.[10] The specific market that we construct is for membership in an instream flow trust fund. The trust fund payment vehicle is one that has been widely used for valuing goods with significant nonuse components (eg. Boyle and Bishop 1987; Walsh, Loomis and Gillman 1984; Bowker and Stoll 1988).

The fact that the services at issue are nonexcludable raises some issues of interpretation.

Recall Mitchell and Carson's (1989) definition of the basic theoretical construct in the contingent valuation context: "the maximum amount of money the respondents would actually pay for the public good if the appropriate market for that public good existed".[11] Does an actual cash trust fund provide a criteria for this construct? The problem is that given nonexcludability, there is a strong likelihood of free rider behavior. In a sense there is <u>no</u> imaginable "appropriate market" for goods lacking the excludability criteria. In this sense, it could be argued that our actual cash trust fund measure is not a criteria, but another measure and that this exercise is one in "construct validity".[12]

We will briefly described the specific policy setting of the application before turning to the next section. Instream flows are a controversial policy issue in many western states. Historically only diversionary uses of water have been recognized as "beneficial uses" under the prior appropriation doctrine. In Montana instream flows were not recognized as a beneficial use under state law until 1975. While instream flow reservation policies are being developed and implemented in many states (McKinney and Taylor 1988), these policies at best maintain the status quo. Only by creating at least limited markets in instream rights can potentially efficient transfers occur that reduce diversionary uses such as irrigation and increase streamflow. This issue has long been debated in the Montana legislature. In 1989, the legislature passed House Bill 707, which gives the Montana Department of Fish, Wildlife and Parks (DFWP) the authority to lease water from willing sellers to keep water in a given stream to benefit fish populations. Water could be leased on up to five streams during the four years of the initial pilot program. This program was extended by Senate Bill No. 425 in

1991 to allow for leasing of water on up to ten streams for periods of up to 20 years. The streams mentioned above, Big Creek and Swamp Creek, were sites of the first potential water leases identified by Montana DFWP under this program. This institutional setting provided an opportunity to implement the trust fund experiment which we describe below.

THEORY AND METHODS

The value individuals place on increased stream flow and protection of specific fisheries can be derived from responses to both a hypothetical and actual cash trust fund. As noted, a trust fund payment vehicle has been used successfully in a number of other studies related to wildlife valuation. In this section a simple model of total value for instream flows is described that includes direct as well as existence services. The conceptual basis for measuring existence values in a total valuation framework has been previously examined by Randall and Stoll (1983) and Peterson and Sorg (1987). Only modeling of the choice problem under conditions of certainty is examined; option values are not investigated. The model presented here utilizes an indirect utility function[13] to define the welfare measures at issue. This treatment is similar to one developed by Boyle and Bishop (1987) for analysis of values related to bald eagles in Wisconsin. For brevity, only the main elements of the model are presented.

A compact way of describing the satisfaction that individuals derive from consumption of goods and services is a utility function. The level of well-being that respondents would experience with increased streamflows (water) is a function of their level of nonconsumptive or other direct uses (Nw), the water level which results in a viable restored fishery (W) which provides them with existence value, and a vector of all other goods and services ($\tilde{Z}$) not expected to be affected by increased streamflow. An individual's utility function, assumed to have the properties required by consumption theory, is then given by:

$$U(N_w, W, \tilde{Z}) \tag{1}$$

The visitor is assumed to maximize her level of well-being subject to her budget constraint (income) and prices corresponding to the set of goods and services modeled (Pw,Pz) where Pz is a vector and the existence service (being a pure public good) is unpriced. The solution to the consumer's constrained maximization problem results in optimal levels of goods and services. This optimal solution can be equivalently expressed in terms of an indirect utility function, V(.), where the arguments are prices and income, Y. For example, in the current situation where there are inadequate streamflows for viable fishery populations, let (Nw, W = 0), the maximum attainable level of well-being for an individual is given by:

$$U(0, 0, Z^*) = \overline{U} = V(P_w^m, 0, P_z^0, Y) \tag{2}$$

Where $\overline{U}$ is the reference or current level of utility. Note that the price of <u>in</u> <u>situ</u> water related uses, P_w^m, is a price sufficiently high to make direct use services zero. This model provides a compact way of describing the value associated with changes in the current situation. If streamflow and hence fishery resources were present at some viable recovery level $\overline{W}$, and direct use of the water resource was possible at a finite price, then there is some amount, WTP^1, which would make an individual ambivalent between the current level of services and one with adequate streamflow:

$$V(P_w^1, \overline{W}, P_z^0, Y-WTP^1) = V(P_w^m, 0, P_z^0, Y) \tag{3}$$

Because WTP^1 is willingness to pay for an improvement, this is a compensating variation welfare measure (Hicks 1943). This measure provides a net total valuation estimate for increased streamflow, since it includes both nonconsumptive and other direct uses of the resource as well as existence value. WTP^1 can be estimated using contingent valuation or an actual cash transaction trust fund. We have previously implemented a trust fund valuation for several Montana rivers using a dichotomous choice question format (Duffield, Brown and Allen forthcoming). For the case at hand we chose to use a payment card question format. The latter is a feasible approach for the cash transaction instrument and in fact corresponds to the common practice of fund-raising mailings on the part of conservation organizations.

Unlike dichotomous choice, payment card responses are fairly straightforward to analyze in that the responses can be interpreted as discrete approximations to the true WTP_1. As is the usual practice, we anticipated examining the extent to which the variation of WTP_1 across respondents could be explained by measures of preferences and income. We basically postulated two different kinds of hypothesis. One hypothesis could be called the "naive economist" hypothesis that both contingent valuation and the cash trust fund would elicit the same values. The other hypothesis was suggested by a social-psychologist, Stewart Allen, who participated in survey design. Allen's perspective was that contingent valuation responses measure behavioral intent (to pay a cash contribution at some future date) while the cash responses are the actual behavior at issue. Allen's hypothesis, based on the psychology literature, is that the more similar the setting for the behavioral intent is in time and circumstance to the actual behavior, the more similar will be the measures resulting from the two methods. This hypothesis did not specify the direction of differences, but implies that differences may occur.

In order to explore the latter hypothesis (as described in greater detail in the following section), we chose to implement three different treatments: cash-TNC, hypothetical-TNC, and hypothetical-UM. The first two treatments correspond to mailings that went out under Montana Nature Conservancy letterhead and are an actual cash trust fund request and a hypothetical (contingent valuation) request respectively. These two treatments were as similar as possible, differing only in the actual request for cash. Both included a brochure describing the "Montana Water Leasing Trust Fund". In other words, the setting for the behavioral intent in the hypothetical request was very similar to the setting for the actual cash donation behavior. The third treatment went out under University of Montana letterhead and was more hypothetical in that it lacked a brochure and referenced only a "trust fund" that "could be established". This treatment was intended to be similar to the "typical" academic contingent valuation study.

To this point in the discussion we have implicitly focused on willingness to pay (amount contributed) as the key measure of validity. As it turned out, another behavioral dimension that is quite interesting is the participation level in the various treatments. We were aware that the free rider problem might be an important phenomena for the resource services at issue. However, we had no prior hypothesis how this might affect willingness to pay across treatments. We also had no theoretical basis for predicting a priori how response rates would vary across the survey instruments. Because it was apparent from our pre-test (described below) that the response rate to the cash survey would be fairly low, we considered ways to sample and analyze nonrespondents. We felt it was unethical to recontact the cash subsample participants. Our approach was to aim for a high response rate for the University of Montana subsample as a way of characterizing the population. In order to address issues like the choice to respond or not respond to the cash survey, we anticipate using the pooled subsamples in a selection function approach (Manly 1985). We may also implement this procedure for analysis of the choice to contribute. While previous contingent valuation studies have focused on explaining willingness to pay, for our data set the choice to participate is equally important.

A final methodological issue is the extent to which the total valuation responses for our application actually relate to existence uses as opposed to direct use. Note that we are using the term existence rather broadly to include all nonuse motives, including those sometimes described as existence, bequest, and altruistic motives. There are a number of alternative methods that have been reported in the literature for estimating the share due to existence motives in a total valuation model. One approach is to first determine total valuation (through a contingent valuation question) and then ask respondents to apportion total value by percent among the various categories (Sutherland and Walsh, 1985; Walsh, Loomis and Gillman (1984)). A problem with this approach is that there is no evidence that respondents can give meaningful responses or even that the various use categories are well understood. An alternative is to ask a series of contingent valuation questions that identify valuation with and without direct use (Boyle and Bishop, 1987). This may be a good approach, but valuation in sequential questions is demanding for the respondent and may be affected by respondent fatigue. Bias may be introduced by the question sequence. Alternatively, the two questions can be posed to separate samples, which is more costly. A related strategy used by Brookshire, Eubanks and Randall (1983) and Stoll and Johnson (1984) is to ask respondents if they expect to utilize the site. The WTP response of nonusers is assumed to be purely existence value. As noted by Loomis (1987), a problem with this approach is that even users may be motivated by existence or bequest uses.

Another method of identifying the share of total valuation associated with existence motives is to examine covariate effects in a total valuation model. Consumption theory suggest that given a budget constraint, the allocation of expenditure among alternative goods is entirely due to preferences. By developing a functional relationship between WTP and measures of preference, it may be possible to analytically derive the share of WTP due to various motive categories such as indirect use. Social-psychology methods can be applied to develop a set of Lickert scaled attitude measures.[14] A detailed discussion of the development of these types of measures is provided in Duffield, Brown and Allen (forthcoming). For our application, these measures indicate preferences for various types of nonuse or existence services. Respondents were also asked about their past and expected future direct use of the rivers to which Big Creek and Swamp Creek are tributaries. For specifications of the relationship of willingness to pay and measures of preferences that are homogeneous in preferences, it is possible to analytically derive the share of total valuation due to specific motives. For a function $y=f(\tilde{x})$ that is homogeneous of degree r, by Euhler's theorem:

$$\sum_{i=1}^{N} f_i x_i / ry = 1 \tag{4}$$

where f_i is the partial of the function f with respect to the i^{th} variable, x_i. Accordingly, the term $f_i x_i / ry$ has the interpretation of being the relative share of $f(\tilde{x})$ due to the i^{th} factor. This approach has been previously applied (Duffield, Brown and Allen forthcoming; Duffield 1991) and has provided results that are generally consistent with the sequential question approaches of both Boyle and Bishop (1987) and Walsh, Loomis and Gillman (1984). With our data set, it is also possible to apply the method used by Brookshire, Eubanks and Randall (1983). We do not report results for either method here.

SURVEY METHODS AND INSTRUMENTS

As noted previously, we developed three different treatments. The general characteristics of each treatment are summarized in Table 1. The three treatments include a cash trust fund mailing (Cash-TNC) that went out under The Montana Nature Conservancy letterhead and

Table 1. Summary of survey instruments.

Item	Cash-TNC	Hypo-TNC	Hypo-UM
Payment	cash	hypothet.	hypothet.
Named/existing trust fund	yes	yes	no
Brochure on trust fund in mailing	yes	yes	no
Letterhead	TNC	TNC	UM
Followup mail contacts	no	no	yes

Notes: Cash-TNC refers to The Montana Nature Conservancy mailing requesting actual cash donations to the Montana Water Leasing Trust Fund; Hypo-TNC refers to the contingent valuation survey that was sent out under The Montana Nature Conservancy letterhead; Hypo-UM refers to the contingent valuation survey that was sent out under the University of Montana letterhead.

included a brochure and payment card. This treatment solicited actual cash contributions to a trust fund that was established for purposes of this study through an agreement between The Montana Nature Conservancy and the Montana Department of Fish, Wildlife and Parks. This trust fund is called the Montana Water Leasing Trust Fund and was described in the brochure and cover letter. The second treatment was a contingent valuation survey that went out under The Montana Nature Conservancy letterhead (Hypo-TNC) and included the same descriptive materials as the cash mailing. The third treatment was a contingent valuation survey that went out under University of Montana letterhead and made reference only to a trust fund that "could be established".

All three surveys contained five sections. The first section asked general questions about recreational use, particularly relating to fishing. The second section contained questions about specific past and expected future use of the Big Hole and Yellowstone Rivers. The third section contained a series of Lickert-scaled questions designed to measure preferences and attitudes. For example, respondents were asked if they agreed or disagreed with the statements: "I have little concern for endangered species" and "I would be willing to contribute money or time to help Montana rivers even if I could never visit them". The attitude questions were designed to measure independent dimensions of individual preferences relating to use and valuation of natural resources. The first three sections are identical on all survey instruments. The fourth section contained the cash or contingent valuation question series. This section was structured to include a lead-in question asking about familiarity with trust funds, a section describing the resources at issue, the payment card question, and a follow-up question to help interpret responses (including identification of protest responses). The fourth section differs slightly across all three treatments, primarily in the actual wording of the payment question. The fifth section included questions on respondent socio-economic characteristics, including residence, age, gender and education. On the Hypo-UM treatment only, a question on household income was included. Our general aim in survey design was to have a fairly compact survey that would not be burdensome and would result in high question item-participation.

The sample frame was Montana resident and nonresident fishing license holders. In a recent year, 1987, there were 231,134 licensed Montana resident anglers and 103,974 nonresident (out of state) licensed anglers. This sample frame was selected for several reasons. One consideration was that the names and addresses for these populations were readily available in computerized form (and could be randomly drawn) from Montana DFWP records. Secondly, this group was likely to be interested in the resource. Particularly for nonresidents, there is no other readily available sample frame that includes a fairly large population that might be concerned with the resource at issue. Selection of a user group like anglers diminishes the probability that contributors would be motivated entirely by existence motives. Nonetheless, our judgement was that given the nature of the resource (small spawning tributaries for endangered species), existence motives would be dominant even for this user group. It may be noted that a licensed angler sample frame in Montana includes a fairly substantial proportion of the population - about 37 percent based on the U.S. Fish and Wildlife Service national fishing and hunting survey for 1985.

The survey instrument was initially drafted in June/July 1990 and refined through focus group sessions with Missoula-area residents in August 1990. The focus groups were used to insure that the questions were understood by respondents and to refine the choice of language and level of information. Initial payment card levels ($10, $25, $50, $100 and $250) were selected based on earlier related work on Montana instream flows (Duffield, Brown and Allen forthcoming). The survey instruments were pretested in September 1990, with 100 mailings of the Cash-TNC instrument and 50 each of the hypothetical instruments. Because actual cash contributions were received for bid levels ranging from $10 to $250, the initial bid levels were retained in the final survey instruments.

The main finding from the pre-test concerned survey response rates (percent of surveys returned compared to surveys mailed). The response rate to the cash survey instrument was only around 10 percent. We suspect that low response rates may well be typical for other actual conservation organization solicitations. We used our pre-test response rates to allocate our "survey budget" so as to receive about an equal number (400 to 500) of responses for each treatment. Our budget permitted about 9,000 individual mailings and we chose to do half to residents and half to nonresidents. The allocation among the three instruments was about 5300 to Cash-TNC, 2400 to Hypo-TNC and 1200 to Hypo-UM (Table 2).

The University of Montana mailing was relatively small reflecting our assumption (based on previous studies including Duffield and Allen 1988) that a fairly high response rate for this subsample would be achieved even without followup mailings. In fact we chose to implement

Table 2. Sample size and response rates for Montana Water Leasing Trust Fund mailing.

	Mailed	Delivered	Returned			
			First 7 days		Overall	
			N	%	N	%
Residents						
Cash	2622	2278*	137	6.0	205	9.0
Hypo.	1166	1013*	130	12.8	193	19.1
Univ.	603	524	98	18.7	388	74.0
Nonresidents						
Cash	2682	2372*	145	6.1	306	12.9
Hypo.	1192	1054*	159	15.1	288	27.3
Univ.	597	528	127	24.1	407	77.1

* Estimated from nondeliverable rate for University survey.

follow-up mailings for the University of Montana subsample as the most efficient way to characterize the overall populations. We used the Dillman (1978) total design method including an initial mailing, postcard reminder, second mailing to nonrespondents and a third (certified) mailing to nonrespondents. As noted, we felt that for ethical reasons it would be inappropriate to recontact individuals responding to the cash treatment. We also felt it would be, if not unethical, at least impolite (and certainly burdensome on The Montana Nature Conservancy) to recontact the Hypo-TNC subsample.

The initial mailing for all instruments went out on November 25, 1990. The followup postcard was mailed one week later (December 3) and the second mailing three weeks after the initial mailing (December 14). The certified mailing went out six weeks after the second mailing, on January 29, 1991. The time profile of the responses to all three instruments are shown in Figures 1, 2, and 3. Note that for the University of Montana subsample there are peaks in the relative frequency of daily responses following the initial mailing (day 1), the second mailing (day 18) and the certified mailing (day 64). The Dillman procedure mailing date for the postcard reminder (day 7) is before the response to the initial mailing has fully died out.

About 13 percent of the University of Montana mailing proved to be undeliverable, either due to bad addresses or individuals having moved. Undeliverables from the initial and following mailings were noted and not included in subsequent mailings. However, it was somewhat surprising to find that undeliverables continued to be a fairly substantial share of

Figure 1. UM - Responses by day

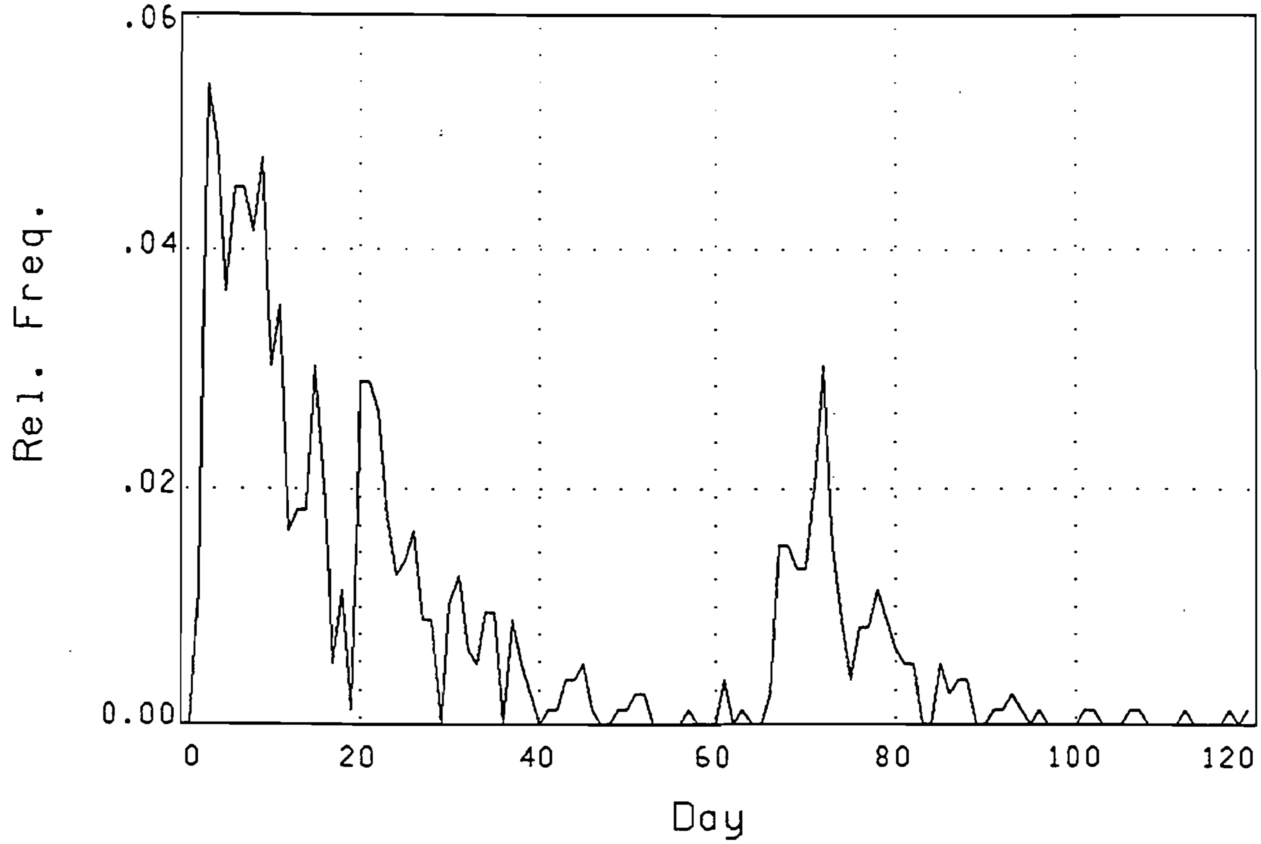


Figure 2. TNC Hypothetical - Responses by day

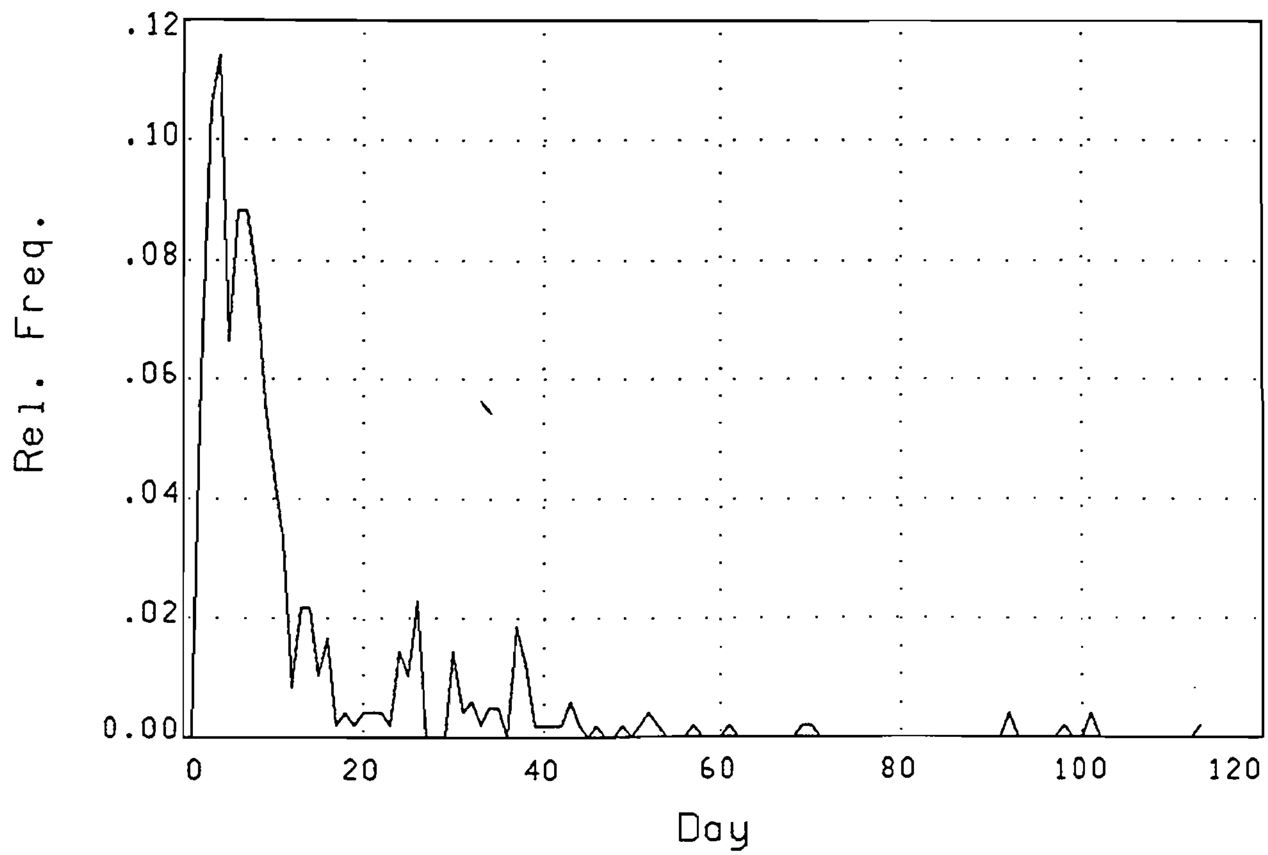
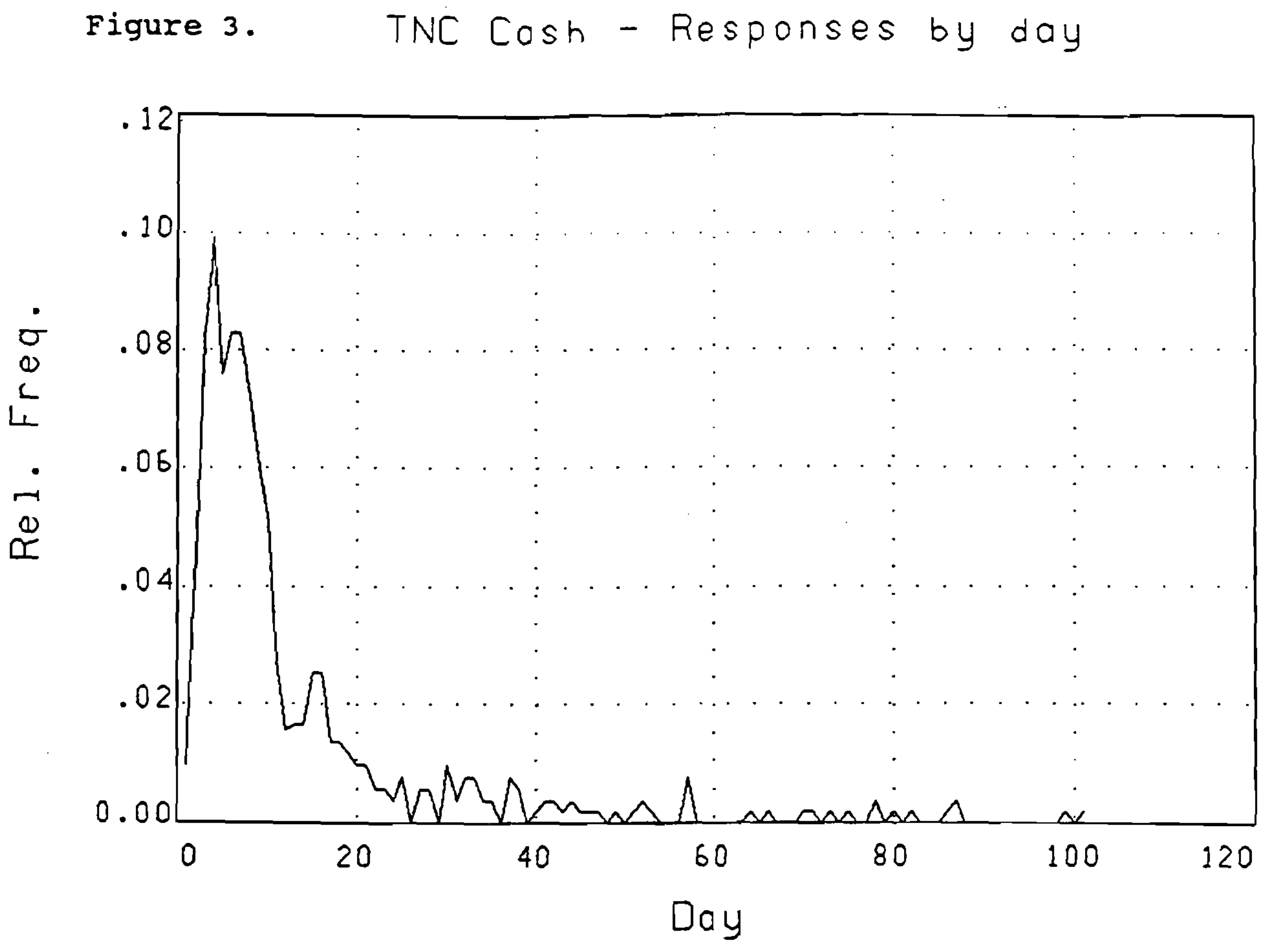


Figure 3.


TNC Cash - Responses by day
Rel. Freq.
.12
.10
.08
.06
.04
.02
0.00
0
20
40
60
80
100
120
Day

each successive mailing, including the certified mailing. While some of this may indicate that certain individuals moved between mailings, it appeared to be primarily due to the failure of the postal service to return all undeliverable pieces. We interpolated the undeliverable rate to the TNC subsamples.

RESULTS

Comparisons of response rates and willingness to contribute

Table 2 compares the response rates for the three survey types for nonresidents and residents separately. The response rate was lowest for TNC-Cash and highest for University both within the first seven days (before the first follow-up postcard) and overall. These differences were statistically significant between all pairs for both residents and nonresidents ($P < .001$, based on log-linear models and follow-up chi-square tests) for both the first wave and overall. Nonresidents had higher response rates for each type of survey, both overall and in the first seven days. For the overall response rate, the differences were statistically significant ($P < .001$) for the TNC-Cash and TNC-Hypothetical, but not for the University survey. For the first seven days, the differences were not statistically significant. However, the higher response rate for nonresidents occurs despite the expectation that it would be lower than for residents, all other things equal, because of differences in mail delivery times.

The percent of respondents expressing a willingness to contribute to the trust fund (in the TNC-Cash survey, this means they actually contributed money) varied widely among the survey types and between residents and nonresidents (Table 3). Nonresidents had

Table 3. Number and percent of respondents and of deliverables willing to contribute to Montana Water Leasing Trust Fund.

	First 7 days			Overall		
	n	% of resp.	% of deliv.	n	% of resp.	% of deliv.
Residents						
Cash	13	9.5	0.6	26	12.7	1.1
Hypo.	44	33.8	4.3	64	33.2	6.3
Univ.	21	21.4	4.0	77	19.8	14.7
Nonresidents						
Cash	53	36.6	2.2	136	44.3	5.7
Hypo.	87	54.7	8.3	162	56.3	15.4
Univ.	59	46.5	11.2	171	42.0	32.4

significantly higher contribution rates than residents in all three surveys ($P < .001$, loglinear models, chi-square tests). The rate for the TNC-Hypothetical was significantly higher than for the TNC-Cash and the University in both the first seven days and overall. The University rate was significantly higher than the TNC-Cash in the first 7 days, but not overall. There was no significant difference between waves for the TNC-Hypothetical and the University surveys; the TNC-Cash rate was significantly higher for nonresidents in the second wave (51.2% vs. 36.6%, $P = .010$); it was also higher for residents in the second wave (19.1% vs. 9.5%, $P = .051$).

When the number of contributors is expressed as a percent of all deliverable surveys, the TNC-Hypothetical and University did not differ significantly for either residents or nonresidents for the first wave. They did differ significantly overall, but this reflects the higher response rate for the University survey. The TNC Cash was significantly lower than the others for both residents and nonresidents and for both the first wave and overall. The TNC-Hypothetical rate was 6 times higher for residents and 3 to 4 times higher for nonresidents, in both waves.

The distributions by category of dollar contribution amounts for those who said they would contribute and the average amounts per contributor were very similar for the three surveys when residents and nonresidents are looked at separately (Table 4). The differences between survey types are not statistically significant for either residents or nonresidents (chi-square test on distributions and ANOVA on log of amounts). The differences between waves (not

Table 4. Relative frequency distribution (in %) of contributions and average contribution per contributor, per respondent and per deliverable mailing.

		Amount ($)*					Average Contribution		
	N	10	25	50	100	250	Per Contrib.	Per Resp.	Per Deliv.
Residents									
Cash	26	54	42	4	0	0	17.69	2.24	0.20
Hypo.	60	75	18	7	0	0	14.92	4.64	0.88
Univ.	77	71	23	5	0	0	15.26	3.03	2.24
Nonresidents									
Cash	136	41	35	17	6	1	28.43	12.60	1.63
Hypo.	157	39	36	17	8	1	31.85	17.36	4.74
Univ.	170	38	39	14	8	1	31.18	13.02	10.04

* The 5% of contributions which were not one of the amounts listed were put into the nearest category.

reported here) were also not statistically significant. The nonresident/resident differences are statistically significant ($P<.001$, chi-square and ANOVA) with nonresidents contributing about twice as much per contributor on average. For both residents and nonresidents, the average contribution per respondent does not differ significantly between University and TNC-Cash, but TNC-Hypothetical is significantly greater than both (ANOVA; Newman-Keuls); it is almost twice as large as TNC-Cash for residents. Finally, the average contribution per deliverable survey was much greater for University than for the others, as expected because of the high response rate. The average per deliverable for TNC-Hypothetical is several times larger than for TNC-Cash.

We next compare the respondents and the contributors (those expressing a willingness to contribute) across the three surveys on the use, attitude and demographic variables. A full-scale comparison is beyond the scope of this paper; a summary of preliminary univariate results is presented.

Comparison of respondents

A comparison of the respondents to the three surveys by residence reveals that there are some large differences between residents and nonresidents, but surprisingly minor differences between the surveys. Even respondents to the University survey, in which individuals were contacted several times and which had over a 70% response rate, was not very different from the other two. A brief summary follows of the results of comparisons between the three surveys, controlling for residence.

1. Use: There was little difference (none statistically significant) between the use levels of rivers in general and of the Big Hole/Yellowstone. For example, the percent who had ever visited the Big Hole or Yellowstone ranged from 63% to 67% for residents and from 70% to 73% for nonresidents. There was also almost no difference between the percents saying they intended to visit the Big Hole or Yellowstone in the next 3 years (65% to 68% for both residents and nonresidents).

2. Fishing: There was little difference in the ratings of fishing as a favorite activity and on the type of equipment used.

3. Attitudes: The only attitude question on which there were was a significant difference was the response to the statement "Rivers have enough water already." Respondents to the TNC surveys were more likely to strongly disagree with this statement than respondents to the University survey (residents: 19% and 17% for TNC-Cash and Hypothetical, respectively, versus 11% for University; nonresidents: 23% and 21% versus 12%).

4. Conservation groups: TNC-Cash respondents were more likely to be a member of a conservation group (residents: 26%, 22% and 20% for TNC-Cash, TNC-Hypothetical and University, respectively; nonresidents: 58%, 47%, 49%), though the difference was statistically significant only for nonresidents.

5. Demographic variables: There were no significant differences in the age distributions. For residents only, there was a much higher proportion of females responding to the University survey (32% versus 22% for TNC-Cash and 15% for TNC-Hypothetical). Again for residents only, there was lower proportion of respondents with at least a college degree than for the TNC surveys (25% versus 38% for TNC-Cash and 36% for TNC-Hypothetical).

Overall, the only statistically significant difference between TNC-Cash and Hypothetical respondents was on membership in conservation groups for nonresidents, and this was only marginally statistically significant.

The similarity of the three groups was also confirmed by some preliminary multivariate analyses; for example, in a linear discriminant analysis with some of the major variables there was only marginal improvement in predicting which survey type an individual had responded to.

A comparison of resident and nonresident respondents is not of particular interest at this point, other than to say that, as expected, there were major differences in a few areas. Nonresident respondents rated fishing as an activity much higher, they were much more likely to be fly-only fishermen, they were much more likely to be a member of a conservation group, and tended to be older and better educated. Differences in attitudes tended to be smaller, but still apparent.

Comparison of contributors

We also compared contributors across the three surveys, a "contributor" being a respondent who expressed a willingness to contribute to a trust fund. There tended to be larger differences than when comparing respondents. However, the sample sizes were much smaller, particularly for residents (since the proportion of respondents indicating a willingness to contribute ranged from 13% to 56% across groups). Therefore, statistical tests are less sensitive to small differences than with respondents. A summary of the results follows.

1. Use: TNC-Cash contributors tended to be slightly heavier users of rivers than TNC-Hypothetical and University, but the difference was not statistically significant. There was little difference between the percents who had ever visited the Big Hole or Yellowstone or who said they intended to visit in the next three years.

2. Fishing: There was little difference in the ratings of fishing as a favorite activity. Contributors in the TNC-Cash survey were more likely to be fly-only fisherman (residents: 54% for TNC-Cash versus 24% for TNC-Hypothetical and 28% for University; nonresidents: 75% versus 62% and 60%), but the differences were only marginally statistically significant.

3. Attitudes: There was only one statistically significant difference, though the observed differences on many questions were in the direction one would expect.

TNC-Cash contributors were more likely to strongly disagree with the statement that rivers have enough water already (residents: 42% for TNC-Cash versus 23% for TNC-Hypothetical and 18% for University; nonresidents: 36% versus 26% and 18%), though only the difference for nonresidents was significant (chi-square test, $P=.004$). Contributors were more likely to strongly agree with the statement that private groups play a major role in protecting the environment and with the statement that "I am willing to give even if I cannot visit," though the differences were not statistically significant.

4. Conservation groups: TNC-Cash respondents were more likely to be a member of a conservation group (residents: 54% for TNC-Cash, versus 33% for TNC-Hypothetical and 34% for University; nonresidents: 74% versus 62% and 63%), though the difference was statistically significant only for nonresidents.

5. Demographic variables: Among residents, TNC-Cash contributors tended to be the oldest best educated and University contributors the youngest and least educated (52% age 50 or over for TNC-Cash, 28% for TNC-Hypothetical and 15% for University, $P=.03$; 71% with at least a college degree for TNC-Cash, 37% for TNC-Hypothetical and 26% for University, $P=.005$). The proportion of females was significantly lower among the TNC contributors (14% and 13%) than among the University contributors (34%, $P=.011$). Among nonresidents, there were no significant differences between the three surveys on the demographic variables.

Preliminary multivariate analyses confirm that there are not large differences among the contributors to the three surveys.

Further analyses will attempt to identify which characteristics are most associated with the decision to contribute, both conditional on the decision to participate in the survey and unconditionally. The latter will use the University respondents as the "population" of potential respondents and contributors for all surveys.

CONCLUSIONS

Preliminary analyses seem to suggest that there are not major differences between the individuals who responded to the three types of surveys nor between those who indicated a willingness to pay. Among contributors, the average contribution amounts were surprisingly similar across surveys. What differed greatly among the three surveys was the participation rate. This difference is in part due to the additional mail contacts made to the sample receiving the University of Montana hypothetical treatment survey.

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1. Ohio v. United States Dep't Interior, 880 F.2d 432 (D.C. Circuit 1989).

2. See 56 Federal Register 82:19752-19762 (April 29, 1991).

3. 56 Federal Register 19762 (29 April 1991).

4. Carson, Hanemann and Kopp (1991) also note that one could just as well state that CVM is the "most reliable" method for estimating nonuse values given that it is the only available method.

5. See Mitchell and Carson (1989) at 122 and Chapter 10.

6. Mitchell and Carson (1989) at 123 and Chapter 9.

7. Mitchell and Carson (1989) at 190-191.

8. See Mitchell and Carson (1989) at 191. Within construct validity, there is both convergent validity (in which one examines the correlation with other measures of the same theoretical construct) and theoretical validity. The latter examines whether the measure is related to measures of other constructs as predicted by theory, for example prices should be inversely related to the quantity demanded.

9. As Mitchell and Carson (1989) note, some of these early comparisons confused criterion validity with construct validity, treating the revealed preference estimates as though they provided an accurate criteria for judging contingent valuation estimates.

10. Mitchell and Carson (1989) call the class of goods which are similar to private goods (excludable, rival) but not actually traded in organized markets "quasi-private" goods. Fishing access is a good example. In many European countries such as Norway there are highly developed markets for the right to fish.

11. Mitchell and Carson (1989) at 190.

12. Or more precisely, "convergent validity".

13. An alternative and equally accessible approach is to instead utilize the consumer's expenditure function. See, for example, Mitchell and Carson (1989) at 26-27.

14. See the discussion of Part III of the survey instrument below.

STRATEGY FOR ESTIMATING TOTAL VALUE: A CASE STUDY INVOLVING GRAND CANYON RESOURCES

Richard C. Bishop and Michael P. Welsh

Beginning with Krutilla's (1967) seminal article, "Conservation Reconsidered," there has been a growing consensus that counting only the use values of environmental resources may undervalue them. Total valuation would involve not only those values associated with in situ use of resources (e.g., outdoor recreation) and consumption of products produced from resource exploitation (e.g., commercially caught fish), but also the so-called non-use values. Two branches have evolved in the theoretical literature on non-use values. One has focused on valuation under uncertainty, with particular emphasis on the concept of option value (Weisbrod 1964; Long 1967; Lindsay 1969; Byerlee 1971; Cicchetti and Freeman 1971; Schmalensee 1972; Graham 1981; Bishop 1982; Freeman 1984; Chavas et al. 1986; Smith 1987b; Hartman and Plummer 1987; Cory and Saliba 1987; Smith 1990). A second branch has focused on existence value (including bequest value) (Randall and Stoll, 1983; McConnell, 1983; Madariaga and McConnell, 1987; Smith, 1987; Boyle and Bishop, 1987; Freeman, forthcoming). Total valuation of any resource or environmental asset would account not only for use values, but also for existence values and uncertainty.

A substantial number of contingent valuation studies have attempted to measure total values or at least quantify all or part of the non-use values. Fisher and Raucher (1984) list nine applied studies on water quality conducted between 1974 and 1983. Additional studies include Brookshire et al. (1983), Schulze et al. (1983), Walsh et al. (1984), Walsh et al. (1985), Sutherland and Walsh (1985), Hageman (1985), Stoll and Johnson (1985), Boyle and Bishop (1987), King et al. (1988), Loomis (1989), Whitehead and Blomquist (1990), and Welle (1990). As might be expected in a rapidly developing new area of research, these studies display great diversity in terms of underlying theory and definitions, empirical methods, and overall quality.

As consensus increases on the theoretical possibility of non-use values, it is important to build consensus on methods of empirical measurement as well. To that end, the current paper develops a strategy for estimating the total value of some resources associated with the Colorado River, mostly in the Grand Canyon. Several questions are addressed: How are existence values to be defined for the resources in question? How should one go about determining which, if any, of the resources being studied has non-use values? How can the resource issues be described to contingent valuation survey respondents in terms that they, as non-scientists, can understand and evaluate? How should one go about defining the population (e.g., local, regional, national) that will serve as the sampling frame for total valuation? Is it theoretically justifiable to divide total values into component parts? What are the practical implications of the large and still expanding literature on valuation under uncertainty? The case study is still in the preliminary stages of implementation, with numerical results many months away. Nevertheless, the conceptual problems and methodological issues we address will be similar for any total valuation study, and our work will provide several generally applicable principles.

Our first task will be to describe the resource policy issues in more detail. Next, a theoretical model of total valuation under certainty will be tailored to the problem and then used to address various issues of research design. Finally, uncertainty will be added and inferences drawn about its implications.

We will intentionally avoid more difficult issues about the potential accuracy of contingent valuation in measuring total values. Such questions must, of course, be asked eventually, but doing so here would require a second paper, and we would argue that the issues addressed here must take priority. Ultimately, as Mitchell and Carson (1989, p.190) point out, "The validity of a measure is the degree to which it measures the theoretical construct under investigation." The first step toward a valid contingent valuation study (if one is possible) is to design a theoretically and methodologically sound study at the outset. This paper focuses on development of sound strategies for total valuation studies. Elsewhere, we have surveyed the literature on contingent total valuation and assessed its potential success in the present application (Bishop et al., 1991). While we find reasons for optimism in past studies, research is still very limited on the validity of contingent total values. Some would conclude that total values can be measured with a satisfactory level of accuracy, while others maintain that the evidence accumulated thus far is far from conclusive. Unless we try to measure total values, using theoretically and methodologically sound approaches, we will never know whether it can be done. In that spirit, we turn now to background material on the case study.

THE POLICY ISSUES

The Grand Canyon is often mentioned as an environmental resource that could hold substantial non-use values (e.g., see Freeman, forthcoming, and U.S. Department of the Interior, 1991). The particular policy issues that are the subject of study here involve potential effects on Grand Canyon resources of operations of Glen Canyon Dam. The dam is located upstream from the Grand Canyon, near Page, Arizona, and collects water from the main stem of the Colorado River and several tributaries to form Lake Powell. Below the dam, the river flows freely for more than 200 miles, mostly within Grand Canyon National Park.

Until recently, dam operations were based primarily on criteria relating to water conservation and delivery, and power generation. We will take these criteria to be the baseline for our study and will refer to them here as "current operating criteria." A wide range of releases are needed to fulfill these criteria. One reason is that annual inflow to Lake Powell varies widely; historical annual inflows have ranged from less 9 million acre-feet to over 20 million acre-feet. Over the course of any given year, average monthly dam releases change with water availability and electricity demand. In a low-water year, average daily discharge rates in some months may fall below 9,000 cubic feet per second (cfs). In high-water years, average daily flows may exceed 40,000 cfs in the late spring. Flows during any given day are affected by both hydrological conditions and power demand. The amount of electricity demanded varies greatly during a typical 24-hour period, particularly during the summer and winter months. Hydroelectric power, like that generated at 1,300 mega-watt

Glen Canyon Power Plant, is ideal for generating power "on-peak," because output can be increased and decreased more easily and economically to meet daily peaks in the amount of electricity demanded than power from fossil-fuel plants and nuclear plants. This is accomplished by increasing and decreasing the flow of water through the turbines. Thus, under normal operations of the Glen Canyon Power Plant, it is not unusual for discharges to fluctuate by 10,000 cfs and more each day, particularly during low-water years when water is scarce and releases are minimized during times of the day when power demand is low. In high-water years, high, relatively stable flows may occur for many days at a time.

This ever-changing pattern of water releases affects downstream resources. Many sand beaches along the river are eroding away and how the dam is operated affects the rates of erosion and possible beach building. Riparian ecosystems--with their associated flora and fauna--depend on these beaches. Cultural resources of current, historic, and pre-historic Indians are being lost in eroding areas. Beaches are also important for recreation, providing camping and resting places for white-water boaters in an environment that is otherwise steep, rocky and brushy.

Much biological and physical science research is currently in progress in wide-ranging efforts to understand how the river acquires, moves, and loses sediment; how the ecosystems along the river function; and what cultural resources are at risk. Beach erosion and aggradation involves complex processes that are not completely understood. However, it is nearly certain that large daily fluctuations in dam releases increase the rate of erosion. When the water comes up, beaches absorb water. When the water recedes, and particularly when it recedes quickly, the water stored in the beaches runs out, tending to pull sand into the river channel in the process. Once the face of a beach near the water's edge is dislodged, additional erosion may occur due to the instability of steep banks. Longer-run changes in flows may disturb the physical equilibrium established under other flows, causing sand losses into the channel. (Interestingly, it may be possible to use the dam to build beaches in some areas. While the dam has trapped most of the sediments that historically served to build beaches during floods, some new sediments from side canyons still enter the river channel downstream from the dam. Given enough time for substantial amounts of sediment to accumulate in the channel, the dam could be used to create artificial floods to move sediments out of the channel and up onto the beaches.)

Habitats of native fishes are also affected by dam operations. The area of the canyon around the mouth of the Little Colorado River provides habitat for one of the last remaining populations of the endangered humpback chub. Other fishes native to the Colorado are found in the Grand Canyon, and some have become quite rare as more and more dams have been built on the Colorado and its tributaries. How the dam might be operated to enhance the habitats of the chubs and other native fishes is the subject of current research.

Recreational resources are also involved. Lake Powell began to fill after completion of the Glen Canyon Dam in 1963. Soon, cool water from deep in the reservoir began flowing downstream, creating excellent conditions for trout. By 1980, the 15 miles of river between the dam and Lees Ferry had become one of Arizona's "Blue Ribbon" trout fisheries, attracting national attention as anglers took many trophy-sized rainbow and other trout in a spectacular setting. Water releases from the dam affect the conditions under which anglers must operate boats and fishing tackle. In the longer run, fish populations themselves are affected by dam operations. Fluctuations may strand trout that eventually die. The habitat for trout to spawn and their food supplies are also affected as areas are alternately flooded and dewatered. Dam operations could be changed to enhance fishing conditions and increase the numbers of naturally reproduced trout in the fishery.

Over the same period as the trout fishery was evolving, white-water boating through the Grand Canyon became increasingly popular. This is one of the premier white-water rafting resources in the world because of the numerous challenging rapids and the magnificent natural setting. Both commercially guided and private trips are taken under the strict management of the National Park Service. Dam releases directly affect white-water recreation in a number of ways (Bishop et al., 1987). Grand Canyon trips are considered to be wilderness recreation, and daily fluctuations can detract from the perceived naturalness of the environment. As has been mentioned, beaches are used for camping. High water or the possibility of increasing water levels makes beaches less available for this purpose. Running rapids is an important part of a Grand Canyon river trip, and the water levels affect the enjoyment and safety of this activity. In cases of extremely high or low flows, passengers may have to walk around certain rapids and this detracts very much from the trip. Visiting attractive natural areas, Indian ruins, and other attraction sites along the river also influences the enjoyment of a trip through the Grand Canyon. Water releases affect the speed of travel and thus the time available to stop along the way. Changing water levels on a daily basis requires that commercial guides and private river runners give careful attention to mooring of boats at night to avoid being left high and dry on a beach the next morning.

Economic research to date has had two foci: First, economic tools are being employed to quantify, in monetary terms, the effects of dam operations on the quality of river recreation (Bishop et al. 1987, U.S. Department of Interior 1988). Secondly, if dam operating criteria were altered to reduce adverse environmental or recreational effects downstream, this would almost certainly affect the economic value of the electricity generated at the dam. Hence, studies are in progress to understand the effects of alternative dam operating criteria on the value of power produced at Glen Canyon Dam. The issue, now, is how to expand the economic research to estimate the total value of the effects of possible modifications in dam operations.

TOTAL VALUATION UNDER CERTAINTY

A Simple Model

On an abstract level, existence value can easily be integrated into the traditional theory of welfare measurement under certainty. We can modify the theory of utility maximization in the following way:

$$\text{Max } U(X, Q) \qquad \text{subject to } p\,X \leq I$$

where $U(\cdot)$ is a utility function representing the preferences of the individual, X is a vector of goods that can be purchased, p is a vector of prices for these goods, and I is the individual's income. The vector Q represents the quality of the environment, exogenously determined and including the quality of all service flows from Grand Canyon resources that influence this consumer's welfare. For example, if she is a white-water boater, Q might include the availability of beaches for camping. If she cares about whether the humpback chub becomes extinct, then its status would also be included. The elements of Q are so defined that, if $Q' \geq Q$, then $U(X, Q') \geq U(X, Q)$. We make the usual assumptions about the characteristics of the utility function and include the elements of Q under those assumptions as if its elements were more conventional goods and services. The solution to this problem, X^*, will generally be a function of p, Q, and I. Substitution of the market demands, $X^*(p,I,Q)$, for X in the utility function defines the indirect utility function, $V(p,I,Q)$.

The dual associated with the utility maximization problem can be written:

$$\text{Min } pX \qquad \text{subject to } U(X, Q) \geq U,$$

where U is some reference level of utility. The solution to this problem, X^c, will be a function of prices, environmental conditions, and the reference utility level. Substitution of the optimal choice, $X^c(p,Q,U)$, into the objective function yields the expenditure function $e(p,Q,U)$.

Now suppose that a change in dam operations is proposed that would affect the price of electricity, the quality of the recreational environment, and other environmental quality elements. It is conceivable, as well, that the change in the price of electricity may affect the prices of other market goods and services. Let p and Q be the price and environmental quality vectors under current operating criteria and p' and Q' hold under some proposal being evaluated. Following Randall and Stoll (1983), we define total value, TV, implicitly from the following relationship:

$$V(p, I, Q) = V(p', I - TV, Q').$$

In terms of the expenditure function,

$$TV = e(p, Q, U) - e(p', Q', U).$$

This is a compensating measure of welfare. The corresponding equivalent measure is easily defined in a parallel fashion.

So long as we maintain the assumption of certainty, TV, as defined above, incorporates all the potential effects: the electricity and related market price changes, the value of changes in recreational quality, and existence value. Of course, to the extent that an individual is not actually subject to all of these effects, the problem is simpler. Many people may only be affected by the change in the prices of electricity and other market goods, in which case the problem collapses to the traditional, textbook case. The total valuation framework simply allows incorporation of non-market use values and existence values into the traditional framework to the extent that they are empirically relevant.

It will be useful for theoretical purposes to distinguish between use values and existence values. Let us define a price vector for market goods, p'', such that the consumer would not make a raft or trout fishing trip or otherwise use the non-market resources of the canyon. For purposes of isolating existence value, we will assume that prices (p'') reflect the baseline prices of electricity and other goods not involved in recreational use. Environmental quality under the baseline is Q. Existence value would be positive for $Q' \geq Q$ when $V(p'',I,Q') \geq V(p'',I,Q)$. An intuitively appealing way to define existence value is EV_0, defined by:

$$V(p'', I, Q) = V(p'', I - EV_0, Q').$$

Defined in this manner, EV_0 is a conditional existence value in a sense much like that found in Boyle and Bishop (1987). It is conditional in that all non-market uses of the resource are constrained to be zero through the price vector and in that the prices of electricity and non-recreational goods reflect current operating criteria.

If separating existence value and use value were necessary, the approach that goes back at least to McConnell (1983) must suffice. Letting UV equal use value,

$$UV = TV - EV_0$$

For the non-user of recreational resources, electricity from Glen Canyon Dam, and goods and services dependent on the price of Glen Canyon Dam electricity, EV_0 equals TV. For the user of any of the environmental resources and/or market goods and services in question, any jointness between use values and existence values is fully reflected in TV.

To summarize, existence values are easily integrated with other values in an internally consistent way so long as total value can be used as the welfare measure. What we have done so far is fundamentally consistent with all the major theoretical treatments of existence value in the published literature, as cited above. If existence-related effects are present in a utility function, the conventional logic of welfare measurement easily accommodates this new dimension.

While existence values fit nicely with the traditional theory of value, more needs to be said about them. Because they are not revealed in markets or through other behavior to the same degree as use values, substantial attention has been given in the literature to the possible motivations for holding them.

On the Motivation for Holding Existence Values

The tradition of basing economic values on individuals' tastes and preferences lies at the very roots of welfare theory. Behavior is normally taken to be the way that tastes and preferences are revealed. If a member of society behaves as though his or her economic welfare is, in fact, affected by some variable, that is normally taken as sufficient evidence that his or her welfare is affected by that variable. Once the concept of total value is adopted and the theoretical possibility of existence value is admitted, behavior becomes less than a perfect indicator of welfare. Contribution to and membership in environmental organizations is often taken as an indicator of existence values, although as Freeman (forthcoming) has recently pointed out, there are mixed messages that make it nearly impossible to infer much about existence values from contributions and memberships. Ultimately, the economic researcher must base judgments about whether existence values are real or not at least partly on what people say, rather than what they do.

In addition, the study of motivations can help identify and characterize which environmental service flows are important to people. It is probably acceptable at a theoretical level to put Q in the utility function as we did here. However, as Brookshire et al. (1986) pointed out, that does not tell us very much about what people are really valuing. For example, how should the humpback chubs be viewed? Should we simply include the population of chubs in the utility function? It is intuitively plausible that the loss of a large share of the population to a natural cause, say a storm event, would have one value for this loss and an equal population reduction due to a human-caused effects such as chemical spill would have another, possibly much higher, value for the loss. It is important for policy to know as much as possible about what people are really valuing when they express existence values. The study of motivations seem to be the most direct route to understanding what is being valued.

Motivations may also be important because, as Madariaga and McConnell (1987) have shown, motives can have implications for the interpretation of existence values in a benefit-cost framework. Madariaga and McConnell showed that values based on certain forms of altruism could be incorrectly interpreted.

Let us ask why people might place a value on maintaining a resource even if they would not personally benefit through use. Altruism has played a key role in the conceptual literature on existence value (see, for example, McConnell, 1983, and Randall and Stoll, 1983). Bishop and Heberlein (1984) suggested that existence value might stem from several kinds of motives. One is benevolence toward relatives and friends. Giving of gifts to friends and relatives is very common and would appear to stem partly from altruism. Why should such activities not extend to natural resources use opportunities? If Alpha would enjoy knowing that her neighbor, Beta, has the opportunity to watch birds in a certain marsh, both could benefit from marsh preservation. If Beta actually goes bird watching there, he receives a use benefit, but the value would not end there. Alpha would also benefit personally, and counting only Beta's use value would miss this existence value that accrues to Alpha.

Bishop and Heberlein also noted that existence value could be motivated by sympathy for and empathy with people and animals, by environmental linkages, by feelings of environmental responsibility, and by bequest goals. They pointed out (p.10):

> Even if one does not plan to personally enjoy a resource or do so vicariously through friends and relatives, he or she may still feel sympathy for people adversely affected by environmental deterioration and want to help them. Particularly for living creatures, sympathy may extend beyond humans.

Those who have watched the animal rights and anti-hunting movements cannot help but be impressed by the intensity of preferences that some people exhibit in that context, and potential future use values could hardly explain their motives. Such concerns may partly motivate Randall and Stoll's (1983) so-called Q-altruism. Environmental linkages relate to the "you've-got-to-stop-'em-somewhere" attitudes. Environmental concerns are widespread, and environmental events at Location A, which a given individual does not use, may cause her/him to feel more or less confident about events at Location B, which the individual does use. Motives based on feelings of environmental responsibility have to do with people's concerns about the effects of their consumption on environments that they do not personally plan to use. For example, if Gamma's consumption of electricity would contribute to deterioration of Grand Canyon beaches, then she might be willing to pay something to reduce or eliminate this effect so that she is not responsible for such harm. Bequest motives are an extension of motives relating to benevolence toward relatives and other people into the temporal realm. The beneficiaries may well receive use benefits, and those use benefits are quite correctly counted. The point, however, is that the benefits do not end there. If the benefactor's utility depends on the bequest, an additional value is created, and this additional value is missed if the beneficiary's use value alone is included in benefits.

Of course, the ultimate actuality of existence values and their underlying motivations are empirical issues. The point here is that people could hold existence values for quite plausible, rational reasons. Because of the lack of revealed preference information, such motives must be examined empirically for clues about the preferences that undergird existence values. This will involve building linkages to other social scientists, most notably social psychologists who study attitudes.

It is worth noting in passing that our discussion of motives would lead us to question whether there is any merit in the direction taken in the paper by Brookshire et al. (1986). They tried to argue that existence values, though they could represent real willingness to pay, should not be considered as economically relevant because they may reflect ethical considerations other than the efficiency ethic that underlies benefit-cost analysis. To the contrary, ethical considerations must be viewed as very important foundations for the tastes and preferences that influence economic activity within the market and outside. Brookshire et al. tried to establish that commitments to some ethical stands can lead to "counter-preferential choices" (p.1510 and elsewhere), but surely this runs contrary to welfare theory. No one would propose discarding a portion of the compensating variation associated with the availability of a market good at a stated price simply because some purchasers wish to use the good for charitable purposes. Why try to establish such an exception for the existence of public resources simply because those who are concerned about them are basing those concerns on altruistic motives? Similar objections should be raised with respect to Kahneman and Knetsch's (forthcoming) argument that existence values should be disregarded because they involve the purchase of "moral satisfaction."

Implications of the Simple Model

Though obvious, it is worth reminding ourselves that defining the nature of the proposed transaction for purposes of a contingent valuation exercise is never trivial. Fischhoff and Furby have offered a succinct statement of the problem (p. 151, emphasis in original):

> Any proposed transaction has three constituents: something being received, something being given in exchange, and a social context within which the exchange would be enacted. In an economic transaction, these might be called the good, the payment, and the marketplace. . . . For a transaction to be satisfactory, each of these three constituents must be well defined and well understood by all the participants.

They explore in some detail the characteristics of each of these constituents of a satisfactory transaction. With respect to the good, they said (p. 153, emphasis in original):

> Although they are transferred as wholes, goods may be thought of as bundles of attributes, representing outcomes of accepting the transaction that might be valued either positively or negatively. The first step in defining a good is identifying its potentially valued attributes.

They pointed out that (p. 159, emphasis in original):

> Any transaction involves a change of state. . . . We use reference level for the state obtained if the transaction is not enacted and target level for the state obtained if it is. . . . Reference and target levels must be specified for every (potentially) valued attribute affected by the transaction.

For our purposes, the relevant "bundle of attributes" is represented by Q. The problem is to define the reference levels of Q and target levels under alternative dam operating scenarios. Doing so will require calling on several disciplines. Environmental scientists will need to tell us which aspects of the environment are potentially affected by dam operations. Engineers, lawyers, and resource managers will need to indicate what sorts of modifications in dam operations are legally and technologically feasible. The environmental scientists will then need to help us understand the environmental effects of feasible changes in operations. Having come this far, however, there will still be several questions to be addressed in preparation for the contingent valuation survey.

What are the important elements of Q? During the early stages of the research process, when dealing with environmental experts and decision makers, it is important to be as comprehensive as possible in defining the set of potentially affected resources. On the other hand, once we get to the contingent valuation phase, describing the conditions of a large set of resources under both the reference and the target conditions in terms the general public can understand could be a formidable (if not impossible) task. It may be necessary to reduce the number of resources considered in order to simplify the information that must be conveyed to participants in the contingent valuation survey.

Fortunately, it is not clear that the full list of resources would be relevant for total values. Given recent interest in endangered species, it seems likely that the humpback chub would be included, although even here verification is needed. The beaches along the river corridor and associated cultural and natural resources are likely to be an important component. It is less clear whether the trout fishery, made up as it is of an introduced species, would have substantial non-use values. It will be necessary to investigate whether non-users feel that they benefit from the trout fishery and why. Riparian birds found throughout the Southwest represent a similar case. Perhaps the fact that such birds are relatively common through out the Southwest and have colonized the Canyon as a result of dam operations means that they can be ignored for our purposes and perhaps not.

Our primary tools for sorting out which resources are important to potential respondents and which are not will be focus groups and an attitude survey. Focus groups are a qualitative research tool commonly used to gain insights into the range of understanding, attitudes, perceptions, opinions and thought processes of participants with respect to a specific set of issues. The first step in the research plan will be to employ focus groups to try to gain a better understanding of which attributes of the riverine environment are important to people and why. Focus groups should be viewed as an important step toward quantitative research for assessing attitudes toward and values for possible impacts of changes in dam operations, not as a substitute for quantitative research. Focus groups are a fertile source of hypotheses that can then be more systematically, quantitatively tested. Based on results from the focus groups, an attitude survey using standard methods from social psychology will be conducted to more systematically explore hypotheses about which environmental attributes are important and why.

Do possible changes in sources, prices, and availability of electricity have existence values? While the concept of existence value evolved with specific reference to natural environments, existence values for other resources cannot be ruled out a priori. Power resources may provide a case in point. If the alternatives under consideration would involve increases in the cost of power, affect reliability of service, or otherwise affect the final consumers of electricity, existence effects are a possibility. One might speculate that the effects on the overall power system, in terms of the price of power to final consumers, reliability of the system, etc., will be so small that they will be of little consequence for non-use values. However, if there will be any substantial impacts on consumers of electric power and if other people care about these impacts for purely altruistic reasons, consideration should be given to how this might be addressed empirically in a total valuation framework. It is also conceivable that increasing dependence on fossil fuels for on-peak power could increase air pollution or have other environmental effects that would need to be considered. The focus groups and the attitude survey will be used to explore whether there might be existence effects for changes in power generation at Glen Canyon Dam.

What should be the geographic boundaries for the contingent valuation survey? In theoretical terms, the problem here is to delimit the population of individuals who have Colorado River environmental resources as part of Q in their utility functions. This issue will also be addressed as part of the focus groups and in the attitude survey. The conclusion could be that residents of only a few states in the Southwest are subject to significant non-use effects or that some broader group, say the West or the entire nation should be included in the final study. The end result of the attitude survey will thus not only provide evidence regarding which resources are most relevant to people and why, but also evidence regarding the boundaries of the population that should be used as a sampling frame for the contingent valuation survey.

Is it both feasible and desirable to segment total values into their component parts? Some past empirical studies (e.g., Walsh et al. 1984 and Loomis 1989) have asked respondents to segment their total values into, for example, existence values (narrowly defined), bequest values, option values, and use values. To us, this practice seems highly questionable. Suppose that a contingent valuation exercise has just elicited an individual's total value for some change in Glen Canyon Dam operations, and we now ask her what share of her total value should be attributed to her desire to bequeath environmental resources to future generations. One way for her to interpret the question, if she behaves according to the homo economicus model, is to try to value the change as if she had a different utility function, one that included only bequest motives. This is a big step. The original contingent valuation exercise asked her to reveal her hypothetical value for the resources based on her real preferences. Now she is being asked to predict what her hypothetical value would be based on hypothetical preference. Such an exercise could even be theoretically impossible. If we think of Grand Canyon resources as fulfilling various goals in her preferences (future use, leaving bequests for others, reducing the extent to which her consumption causes environmental harm, making resources available to friends and relatives, etc.) and if there is complementarity or competitiveness between these goals, she will run immediately into a problem of allocating joint benefits when she tries to segment her total value into categories.

Nor does segmenting total values into component parts appear to serve any useful purpose in public decision making. For purposes of benefit-cost analysis, total value would seem to be the relevant concept. Does it really matter for the decision maker that some percent of the total value stems from, for example, bequest motives? Admittedly, it may be worthwhile to measure use values separately since they can be estimated using methods other than contingent valuation, in which many economists have more confidence. But once the focus turns to total valuation, there appears to be no reason, either theoretical or practical, to require that the values be segmented.

The next step is to add uncertainty and option value to this framework.

ALLOWING FOR UNCERTAINTY

Adding Uncertainty to the Model

Weisbrod's original paper on option value was so influential because its argument was so intuitively appealing. Using Sequoia National Park as an example, Weisbrod posed the problem of whether the trees in the park should be cut if the value of the resulting wood products exceeds the value that consumers place on use of the living trees for recreational and aesthetic enjoyment. He reasoned that there could be many people who are not currently using the trees for recreation and aesthetic enjoyment who would, nevertheless, place a value on the option of using them for such purposes in the future. However, options to enjoy Sequoia National Park in the future cannot be purchased in the market. Once cut, the trees cannot be replaced for centuries even if demand for their enjoyment turns out to be large in the future. Maintaining the option of future enjoyment takes on the characteristics of a public good in that not cutting the trees makes the option of future enjoyment available to all. Hence, economic assessment of the relative values of cutting the trees and preserving them would not be complete without including, on the preservation side of the ledger, the value of the options for future enjoyment.

For such a seemingly obvious point, Weisbrod's conclusion has generated a surprisingly large, and sometimes contentious, literature. The issue, and it has turned out to be a difficult one, is the relationship between willingness to pay for options and the traditional welfare measures. At its root, the debate has centered around how the conventional Hicksian measures of value, developed assuming certainty, should be applied when the individual whose welfare is being measured is uncertain about economic or other parameters. Some basic definitions and theoretical conclusions have emerged.

Let us begin by revising the indirect utility function to be $V[P(s), I(s), Q(s), s]$. The variable s is added to represent various states of the world that may occur in the future. Prices, income, the status of the resource, and preferences themselves may depend on the state of the world. Thus, $V(\cdot)$ is a conditional indirect utility function. For each state of the world, s, we can define a compensating measure of the welfare change, TV(s), in the usual way,

$$\tilde{V}\ [P(s), I(s), Q(s), s] = V\ [P'(s), I'(s) - TV(s), Q'(s), s],$$

where P(s), I(s), and Q(s) represent the values of economic parameters in the absence of the modification in dam operations or other steps to reduce adverse impacts of dam operations. Adding primes to these symbols signifies the values of the parameters if some modifications are made or other steps taken. The Hicksian equivalent measure of value could be defined in a parallel fashion. Once uncertainty is introduced, such values should be thought of as ex post values because they are realized only after the state of the world, s, is known. In the terminology being used here, these are ex post measures of total value. Letting E symbolize the expected value operator over s, E[TV(s)] is the expected value of TV(s), the expected value of the ex post welfare measures.

Option price has evolved as an alternative to the ex post measures. In the present case, option price would measure the total value ex ante, before the state of the world is known. To simplify the exposition, assume that the consumer maximizes the expected value of utility. If

$$E\{V[P(s), I(s), Q(s), s]\} < E\{V[P'(s), I'(s), Q'(s), s]\},$$

then the consumer is said to be better off ex ante if the proposal is adopted. If the inequality is reversed, he or she is said to be worse off ex ante. In either case, the compensating measure of option price, OP, is implicitly defined as:

$$E\{V[P(s), I(s), Q(s), s]\} = E\{V[P'(s), I'(s) - OP, Q'(s), s]\}.$$

The option price is a state-independent payment. That is to say, income is decreased by OP regardless of which state of the world ultimately occurs. If the proposal would increase the expected value of utility, OP is interpreted as the maximum sure amount that this consumer would be willing to pay ex ante (before the state of the world is known) to see the alternative in question adopted. If the proposal would reduce the expected value of utility, then OP would be negative and is interpreted as the minimum sure compensation the consumer would have to be paid ex ante to get him or her to acquiesce to the adoption of the proposal. OP, here, is to be interpreted as an ex ante measure of total value under uncertainty.

Option value, which will be symbolized as OV, can be defined in the total valuation context as

$$OV = OP - E[TV(s)]$$

That is, option value is taken to be the difference between option price (an ex ante measure of total value) and the expected value of the ex post total values. It might be interpreted roughly as an adjustment for the risk preferences of the consumer. Risk preferences affect how the consumer assesses the relative risks of paying the option price ex ante and signing a contract to pay TV(s) ex post, where, recall, the value of TV(s) will depend on the particular state of the world that ultimately occurs. It is now well known that the sign of option value cannot be predicted a priori except in special cases, a result that would certainly carry over to the total valuation version developed here. Furthermore, it is conceivable that option value could be substantial in absolute value (Freeman, 1984). Many today are questioning whether expected utility maximization is an empirically justifiable assumption. If expected utility maximization is rejected and a more general definition of option price adopted, then option value could conceivably take on any value, positive or negative, large or small, depending on how consumers actually deal with uncertainty.

It is now clear that option value is not a separate value at all. It simply measures the difference between two alternative welfare measures under uncertainty, OP and E[TV(s)]. Defining the non-use portion of total value as option value plus existence value is not justified. Instead, once uncertainty is admitted into the problem, the task is to choose which of the welfare measures under uncertainty is appropriate.

Just how welfare changes ought to be valued in the presence of uncertainty is not a simple question. One approach would be to use ex post measures such TV(s) or E[TV(s)]. Alternatively, some ex ante measure like option price could be used. Ex ante measures appear to have more support (Smith, 1987b; Freeman, forthcoming). Ex ante values take risk preferences into account, and there is growing recognition that the allocation of risk, along with the allocation of resources, goods, and services, is important.

The difficulty is that ex ante measures other than option price have also been suggested. Option price can be thought of as one set of possible state dependent payments, where the payment is the same in all states. It is simply one point, among an infinite number of points, along the individual's willingness-to-pay (WTP) locus (Graham, 1981). In our total valuation framework, the willingness-to-pay locus can be defined as follows. Let [W(s)] be a vector of state dependent payments, defined over all possible states of the world, such that

$$E\ \{V[P(s), I(s), s]\} = E\ \{V[P'(s), I'(s) - W(s), Q'(s), S]\}$$

OP is obviously the special case where W(s) = W(t) for all states s and t. Referring to the definition of TV(s) indicates that the point represented by the vector [TV(s)] defined over all states is also on the willingness-to-pay locus. The aggregate willingness-to-pay locus is found by vector addition of the individual loci. It bounds the set of state-dependent payments that all members of society combined could make and still be at least as well off ex ante as they would have been under baseline conditions.

Points other than OP along the individual WTP locus represent different payments in different states, but by the definition of the locus, the consumer is indifferent between paying the option price and paying other amounts recorded along the locus. Why, some would ask, should option price command any special attention compared to other points. Once the possibility of a range of combinations of state-dependent payments is admitted, then the possibility of Pareto superior reallocations of risks among consumers follows. Taking the "without-project" state as the baseline, the aggregate willingness-to-pay locus reflects the Pareto frontier for the project across all possible combinations of state-dependent payments (i.e., all possible inter-consumer reallocations of risk) that would leave the members of society no worse off than without the project.

The issue then becomes whether or not to count the benefits from potential risk redistributions that will not, in fact, be realized. One side argues (based on Graham 1981) that just as the conventional potential Pareto improvement criterion under certainty counts hypothetical payment as benefits and costs, so a comparable measure of social welfare under uncertainty should count hypothetical payments involving reallocations of risk, as reflected in the willingness-to-pay loci of consumers. The aggregate willingness-to-pay locus would be used as the welfare measure in benefit-cost analysis, except under special cases discussed in Graham (1981). The other side, based on Mendelsohn and Strang (1984) and Ready (1991), argues that redistributions of risk that are only hypothetical, that in other words are not actually realized under the project, should not be counted in defining benefits and costs. So long as project financing (to be discussed momentarily) is not an issue, option price takes into account any redistributions of risk that will actually be accomplished through the project and is thus, under the second point of view, the correct welfare measure.

The other issue raised in the more recent literature on this subject is project financing. Both Graham (forthcoming) and Ready (1991) have expanded the analysis to explicitly account for the fact that members of society may actually pay different amounts in different states. In addition, while Graham (1981) focused on valuation of a single project, Graham (forthcoming) allows a full set of mutually exclusive projects to be considered, thus allowing for identification of a Pareto optimal project out of the set. Optimal project financing must satisfy two conditions: (1) project financing must be conducted so that the state-dependent contributions of all members of society combine to realize a Pareto optimal allocation of risk, and (2) the financing plan must exactly pay for the project in all states. Not covering all real costs in all states makes a project infeasible, since real resources used in the project cannot be used elsewhere. If contributions exceed costs in any state, then a dilemma is created. Throwing the extra resources into the ocean would cause a divergence from Pareto optimality. Redistributing them to consumers could disturb the optimality of the allocation of risk. If surplus resources are redistributed to consumers in a Pareto optimal way, then in effect, conditions (1) and (2), as just stated, are met after all. This framework for financing is combined with the aggregate WTP locus (appropriately redefined to explicitly allow for project financing) and a production possibilities set for public projects to form the full, general net benefit criteria that can be used, at least in theory, to define Pareto superior and fully Pareto optimal projects, if one accepts the WTP locus as the correct welfare measurement.

Having rejected the WTP locus for reasons given above, Ready (1991) incorporates the possibility of project financing into a definition of "generalized option price." A "maximum agreeable payment (MAP) vector" is constructed for each consumer, the elements of which consist of generalized (state-independent) option price plus the actual (possibly state-dependent) contribution of the consumer toward project costs in each state. Ready then proposes two welfare criteria that must be met for a project to constitute a potential Pareto improvement: (1) the project must be feasible (i.e., actual contributions must at least cover project costs in all states), (2) the sum of the MAPs over all consumers must exceed the cost of the project in all states. Ready does not generalize his framework to many projects and Pareto optimal choices, but a full, general framework comparable to Graham's could certainly be constructed. The issue continues to be whether state-dependent payments along the WTP locus, or generalized option price is the valid welfare measure.

Having reviewed recent theoretical contributions on valuation under uncertainty, the task now is to draw implications for the case study.

Empirical Implications of Uncertainty

Let us first of all consider questions of project financing. To the extent that alternative plans for operating Glen Canyon Dam have implications for the general taxpayer, the effects are likely to be slight in relative terms. Not only are the amounts likely to be minuscule on a per-taxpayer basis, but under current federal law, power rates must be set to cover project cost. To the extent that dam operating alternatives would reduce the ability of the dam to generate power on-peak, this law will require that power rates be adjusted so that the flow of funds into the federal treasury will be approximately the same. So far as repayment of project costs is concerned, little effect will be felt by the general taxpayer. Power consumers may have to pay more, but this possibility is already included in our analysis by including electricity prices in the price vector. Our definition of total value under uncertainty, OP, may be interpreted as a generalized option price.

Next, we would argue that generalized option price should be the guiding concept in this case. To the extent that one agrees with Ready (1991), as we do, generalized option price is the theoretically correct concept. Even if one is inclined to look toward the aggregate willingness-to-pay locus as the theoretically preferred measure, implementation appears to be far beyond our current capabilities. Generalized option price must serve as the practical expedient, at least for the time being.

Making total valuation of option price the goal does have practical implications for the wording of contingent valuation scenarios. To the extent that it is possible to do so, contingent valuation scenarios should be written to measure maximum certain ex ante payments. They should be written to focus attention on willingness to pay now, while respondents are confronted with whatever uncertainty they face, for environmental services and electricity in the future. This seems to be disappointingly little to glean from all the theoretical debate over valuation under uncertainty, but ways for further implementing the ideas in this section are not obvious. In the long run, project design needs to consider how the production of public goods and actual payments to cover project costs can improve the allocation of risks confronted by consumers, but the practical implications of this prescription for the case study at hand are not clear to us at present.

CONCLUSIONS

This paper used a case study in order to explore economic and survey-design principles needed to measure total values of environmental resources. We conclude by stepping back from the specifics of the case presented and stating in more general terms what has been learned about total valuation strategies.

The first step toward a valid total valuation study is to be sure that the empirical work is as carefully and completely grounded in theory as is reasonably possible. Theory in some form always guides the design empirical work and the interpretation of results, either implicitly or explicitly. Making the theory of what one is trying to measure explicit at the outset will clarify the issues that must be addressed in study design. Extending previously applied welfare concepts to total valuation appears to be straightforward.

Total valuation studies will be strengthened by determining what people value and why. Existence values do not manifest themselves via the usual channels of revealed preferences. There appears to be no alternative to examining preferences directly. Most past studies, to the extent that they have dealt with this question at all, have investigated preferences as part of the contingent valuation survey. We see significant advantages to applying such tools as focus groups and attitude surveys prior to designing contingent valuation instruments, particularly in cases like the one addressed here that involve substantial complexity. That way, contingent valuation scenarios can be designed using an empirical understanding of what respondents value and why, rather than the investigator speculation. Also, the contingent valuation instrument itself can then be designed to gather data on preferences of individual respondents that can be used to explain statistically their responses to valuation questions. In this way, values can be related to empirically based assessments of the resource attributes that people value. Because we economists lack training in methods of researching preferences, attitudes, behavioral intentions, and opinions, collaboration with social psychologists and other social and behavioral scientists is highly desirable.

While the conceptual underpinnings of total valuation have evolved in the context of environmental amenities, other resources could also have existence values. In our case, this issue arose because possible steps to protect and enhance environmental resources could impact electric power production. The question then became whether values beyond use values might be associated with the power. Similar questions involving non-amenity resources are likely to arise in other studies. If so, there is nothing in the logic of total valuation that would rule out such values and they should be addressed. This is an additional aspect that could be profitably researched using focus groups, attitude surveys, and related tools. Beyond that, non-amenity existence values deserve attention in future basic research on total valuation.

Focus groups and attitude surveys could also help identify the population that holds potentially significant total values. If such values are, for the most part, a local or regional phenomenon in specific applications, then large amounts of resources could be wasted on a national survey. Conversely, a contingent valuation survey that misses many members of society who hold total values could substantially underestimate aggregate values. Thus, the geographic extent to the relevant population must be considered with care.

We found neither a theoretical justification nor a practical need for segmenting total values into component parts. The temptation to try to persuade respondents to segment their total values into use, existence, bequest, and option values, or some other taxonomy, should be resisted.

It is sometimes said that non-use values consist of existence values and option values, but this is not a theoretically valid statement. Option value is simply the difference between two possible measures of welfare, option price and the expected value of the ex post measures. The theoretical literature on welfare evaluation under uncertainty warrants continuing attention from applied researcher as it continues to evolve. At present, however, the concept of generalized option price, adapted to a total valuation framework, should be the foundation for applied studies. This means that contingent valuation scenarios should be framed in terms of maximum <u>ex ante</u>, state-independent payments to achieve <u>ex ante</u> improvements in well-being or to avoid <u>ex ante</u> reductions in welfare.

The well-being of people may be affected by what happens to resources that they do not use. As we have seen, traditional welfare theory is rather easily adapted to include this possibility. The nature, extent, and magnitude of the total values depend on empirical estimation. Valid empirical estimation requires careful attention to theoretical principles and collaboration with other social and behavioral scientists from the outset.

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ENDNOTES

1. During the last several months, flows have been manipulated for research purposes, thus deviating from our "current operating criteria." Furthermore, concern about the impacts of dam operations on Grand Canyon resources has intensified. This led to a decision to prepare an Environmental Impact Statement on Glen Canyon Dam operations. However, completion of this process will take many more months. In the meantime, beginning on August 1, 1991, proposed interim flow restrictions were mandated to serve until November 1, 1991, when Secretary of the Interior Lujan is to announce interim operating criteria that presumably will be in force until a decision is made regarding new, permanent operating criteria for Glen Canyon Dam, based on the Environmental Impact Statement and other considerations. Thus, when we refer to current operating criteria, we refer to the criteria in force from the closing of the Dam in 1963 until mid-1990, when the research releases began.

2. Under extreme conditions, flows can be even larger. For example, under flood condition in 1983, the discharge rate reached 92,600 cfs.

3. Most of this research is being conducted under the auspices of the Glen Canyon Environmental Studies, a multi-agency effort under the auspices of the U.S. Bureau of Reclamation.

4. Some fishing does occur below Lees Ferry including fishing in the Grand Canyon itself. However, most of the fishing occurs upstream and our study was limited to the segment between the dam and Lees Ferry.

5. The range of possible modifications in dam operations for our study has been clarified somewhat by the decision process which now involves the preparation of an Environmental Impact Statement for Glen Canyon Dam operations. Formal alternatives are being defined as part of that process which delimit the alternatives that will need to be covered in the total valuation study.

6. In benefit-cost terms, there may be an important problem of "accounting stance" here. Since there is international interest in the Grand Canyon, it is conceivable that the welfare of people all over the world could be affected by dam operations. Others would argue that people outside the U.S. are not members of "society" for purposes of counting social benefits and social costs in this case. As a practical matter, we will take the U.S. population as the maximum population of interest for this study, while admitting that a broader definition is conceivable.

7. More general formulations, which do not depend on expected utility maximization are possible (see Graham, forthcoming, and Ready, 1990), but would add nothing of empirical relevance here.

8. That is, the marginal rate of substitution of dollars paid in each pair of states must be equal for all consumers.

9. Notice that there is no issue of deficit financing here. If real resources (land, labor, and capital) are used in a project, real costs are generated for someone. Deficits only change the incidence of costs.

10. Not that these two criteria are not really redundant since generalized option price could be negative for some consumer, indicating that they are ex ante losers.

DESIGN OF OPTIMAL SAMPLES FOR CLOSE-ENDED CONTINGENT VALUATION QUESTIONS[1]

by

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ABSTRACT

This paper develops a model for optimal survey design for the close-ended, or dichotomous choice, contingent valuation method that finds the bid amounts as well as the sample sizes corresponding to each bid. The model uses an iterative procedure that selects the survey design that minimizes the mean square error of the welfare measure. A set of Monte Carlo simulations shows the model to produce significantly lower mean square errors for the welfare estimate than those for the next best model.

Survey design under alternative assumptions regarding the statistical distribution of the welfare measure is also addressed. The model produced significantly different surveys designs depending on whether the distribution was assumed to be symmetric or asymmetric.

OPTIMAL BID SELECTION FOR DICHOTOMOUS CHOICE CONTINGENT VALUATION SURVEYS

INTRODUCTION

The survey design problem for the dichotomous choice (DC) contingent valuation method (CVM) has received considerable attention of late. Among the papers that have addressed this topic are Duffield and Patterson [10], Cameron [7], Boyle, Welsh and Bishop [6], and Bishop and Heberlein [4]. Each of these papers explores the determination of at least several of the components of the DC CVM survey design process, which consists of finding the total survey sample size (N), the bid amounts ($\$b_1, \$b_2, \ldots, \$b_m$) to be posted in the surveys, and the allocation of the total sample size between the different bid amounts ($n_1, n_2, \ldots, n_m$), i.e., the number of surveys that post each bid amount.[2]

Of these papers, Duffield and Patterson (D&P) [10] is at the forefront of the topic of optimal survey design. Given pre-test data on the parameters of the statistical distribution of willingness to pay (WTP), the total sample size, and *given* the set of bid amounts, their model determines the optimal allocation of the total sample size among the different bid amounts.

Even though Duffield and Patterson's paper is the most comprehensive to date, it only addresses part of the DC survey design process. They have left unanswered the question of the formulation of the optimal bid levels themselves. The primary goal of this paper is to develop a model that finds the optimal vector of bid amounts along with the optimal allocation of the total sample size among these bid amounts. In the last section, simulations are conducted to test the optimality of the design.

Several studies have either directly or indirectly demonstrated the need for an algorithm that determines the individual bid amounts. The results of a study by Kriesel and Randall [16] provide an example of the problems associated with having a inadequate bid design. They constructed a DC CVM survey on the WTP for an increase in air quality in which the bids turned out to be too low. Unfortunately, as will be explained below, 60% of the respondents were willing to pay the highest posted bid, yielding an underestimate of WTP. In both an empirical and theoretical analysis, Cooper and Loomis [9] directly addressed the issue of the sensitivity of mean WTP to the choice of bid values. Based upon an empirical analysis of 10 different DC CVM data sets, they found that the estimate of mean WTP was sensitive to the specification of the vector of bid values, regardless of the functional form chosen for measuring WTP: estimated mean WTP decreased by as much as 57% with the removal of the 4 highest bids from a set of 15.

Another topic to be examined in this paper is the effect on survey design of changing the distributional assumptions for WTP. Largely in the consideration of convenience, DC CVM studies to date have assumed WTP to have a logistic or normal distribution. However, little evidence exists to suggest that WTP is distributed symmetrically. The author, in the course of research for another paper, examined several open-ended (OE) CVM data sets, and using a Box-Cox test, found them to be distributed lognormally. [3]

DC CVM METHODOLOGY

As a result of the dichotomous responses to the DC CVM questions, the only information provided by the respondent t, where $t = 1,\ldots,N$, is whether WTP_t is above or below the posted bid amount (b_i). Since the researcher does not know the individual's true WTP, WTP_t is a random variable. As Hanemann [14] notes, the expected value of this variable, and of any other random variable, can be expressed in continuous form as

$$(1) \qquad E(WTP) = \int_{-\infty}^{\infty} bf(b)\,db = \int_{0}^{\infty} [1-F(b)]\,db - \int_{-\infty}^{0} F(b)\,db,$$

where F(b) is the cumulative density function that represents the probability of a "no" response and f(b) the probability density function.[4] Assuming that in most cases WTP is a nonnegative random variable (i.e., we are dealing with goods that provide positive utility), (1) reduces to

$$(1.1) \qquad E(WTP) = \int_{0}^{\infty} [1-F(b)]\,db.$$

Equation (1.1) assumes $\lim_{b\to 0}F(b) = 0$ and $\lim_{b\to\infty}F(b) = 1$. As is commonly done in empirical studies, if the upper range of the distribution is truncated at the highest observed WTP value (e.g., Bowker and Stoll [5]), equation (1.1) does not strictly hold (Boyle, Welsh, and Bishop [6]). The truncation bias decreases as $F(b_{max})$ approaches one. Thus, Kriesel and Randall's 60% acceptance rate for the highest bid value, or $F(b_{max}) = 1 - .60 = .40$, represents a serious truncation of E(WTP).

The primary goal of this paper will be achieved by devising a model that selects the bid design that minimizes the mean square error (MSE) of $W\hat{T}P$ (the estimate of the true population mean, WTP, will be denoted as $W\hat{T}P$).[5] While the opinion as to what decision rule criteria is most important is not always unanimous, the criterion of MSE is one of the generally accepted decision rules for measuring the performance of an estimator (Judge, et al. [18]). MSE is defined as the variance of $W\hat{T}P$ plus the square of the bias of $W\hat{T}P$, or

$$MSE(W\hat{T}P) = E[W\hat{T}P - E(W\hat{T}P)]^2 + [E(W\hat{T}P) - WTP]^2.$$

The minimum MSE criteria is chosen over a minimum variance criteria (D&P [10]) because of its greater generality. While the minimum variance criteria should produce the value for $W\hat{T}P$ with the narrowest confidence interval, it does nothing to insure that this value is unbiased. The minimum MSE criteria strikes a balance between the criteria of unbiasedness and minimum variance.

EXPERIMENTAL DESIGN LITERATURE REVIEW

A. General Approaches.

The most rigorous work in the field of optimal design for binary data has been performed on biological assay and fatigue experiment data. Examples of this work are provided by Finney [11;12], St. John and Draper [24], Little and Jebe [19], Abdelbasit and Plackett [1], Minkin [22], and Wu [27]. These authors utilize the criteria of D-optimality, which uses two different bid values, or C-optimality, which uses one bid value that is updated sequentially. However, these models are not particularily useful for DC CVM. D&P [10] and Cooper [9.1] note several limitations of D-optimality with respect to its application to DC CVM, namely that it focuses on only two points in the integral range in equations (1) and (1.1) and that it minimizes the variance of the estimated logit coefficients and not necessarily the variance or mean square error of the WTP estimate. Because C-optimality requires repeated survey updates, it is too slow for use with mailed-in DC CVM surveys.

In sum, the current state of the statistical design literature is not directly applicable to DC CVM. Even so, the literature may serve as a useful starting point for developing the sample design problem for DC CVM.

B. Current DC CVM sample design approaches.

D&P [10] proposed and tested a model for determining the optimal sample sizes $(n_1, n_2, \ldots, n_m)$ given a loosely chosen set of bids $(b_1, b_2, \ldots, b_m)$, the number of unique bids (m), and the total sample size (N). Specifically, they constructed the problem as a minimization of the variance of the expected value of willingness to pay subject to $\Sigma_i^m n_i = N$, where n_i is the number of individuals facing bid amount b_i and N is the total sample size. The variables to be considered in the design problem are b_i, n_i, and m, where m is the number of different bid prices posted $(m \leq N)$. In D&P's [10] model, open-ended pre-test survey results are used to construct a prior probability density function for

WTP. The mean of this prior density function serves as a proxy for WTP.

Significantly, the D&P [10] model does not address how $b_1,\ldots,b_m$ should be chosen. What has been used in past research to determine $b_1,\ldots,b_m$ is a simple criteria, such as roughly equal log-linear increments between bids and a pre-specified m (e.g., Bergland, et al. [3]). Quantitative information has been used in a strictly informal manner.

C. Proposed bid selection approach.

As do D&P [10], the total sample size (N) of the survey will be taken as given; available research funds are assumed to be the primary determinants of N. Of course, N can be varied to test the relationship between it and the variance of the WTP estimate.

In choosing $b_1,\ldots,b_m$ and $n_1,\ldots,n_m$, the importance of selecting minimum MSE criteria over the minimum variance criteria should be stressed. Ideally, the process of choosing $b_1,\ldots,b_m$ must minimize the possibility that the distribution of these bids is different from the distribution of the actual WTP_t, $t = 1,\ldots,N$. The lower these bids are set relative to the actual WTP_t values, the greater the proportion of respondents answering "yes" to the DC WTP questions. The reverse would hold if the bids levels were set too high. In situations with a large enough distance between the centers of mass of the distribution of the posted bids and that of the true WTP_t values, the dependent variable will show little variation and the results of the econometric model run on this data would be poor.

Although both n and **b** (where n and **b** are m X 1 vectors) should be endogenously determined, it may not be possible to choose them simultaneously. Without explanation, Minkin [22] notes that "the task of directly finding the allocation that minimizes the volume of the likelihood regions ... does not appear feasible in general." Because he cannot find the allocation in general, he restricted himself to a two-point model, which is of little use in CVM. The most manageable way to tackle the problem appears to be to choose the vectors n and **b** in an iterative two-step procedure. Given the computational speed of contemporary computers, the inability to chose the n_i's and b_i's simultaneously is not a significant problem. A two step program designed to choose the MSE minimizing allocation can be done by conducting a scan over the integer values of m = 1 to N.

BID DISTRIBUTION WITH EQUAL AREA BID SELECTION (DWEABS)

DWEABS is an iterative two-step model. In step 1, given the number of unique bid values (m), total sample size (N), and a prior probability distribution for WTP, DWEABS sets the bids at equal probability increments (i.e., the area under the probability density function is divided into equal areas). In step 2, for the set of bids selected in step 1, and given N and the prior probability distribution, the variance minimizing allocation $n_1,\ldots,n_m$ is determined. The two steps are recalculated for m = 1 to N to find the MSE minimizing m^* and allocation $([b_1^*,n_1^*],\ \ldots,[b_m^*,n_m^*])$. This procedure appears to be a systematic and tractable solution to the key bid design issues in DC CVM.

In step 1, the area under the prior (from pre-test data) probability density function $f(WTP|\theta)$ is divided into equal areas with the bids set at the levels corresponding to the borders between the areas. Formally, given P_i, b_i is set at $F(b_i) = P_i$, or $b_i = F^{-1}(P_i)$, for $i = 1,\ldots,m$. For example, if $m = 1$, the area under the CDF is divided into two equal areas, with the separation occurring at $P_1 = .5$, and correspondingly, $b_1 = F^{-1}(.5)$. If $m = 2$, $P_1 = .333$, $P_2 = .666$, and thus $b_1 = F^{-1}(.333)$ and $b_2 = F^{-1}(.666)$. [6]

Division of the distribution into equal areas for the selection of the bid values is a sensible choice for an algorithm that can be generalized to any value of m and any distribution. DWEABS allocates half of the bi's each side of the median.

As stated above, if $m = 1$, the model sets the bid at $b_1 = F^{-1}(.5)$. If one could only choose one bid point, the obvious candidate is the median or the mean (in fact, C-optimality confirms this observation), which are identical for a symmetric distribution. Assuming that the prior distribution is true, a respondent would be equally likely to accept or reject the bid, thereby maximizing the probability that the responses are equally balanced between "1's" and "0's". For an even m, half the bid points would be set on one side of the median and half on the other at equidistant probability increments. For any odd m, m/2 is the median.

With DWEABS, the truncation point T (replacing ∞) on the upper limit in expected value function (equation 1.1) is not fixed a priori, as in Bowker and Stoll [5] and D&P [10], but is an increasing function of m. As m increases, more bids are generated further into the tails of the distribution, i.e., bids are selected in a process that moves away from the center of the distribution as m increases.

In this selection process, the increments between the bids increase as the distance from the median increases. As the size of m is finite, this tendency is an efficient allocation of the bid amounts; bid amounts are placed closer together in the region of highest density and further apart as the density decreases. For example, if the median and standard deviation of a distribution were \$50 and \$10, respectively, one would expect the representative respondent to make a finer distinction (i.e., the higher the likelihood a "yes, would pay" response to b_i changes to a "no, would not pay" response to b_{i+1}) between the bid values \$50 and \$60 than between \$200 and \$210. By using relatively simple rules of thumb such as equal log intervals between bids, some researchers in the field have recognized that as the bid values increase, the dollar increments between them should increase.

By construction, DWEABS is designed to achieve a trade-off between the response information received from concentrating the bids in the center of the distribution and the response information receive from placing the bids in the extreme tails of the distribution. Even though placement of the bids far into the tails of the estimated distribution will increase the probability that at least part of the actual distribution will be covered and that the set of responses will be balanced between "1's" and "0's", this placement should be avoided. For example, with m = 2, the widest allocation of bids would be $b_1 = \text{plim}_{P\to 0}F^{-1}(P)$ and $b_2 = \text{plim}_{P\to 1}F^{-1}(P)$. However, allocation of the sample to these two bid points would provide little input to respondent behavior within the relevant range of WTP. Recall that from equation (1.1) that $\hat{WTP}$ is estimated over the entire range of WTP. On the other hand, the extreme point bid values do provide valuable input to finding the endpoints of the $\hat{WTP}$ distribution.

In step 2, given the bid points determined in step 1, the mean square error minimizing allocation of $n_1,\ldots,n_m$ is derived. The criteria is to choose $n_1,\ldots,n_m$ to minimize $MSE(W\tilde{T}P \mid b_1,\ldots,b_m, \Theta) = bias^2 + var(W\tilde{T}P)$ subject to the total sample size constraint, i.e.,

$$(2)\quad \min_{n_1,\ldots,n_m} \ (WTP - W\tilde{T}P)^2 + var(W\tilde{T}P)$$

$$s.t. \sum_{i=1}^{m} n_i = N, \text{ where } n_i \geq 0 \text{ for } i = 1,\ldots,n$$

where estimated WTP in the design program is denoted as $W\tilde{T}P$ to differentiate it from $W\hat{T}P$, which is estimated from regression analysis of the responses to the DC CVM survey developed by the minimization of the MSE of $W\tilde{T}P$.

Because discrete bid amounts $b_1,\ldots,b_m$ are handed down to step 2, a discrete linear approximation of the continuous mean for a nonzero variable (equation 1.1) and variance of willingness to pay must be made. D&P [10] have developed nonparametric trapezoidal approximations for these estimators. Based on the trapezoidal approximation to an integral, with the integral cut into m sections of length Δb_i, their truncated $W\tilde{T}P$ approximation to $\int_0^\infty[1 - F(b)]db$ is

$$(3)\qquad W\tilde{T}P = \sum_{i=1}^{m} \Delta b_i p_i,$$

where:

$$\Delta b_i = (b_{i+1} - b_{i-1})/2, \quad \text{for } i = 2,\ldots,m-1,$$

$\Delta b1 = (b_2 - b_1)/2$ and $\Delta b_m = (b_m - b_{m-1})/2$,

$p_i = 1 - F(b_i) = n_i^y / n_i$ is the percentage of positive responses to b_i. [7]

As m increases, the approximation in (3) more closely approaches the limits of the integral (1.1) over 0 to ∞. The trapezoidal approach is favored over the Simpson's Rule as the latter approximation is valid only for even numbered increments.

Using the fact that n_i^y is a binomial random variable with parameters n_i and p_i, where $\pi_i = 1 - F(b_i)$, the variance of n_i^y is $n_i\pi_i(1 - \pi_i)$, and hence, $var(p_i) = \pi_i(1 - \pi_i)/n_i$. Using this derivation, the D&P [10] equation for the variance of the WTP estimator in (3) is

$$var(\tilde{WTP}) = \sum_{i=1}^{m} (\Delta b_i)^2 \pi_i (1-\pi_i)/n_i, \tag{4}$$

noting that the Δb_i's are exogenous to step 2.

D&P [10] minimize (4) subject to the constraint that $\Sigma_i^m n_i = N$. However, for the reasons discussed earlier, minimizing MSE is preferable. To minimize MSE with respect to $n_1,\ldots,n_m$, the formulas in (3) and (4) are substituted for the mean and variance in (2). Since the bias portion is not a function of the n_i's, the first order conditions for equation (2) and the constrained version of equation (4) are the same for a *given* set of bids. Hence, the D&P [10] approach finds the MSE, and variance, minimizing n_i's only for the given set of bids. For any N, this will be the MSE minimizing sample design only by chance. In DWEABS, the model is iterated over $m = 1$ to N using (2) as the objective function to find the optimal MSE minimizing sample design ($b_1,b_2,\ldots,b_m$; $n_1,n_2,\ldots,n_m$). Unlike the D&P [10] approach, DWEABS examines the bid design at every possible value of m.

By equations (3) and (4) and by the bid selection properties of DWEABS, $\partial bias/\partial m < 0$ and $\partial var/\partial m > 0$. The former occurs because the accuracy of the trapezoidal approximation of E(WTP) increases as the number of increments (m) increases. The latter occurs as the spread of the bid values increases with m.

Setting up equation (4) as a LaGrangian subject to the sample size constraint, taking the first order conditions and solving them for n_j gives the optimal n_j^* (*see the* D&P [10] result, which is a variation on a result by Cochran [8]).[8]

EMPIRICAL ESTIMATION OF THE OPTIMAL BID DESIGN

Using DWEABS, optimal bid designs are estimated under four different distribution assumptions. Two of the distributions -- the normal and the logistic -- are symmetric and the other two -- the lognormal and the gamma -- are asymmetric. Open-ended (OE) WTP responses to a pre-test survey are utilized to produce estimates of the parameters of the distribution needed by DWEABS. The pre-test information could also take the form of some previously estimated open-ended or close-ended equation for WTP. Of course, as economic theory gives no guidance on the choice of statistical distribution to expect, these equations in and of themselves would provide little feedback on the nature of the distribution.

As noted earlier, little evidence exists to indicate that WTP values are distributed normally. Boyle, Welsh, and Bishop [6, p. 96] note that "estimated CDF's can have fat tails." Although it does not address the condition of asymmetry, the fatter tails of the logit distribution better make it better suited in general to CVM applications than the normal distribution.

For each of the four distributions, the bid programs were written in the Gauss language for use on a MS-DOS compatible personal computer. In these programs, the functions $b = F(P)^{-1}$ are approximated numerically, obviating the need to derive inverses of the open-form distributions.[9]

RESULTS

For the following case study, DWEABS is used to determine the optimal bid allocation for a typical DC CVM question. This dichotomous choice question is aimed at recreationists who had hunted deer in California during the season prior to the questioning. The proposed question is "Would you be willing to pay an additional $X over your actual trip costs to hunt this specific [deer hunting] zone? Answer "YES" or "NO"."

The OE data used to provide the sample information for the above question come from the California Deer Hunter Pre-test Survey (Loomis, Creel, and Cooper [20]) and pertain to the 1986 deer hunting season. The data set contains the responses to the sequence of questions: (1) "Was this deer hunting trip worth more than you spent?", and (2) "If YES, how much would you be willing to pay over your actual trip costs to hunt this specific zone?" For this data, the sample mean, sample standard deviation and median WTP are $130.00, $157.00, and $100.00, respectively. Since the mean is greater than the median, the data exhibit a positive skew.[10]

Table I presents the E(WTP)'s calculated using equation (1.1) for the four distributional assumptions, where the truncation point T is set greater than F(T) =.99. Also presented are the calculated medians of the four distributions, set at F(WTP) = .50. The priors listed in the table headings are the simple arithmetic means of the OE data, as well as their standard deviations and medians. Because WTP values < 0 are censored from E(WTP), with the symmetric logit and normal distributions, E(WTP) is greater than the median.[11] As is expected, median WTP varies little between the logit and normal models. Note that the mean and median of the lognormal distribution are closest to the mean and median of the pre-test data, with those from the gamma following close behind. Given the results of the Box-Cox test for lognormality, this result may not be surprising.

TABLE I. Estimated mean and median WTP using Equation (1.1) under the four distributional assumptions.

DISTRIBUTION	MEDIAN OF THE DISTRIBUTION	E(WTP)
LOGNORMAL	\$100.00	\$131.90
GAMMA	\$95.10	\$128.70
NORMAL	\$130.00	\$147.32
LOGIT	\$130.00	\$147.32

Source: (Cal. Deer Hunter Pre-test data prior information: sample mean = \$130, standard deviation = \$157, median = \$100).

Note: Gamma parameters b = 113 and c = 1.16

Using a sample size N of 100 for the proposed DC CVM survey, Table II presents the optimal sampling plans based on the results of the scan over values of m = 1 to 100 for the MSE minimizing sampling plan under each of the distributional assumptions. Under the normal, logit, lognormal, and gamma distributions, the m^* are 11, 13, 43, and 43, respectively. Note that the asymmetric distributions produced the highest values for m^*. As would be expected based on the similarity of the logit to the normal distribution, the optimal sampling plans under those two cases are quite similar.

Because some researchers may not have their desired total sample size N constrained from the onset, it is interesting to see the effects of increasing N, as against the optimal procedure for allocating the given N, on MSE. Table III presents the MSE and *m* for the optimal sample designs for several different N's ranging from 10 to 1000. As is evident from the results in the table, MSE decreases at a decreasing rate as N increases. If N is not fixed a priori, N can

TABLE II. Optimal sampling scheme under four distributional assumptions, where N=100 (California Deer Pre-test data). Note: due to rounding error, the figures under SAMPLE may not sum to exactly 100.

GAMMA		LOGNORMAL		NORMAL		LOGISTIC	
BID	SAMPLE	BID	SAMPLE	BID	SAMPLE	BID	SAMPLE
$8	1	$43	1	$1	2	$3	4
$12	1	$46	1	$15	7	$35	8
$16	1	$52	1	$51	10	$62	8
$19	1	$55	1	$84	10	$86	8
$23	1	$59	1	$115	10	$109	7
$27	1	$62	1	$146	10	$130	7
$30	1	$65	1	$176	10	$152	7
$34	1	$67	1	$209	11	$175	8
$38	1	$70	1	$246	11	$199	8
$42	1	$73	1	$291	13	$226	8
$46	1	$76	1	$354	6	$257	9
$50	1	$79	1			$299	12
$54	1	$83	1			$365	5
$58	1	$86	1				
$63	1	$90	1				
$67	1	$93	1				
$72	2	$97	1				
$77	2	$101	1				
$82	2	$106	1				
$87	2	$110	1				
$92	2	$115	1				
$98	2	$120	1				
$104	2	$126	1				
$110	2	$132	1				
$116	2	$138	1				
$123	2	$145	2				
$129	2	$152	2				
$137	2	$160	2				
$145	3	$168	2				
$154	3	$178	2				
$163	3	$188	2				
$172	3	$199	2				
$183	3	$212	3				
$194	3	$226	3				
$207	3	$243	3				
$221	4	$262	3				
$236	4	$285	4				
$254	4	$312	4				
$275	5	$346	5				
$300	6	$390	6				
$336	7	$452	8				
$383	8	$549	12				
$459	4	$743	6				

be chosen using some convergence criteria on the change in MSE associated with a change in N. Of course, the tolerance on the convergence criteria would be subjective. Judging from the results in the table, it may be safe to predict that the decrease in MSE associated with a doubling of N from 1,000 will not be worth the additional mail and processing cost.

TABLE III. Relationship between Mean Square Error (MSE), number of unique bid values, and total sample size (m).

TOTAL SAMPLE SIZE (N)	NO. OF UNIQUE BIDS (m)	MEAN SQUARE ERROR
10	5	1747.6
20	6	1005
30	7	727.7
40	8	577.1
50	9	480.5
100	13	267.3
200	21	146
300	27	101.9
400	33	78.73
500	40	64.4
1000	71	34.34

Source: California Deer Hunter Pre-test data.

TEST OF THE VALIDITY OF THE DWEABS MODEL

The efficiency of a survey design produced by DWEABS model relative to a survey design produced using current state of the art techniques was tested through a Monte Carlo simulation technique. For this simulation, the total survey sample size N was set at 500, which should be large enough to remove the potential for small sample biases. The necessary parameters, logistic mean WTP (at $147.32 [see Table I), and variance were derived from the California Deer Hunter pre-test data.

In step 1, a DWEABS specified bid design and the frequently used equal log-linear increment spacing design were created. Applying the DWEABS approach to the pre-test data used in the empirical section, the optimal survey design was developed using the procedure described earlier. The optimal number of unique bids amounts (m) was 40, with the values ranging from \$1 to \$464. For the comparison design with equal log-linear increments, the number of unique bid amounts was set at 15, which is somewhere in the average range of the choice for m; to the best of the author's knowledge, no one has ever used anywhere near 40 different bid levels for a DC CVM survey. To put this model on an equal footing with the DWEABS plan, the endpoint bids were also set at \$1 and \$464, where the upper value represents the predicted 97.6 percentile of the distribution. As the choice of these endpoints alone uses more pre-test information than is typical of most CVM survey designs, this log-linear survey plan is better constructed than the typical plan. Again using N = 500, the subsample sizes (n_1, $n_2, \ldots, n_{15}$) are found for the log-linear plan using the D&P [10] approach (equation 6). Next, for both models, the estimated probabilities $\hat{F}(b_i)$ associated with each bid value were calculated and saved.

In step 2, N survey responses (i.e. "yes" and "no" 's) to the DWEABS and the log-linear surveys were generated. Specifically, for each set (b_i, n_i), where $i = 1,\ldots,m$, n_i survey responses to the data sets were generated using a binomial distribution with parameters n_i and $1 - \hat{F}(b_i)$.

In step 3, for the two designs, maximum likelihood logit was used to estimate the coefficients (α,β), with the "1/0" ("yes/no") responses as the dependent variable and a constant and the bid vector as the regressors. The $\hat{F}(b_i)$'s were re-estimated based on these coefficients, and using equations (4) and (5), $\hat{WTP}$ and var($\hat{WTP}$) calculated based on these probabilities. Based on these statistics, the MSE's associated with each set of simulated survey responses are calculated using equation (3).

Steps 2 and 3 were performed 1,000 times, thereby generating 1000 sets of simulated survey responses. At 177.58, the average MSE of WTP for the DWEABS survey responses was almost three times lower than that for the log-linear model, which had an average MSE of 311.53. Average mean and variance across the 1,000 iterations for the DWEABS model were \$152.07 and 45.63, respectively, and \$161.54 and 58.52 for the log-linear model. Based on these values, a 90% confidence interval for the DWEABS mean was \$140.96 to \$163.19 and \$148.96 to \$174.13 for the other (the two means are distributed normally due to the central limit theorem). As is evident from these confidence intervals, the DWEABS results cover the true mean of \$147.32, while the next best model does not.

CONCLUSION

This paper has presented a procedure for determining the optimal sample design for a Dichotomous Choice Contingent Valuation Method (DC CVM) survey. Using prior information on the underlying distribution of Willingness to Pay (WTP) and the proposed sample size, the model (DWEABS) selects the optimal number of bid amounts (m), the dollar value of each bid amount ($b_1,\ldots,b_m$), and the sample size ($n_1,\ldots,n_m$) corresponding to each bid amount, i.e., the number of surveys that post each bid amount. Previous models do not address the formulation of ($b_1,b_2,\ldots,b_m$), which is a crucial component of the overall sample design.

The DWEABS model uses an iterative procedure. For each possible value of m (an integer from 1 to the total sample size N), the model finds the appropriate vector of bid values ($b_1, \ldots, b_m$). Next, for each of these N vectors, the model finds the vector of sample sizes ($n_1, \ldots, n_m$) that minimizes the mean square error (MSE) of expected WTP for that particular sampling plan. The optimal sampling plan ($b_1, \ldots, b_m$; $n_1, \ldots, n_m$) is the one with the lowest MSE.

The DWEABS model is nonparametric and can be used with any statistical distribution assumption for WTP. The optimal m chosen tends to be lower (by more than a factor of 3) for the symmetric distributions than for the asymmetric distributions. For any given m, the asymmetric distributions, such the lognormal and the gamma, produced the highest maximum bids and tended to sample proportionately more at the upper end of the bid range than the symmetric distributions.

An implicit underlying theme of this development is that quality pre-test information is necessary for the construction of a good DC CVM sampling plan. At best, the researcher should produce a small run of preliminary surveys that ask open-ended versions of the planned DC CVM questions.

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ENDNOTES

1. This paper is a condensed version of a paper entitled "Optimal Bid Selection for Dichotomous Choice Contingent Valuation Surveys" that will be appearing in the forthcoming November, 1992 issue of the Journal of Environmental Economics and Management.

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2. For readers unfamiliar with the DC CVM appproach, note that each respondent faces only one of these bid values in the survey question.

3. Several papers have accounted for this asymmetry by using Equation (10) in Hanemann [13]. However, this specification is not compatible with utility maximization (ibid), though it may be an adequate local approximation to a true model. See footnote 10 for a further discussion of lognormality.

4. If F(bi) is logistic, the parameters estimates necessary to calculate F(bi) can be expressed in the logistic framework as $F(b_i) = Prob(WTP_t \le b_i) = [1 + exp(-(\alpha+\beta b_i))]^{-1}$, where $\alpha + \beta b_i$, $\beta < 0$, is the individual's utility difference equation (Hanemann [13;14]). Estimates of α and β can then be found using a logit regression.

5. Though WTP is used here, the analysis is equivalent with regards to WTA.

6. See the forthcoming November, 1992 issue of the Journal of Environmental Economics and Management for further detail.

7. The equations for Δb_1 and Δb_m are slightly different than those of D&P as a stricter application of the trapezoidal function (Stein [25]) is used here.

8.The case where respondents are faced with actual cash bids (e.g. Bishop and Heberlein [4]) is not discussed here as this form of DC CVM is rarely used.

9.Hard copies plus floppy disk copies (on a user-supplied diskette) of the DWEABS programs are available from the author free of charge from the address listed on the first page of this paper.

10.A box-cox test Johnson [17] was run on the pre-test data to test the null hypothesis that the data is lognormally distributed versus the alternative hypothesis that the data is normally distributed. This test assumes that there exists a value λ by which the random variable y is transformed such that $(y_t^\lambda - 1)/\lambda = x_t$. At the extremes, if $\lambda = 0$, y_t is distributed lognormally, and if $\lambda = 1$, y_t is distributed linearly. With an estimated λ of 0.015 and with a χ^2 value on the test of 0.916, the null hypothesis was not rejected at the 90% level of confidence.

11.Negative WTP values could be possible for those respondents whose true WTP is less than the actual trip cost. Due to the wording of the question, this condition is not possible for the California Deer Hunter Pre-test data set. If negative WTP values are possible, the bid values could be unconstrained and equation (3) would approximate equation (1). Unfortunately, it is not practical to present respondents with negative bids.

OPTIMAL EXPERIMENTAL DESIGN FOR THE DOUBLE-BOUNDED LOGIT MODEL

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Abstract: Environmental economists are beginning to use a double-bounded dose-response model to estimate economic values of environmental amenities using the Contingent Valuation Method. Optimal Experimental Design results have previously been derived for the standard, single- bounded model. This paper derives the D-Optimal, C-Optimal and Fiducial Method optimal designs for the double-bounded logit model.

1. INTRODUCTION

Environmental economists have adopted dose-response models for use with the Contingent Valuation Method (CVM), a popular and widely accepted method used for determining the economic values of environmental amenities such as air or water quality, existence of wildlife, or quality of outdoor recreational experiences. Many have become interested in adapting Optimal Experimental Design results for use with CVM surveys. The Contingent Valuation Method uses surveys to elicit willingness to pay or willingness to accept compensation payment for a hypothetical change in the availability of a particular environmental amenity or other non-market good. The willingness to pay (WTP) or willingness to accept (WTA) responses collected, are used to estimate welfare benefit measures deemed to be appropriate for use in an economic analysis, such as benefit-cost analysis, of a project affecting that environmental amenity. Individual WTP or WTA values are generally elicited through a discrete-choice, market-type questioning format. The procedure is to ask a random sample of individuals, via mail, telephone or in-person survey, if they would be willing to pay or willing to accept some given dollar amount for a hypothetical change in the availability of a particular environmental amenity or attribute. The yes/no responses are recorded along with the dollar amounts, called the bid amounts, offered to each individual. Each observation in the sample reveals whether or not an individual's maximum willingness to pay, or minimum willingness to accept payment, is greater or less than the fixed dollar bid amount offered. Typically, the sample is divided into several sets which are offered different bid amounts.

A bidding procedure which is gaining popularity in the CVM world is called the double-bounded procedure (Hanemann, Loomis and Kanninen, 1991). Here, respondents are asked whether they are willing to pay (accept) some initial dollar bid amount, and then are asked one follow-up bid which is higher (lower) if the response to the first bid is yes (no). The data collected in this case is more like categorical data, since with two bids per observation, it is possible to place each individual's willingness to pay (accept) in one of four categories; in the previous case, hereafter referred to as the single-bounded procedure, there are only two categories. It has been shown (Hanemann, et al) that estimation using the double-bounded procedure is statistically more efficient than estimation using the single-bounded procedure. Furthermore, many CVM practitioners agree that the double-bounded procedure retains a market-type flavor, which improves the reliability of responses. Several CVM studies use the double-bounded procedure, and its use is expected to increase in the future.

Each CVM study that is performed is specific to the environmental scenario being evaluated and cannot, according to economic theory, be applied to any other environmental amenity or other circumstance. Consequently, CVM studies are performed regularly to address a variety of environmental issues. The costs associated with these endeavors however, are not insignificant. It therefore is essential to address the problem of Optimal Experimental Design in the context of Contingent Valuation surveys, and in particular, to derive optimal designs for the double- bounded procedure.

The purpose of Optimal Design is to design an experiment, or survey, so that the fixed number of responses collected provide the most information possible about the estimators of interest. Optimal Design results for many potential design objectives have been derived for the single-bounded model by Minkin (1987), Abdelbasit and Placket (1983) and Wu (1988). This paper derives results for several design objectives for the double-bounded logit model.

Experimental Design for quantal response models similar to those used in CVM studies has been developed extensively in the bioassay field. A dose-response model predicts the effect on laboratory animals of varying doses of some substance. The effect is usually measured in terms of the percentage of animals that die when administered a specific dose. The information used for estimation are the dose, the die/survive response, and any characteristics of the animal to be used as independent explanatory variables. The model estimated is a probability curve, often the logistic curve, showing the estimated relationship between dose and response as the probability an animal with particular characteristics, given some dose, will die. In the case of CVM, the dose is the bid amount offered and the response is "yes" or "no" depending on whether or not the individual is willing to pay or accept that amount. The data used are the bid amounts, the yes/no responses and any characteristics of the individuals or environmental scenario being valued. As in bioassay, a probability curve can be fitted to the responses so that any dollar amount can be associated with a probability that an individual with particular characteristics will be willing to pay or accept that amount. From this probability function, estimators of welfare benefit measures can be derived.

There are several potential objectives that might be used in designing a CVM study. Silvey (1980) reviews Optimal Experimental Design criteria and discusses several of these objectives. One objective used extensively in the Optimal Design literature is called D-

Optimality. This is the maximization of the determinant of the Fisher information matrix, which is the negative of the expected value of the Hessian of the log-likelihood function. The information matrix is asymptotically equivalent to the inverse of the covariance matrix of the maximum likelihood estimators, so maximization of the determinant of this matrix in some sense jointly minimizes the asymptotic variances of the estimators. In terms of the CVM model presented in this paper, this corresponds to jointly minimizing the asymptotic variances of the estimators of the parameters α and β.

The ultimate goal of a CMV study is to provide an accurate assessment of the value of the environmental amenity in question, usually through estimates of mean or median willingness to pay. The optimization criterion for design might be something more specific than D-Optimality, such as the minimization of the asymptotic variance of one of the willingness to pay estimators. A C-Optimal design minimizes a function of the coefficient estimators. The example demonstrated in this paper minimizes the variance of the estimator of $-\alpha/\beta$, the mean and median of the distribution of WTP.

The mean and median of the WTP distribution involves the ratio of the parameters α and β. Taking the ratio of the estimates of these parameters does not generate an unbiased estimate of mean or median WTP. Another criterion that might be considered useful is the minimization of the length of the fiducial interval (Finney, 1970) of the estimator of WTP. The fiducial interval for a ratio of random variables is similar to a confidence interval, but it is more complicated because it takes account of the bias of the estimator.

These criteria will be used to find optimal bid designs for the double-bounded experiments. The resulting optimal designs are attained as a result of non-linear optimization and will therefore be dependent on the parameter values that are to be estimated. If the parameter values were known *a priori*, though, there would be no need to perform the experiment. This problem can be mitigated by using a sequential estimation procedure where the best available estimates of the values of the parameters are used for determining subsequent optimal designs. Estimation is performed using the current design and all old observations. The resulting parameter estimates are then used for further iterations. The standard procedure used by CVM researchers is to use a two-step experimental structure which, it is believed, will suffice to approximate the optimal experiment. The procedure is to first perform a pilot study using reasonable starting values, and follow with a full experiment using the design derived from the pilot results.

In Section 2, the double-bounded model is presented, and in Section 3, the optimal design results for the double-bounded logit model are derived.

2. THE DOUBLE-BOUNDED MODEL

Let there be N survey respondents. Respondent i is offered an initial bid amount B_i and one of the follow-up bids (B_i^d, B_i^u), where $\beta_i^d \leq \beta_i \leq \beta_i^u$. If d_i is a binary indicator variable for the yes/no responses to the two bid offers and π represents the response probabilities, then the log-likelihood function for the double-bounded model, parameterized by θ is:

$$\ln L^D(\theta) = \sum_{i=1}^{n} \{d_i^{yy} \ln \pi^{yy}(B_i, B_i^u; \theta) + d_i^{nn} \ln \pi^{nn}(B_i, B_i^d; \theta) \quad (1)$$

$$+ d_i^{yn} \ln \pi^{yn}(B_i, B_i^u; \theta) + d_i^{ny} \ln \pi^{ny}(B_i, B_i^d; \theta)\}.$$

The ML estimator for the double-bounded model, $\hat{\theta}$, is the solution to the equation $\partial \ln L^D(\hat{\theta})/\partial\theta = 0$. The asymptotic variance-covariance matrix for $\hat{\theta}$ is given by:

$$V^D(\hat{\theta}) = \left[-E \frac{\partial^2 \ln L^D(\theta)}{\partial\theta\,\partial\theta'} \right]^{-1} \Bigg|_{\theta=\hat{\theta}} \equiv I^D(\hat{\theta})^{-1} \tag{2}$$

Where $I^D(\hat{\theta})$ is the Fisher information matrix for θ at $\theta = \hat{\theta}$.

For estimation purposes, a functional form must be specified for the response probabilities, π. Following Hanemann et al, the response probabilities are:

$$\pi_i^{yy} = 1 - G(B_i^u;\ \theta) \tag{3a}$$

$$\pi_i^{nn} = G(B_i^d;\ \theta) \tag{3b}$$

$$\pi_i^{yn} = G(B_i^u;\ \theta) - G(B_i;\ \theta) \tag{3c}$$

$$\pi_i^{ny} = G(B_i;\ \theta) - G(B_i^d;\ \theta) \tag{3d}$$

G will be represented by the logit function:

$$G(B;\theta) = \frac{\exp(\theta)}{1+\exp(\theta)} \tag{4}$$

where $\theta = \alpha + \beta B$.

The Fisher information matrix is:

$$I^{D}(B, B^{u}, B^{d}; \theta) = \frac{G_{\theta}(B^{u}; \theta)\, G_{\theta}(B^{u}; \theta)'}{\pi^{yy}} + \frac{G_{\theta}(B^{d}; \theta)\, G_{\theta}(B^{d}; \theta)'}{\pi^{nn}} + \frac{QQ'}{\pi^{yn}} + \frac{RR'}{\pi^{ny}} \qquad (5)$$

where G_{θ} represents the vector $(\partial G/\partial\alpha, \partial G/\partial\beta)'$; π^{yy}, π^{nn}, π^{yn}, and π^{ny} are the probabilities on the right-hand side of equations 3a-d, and the vectors Q and R are defined by $Q \equiv [G_{\theta}(B^{u};\theta) - G_{\theta}(B;\theta)]$ and $R \equiv [G_{\theta}(B;\theta) - G_{\theta}(B^{d};\theta)]$.

2.1. D-Optimal Design for the Double-Bounded Model

D-Optimality for the single-bounded logit case has been solved by Abdelbasit and Placket (1983) and Minkin (1987). Minkin assumed the usual logit log-likelihood function:

$$\ln L(\gamma;y) = \sum_{i=1}^{n} y_i \ln \frac{\exp(\gamma_i)}{1 + \exp(\gamma_i)} + (1 - y_i) \ln \frac{1}{1 + \exp(\gamma_i)} \qquad (6)$$

where $\gamma_i = \alpha + \beta B_i$ and y_i represents the yes/no response of respondent i. He shows that maximization of the determinant of the Fisher information matrix for (α,β) using an even number of observations, occurs with half of the observations at $\gamma_i = 1.5434$ and the other half at $\gamma_i = -1.5434$. The case of an odd number of observations is complicated. The result approximates the case with an even number, and will not be considered in this analysis. Given initial guesses of the parameters α and β, the optimal design is a two-point design which is symmetric about the median of the distribution $-\alpha/\beta$. The resulting value of the determinant of the information matrix with sample size n, is $n^2(.0501)/\beta^2$.

Design for the double-bounded case is much more complicated than that for the single-bounded case. In the double-bounded case, there are three bid amounts specified for each observation. Although each person is asked only two bids, all three bids enter the log-likelihood function because *a priori*, it is not known which response any individual will give to the initial bid. The information matrix is specified in equation 5. In order to demonstrate the Optimal Design problems analytically, three simplifying assumptions are made which seem intuitively reasonable and prove to be correct for the general case. We assume that there is only one optimal bid scheme; the first bid is the median value, $-\alpha/\beta$; and the follow-up bids are symmetric about the median. These restrictions reduce the problem from one of solving simultaneously for three bids, to one of solving for only one, namely, the distance between the median and the follow-up bids.

Under these assumptions, the elements of the Fisher information matrix for the double-bounded logit model are functions of the parameters (α,β) and the distance between the initial bid, $-\alpha/\beta$, and the follow-up bids. The elements of the information matrix are:

$$I_{\alpha\alpha} = \frac{-(-1-4e^{w}+e^{2w})\,n}{4(1+e^{w})^2} \tag{7a}$$

$$I_{\alpha\beta} = \frac{\alpha(-1-4e^{w}+e^{2w})\,n}{4\,\beta\,(1+e^{w})^2} \tag{7b}$$

$$I_{\beta\beta} = \frac{-(\alpha^2+3e^{w}\alpha^2-5e^{2w}\alpha^2+e^{3w}\alpha^2+8e^{w}w^2)n}{4\,\beta^2\,(-1+e^{w})\,(1+e^{w})^2} \tag{7c}$$

where w/β is the distance between $-\alpha/\beta$ and the follow-up bids. The determinant of this matrix is:

$$Det\,[\,I\,(\alpha,\beta)] = \frac{e^{w}\,w^2\,(-1-4e^{w}+e^{2w})\,n^2}{2\,\beta^2(-1+e^{w})(1+e^{w})^4}\,. \tag{8}$$

We maximized the determinant numerically. The solution is a single bid scheme for all observations:

$(\theta^d, \theta, \theta^u) = (-1.979726, 0, 1.979726)$. The value of the determinant is approximately $n^2(.2870)/\beta^2$.

The optimal design is quite similar to that derived by Minkin for the single-bounded case. Since the initial bid is the median value, half the respondents will respond "no" and half will respond "yes" to this bid. Then half the observations will occur at $\theta^d = -1.979726$, ($F(\theta^d) = .8787$) and half will occur at $\theta^u = 1.979726$ ($F(\theta^u) = .1213$) which is similar to the Minkin design. In this case however, the design pushes the second bid further out than the bids in the single-bounded case. This is because the initial bid provides information on whether the individual has a willingness to pay above or below the median. Given this information, the second bid can obtain more information by bounding a larger number of the observations from above and below.

2.2. C-Optimal Design

Next, the problem of minimization of the asymptotic variance of median willingness to pay is considered. In the simple model specified here, the mean and median willingness to pay are both equal to $-\alpha/\beta$. The design for the case of minimizing the variance of the median of a normal distribution for the single-bounded case has been established by Wu (1988). He showed that efficient estimation of the dose corresponding to the p^{th} percentile occurs with a one-point design with all design points at $\theta^{-1}(p)$, when p lies within the bounds (.058, .942). Efficient estimation of the median therefore occurs with all design points at the median value, $-\alpha/\beta$. The result also holds for the logit model. The resulting variance is equal to $4/n\beta^2$. The parameters α and β are not individually estimable in a one-point design; there must be information about two points on a two-parameter density to estimate the two parameters of the density curve. The one-point design works only if the one point is the median exactly. Then the response rate should be exactly half, and the median is estimated to be the design point itself, a trivial result. If the design point is misspecified however, or if it is some point other than the median, it is impossible to estimate the curve or to estimate the median correctly.

For the double-bounded, C-Optimal design, the asymptotic variance of $-\alpha/\beta$ is calculated using the delta-method for the asymptotic distribution of a ratio of two normal random variables:

$$avar\left[\frac{-\alpha}{\beta}\right] \doteq \frac{1}{\beta^2}\left[\left[\frac{\alpha}{\beta}\right]^2 var(\alpha) - 2\left[\frac{\alpha}{\beta}\right] cov(\alpha,\beta) + var(\beta)\right] \tag{9}$$

Equation 9 is minimized numerically using the inverse of the Fisher information matrix, defined in equations 7a-c, as the asymptotic covariance matrix of (α,β). The solution to the minimization of equation 9 is $(\theta^d,\theta,\theta^u) = (-1.098612, 0, 1.098612)$, which corresponds to probability values of (.25,.50,.75). Again, the similarity to the single-bounded case can be noted. Since the optimal design in the single-bounded case has all design points at the median value, it is not surprising that the double-bounded design places the initial bid at the median value, and follow-up bids at the median values, conditional on the first response. The variance of the median is $16/5n\beta^2$, a 20% improvement compared to the single-bounded case.

2.3. Fiducial Method Design

The Fiducial Method refers to the minimization of the length of the fiducial interval of a parameter or a function of a parameter. According to Finney (1970), "there is a fiducial probability F that the true value lies between specified upper and lower limits if the lower limit is the lowest value and the upper limit the highest value which would not be contradicted by a significance test at the 1/2 F probability level." Again, since median WTP is the value of interest in this study, minimization of the length of the fiducial interval of the estimator of median WTP, $-\alpha/\beta$, is performed. Finney derived the fiducial interval for an estimator of $\mu = \alpha/\beta$. If the estimators of (α,β) are normal random variables (a,b) with E(a)

$= \alpha$ and E(b) $= \beta$, then (a - μb) is a normal random variable with E(a - μb) = 0 and Var(a - μb) $= (\nu_{\alpha\alpha} - 2\mu\nu_{\alpha\beta} + \mu^2\nu_{\beta\beta})$. Then for t_q equal to the value of a chi-square with probability value q, the following expression holds:

$$P[(a - \mu b)^2 \leq t_q^2\ (\nu_{\alpha\alpha} - 2\ \mu\nu_{\alpha\beta} + \mu^2\nu_{\beta\beta})] = q \tag{10}$$

where $(\nu_{\alpha\alpha},\nu_{\alpha\beta},\nu_{\beta\beta})$ are the variances and covariance of (a,b). The length of the q-level fiducial interval is derived by solving the quadratic expression in equation 10 for the values of μ, which are the upper and lower values of the fiducial interval. The length of the interval is:

$$FI = \frac{2t_q}{(1 - g)\beta}\left[\nu_{\alpha\alpha} - 2\left[\frac{\alpha}{\beta}\right]\nu_{\alpha\beta} + \left[\frac{\alpha}{\beta}\right]^2\nu_{\beta\beta} - g\left[\nu_{\beta\beta} - \frac{\nu^2_{\alpha\beta}}{\nu_{\beta\beta}}\right]\right]^{1/2} \tag{11}$$

where $g = t_q^2\nu_{\beta\beta}/\beta^2$. As the sample size n increases, g tends toward zero since $\nu_{\beta\beta}$, the estimated variance of the estimator b, tends toward zero. The fiducial interval is therefore a function of the sample size n. As n increases, g tends toward zero, and the fiducial interval tends toward the length of a standard asymptotic confidence interval for median WTP. This interval would be minimized when the asymptotic variance is minimized. The optimal designs for some smaller sample sizes are presented in Table 1. For a very large n, the optimal design tends toward the C-Optimal design.

These three design problems have been solved for the probit single-bounded case. Alberini and Carson (1990) found that for D-Optimality, with an even number of design points, half of the standardized design points should be at -.372581 and half at .372581. For the Fiducial Method with $n = 900$, they found that half the standardized design points should be at -1.138101 and half at 1.138101. As mentioned previously, minimization of the variance of median WTP has been solved by Wu(1988), and the solution is a single design point at the median value.

The theoretical performance of the designs described above are displayed in Table 2. For each case, the determinant of the Fisher information matrix and the asymptotic variance of median WTP is calculated. The D-Optimal design performs poorly relative to the other designs in terms of the C-Optimal criterion, the minimization of the asymptotic variance of median WTP. Conversely, the C-Optimal and Fiducial Method designs perform poorly in terms of the D-Optimal criterion, the maximization of the determinant of the Fisher information matrix. The differences in performance are more significant in the single-bounded case than in the double-bounded case. These results demonstrate the fact that the different criteria emphasize different types of information; the D-Optimal criterion derives the most information from points closer to the tails of the distribution, while the C-Optimal and Fiducial Method criteria derive the most information from points closer to the center of the distribution.

An interesting question is how much greater the sample size would have to be in the single-bounded case to be as efficient as the double-bounded. The answer can be derived using Table 2. Clearly, it depends on the criterion used. If C-Optimality is the criterion, the single-bounded sample size would have to be 1.25 times that of the double-bounded sample. This result seems surprisingly small. The reason is that for C-Optimality, most of the information about the median value is found at that median value, and this is where all the n observations lie in the single-bound design. The double-bounded design has all the initial bids at the median value and follow-up bids at the conditional median values. The follow-up responses do not provide nearly the amount of information about the median as another observation at the median value would. For D-Optimality, the single-bounded sample size would have to be 2.04 times the double-bounded sample. Here, it is clear that the follow-up bid procedure provides a great deal more information per observation than the single-bid procedure. This is because the follow-up bid is in the appropriate tail, given the initial response, and the outer sections of the distribution are where most of the information for the D-Optimal criterion is obtained.

3. CONCLUSION

Optimal Experimental Designs for the double bounded logit model have been derived for the D-Optimal, C-Optimal and Fiducial Method criteria. The theoretical designs derived are subject to several shortcomings, the most obvious being the dependency of the designs on the true parameter values not yet estimated. In addition, the designs are one or two-point designs which are not appealing to the applied researcher concerned with uncertainty about the true parameter values. Sequential experimentation or Bayesian techniques are recommended as alternative approaches. These techniques are being studied by the author, and will be presented in subsequent work.

Table 1. Optimal Design Points for the Standardized Logit Model

	Double	Single-Bounded
D-Optimal	1.979726	1.5434
C-Optimal	1.0986	0.
Fiducial Method (n = 500)	.934	.6105
Fiducial Method (n = 1000)	1.029	.508
Fiducial Method (n = 2000)	1.066	.425

NOTE: The initial bid in the double-bounded case is zero (standardized). The follow-up bid is +/- the value listed in the table, depending on the response to the initial bid. In the single-bounded case, half the sample is asked + and half is asked - the value listed in the table.

Table 2. **Theoretical Comparison of Optimal Designs**
Logit Model

	Det I	Avar(WTP)
Double-Bounded Model		
D-Optimal	$\frac{.2870\ n^2}{\beta^2}$	$\frac{3.379}{\beta^2\ n}$
C-Optimal	$\frac{.2122\ n^2}{\beta^2}$	$\frac{3.20}{\beta^2\ n}$
FI (n = 500)	$\frac{.1813\ n^2}{\beta^2}$	$\frac{3.211}{\beta^2\ n}$
FI (n = 1000)	$\frac{.1996\ n2}{\beta^2}$	$\frac{3.202}{\beta^2\ n}$
Single-Bounded Model		
D-Optimal	$\frac{.0501\ n^2}{\beta^2}$	$\frac{6.894}{\beta^2\ n}$
C-Optimal	0.	$\frac{4}{\beta^2\ n}$
FI (n = 500)	$\frac{.0194\ n^2}{\beta^2}$	$\frac{4.384}{\beta_2\ n}$
FI (n = 1000)	$\frac{.01420\ n^2}{\beta^2}$	$\frac{4.264}{\beta^2\ n}$

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INDIRECT OPTION VALUE

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ABSTRACT

The purpose of this paper is to bridge what appears to be a gap in the economic theory of option value modeled as a "risk premium." Individual understanding of the consumptive uses of an option may be more comprehensive. Options may represent "property rights" perceived as opportunities for personal freedom of choice in the current period. It is hypothesized that the value of an option is equal to individual utility from indirect use of the resource in the process of transacting activities related to possible trips to the site and enters the utility function as one of several uses of the environmental resource in the current period. The hypothesis cannot be rejected on the basis of an empirical test with a sample of college students at a land-grant university in the Rocky Mountains.

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INTRODUCTION

If we hope to progress in understanding options in the context of nonmarket valuation of environmental resources, perhaps we should consider the possible advantages of modeling them on the theory of transaction costs. This approach would introduce indirect use (through books, magazines, TV, videos, etc.) as suggested by several members of W-133 (Randall and Stoll, 1983; Walsh, 1986; Boyle and Bishop, 1987; and others). See Appendix Tables 2 and 3.[1]

What we choose to call the indirect use value of an option would be modeled within the theory of nonmarket consumer demand holding all other variables constant except transacting. The concept of transacting would distinguish indirect uses of the resource related to a possible trip from other indirect uses. Most notably, the assumption of uncertainty would be initially relaxed. It could be introduced later to estimate ex ante values for all categories of total value (Randall, 1992).

Previous models of option value as a risk premium held all other variables constant except individual uncertainty of future supply and demand for onsite recreation use. The semi-option value model assumed uncertainty of current information on benefit and cost available to public resource managers would be resolved in the future.

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[1]Indirect use is defined broadly in this paper as resource-related nonmarket consumptive activities of: watching TV, videos, and movies; listening to radio; reading newspaper and magazine articles, maps, etc.; attending talks, slide shows and training sessions; discussing with other persons; resting and relaxing, quiet reflection, etc.; shopping to buy trip supplies, clothing, equipment, etc.; making reservations for airline, lodging, car rental, etc.; renting equipment, trying it out, etc.; borrowing equipment, etc., from friends; preparing food, making things, cleaning, repairing, etc. Indirect use while on the job, attending work-related meetings, driving to or from work, during work breaks, and at lunch time, also could be included. It is intended to concentrate our attention on all informational and other activities preparing for a possible recreation trip.

Recently, the traditional model stating that option value (OV) is the difference between option price (OP) and expected consumer surplus (ES) has been challenged as lacking in internal consistency and meaning as a separate category explaining the complex reality of total value. Smith (1987) is adamant that the model mixes two perspectives of welfare that are fundamentally noncomparable: OP as ex ante planned use value and ES as ex post actual use value (i.e. after the uncertainty has been resolved).

Several attempts to measure option value as a separate category of total value appear to have failed. Freeman (1992) concludes the results are not consistent with his model that claims OV is the algebraic difference between OP and ES, nor with any known economic theory. Also, magnitude of the reported value of an option in relation to onsite use value has been much larger than expected based on the traditional model of option value (Freeman, 1984, 1985). This suggests that individual understanding of the consumptive uses of an option may be more general than the uncertainty assumption would suggest. As a result, other more comprehensive models cannot be ruled out as alternative explanations of observed WTP for an option.

TRANSACTING IN NONMARKET VALUATION

The concept of transacting is most closely associated with the early work of Ronald Coase (1937). It was one of several important contributions to economic theory for which he was awarded the 1991 Nobel Prize in Economics. He observed that some important economic phenomena can only be understood when transacting is made an explicit part of the model. In functioning markets, transacting includes the activities of searching for alternative buyers or sellers, gaining better information, negotiating, consummating exchanges, etc.

Especially relevant to nonmarket demand for recreation resources, is the insight that the purchase of market goods or services really entails two exchanges: first, for the right of ownership and second, for the service of delivery. Transportation would not be considered a part of transaction costs, because transacting involves only exchange of the right of ownership. If buyers wish to obtain possession as well, they can enter separate exchanges with the providers of transportation services.

There are two necessary adjustments in the concept of transaction costs in the context of nonmarket demand for recreation resources: First, market transactions occur before and contribute to exchange of the right of ownership of goods and services. In the case of nonmarket recreation demand, payment now (buying a fishing or hunting license, etc.) for the right or opportunity of access to environmental resources enables individuals to begin indirect use for transacting activities related to the real possibility of travel for direct use.

Second, market transaction costs can shift the supply curve for final goods and services to the right and the demand curve to the left, which lowers the equilibrium quantity consumed. While this principle may apply equally to market and nonmarket demand, the latter is unique in that consumers are producers and transacting can be an indoor recreation activity that optimizes benefit in relation to cost independent of whether an actual trip occurs (final demand).

INDIRECT OPTION VALUE

Defined: knowing you have the right of possible access to the resource. Payment guarantees individual freedom of choice during the current option period, usually one year (renewable with annual payment). Without payment, right of access would not be available and the resource could not realistically enter the individual's decision set of alternative opportunities.

Choice: search for and examination of alternative opportunities.

Right: property right to a stream of benefits from indirect use of the resource in the process of transacting for a possible trip to the site. Perceived as a human right to personal freedom or control, which may be a benefit, a dimension of leisure that facilitates the realization of benefits, or both (Driver, et al., 1991).

Knowing: may represent the annual stock of a flow of mental activity "imaging" or visualizing yourself onsite.

Weisbrod (1964) in the original paper, proposed that an option "may be 'consumed' (enjoyed) by all persons...that is, current production enters positively into the utility function of prospective users." (p. 473, parenthesis in the original). The indirect use value of an option is an expression of the sum of utility from transacting activities related to possible trips to a site and enters the utility function as one of several uses of the environmental resource in the current period.

Purchase of an option enables transacting benefits to be "produced" by households combining leisure time and effort, purchased goods and services, environmental quality and other public goods. To optimize enjoyment of subjective experience, they will pursue transacting activities until their marginal benefits equal marginal costs. The optimizing process is constrained by a limited budget, leisure time, and technology (knowledge, skill, and durable capital resources).

If direct use of the resource occurs as an outcome of the transacting activity (choice), it would be a separate exchange of total direct travel cost for the benefit of onsite environmental services. Weisbrod (1964) assumes that since environmental resources provide nonstorable services, onsite use cannot be purchased or produced prior to consumption.

IMPORTANCE OF THE PROBLEM

Can we transfer what has been learned about the theory and measurement of the nonmarket valuation of recreation resources for onsite consumption to those activities that are offsite, i.e., the indirect-use values of natural resources? This question is increasingly important because the rate of change has speeded up a lot in the quarter century this committee has studied the economics of outdoor recreation.

Robinson (1981, 1988, 1991) reports that average leisure time of adults increased by 6-7 hours to 40-41 hours per week in the 20-years prior to 1985. Fewer men worked and women spent less time on household chores. Enforced leisure time increased even more last year with a reported 20 percent of the work force unemployed during part of the year. This is not inconsistent with data showing increased hours worked by those employed full-time. Government statistics indicate that the average U.S. worker was on the job 3-4 hours more per week than 20 years ago. Apparently, there has been an increase in overtime, because it is cheaper to pay employees time-and-a-half than to pay new employees wages and benefits (now one-third of compensation).

Robinson (1991) found that most leisure time is used for indoor recreation activities such as watching TV and videos (16 hours per week), visiting with friends and relatives, using exercise equipment, etc. Indications are that indoor recreation is increasing relative to outdoor recreation. National surveys of outdoor recreation find that adults take shorter trips, participate in fewer activities, and overall growth is flat.

With more leisure time devoted to indoor recreation, there are shifts in demand for information on wildlife and natural resources, reflecting technological advance and changes in income and relative prices of indirect and direct use. Also, preferences have changed for human rights in general, worldwide, with the right of access to a natural clean environment becoming increasingly important. It should not be surprising if the indirect use value of an option for possible access to environmental resources would be of increasing importance under these circumstances.

LITERATURE REVIEW

Csikzentmihaly (1983; 1990; 1991) described self-reports by a sample of 107 adults who rated satisfaction of individual activities (10-point scale) at random times within 2-hour periods from 8 AM to 10 PM during a week. The total of 4,791 responses indicate that individuals often optimize enjoyment of subjective experience from nonmarket consumption activity valued for itself even if nothing else happens as a result. Economists will not be surprised that he reports equilibrium analysis appears to be a general human activity across indoor and outdoor recreation and individuals in all walks of life. He reports optimal enjoyment (or utility) occurs when individuals achieve an equilibrium between the challenge of the opportunity present in any given situation compared to their skill and other endowments (presumably available budget, leisure time, equipment, etc. that may represent constraints).

Loewenstein (1987) asked 30 undergraduates at the University of Chicago to specify the most they would pay now to obtain a kiss from the movie star of their choice at designated times. With WTP for immediate direct use set at 1.0, indirect option value increased the initial value to 1.30 for a delay of 3-hours; compared to 24-hours, 1.59; 3-days, 1.78; 1-year, 1.31;

and 10-years, 0.64. Conclusion: individuals were WTP 30-78 percent more for indirect use of the resource for transacting activities during the current one-year option period. He assumed indirect use was primarily anticipation rather than preparations such as special clothing, haircut, cologne, etc. Limitation: he could not estimate a demand curve for indirect use since transacting hours were not reported.

McInnis and Price (1990) asked 193 undergraduates at a large western University the effect of visualizing activities on possible recreation trips during Spring break (6 or more days). The before and after study found that spending considerable time imagining what they would do had a positive effect on satisfaction (a 5-point scale) whether or not the actual trip turned out as imagined. This is part of a growing literature on "imaging" possible leisure activities.

Cadez and Gartner (1985) asked a random sample of 1,500 Utah households about their vacation decisions (trips of 4 or more days) in a telephone survey during the Fall of 1982. They report that transacting activities were a major part of the vacation process of 80.2 percent of the respondents. Requests for brochures, itinerary and route selections often took more time than the actual trip. Many people received almost as much enjoyment from reading about certain areas and planning their trips around visits to these areas as actual visitation.

SURVEY DESIGN

The data are from a 1991 study of 37 undergraduate students in a natural resource economic course at Colorado State University, Fort Collins. The questions were self-administered. Individuals filled out the questionnaire at a time convenient to themselves. See the Appendix.

The sample may represent land-grant college students as a group, but differs in important ways from the adult population. Few are employed full-time (about 10 percent) but nearly half work part-time. They are probably more active in outdoor sports and recreation because of age (23.5) and available leisure time (36.7 days vacation), even though they are constrained by lower income ($21,600) and by available free time during Fall semester.

First, they were asked to recall the number of occasions during the last 4-week period in October they considered (anticipated, planned, or prepared for) possible recreation trips. Then they were asked how much time they spent on the average occasion.

This was followed by a question on how much it cost in total out-of-pocket expenses during the month. From this starting point, they were asked to estimate the maximum amount of money they would pay to increase or reduce their total transacting time by one hour.

Subsequently, they were asked, on average, about how much time they devote to considering a possible trip to a recreation site before they no longer enjoy doing so, if they do not actually take the trip. They also reported how many trips were considered and how many actually occurred. They described the most important recreation sites considered including location, expected activities, and number of days away from home.

TESTING THE INDIRECT OPTION VALUE HYPOTHESIS

HYPOTHESIS

If (A) in the current period, individuals consider a possible trip to a recreation site, in the process of optimizing enjoyment of nonmarket consumption of transacting activities, then (B) current period utility and consumer surplus of an option (knowing they have the right of possible access) will be positive.

EMPIRICAL TEST

Nearly 90 percent (33 cases) said that during 4 weeks in October, 1991, they enjoyed 19.8 hours (72.4 occasions averaging 16.4 minutes) considering 9.4 possible recreation trips and would pay \$4.67 for an additional hour (95% confidence limit ± \$1.82). About 5 percent (2 cases) said they would pay \$4.50 to reduce it one hour (one of these had enjoyed it but was beyond optimal time). Nonresponse was about 5 percent (2 cases).

Marginal benefits were \$4.11 (95% confidence limit ± \$1.76) per hour for those who reported positive and negative values. For the average trip considered, total transacting benefits were estimated as \$9.88 for 2.11 hours. For optimal transacting time of 3.73 hours per trip, total benefits would rise to \$18.81.

The values are not trivial. Table 1 shows that indirect use for transacting is 62 percent as important as direct use in this case, or 4.9 hours indirect compared to 7.9 hours direct per week. Annual indirect use value would equal approximately \$1,500 for 26.6 recreation visitor days (12-hours) per year, based on reported seasonal indirect use activities.

The hypothesis cannot be rejected on the basis of the empirical test. The activity occurred more often than can be attributed to pure chance and the predicted marginal values were significantly different from zero. However, the nature of the test is such that other models cannot be ruled out as alternative explanations of option value.

Table 1. Weekly Direct Use and Indirect Use of Environmental Resources for Transacting Possible Trips Reported by College Students, Colorado State University, October 1991.

Activities	Number of Occasions per week	Average time per occasion, minutes	Total time per week, hours[a]	Average Cost per week, dollars
<u>Indirect Use</u>	18.1 (6.96)[b]	16.4 (3.87)	4.9 (1.67)	\$5.91 (1.04)
<u>Direct Use</u>	4.3 (0.53)	110.2 (13.76)	7.9[c] (1.18)	\$12.68 (2.75)
Travel	1.7 (0.27)	67.4 (9.21)	1.9 (0.42)	\$5.52 (1.09)
Onsite	2.6 (0.31)	139.0 (19.13)	6.0 (0.92)	7.16 (1.83)
<u>Total Use</u>	22.4 (7.25)	34.3 (4.04)	12.8 (1.97)	\$18.59 (3.01)

[a] Four weeks in October. All respondents reported participating in direct and indirect use.

[b] Standard error of the mean.

[c] For 1.1 trips per week.

TRANSACTING DEMAND CURVE

Analysis is in progress. To illustrate the relationship, Figure 1 shows an approximation of the representative individual demand curve. The net value of transacting time is expected to change as a result of changes in hours devoted to the activity, indicating diminishing marginal benefit. Demand shifters would include the relevant variables: income, age, leisure time, available substitutes, site quality, etc.

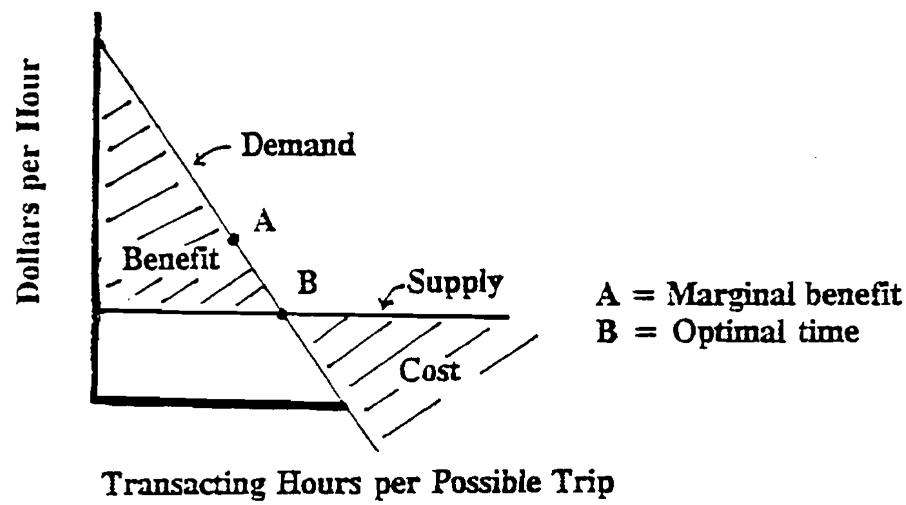

Figure 1. Representative Individual Demand for Transacting

Obviously, transacting activities can contribute to the cost and benefit of an actual trip. However, transacting activities also can have a consumptive value similar to the sightseeing value of travel time on recreation trips (Walsh, et al., 1990). Once individual demand for transacting time is fully satisfied at B, 3.7 hours, what was a benefit would become a cost as more transacting time might be necessary for an actual trip. As transacting time becomes more unpleasant with each additional hour beyond 3.7 per trip, it shifts the supply curve for an actual trip (not shown) and would be optimized where the resulting shift in the final trip demand curve equals the cost of the last transacting hour.

SOME CONCEPTUAL AND RESEARCH ISSUES

(1) Boundary between direct and indirect use. This raises the question of possible double-counting; indirect use value of an option already may be imbedded in current TCM trip decisions and in CVM willingness to pay for onsite recreation use. Transacting may be a necessary cost that contributes to the quality of direct use.

Comment: This is an empirical question deserving of future research. Existing evidence suggests the possibility of little or no imbedding. In past studies, individuals were asked to separately report onsite use value and indirect use value of an option (Sanders, et al., 1990).

(a) Payment to actually visit these rivers for recreation use.

(b) In addition to your actual recreation use value, how much of an "insurance premium" would you be willing to pay each year to guarantee your choice of recreation use of these rivers in the future?

Our current study shows that, on average, 3.7 hours of transacting for a possible trip not taken is experienced as a beneficial activity one chooses to do freely for its own sake. In other words, it is not a joint product with an actual trip, and would not likely be imbedded in onsite use values.

Planning for some actual trips may increase transacting time beyond optimum and it would become a necessary cost rather than a benefit, i.e. reserving airline, lodging, rental auto, etc. (Figure 1). Such transaction costs may add to the travel cost of the actual trip but that would not represent double-counting.

It is well known that if any costs, such as an entrance fee or transaction cost were equal for all participants or distance zones, they would have no effect on TCM benefit estimates. Moreover, to include such transaction costs in the price variable would be unique to TCM studies in the past 25 years that define price as variable cost of private vehicle operation.

(2) Difficult to measure. In the weak complimentary approach to demand estimation for indirect use of natural resources, it may be impossible to separate the input of the natural resource from that of the program director, writer, artist, photographer, etc. in the price of goods and services purchased.

Comment: This is correct. Perhaps the concept of subjective opportunity costs from the Austrian School would be useful. Our current study shows that the actual recreation resource featured in TV programs, magazine articles, etc. contributed approximately 60 percent of individual enjoyment of considering possible recreation trips, with the balance from artistic and persuasive skills of the producer and writer.

Also, purchased goods and service inputs are not usually as significant as the opportunity cost of time. For many occasions of indirect use, the opportunity cost of time is virtually the only input, i.e. discussing possible recreation trips with friends and family members. So it would be incorrect to assume that indirect use of the resource is zero if there are no purchased goods and services.

(3) Indirect use may occur after destruction of the resource. Pictures and videos prepared before the resource is destroyed could be enjoyed later providing a continuing stream of benefits to viewers.

Comment: This is an empirical question. Perhaps disutility from knowing that they lost the prior right of access to the resource would offset positive utility of watching a video of the resource.

(4) Total value is the correct measure. The WTP judgment is based on a holistic assessment of all sources of utility to reach a total value. For applied benefit-cost research, the decisionmaker is best served by a single discrete choice question on total value.

Comment: This is probably correct for environmental damage assessment and for many environmental protection questions. Also it seems intuitively correct to assume that a holistic assessment of total value could include indirect use value of an option, particularly if the scenario is designed to remind respondents of the specific benefits they are intended to consider, including direct and indirect uses and so-called nonuse services. However, the policy issue hopefully will more often be the management of environmental resources rather than damage assessment, in which case the use vs. nonuse value distinction becomes relevant to questions of program review and source of revenue, usually user fee vs. tax.

Also, beyond the immediate applied policy question, the scientific objective is to explain total value. Future experiments could test first, whether use and nonuse demand for environmental services is correctly modeled as motivation or preference. Possibly household reporting of use and nonuse values will prove to be more analogous to that of a business firm determining the contribution of various activities or outputs to total cash flow or profit of the enterprise. So-called motivation or preference may really be individual experience of the benefits and costs to themselves of the activities represented by each category of preference.

If this proves correct, it would represent a long methodological step forward from reliance on a century-old model of motives for total value judgments.

Second, experiments could test whether demand is realistically limited to direct and indirect outdoor recreation use plus nonuse values for others and for the resource itself, as proposed by Mitchell and Carson (1989). Demand for all types of indirect use as indoor recreation, including current period option value, easily could be added to the possible categories of total value, if warranted.

(5) Boundary between indirect use and nonuse values. Although indirect use is logically a form of use value, it may be hard to distinguish, in observation, from nonuse values.

Comment: This is an important issue. In future research, it may be fruitful to model so-called nonuse as part of indirect use in a general theory of nonmarket consumption activity. The offsite utility and consumer surplus reported for knowing the resource is protected may represent the annual stock of the flow of indirect use, optimizing enjoyment of subjective experience in the mental activity of "imaging" or visualizing the resource. This would represent a distinct approach encompassing all indirect use since mental activity occurs while individuals are doing something else. This includes rest and relaxation, but obviously not limited to that activity, since mental activity would occur while they are discussing a possible recreation trip with others, etc.

In our current study, we asked individuals to report on a 5-point scale the importance of several mental activities (Table 4). Visualizing themselves participating in onsite activities was the most important (4.41). This could be reasonably interpreted as indirect option value. It was followed by visualizing wildlife in the natural ecosystem without any people in the picture

(4.31), or existence value. Next in importance was visualizing future generations participating in recreation activities (3.77) or bequest value. Surprisingly, visualizing other persons currently participating in recreation activities was least important (3.31). Similar approaches may help explain the relative value of individuals knowing the resource exists for themselves, for others, and for itself.

CONCLUSIONS

This paper addressed the problem of developing a more comprehensive model of option value than the traditional uncertainty-based model. What we propose to call the indirect use value of an option is modeled within the theory of nonmarket consumer demand holding all other variables constant except transacting. This approach has the advantage of introducing the indirect use of environmental resources while transacting for possible travel to recreation sites.

The basic hypothesis is that an option, defined as the right to possible access, provides current period utility from current period consumption of transacting activities. An empirical procedure was adopted to explore the benefit and cost of transacting activities by a sample of college students at a land-grant university in the Rocky Mountains.

The hypothesis cannot be rejected on the basis of the empirical test. However, the nature of the test is such that other models cannot be ruled out as alternative explanations of option value. The values reported should be considered first approximations to be improved with further research. The estimates are sufficient, nonetheless, to demonstrate that the indirect use value of an option may explain an important part of total value.

The results support a recent court decision that the benefit estimation procedures of federal agencies be enlarged to include option value. The model possibly could help remove a shadow over U.S. Court of Appeals ruling in the case, State of Ohio v. U.S. Department of the Interior (880 F.2nd 432 (D.C. Cir. 1989) that states:

"Option and existence values may represent 'passive' use, but they nonetheless reflect utility derived by humans from the resource, and thus prima facie, ought to be included in damage assessment."

The ruling may have been reversable on grounds that the traditional model of option value cannot be a separate category of total value, and is correctly excluded from the typology of possible total benefit categories in recent CVM guidelines (Mitchell and Carson, 1989). But there is no inherent reason why both indirect option value and existence value cannot be modeled as part of total value in the current period.

Further research is recommended to test the general application of the concept and method.

Table 2. Indirect Use of Environmental Resources for Transacting Activities Related In Part, to Possible Recreation Trips by College Students, Colorado State University, October 1991.

Activities	Average Number of occasions per week[b]	Average time per occasion, minutes	Total time for week, hours	Average cost per week, dollars
Shopping to buy trip supplies, clothing, equipment, etc. (30)[a]	0.7 (0.12)[c]	62.3 (9.82)	0.7 (0.18)	$7.70 (1.41)
Making reservations, airline, car rental, lodging, etc. (19)	0.2 (0.04)	31.1 (16.76)	0.1 (0.03)	3.20 (2.10)
Renting equipment, trying it out, etc. (13)	0.2 (0.05)	26.3 (9.91)	0.1 (0.04)	0.94 (0.29)
Borrowing equipment, etc. from friends (19)	0.3 (0.08)	32.2 (8.87)	0.3 (0.16)	0.33 (0.14)
Preparing food, making things, cleaning, repairing, etc. (36)	2.1 (0.38)	62.3 (6.51)	2.2 (0.45)	4.42 (1.08)
Total or average (36)	3.5 (0.44)	58.3 (7.90)	3.4 (0.51)	$16.82 (2.99)

[a] Number reporting participation.

[b] Four weeks in October.

[c] Standard error of the mean.

Table 3. **Weekly Indoor Recreation Activities with an Informational Content, in Part, Indirect Use of Environmental Resources Transacting for Possible Trips by College Students, Colorado State University, October 1991.**

Informational Activities	Average number of occasions per week[b]	Average time per occasion, minutes	Total time per week, hours	Average cost per week, dollars
Discussing with other persons (36)[a]	16.3 (0.77)	25.9 (5.50)	1.8 (0.38)	$1.78 (0.75)
Watching TV, videos, and movies (29)	2.8 (0.48)	52.9 (10.71)	2.5 (1.22)	1.96 (0.47)
Listening to radio (24)	2.8 (0.63)	21.8 (5.32)	1.0 (0.75)	0.36 (0.18)
Reading newspaper and magazine articles, maps, etc. (33)	3.0 (0.47)	29.9 (4.11)	1.5 (0.47)	1.04 (0.25)
Attending talks, slide shows, training sessions (10)	0.4 (0.19)	14.7 (5.38)	0.1 (0.19)	0.28 (0.12)
Resting and relaxing, quiet reflection, etc. (33)	4.0 (0.68)	64.2 (9.88)	4.2 (0.91)	0.63 (0.27)
Total or average (36)	17.1 (2.20)	39.2 (4.84)	11.1 (2.22)	$6.05 (1.25)

[a] Number reporting participation.

[b] Four weeks in October.

[c] Standard error of the mean.

Table 4. **Mental Activity of Visualizing Oneself, Others, and Resources at Possible Recreation Sites, College Students, October 1991.**

Picture Going Through Your Mind[a]	Very Unimportant (1)	Unimportant (2)	Somewhat Important (3)	Important (4)	Very Important (5)	Mean Score
Visualizing yourself participating (37)[c]	0	0	6	10	21	4.42 (0.13)[b]
Visualizing other persons currently participating (36)	1	7	13	10	5	3.31 (0.17)
Visualizing future generations participating (35)	0	6	9	7	13	3.77 (0.19)
Visualizing past generations at sites (35)	1	4	16	11	3	3.31 (0.15)
Visualizing natural resources without people in the picture (36)	1	3	3	6	23	4.31 (0.19)
Other types of mental images, if any[d] (4)	0	0	0	2	3	4.60 (0.29)

[a] Response to the following question: Studies of the human brain and thought process suggest that people often have various pictures going through their minds. How about you? For each of the mental images listed below, check the choice that best describes how important it is to you.

[b] Standard errors in parentheses.

[c] Number reporting participation.

[d] Four respondents reported four images representing subcategories of visualizing themselves participating (highest level of accomplishment, images of past experience, driving to the site, and feeling of being outdoors) and one was a subcategory of the resource (perfect weather, setting).

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QUESTIONNAIRE

ANTICIPATION AS A RECREATION EXPERIENCE

Before you decide to go on recreation trips, you probably spend some time considering the quality of resources and services at places you might visit and thinking about the things you would enjoy doing there. Getting ready to go usually takes some time for planning the route, shopping, and preparing the things you will need.

Colorado State University is studying the value of natural resources for recreation use. One important question is the value of time people like yourself devote to anticipating possible recreation trips. This indirect use of natural resources could be a source of added value. Would you mind if I ask you a few questions? We need your help whether you actually take trips or not.

For purposes of this study, your time considering possible trips is what we are interested in. You are one of a small sample selected at random to represent the population as a whole. Your opinions along with others in the sample will provide important new information to help improve recreation programs. We would sincerely appreciate your participation in this study.

Please answer all questions that apply to you. If you do not understand a question, explain your answer by writing in the margin. There is space on the back page for any other comments. Use the enclosed postage-paid envelop to return the survey form.

1. First, we would like you to estimate how often you consider what it would be like to take possible recreation trips. Please estimate the number of occasions during the past month or typical month (4-week period) that you anticipated, planned, or prepared for possible trips. Check one of the following: October 1991

   0 None, hardly ever
   1 Once a month
   6 A few times a month
   6 Once a week
   12 A few times a week
   2 Once a day
   7 A few times a day
   2 Once per hour
   0 Several times each hour
   0 Almost constantly
   0 Other (please specify) 72.35 average
   (27.85) standard error

2. Although some of these occasions may be fleeting while others are more lasting, please estimate how much time on the average per occasion that you devote to considering possible recreation trips. Check one.

   0 Less than 10 seconds
   0 About 30 seconds
   3 About 1 minute
   7 A few minutes
   17 5 to 10 minutes
   6 About half an hour
   1 About three-quarters of an hour
   2 One hour
   1 More than 1 hour (please specify) 16.43 minutes
   (3.87)

3. Please estimate what the anticipation, planning, and preparations for possible trips cost you during the month in total out-of-pocket expenses. \$23.65 (4.14) 9=zero; 7 1-10; 9 10-25; 9 25-50; 3 50-100

4. Some people feel that their time spent anticipating and preparing for possible recreation trips is an inconvenience while others enjoy it. How about you? During the month, did you: (Check one answer and place a dollar value in the appropriate blank after reading the guidelines below).

   33 Enjoy it. **What is the maximum amount of money you would pay for an additional hour?** \$4.67 (.91)
   or 7 zero; 11 1-4.9; 11 5-9.9; 6 10-25 \$4.11 (0.88)
   2 Prefer to reduce it. **What is the maximum amount of money you would pay to reduce it one hour?** 2-1-5 \$4.50 (.50)

   GUIDELINES: Please tell me the highest amount you WOULD REALLY PAY in added out-of-pocket expenses. In other words, what's it worth to you? Remember it's your choice. Bear in mind how much you are able to pay, other possible enjoyable activities that may be available to you, and how much you enjoy anticipating possible recreation trips.

5. Some of the things you do probably are more stimulating than others and contribute more to your enjoyment of anticipating possible recreation trips. For each of the following activities that apply to you, please estimate your: (1) number of occasions during the month, (2) average amount of time per occasion actually anticipating possible trips, and (3) any out-of-pocket expenses for the activity during the month that you would allocate to anticipating possible trips.

CONSIDERING POSSIBLE RECREATION TRIPS WHILE:	HOW OFTEN (total for month)	AVERAGE TIME (per occasion)	HOW MUCH COST (total for month)
LEISURE ACTIVITIES (with information content)			
Discussing with other persons	16.31 (3.10)	25.89 (5.50)	7.11 (3.01)
Watching TV, videos, and movies	11.33 (1.94)	52.89 (10.71)	7.86 (1.87)
Listening to radio	11.11 (2.50)	21.81 (5.32)	1.44 (0.70)
Reading newspaper and magazine articles, maps, etc.	11.89 (1.88)	29.86 (4.11)	4.18 (1.01)
Attending training sessions, talks, slide shows	1.44 (0.76)	14.72 (5.38)	1.14 (0.48)
Driving to or from recreation sites	6.86 (1.06)	67.44 (9.21)	22.06 (4.34)
Participating in outdoor recreation activities	10.44 (1.26)	138.97 (19.13)	28.66 (7.31)
Resting and relaxing, quiet reflection, etc.	16.00 (2.71)	64.22 (9.88)	2.51 (1.09)
CONSUMER ACTIVITIES			
Shopping to buy trip supplies, clothing, equipment, etc.	2.78 (0.49)	62.28 (9.82)	30.80 (5.64)
Making reservations, airline, car rental, lodging, etc.	0.75 (0.14)	31.08 (16.76)	12.81 (8.39)
Renting equipment, trying it out, etc.	0.75 (0.22)	26.31 (9.91)	3.75 (1.16)
Borrowing equipment, etc. from friends	1.31 (0.34)	32.19 (8.87)	1.33 (0.57)
Preparing food, making things, cleaning, repairing, etc.	8.44 (1.54)	62.31 (6.51)	17.69 (4.32)
WORK ACTIVITIES			
Working on the job	5.40 (1.48)	320.67 (194.58)	4.11 (3.59)
Attending work-related meetings	0.11 (0.05)	18.75 (6.57)	0.50 (0.50)
Driving to or from work	5.83 (1.45)	25.50 (7.30)	5.80 (2.25)
During work breaks	2.91 (0.99)	12.55 (3.58)	0.64 (0.45)
At lunch time	3.43 (1.20)	14.30 (3.72)	4.20 (3.98)
OTHER ACTIVITIES, if any (list them and indicate how often)			
______	___	___	___
______	___	___	___

6. Studies of the human brain and thought process suggest that people often have various pictures going through their minds. How about you? For each of the mental images listed below, check the choice that best describes how important it is to you.

PICTURE GOING THROUGH YOUR MIND ABOUT A POSSIBLE TRIP	VERY IMPORTANT (5)	IMPORTANT (4)	SOMEWHAT IMPORTANT (3)	UNIMPORTANT (2)	VERY UNIMPORTANT (1)	
Visualizing yourself participating in recreation activities	21	10	6	0	0	4.41 (0.12)
Visualizing other persons participating in recreation activities	5	10	13	7	1	3.31 (0.17)
Visualizing future generations participating in the recreation activities	13	7	9	6	0	3.77 (0.19)
Visualizing past generations at the recreation sites	3	11	16	4	1	3.31 (0.15)
Visualizing wildlife and other resources at recreation sites without any people in the picture	23	6	3	3	1	4.31 (0.19)
Other types of mental images, if any (list them and indicate their importance)						
______	3	2	0	0	0	
______	___	___	___	___	___	

7. About how many recreation trips did you consider taking during the past month or typical month (4-week period) and how many actually occurred (or will occur)? Enter a number in each blank.
9.41 number considered (1.14) 4.38 number actually occurring (0.63)

8. Is your enjoyment of anticipating the possibility of taking trips that will not occur more or less than your enjoyment of anticipating trips that actually will be taken? Check one. (5-point scale with 5= much more)
2 much more 3 slightly more 7 same 14 slightly less 11 much less 2.22 (0.19)

9. Is your enjoyment of anticipating possible vacation trips (4 or more days) more or less than shorter trips (1 or 2 days)? Check one.
9 much more 22 slightly more 5 same 0 slightly less 1 much less 4.03 (0.13)

10. Does your enjoyment of anticipating the possibility of taking trips vary from season to season? In the blank next to each season, please enter your estimate of its proportion (percent of 100) of your total annual enjoyment of anticipating recreation trips. (Round to the nearest 10 percent)
23.97 Spring (2.22) 33.75 Summer (2.64) 18.61 Fall (2.37) 23.11 Winter (2.05) ___ 100 Annual

11. Is your enjoyment of anticipating possible future trips to recreation sites you remember visiting in the past more or less than to sites you have never visited before? Check one.
5 much more 14 slightly more 4 same 11 slightly less 3 much less 3.19 (0.20)

12. Is your enjoyment of anticipating possible trips more or less as the time to depart becomes nearer and nearer (or you are about to arrive at the recreation site)? Check one.
20 much more 14 slightly more 0 same 2 slightly less 0 much less 4.44 (0.13)

13. On the average, about how much total time do you spend enjoying the anticipation of a possible trip to a particular recreation site before you no longer enjoy doing so if you do not actually take the trip? 3.73 hours (0.57)

14. Do the actual recreation resources featured in TV programs, magazine articles, etc. contribute more or less to your enjoyment of anticipating possible recreation trips than the artistic and persuasive skill of the producer or writer? Check one.
5 much more 21 slightly more 10 same 1 slightly less 0 much less 3.81 (0.12)

15. Please describe the three most enjoyable trips you considered during the month. Write in their names, locations, your recreation activities anticipated at each, and the expected number of days away from home for each.

16. Recall your uses of leisure time during the month, was the total amount of time spent anticipating possible trips more or less than time on actual recreation trips? Check one.
4 much more 5 slightly more 4 same 16 slightly less 8 much less 2.49 (0.21)

17. How important is your enjoyment of time anticipating trips relative to time on actual recreation trips? Check one.
2 much more 1 slightly more 9 same 18 slightly less 7 much less 2.27 (0.16)

18. For how many years have you engaged in the activity of anticipating possible recreation trips? 14.46 Years (1.16)

19. How would you rate your knowledge of possible recreation trips and your skill in using the types of information you use most frequently in your recreation trip planning?
2 Beginner 13 Average skill 2 Expert 3.49
1 Moderately skilled 19 Highly skilled (0.14)

20. On how many days did you participate in some kind of outdoor recreation activity in the month? 9.84 days (1.18)
How many hours per day on the average? 4.0 hours (0.40)

21. How flexible is your job? Would you have worked more if you had not participated in actual recreation activities? 14 Yes 23 No In anticipation of possible trips? 9 Yes 27 No

About how many hours more would you have worked in the month? 10.55 hours (2.97)

About how much additional money would you have earned (before taxes)? $63.20 (13.00)

22. If you were unable to visit your preferred recreation site, about how many additional miles would you have to travel from your home to reach the next most preferred site? 92.91 miles (44.61)

23. What is your total investment in equipment (at cost) used for possible recreation trips and activities (cameras, binoculars, books, maps, pictures, videos, special clothing, vehicle, etc.)? If an item is also used for other purposes, allocate its cost based on the proportion of recreation use to total use. $1707.41 (359.14)

How much of your total investment in recreation equipment is used in anticipating and planning possible trips? $385.00 (173.24)

The following questions ask for some information about yourself. Your answers will be held confidential and you personally will not be identified in reporting the results of the study.

24. How much vacation do you take each year? 36.74 days (5.52)
25. Are you: 29 Male 8 Female
26. What is your age: 23.53 years (0.54)
27. How many people are in your household, by age group (including yourself)?
2 Infant through Age 12 78 Age 18 through Age 40 0 Age 66 and above
2 Age 13 through Age 17 12 Age 41 through Age 65

28. During the month, were you: (Please check all that apply.)
3 Employed full time 3 Unemployed 0 Homemaker
18 Employed part time 0 Retired 37 Other: STUDENT

29. What is the highest year of formal education you completed? Circle one.

1 2 3 4 5 6 7 8	9 10 11 12	13 14 15 16	17 18 19 20 21 22
Grade School	High School	College or Vocational School	Graduate or Professional School
		34	4

15.46 (0.11)

30. Please check your household income before taxes last year?
13 Under 5,000 4 20,000 to 29,999 0 50,000 to 74,999
8 5,000 to 9,999 1 30,000 to 39,999 2 75,000 to 100,000
5 10,000 to 19,999 1 40,000 to 49,999 2 100,000 and above (Please specify to nearest 10,000) $21.67 thousands (4.96)

If there is anything else you would like to tell us about your enjoyment of anticipating possible trips, please use this space for that purpose.

Your contribution to this study is very much appreciated. If you would like a summary of the results, please write "results requested" on the back of the return envelope. We will see that you get it.

EVALUATING THE EFFECT OF ALTERNATIVE RISK COMMUNICATION DEVICES ON WILLINGNESS TO PAY:RESULTS FROM A DICHOTOMOUS CHOICE CONTINGENT VALUATION EXPERIMENT

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ABSTRACT

Two versions of a contingent valuation questionnaire that differ only in the device used to communicate risks from hazardous waste were sent to California household's. The empirical results demonstrate that different risk communication devices produce statistically different logit equations and hence estimates of willingness-to-pay (WTP) for reductions in exposure to hazardous waste. As evidenced by likelihood ratio tests of the respective logit equations, willingness to pay responses elicited using the risk ladder varied with changes in risk levels. The same was not true of the pie chart risk communication device. This indicates the risk ladder provides responses more consistent with consumer theory than the pie charts. Suggestions are provided for improving risk communication in future contingent valuation surveys.

INTRODUCTION

Researchers in the field of economics have been improving and refining methods to quantify the benefits associated with the programs or regulations which reduce environmental and health risks. No explicit competitive market price currently exists for the general population to purchase such risk reductions. Therefore estimation of the benefits from reducing this risk requires an alternative or nonmarket method. In addition to wage hedonic models, one method being increasingly used by researchers and governmental agencies is the Contingent Valuation Method (see Mitchell and Carson, 1989 for a comprehensive evaluation of the method). Since the Contingent Valuation Method (CVM) provides hypothetical valuations, validation of CVM responses via hedonic property value studies (Brookshire, et al, 1982) and cash markets (Bishop and Heberlien, 1979; Welsh, 1986) have been necessary to demonstrate that credible valuations can be produced by CVM. However, most of these tests are of consumer choices involving certainty. Both the Executive Branch (U.S. Department of Interior, 1986) and judicial review (State of Ohio v. U.S. Department of Interior, 1989) have upheld CVM as an acceptable method. For valuation of resource trade-offs under *uncertainty* the robustness of CVM to different risk communication devices has yet to be demonstrated, however.

A review of recent literature on risk communication and public perceptions of risk showed extensive research being conducted by psychologists, sociologists, political scientists, and economists. Difficulties facing risk communicators was the main topic at the National Conference on Risk Communication held in 1986. Several factors were cited as large obstacles to effective risk communication: 1) risk information is often highly technical, complex, and uncertain, 2) experts provide widely different risk estimates, 3) regulatory agencies often lack public trust and credibility, 4) there are various ways to define risk, 5) strong beliefs held by the public are resistant to change, and 6) many people have difficulty with probabilistic information (Davies et al., 1987). Most of the past comparisons of the effect of risk communication on behavioral choices have focused on alternative narrative descriptions of risk changes and associated contexts (Tversky and Kahneman, 1981). The purpose of this paper is to evaluate CVM responses arising from two commonly used graphical risk communication devices: the risk ladder and risk circles/pie charts. Each of these devices have been used independently to elicit values of risk reduction programs, but the two methods have not been empirically compared for the same magnitude of risk reduction and for the same type of hazard. To allow for progress in value elicitation for risk reduction programs, understanding the implications of using different risk communication devices is very important.

APPLICATION OF CVM TO RISK REDUCTIONS

There are three key CVM design elements that must be coordinated in any survey instrument: (1) the good to be valued; (2) the value elicitation procedure; and (3) the payment vehicle. In this study, the commodity or good to be valued is reduction in risk of premature death, through state-financed incentives for a California program of hazardous waste minimization by private industry. The public provision of a statewide program and the fact that in California the funding of these types of programs is often decided via a popular referendum made the dichotomous choice referendum elicitation format quite credible. The use of a voter referendum elicitation format (where people vote yes or no) made taxes the most logical or credible payment vehicle. Unfortunately, the payment of higher taxes is not an emotionally neutral subject for many people and such a payment vehicle may increase the number of protest responses. However, it is the realistic possibility of this particular payment mechanism that motivated selection of this method.

In terms of value elicitation procedures, most of the previous surveys on WTP for reductions in risk have used open-ended WTP questions (Smith and Desvousges, 1987; Magat, Viscusi and Huber, 1988) or payment cards (Gerking, et al., 1989). Providing a specific maximum dollar amount for a nonmarket product can sometimes be difficult for respondents and in mail surveys they frequently skip these questions. A dichotomous choice format is easier for the respondent to answer and has been shown to be more incentive compatible for unbiased responses (Hoehn and Randall, 1987).

Although the dichotomous choice procedure does not directly provide the maximum WTP for risk reduction by households, there are statistical inference techniques to estimate maximum WTP from data on the probability of a YES or NO response to specific dollar amounts. The probability a respondent will answer "YES" to the WTP question is assumed to be related to the expected gain in well being obtained from receiving the health risk reduction, over and above the satisfaction lost due to paying higher taxes (Hanemann, 1984).

To be more specific, assume a state-dependent utility function (Cook and Graham, 1977) such that U_L and U_D are the utility when alive and dead, respectively. Following Smith and Desvousges (1987:91) this state-dependent utility depends, in part, on income (Y). Further let P_D be the baseline probability of <u>premature</u> death. Baseline expected utility (EU) can be defined as:

$$(1)\ EU = P_D[U_D(Y)] + (1-P_D)[U_L(Y)]$$

The proposed hazardous waste minimization program reduces the probability of premature death from P_D to P'_D but at a proposed cost to the respondent of $X each year. If the reduction in the probability of premature death from P_D to P'_D yields more expected utility that the loss of \$X in income, the person will answer yes to the dichotomous choice question. Specifically the expected utility difference (EUD) is given by:

(2) $EUD = \{P'_D[U_D(Y-\$X)] + (1-P'_D)[U_L(Y-\$X)]\} - \{P_D[U_D(Y)] + (1-P_D)[U_L(Y)]\}$

If this expected utility difference is linear in its arguments and the associated additive random error term is distributed logistically, then the probability a respondent will answer YES to a question asking him or her to pay \$X for a program that would reduce the risk of premature death from P_D to P'_D would be:

(3) $P(Y) = 1 - [1 + e^{Bo-B1(\$X)}]^{-1}$

Maximum likelihood routines can be used to estimate a transformation of equation (3) in the form of:

(4) $\text{Log } P(Y)/[1-P(Y)] = Bo - B1(\$X)$

Estimates of the parameters Bo and B1 allow identification of the cumulative distribution function of WTP for the risk reduction program (Hanemann, 1984). The mean of the cumulative distribution function is the mean WTP. Since WTP for an unambiguous improvement in expected utility is nonnegative, the mean is given by Hanemann (1989) as:

(5) $WTP = (1/B1) * \ln(1+e^{Bo})$.

PAST RISK COMMUNICATION DEVICES IN CVM

The effect of the amount and type of information on consumer's choices has been a source of concern among economists and psychologists for a number of years. Unlike consumer choice under certainty, probabilistic and uncertain events appear to tax the decision making capability of many consumers. Viscusi and Magat (1987: 7) in summarizing their own research on product labelling and that of others with regard to risk communication state: "The existence of limitations on human cognitive capabilities makes the format and wording of labels particularly important."

There has been much innovation in risk communication devices over the short history of contingent valuation of health related risk. Jones-Lee, et al. (1985) used darkened blocks on graph paper to portray the risk in 10,000 of death from transportation accidents. Risk ladders have been used by Mitchell and Carson (1985) as well as Gerking, DeHann and Schulze (1989). In these ladders each rung represented progressively higher and higher risks.

As part of their effort to provide context on risk of death, Smith and Desvousges used both a risk ladder and pie chart to communicate information on risk. The ladder arrays different probabilities of death from a variety of sources, with the most hazardous at the top. Smith and Desvousges used this risk communication tool primarily to communicate the relative risk from hazardous waste as compared to other risks. Their ladder mixed voluntary risk (e.g. smoking) with involuntary risk (e.g. floods).

To actually communicate the change in probability of death associated with the particular programs they were asking WTP about, Smith and Desvousges used a series of three pie charts. The three pie charts were as follows: the first pie chart illustrated a typical individual's risk of exposure to the hazardous substance. This was done by shading in a pie slice equal to the probability of exposure (i.e., if chances are 33%, then one-third of this pie would be shaded in). The second pie chart portrayed the risk of death if exposed to a given dose of the hazardous substance. The third pie chart illustrated the combined (multiplied) results of the first two pie charts. This pie chart was entitled "Combined Risk: Exposure and Death". Generally the size of the darked slice got smaller as one read left to right. In essence this third chart represented the outcome of a compound lottery. People were asked to pay for a reduction in the risk of exposure, shown as a smaller shaded area in the left most pie. Holding constant the middle pie chart (risk of death if exposed) the program people were asked to pay for reduced the amount of the third darkened pie slice (combined personal risk).

While Smith and Desvousges indicate the separation of risk into three pies was an outcome of their focus groups, there seems to be several potential drawbacks to relying on the pie charts to elicit WTP for risk reductions as compared to directly using the risk ladder. Perhaps the most important is that for very low risks, it is difficult for people to: (a) relate the small size of the darkened slice to their relative chances of premature death from this hazard compared to more familiar hazards; (b) given the small baseline risk or darkened area it will be difficult to portray noticeable changes in the third pie chart for most reasonable programs. This failure to communicate visually perceptible differences in reductions in risk levels would tend to result in respondents giving about the same responses across the risk levels. In addition, the risk reduction is being displayed without any comparison to familiar risks, so it is more difficult for the individual to directly judge how much safety they have bought in terms that are directly related to their life experience (and other risks they face). That is, if one wants the marginal rate of substitution between income and risk, it may be helpful to show how the new market basket of risks compares to the old. The risk ladder does a better job of this. Lastly, Smith and Desvousges presented the three related pie charts in the form of a compound lottery. While this provides additional information, it may be confusing to people not use to thinking in these terms. This may provide unnecessary detail as the risk ladder only presents information on the combined probability.

DESIGN OF THE RISK LADDER AND PIE CHARTS

To test the relative effectiveness of the risk ladder and pie charts for eliciting valuations, two versions of a survey were developed. These versions were identical except for the method used to convey risk information. One method utilized a multi-color risk ladder to show a wide range of involuntary risks and provided a perspective on the size of risk from exposure to heavy metals, relative to the other involuntary risks. This communication technique was utilized by Smith and Desvousges (1987) to display relative risks, but not to display the change in risk for the government program people were asked to value. In contrast, we used this risk ladder to show the reductions in risk level from three alternative programs as movements down the ladder and to elicit WTP responses. Thus the ladder was directly used to provide perspective on how much additional safety was to be purchased. A black and white copy of the ladder is shown in Figure 1.

An alternative method of communicating risks was patterned after the original pie chart format of Smith and Desvousges. The risk reduction programs were conveyed visually by shading in portions of the three pie charts to depict the level of risk of exposure, risk of death if exposed and finally the combined personal risk. Figure 2 shows a reduction in personal risk and WTP question used in the pie chart survey version.[1]

FIGURE 1

RISK LADDER

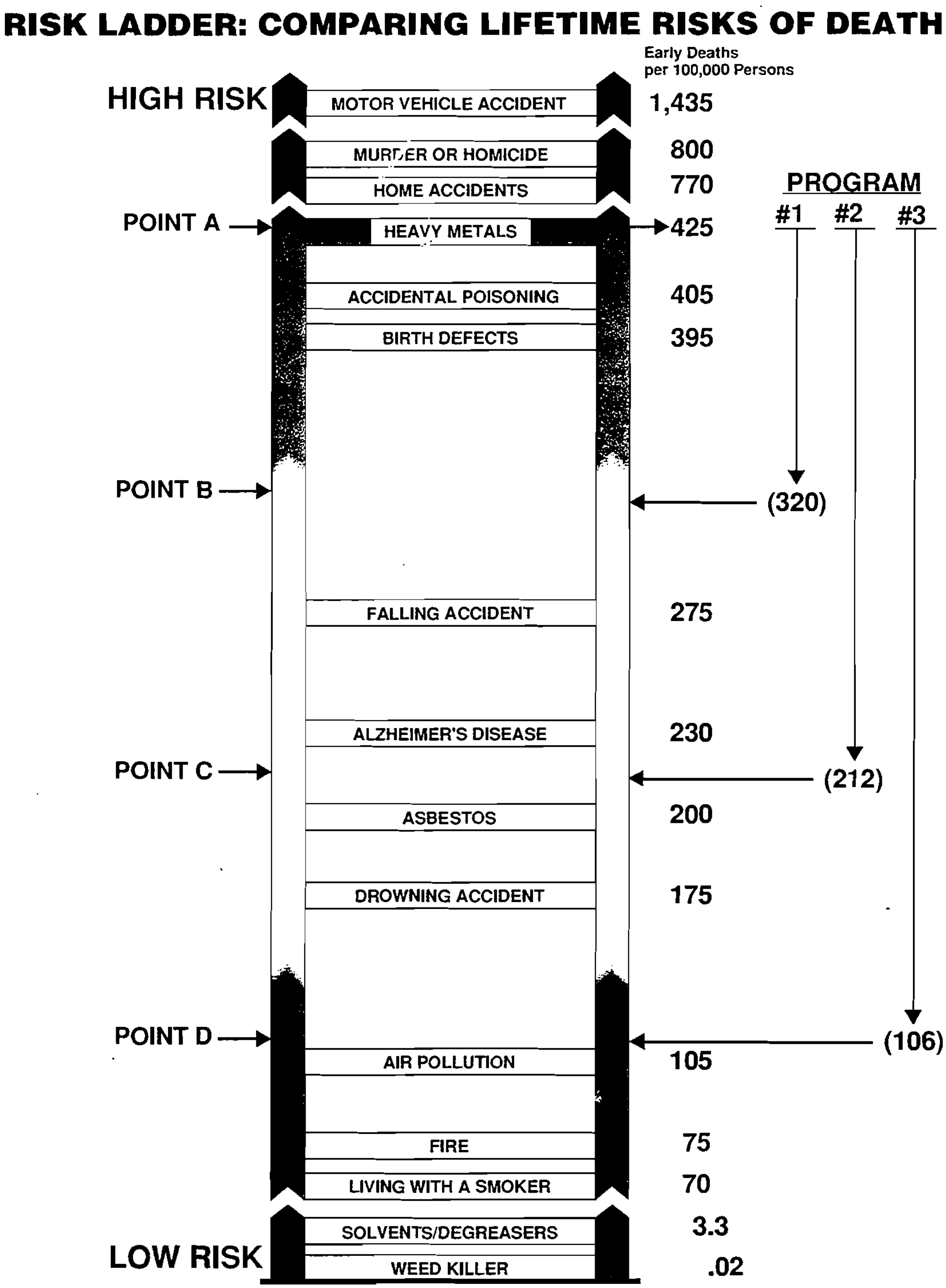
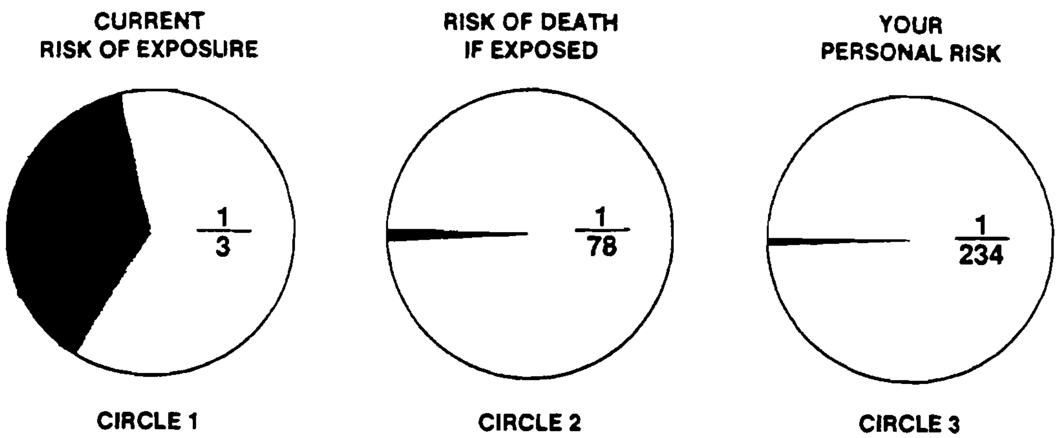


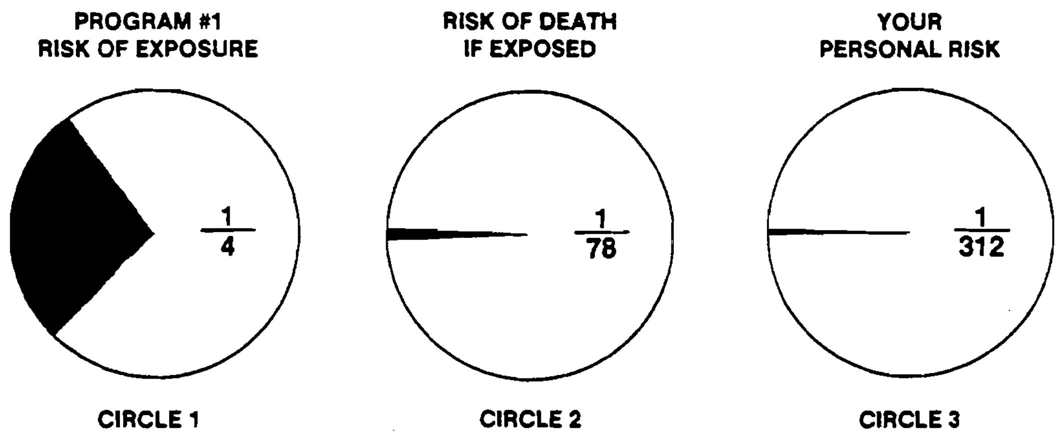
FIGURE 2

RISK PIE CHARTS



PROGRAM #1

1) If the State of California were to increase the funds available for companies to buy waste minimization technologies, your risk of exposure to HEAVY METALS would be reduced from 1 in 3 (circle 1 above) to a risk of 1 in 4 (circle 1 below). Program #1 would result in a 25% decrease in your personal risk of an early death from HEAVY METALS. Your personal risk would be reduced from 1 in 234 (circle 3 above) to a personal risk of 1 in 312 (circle 3 below).



Suppose the State of California put Program #1 to increase funding for waste minimization on the next ballot. Would you vote for Program #1 which reduces your personal risk of premature death from HEAVY METALS by 25%, if it cost your household $__________ in additional taxes each year:

HYPOTHESES ABOUT RISK COMMUNICATION DEVICES

The direct use of the risk ladder for elicitation of WTP may better communicate risks by representing the decrease in risk in terms relative to other experienced risks. In addition, the risk reductions are represented in linear distance rather than an area within a circle. It seems plausible that people can more easily comprehend the magnitude of risk changes when represented as simple lineal distances (which is one dimensional) as compared to area representations of a circle (which involve two dimensions that radiate from small in the center to large at the edge). The main purpose of the research reported here was to investigate the effectiveness of risk pies and risk ladders as risk communication devices. While both techniques have been used to elicit valuations of risk reductions, we are aware of no comparisons of the two techniques for the same level and type of risk.

Our first hypothesis is that the two risk communication devices will yield statistically different logit equations (as in equation 4). Specifically, the null hypothesis is:

(6) $Bo = Ao,\ B_1 = A_1,\ B_2 = A_3,\ \ldots,\ B_k = A_k$

where **B**'s are coefficients from logit equation 4 estimated from responses obtained using the risk ladder and the **A**'s are coefficients from logit equation 4 estimated from responses obtained using the pie charts.

The equalities in equation 6 can be tested using a likelihood ratio (LLR) test. In this case a pooled logit model imposes the restriction in equation 6 as compared to the unrestricted model which allows the coefficients to be different. The test statistic is computed by comparing the log likelihood function of the pooled sample minus the sum of the two log likelihoods for the unrestricted models. Specifically,

(7) $LLR = -2*\{LLpooled - (LL_A + LL_B)\}$,

where LL is log likelihood. This statistic is distributed chi-square with k-1 degrees of freedom.

Our second hypothesis goes beyond the first to ascertain whether either set of CVM responses vary across risk levels. Specifically, a risk communication device that is effective should produce responses that are consistent with consumer demand theory. As one of the first principles of this theory, more of a good is preferred to less. A corollary for economic bads is the less bad the better. If a series of substantial reductions in risk is clearly communicated by device X to consumers, we would expect the responses to vary systematically across those risk reductions. Specifically, one would expect the coefficients in logit equations estimated for each risk level to be statistically different if the substantial reductions in risk have been clearly communicated. This forms the alternative hypothesis to the null hypothesis in equation 8 which states there is no difference in responses across substantial risk levels if the risk communication device is ineffective. Stated in testable form the null is:

(8) $Bo^{25\%} = Bo^{50\%} = Bo^{75\%}$; $B_1^{25\%} = B_1^{50\%} = B_1^{75\%}$; ...$B_n^{25\%} = B_n^{50\%} = B_n^{75\%}$

where **B**'s are coefficients from logit equation 4 estimated from responses for three substantially different risk levels (e.g., 25% reduction in risk, 50% reduction and 75% reduction). The alternative hypothesis is one of statistical difference between coefficients for each risk reduction. As with the first hypothesis, the null hypothesis in equation (8) can be tested using a likelihood ratio test. This time the restricted likelihood function is computed by pooling observations across risk reduction levels for a given risk communication device. Therefore, the null hypothesis in (8) will be tested for each of the two risk communication devices. Given the discussion above, our expectation is that the null hypothesis will be rejected for the risk ladder but accepted for the risk pies.

Our last hypothesis is even stronger than the first two and states the percent of respondents answering yes to any given risk reduction will be lower when communicated using the pie chart as compared to the risk ladder. Specifically, the null hypothesis is equality of percentage yes's (PRY) for any given risk reduction:

(9) $PRY_A = PRY_B$

with the alternative hypothesis being

(10) $PRY_A < PRY_B$

for the reasons cited above (i.e., people will more easily perceive the size of the risk reductions and can relate them to other familiar risks more easily with the risk ladder, treatment B). The hypothesis in equation 9 can be tested using a difference of means test which is distributed with a Student's t distribution. Associated with equation (10) is the implication that $WTP_B > WTP_A$.

SURVEY DESIGN

A full-sized (8-1/2" x 11") multi-color mail survey instrument of twelve pages in length was divided into three sections. The main section of interest here relates to risk communication and elicitation of WTP. This section was designed to accomplish three important functions within the survey.

This section provided information about pathways of exposure to hazardous wastes from various contamination sources. The information was presented in written form and in a full-page drawing. The respondent received a description of a current hazardous waste minimization program in California and how the risk of exposure to hazardous wastes could be reduced by greater funding to this program.

Besides explaining the pathways of exposure and a mechanism for reducing the risks, the second section contained risk communication devices to convey risk levels. The current risk of premature death from exposure to heavy metals was communicated in narrative and illustrated in either the risk ladder or the pie charts depending on the version of the survey (e.g., Figures 1 or 2) to help provide greater comprehension of the risk magnitudes.

The final task accomplished in the second section was the elicitation of WTP responses. Respondents were asked three WTP questions, one for each size risk reduction program (25%, 50%, 75%). Before answering the WTP questions respondents were told to consider only the value to their household from the reductions in risk of exposure to heavy metals. The value elicitation procedure used in the survey was a close-ended referendum format WTP question to specific dollar amounts.

The risk communication devices and intial bid amounts were pretested with a combined telephone-mail-telephone approach. A sample of 200 households were contacted by phone and told they would recieve a survey in the mail. They were to fill out the survey. At a mutually agreed upon time, the interviewer would call them back to obtain their answers, probe these answers and finally discuss comprehension of the survey elements.

SURVEY DATA

A total of 2,000 surveys were mailed to a random sample of California households (1,000 for each version) in late 1989. The response rates of 43% and 47% were obtained for the risk ladder version and the pie chart version, respectively. This yielded a final sample for each version of 374 and 413 surveys. The undeliverable surveys and sample households with a deceased member were omitted for the purpose of response rate calculations. Surveying procedure followed the basic outline of Dillman's "total design method" (Dillman, 1978).

Table 1 (on the next page) presents a comparison of sample characteristics for the risk ladder version and the pie chart version. In general the samples are quite similar. Education and political orientation are nearly identical. The percentage that own their house and mean household income are very close. Because of the similar response rates and characteristics of the two samples, we conclude that differences in the responses are due to risk communication device, not sample differences.

TABLE 1

COMPARISONS OF SAMPLE CHARACTERISTICS BETWEEN RISK LADDER & PIE CHART

VARIABLE	RISK LADDER	PIE CHART
EDUCATION	14.98	15.03
OWN HOUSING	0.74	0.80
CHILDREN	0.45	0.36
INCOME	$48,754	$49,328
POLITICAL ORIENTATION	3.24	3.27
(1=liberal, 3=Middle of road 5=conservative)		

STATISTICAL RESULTS

Table 2 provides the logit equations for three risk reduction programs (25% reduction, 50% and 75%) for each of the two versions of the survey. The same specification of the logit equation is used for both risk communication devices so as to perform the likelihood ratio test of hypothesis number one. The coefficient on dollar bid is significant in all six logit equations at the .01 level. All of the variables have intuitively appealing signs. That is, the more important other community problems relative to environmental issues (e.g., the Other Problems variable in Table 2), the lower the probability of paying a given dollar amount to reduce hazardous waste. The greater the respondent thought their chances of coming into contact with hazardous material from all sources including consumer products, food, water and air (e.g., the Contact variable in Table 2), the more likely the individual was to pay a given dollar amount. The pseudo r square for both risk communication devices indicate similar goodness of fit for both approaches.

TABLE 2
LOGITISTIC REGRESSION ESTIMATES FOR RISK LADDER AND PIE CHART SURVEYS

VARIABLE	25% RISK LADDER COEFFICIENT	T STAT	25% PIE CHARTS COEFFICIENT	T STAT
CONSTANT	-0.7413	-0.757	-1.9482	-2.058
OTHER PROBLEMS	-0.3400	-1.430	-0.31557	-1.447
	0.0505	1.330	0.0723	1.978
CONTACTS EDUCATION	0.1042	2.165	0.1149	2.496
BID	-0.0034	-5.440	-0.003185	-4.715
LOG LIKELIHOOD	-159.45		-169.908	
PSEUDO R SQUARE	0.126		0.125	

VARIABLE	50% RISK LADDER COEFFICIENT	T STAT	50% PIE CHARTS COEFFICIENT	T STAT
CONSTANT	-0.7907	-0.799	-2.203	-2.315
OTHER PROBLEMS	-0.2690	-1.135	-0.3803	-1.730
	0.0577	1.517	0.0626	1.713
CONTACTS EDUCATION	0.0929	1.948	0.1636	3.467
BID	-0.0027	-5.164	-0.003065	-5.170
LOG LIKELIHOOD	-161.04		-167.887	
PSEUDO R SQUARE	0.109		0.154	

VARIABLE	75% RISK LADDER COEFFICIENT	T STAT	75% PIE CHARTS COEFFICIENT	T STAT
CONSTANT	0.27716	0.277	-1.6040	-1.664
OTHER PROBLEMS	-0.99747	-3.726	-0.6745	-2.820
	0.09043	2.315	0.0529	1.427
CONTACTS EDUCATION	0.09440	1.926	0.1710	3.536
BID	-0.00256	-5.556	-0.0030	-5.462
LOG LIKELIHOOD	-154.21		-162.385	
PSUEDO R SQUARE	0.168		0.184	

Where OTHER PROBLEMS is a variable reflecting the importance of other problems facing the communicty relative to the environment. CONTACTS is a variable reflecting the sum of individual's likelihood of coming in contact with hazardous materials from consumer product, air, food and water. EDUCATION measures years of education.

WTP is calculated using equation (5) (Hanemann, 1989) as the mean of a nonnegative random variable. The mean of WTP for the three risk reduction programs for the two survey versions is shown in Table 3. As can be seen in Table 3, the risk ladder yielded higher estimates of mean WTP than the use of the pie chart. This was consistent across all risk reduction program levels.

TABLE 3

COMPARISON OF MEAN WTP FOR RISK LADDER AND PIE CHART

	25% REDUCTION MEAN WTP ($ annual)	50% REDUCTION MEAN WTP ($ annual)	75% REDUCTION MEAN WTP ($ annual)
RISK LADDER	$351	$449	$515
PIE CHART	$243	$295	$313

TESTING HYPOTHESES OF DIFFERENCES BETWEEN RISK COMMUNICATION DEVICES

As discussed earlier, a likelihood ratio test is used to assess whether the logit equations associated with the two risk communication devices resulted in equality of the intercept and slope coefficients. Using equation (7) the likelihood ratio test across the two risk communication devices is computed and reported in Table 4. As is evident in Table 4, the computed likelihood ratio statistics (which are distributed chi-square with k-1 degrees of freedom) for Hypothesis #1 are statistically different from zero at the 5% significance level. This indicates the two different risk communication devices yield statistically different logit equations.

Our second hypothesis was that the responses elicited using the risk ladder would vary across risk reductions and the pie chart responses would not. Based on the likelihood ratio statistic computed across the three risk levels, the coefficients in the individual logit equations estimated from the risk ladder data are statistically different from one another at the 5% level. As shown in Table 4, the likelihood ratio statistic comparing restricted coefficients (e.g., equality across risk levels) to unrestricted is 11.3, greater than the critical chi-square of 9.4. This was not the case for the pie charts, where the likelihood ratio statistic for the restricted and unrestricted coefficients is 5.64, well below the critical chi-square of 9.4. Thus, the alternative hypothesis of a difference in respondent behavior across substantial risk reductions is not supported for the pie charts.

TABLE 4
TESTING STATISTICAL EQUIVALENCE OF RISK LADDER AND PIE CHART RISK COMMUNICATION DEVICES

	25% REDUCTION		50% REDUCTION		75% REDUCTION	
	LADDER	PIE	LADDER	PIE	LADDER	PIE
HYPOTHESIS #1						
Log Likelihood	-159	-169	-161	-167	-154	-162
Pooled Log L across devices	-335		-334		-324	
Likelihood Ratio Statistic	13.0		10.1		16.5	
Critical Chi-Square (5%)	9.48		9.48		9.48	

HYPOTHESIS #2

Risk Ladder

Pooled Log L across 3 risks	-480.3
Likelihood Ratio Statistic	11.3
Critical Ch-Square (5%)	9.4

Pie Charts

Pooled Log L across 3 risks	-502.9
Likelihood Ratio Statistic	5.6
Critical Ch-Square (5%)	9.4

HYPOTHESIS #3

	25% REDUCTION		50% REDUCTION		75% REDUCTION	
	LADDER	PIE	LADDER	PIE	LADDER	PIE
MEAN YES/NO	0.53	0.41	0.54	0.45	0.57	0.45
STD. DEVIATION	0.50	0.49	0.49	0.49	0.49	0.49
MEANS STATISTIC ACROSS DEVICES:	2.930		2.18		3.87	
CRITICAL t (1%):	2.6				2.6	
CRITICAL t (5%):			1.97			

Our third hypothesis test of the equality of the probability of responding yes across survey versions is tested using a difference of means test. The difference of means statistic follows a Student's t distribution. While the bid distribution on surveys mailed out were identical, the mean bid or offer amounts of the returned surveys differed slightly (by less than 7%). For example the difference at the 50% risk reduction level is only $10 (i.e., $224 and $234).

The results of this test are also shown in Table 4. The null hypothesis H_o: $PRY_A = PRY_B$ is rejected at the 1% significance level for the 25% and 75% reduction programs. The null hypothesis of equality of percentage yes for the 50% reduction programs are different at the 5% significance level. As is shown in Table 4, support is given for the alternative hypothesis that $PRY_A < PRY_B$ (i.e., greater proportion of yes from the risk ladder).

DISCUSSION AND CONCLUSIONS

It is well known in psychology and marketing research that alternative methods of conveying information can have profoundly different impacts in terms of a consumer's interpretation and perceptions of the content. In our survey, version B which moved respondents down the risk ladder, was expected to yield perceptions of larger risk reductions than changes in the small slivers in the pie charts of version A. In addition, the elicitation of WTP within the context of other relative risks respondents face provides potential for greater understanding of just what that change in risk means to them in their everyday lives.

We find that the logit equations are significantly different across the two risk communication devices for the same levels of risk. More importantly the responses to substantial reductions in risk as portrayed by the risk ladder resulted in statistically different logit WTP equations at each risk level. Given the large risk reductions of 25%, 50% and 75%, consistency with consumer theory would imply that an effective communication of these changes would have elicited statistically different logit WTP equations. The confirmation of this for the risk ladder but not for the pie charts casts doubt on the ability of the pie charts to effectively communicate risk reductions to most respondents. Lastly, the risk ladder version results in a significantly larger number of people stating yes they would vote in favor of the waste minimization program. WTP estimates are correspondingly higher with the risk ladder than with the pie chart.

Which of these risk communication techniques yields values closer to the "truth" is of course difficult to determine in contingent valuation. Based on our second hypothesis that an additive series of 25% reductions in risk ought result in statistically significant differences in WTP logit equations of those responses, the risk ladder is more consistent with consumer demand theory than the pie charts. In addition, the ladder does a much better job providing information on relative risk, i.e., how the risk under study compares with other, often time, more familiar risks. This aids the respondent in forming their marginal rate of substitution between risks and other goods (as represented by income). While the pie charts might do a reasonable job for communicating the absolute level of risk earlier in the survey, <u>we believe the value elicitation phase should use the risk ladder as the primary communication device in contingent valuation studies.</u> Before this conclusion can be generalized, replication for a wide variety of risk levels is certainly desirable. Of course, psychologists, economists and other scientists should continue to improve upon these risk communication devices and ideally develop new, even more effective ones.

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FOOTNOTES

1. A commentor on the earlier version of this paper presented at the W-133 meeting pointed out that perhaps a more comparable test of the risk ladder and pies would have just compared the last of the three risk pies at each risk level. This would have avoided the possibility that any differences between risk communication devices was due, in part, to the compound lottery effect. However, since our goal was to compare the risk ladder and pie charts that were as similar as possible to Smith and Desvousges, we desired to keep the three pie charts.

An Ethical Justification for Considering Benefits and Costs in Environmental Policy Decisions*

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Some conservationists, biologists, and environmental ethicists have expressed skepticism about, or direct opposition to, the serious consideration of benefits and costs in the decision process for environmental policy. Economists have often defended benefit cost analysis as providing a test for the economic efficiency of proposed policies and a guard against policies that would divert private resources to less productive public uses. These justifications seem quite compelling to the economists who offer them, but they do not always convince the skeptics.

It is tempting to attribute this state of affairs to the general lack of economic literacy among non-economists, and economists often do just that. However, there is another

*This paper sketches some of the conclusions obtained in research under National Science Foundation award number BBS8710153. Primary contributors to the research effort were Alan Randall (Principal Investigator), Donald C. Hubin (Co-Principal Investigator), and Michael C. Farmer (Graduate Research Associate).

possibility that ought at least be considered: economists have done a remarkably poor job of articulating why benefits and costs matter. Perhaps this ineffective exposition betrays an even greater problem: we have not thought carefully about why benefits and costs should matter, especially to people who are not pre-conditioned to view welfare economics as the ultimate moral philosophy.

In this brief paper, I plan to highlight some of our tentative conclusions from an attempt to think seriously about these issues.

1. Benefit Cost Moral Theory

Don Hubin specified "benefit cost moral theory" (BCMT) and examined its acceptability from a variety of philosophical perspectives. BCMT may be stated in several ways, including: Right action is exactly whatever action would have benefits in excess of costs (as economists understand the terms, benefits and costs).

Hubin's bottom line is that there is no respectable modern school of moral philosophy that would find BCMT acceptable. And, of course, it is a rare economist who would propose BCMT in such stark terms.

2. The Justification for Taking Benefits and Costs Seriously

Hubin then observed that many other morally-worthy precepts would be unacceptable when expressed analogously to BCMT. Consider democratic moral theory: Right action is exactly whatever a plurality of the electorate decides to do. Democratic moral theory is obviously unacceptable, but that provides no reason to abandon democracy.

While no respectable modern school of moral philosophy would endorse BCMT, a broadly appealing argument can be developed for taking benefits and costs seriously. First, imagine a coherent moral theory in which the satisfaction of human preferences counts for nothing at all. It turns out that we cannot imagine such a theory. Human preference satisfaction counts for something in any coherent moral theory. Second, benefit cost analysis provides a rather good account of human preference satisfaction.[1]

Now, the different philosophical schools put somewhat different emphasis on human preference satisfaction. For example, it is a high-ranking concern for many kinds of consequentialists; but it is a hierarchically-lower concern -- something to consider only after more pressing moral obligations have been taken care of -- for unreconstructed Kantians. But, the striking conclusion is that there is remarkably broad agreement that human preference satisfaction counts, morally.

Thus, we have a justification for taking benefits and costs seriously. This, after all, is as much as economists really want, anyway. I have come to believe that economists would be much more convincing if they would say, simply: Benefits and costs should be taken seriously because human preference satisfaction is morally important, and BCA provides a rather good account of human preference satisfaction. In addition, this position takes care of a number of issues that continue to vex us: e.g., why should economic surpluses be included in the accounts, and why should existence value be included?

3. Getting Benefit Cost Rules from Contractarian Processes

Mike Farmer (1991) developed a game theoretic model to examine the conditions under which a society of Gauthier-contractarians -- individuals who (unlike Rawlsian contractarians) know their original positions -- would agree to be governed by a benefit cost rule.

It turns out that the commitment of these Gauthier-contractarians to a BC rule is limited, in two ways. First, contractarians instinctively pursue preference satisfaction via the individualistic routes of voluntary exchange, voluntary taxation, and public choice by consent. However, if the transactions costs of compensating transfers to achieve Pareto-safe policy are high, a BC rule is appealing in that it at least maintains a positive-sum game. Second, the BC rule in Farmer's game turns out to be a default rule. His contractarians will reserve the right to bargain for departures from the BC rule that would benefit themselves; and under certain circumstances the group will agree to such departures. Nevertheless, Farmer's Gauthier-contractarians would -- if faced with (realistically) high transactions costs -- agree to a default benefit cost rule. That is, in the absence of overriding concerns, they would decide on the basis of benefits and costs.

4. The Net Present Value Rule

Since discounting has been so controversial among conservationists, Mike Farmer and Alan Randall revisited the net present value rule.

Consider an aggregate production function, $Y = f(D, K, L)$, where Y is output, D is natural resources, K is human-made capital, and L is labor. Following Solow (1974), we can rearrange things in per capita terms,

$$\frac{Y}{L} = g\left(\frac{D}{L}, \frac{K}{L}\right). \tag{6}$$

Solow showed that if D and K were perfect substitutes -- i.e., if human-made capital and technology were excellent substitutes for natural resources in the long-run -- aggregate output could be sustained even as D approached exhaustion.

While Solow did not consider discounting, we can extend his analysis to consider it. Unless we impose a discounting rule -- discounting all future cost and benefit streams at the efficient rate, r -- society would choose some inefficient (i.e., wasteful) investments. That is, ***without*** a discounting rule, present generations would act so as to reduce the potential consumption of future generations. The environmentalists of the 1960s were right: society needs the discipline of realistically high discount rates in order to avoid wasteful investments, e.g., in water resources projects.

But, what about the charge that discounting permits present generations to consciously choose a course of action that may result in environmental disaster several generations hence? First, if we were expecting a disaster, say, 200 hundred years from now, a prudent course of action would be to invest wisely in the interim. Then, we would be rich enough, when the disaster comes, that we could afford to forestall or mitigate it. Again, discounting is vindicated.

However, what if the K that we would be accumulating is not a substitute for the D that collapses in the environmental disaster? Then, being rich would not help.

It seems, then, that when D and K are good substitutes discounting is not just defensible, it is desirable; but when D and K are not substitutes, environmental disaster is a threat even for a society that invests according to a discounting rule. We concluded that the real problem is substitutability of D and K, and that manipulating the discount rate to ration consumption of those particular natural resource that have no substitutes, at best, is a crude instrument and, at worst, would do more harm than good.

5. The Safe Minimum Standard of Conservation

An alternative approach to conservation policy suggested in the writings of the late S.v. Ciriacy-Wantrup and more recently promoted by Richard Bishop (1978) is that of the Safe Minimum Standard (SMS). The safe minimum standard is defined as the minimal level of preservation which ensures survival. A SMS decision rule states that, for any species or ecological community, the safe minimum standard of conservation should be maintained, unless the costs of so doing are intolerably high.

The concept of intolerably high costs requires some interpretation. It has often been argued that the SMS decision rule is empirically empty, because it does not tell us what level of cost is intolerably high. But that is perhaps not the point. Our interpretation of the SMS decision rule is that it calls for an extraordinary decision process before the SMS of conservation can be abandoned. BCA has a "business as usual" flavor; it would tend to dismiss conservation initiatives with benefits just smaller than costs. In contrast, the SMS rule says, in effect: "Time out! The SMS of conservation for [species or community X] is under threat. Now, just how high could the costs of preserving the SMS be, before we as a society would consider them intolerably high?" It is this extraordinary decision process, this sharp break in the continuum of "business as usual" decisions, that gives the SMS rule its appeal.

6. The Broad Philosophical Appeal of a "Decide on the Basis of Benefits and Costs, but Subject to the Safe Minimum Standard" Rule

To this point, we have argued that there are good reasons, valid across the major schools of moral philosophy, to consider benefits and costs when deciding environmental policy issues. So far so good, but it seems we have an obligation to develop a more complete approach. Can a decision rule be developed that incorporates benefit cost considerations and resolves the problems that led us to concede that a strict BC decision rule is broadly unacceptable?

Alan Randall has developed an argument that the rule -- to decide on the basis of benefits and costs but always subject to the SMS -- has broad appeal across the various traditions of western philosophy. Randall's argument was developed in the context of biodiversity and ecostability (e.g., 1991) and we will maintain that context in the summary that follows.

The problem is that of developing a rationale that offers strong protection for ecostability without according it the status of a first principle or a trump that defeats all other human concerns. He argues that trump status for ecostability is not plausible because there are surely other human concerns -- e.g., improving the life prospects of the worst-off members of human society -- that would rank equally with (or maybe even higher than) ecostability.

a. Consequentialism. BCA fits neatly into a consequentialist framework. Benefits and costs are consequences of human actions, and an accounting of benefits and costs according to the potential Pareto-improvement framework is one way (not the only way, but surely one way) to decide whether the expected consequences of a proposed action are beneficial in the net.

Utilitarianism is usually considered a form of consequentialism. BCA fits neatly into a utilitarian framework, given its base in individual preferences and its procedure of aggregating unweighted individual gains and losses.

One of the more persistent arguments against the BCA approach, and many alternative expressions of utilitarianism, is that preferences may be myopic and human understanding of the technical possibilities may be incomplete or mistaken. Not that the BCA approach does worse, in these respects, than other approaches that take citizen opinion seriously. As humans come to comprehend the technology of natural systems and how it limits the performance of anthropogenic technology, this understanding is reflected in a valid BCA. As human preferences extend to the amenity and existence services provided by diverse ecosystems, the valuations that emerge are fully reflected in a valid BCA.

Nevertheless, one must concede that human myopia is a valid concern. How can we be assured that the lure of immediate gratification will not induce us to make decisions that will surely have very unpleasant consequences later on? Elster (1979) has shown that "binding" behavior -- Ulysses bound himself to the mast in advance to prevent himself from doing what he was quite sure he would do in the heat of the moment, i.e., steer his ship into the rocky waters separating it from the sirens -- is consistent with both rational behavior and utilitarianism. Thus, one logically coherent utilitarian strategy would be to make policy choices on the basis of benefits and costs, but subject always to the constraint that actions we are reasonably sure we (or future generations of people we care about) will regret are forbidden. Eco-stability issues may be decided by consulting a BCA but subject to a SMS or similar constraint. Net benefits are maximized because benefits are good consequences, and the constraints are imposed because the consequences of not satisfying them are terrible. Again, the SMS constraint would not accord trump status to eco-stability, but would trigger a serious and searching decision process before it could be relaxed.

b. Contractarian approaches. In contractarian thinking, it is relatively easy to make the case for the SMS rule.

A contractarian approach argues that arrangements are justified if they respect the rights of all affected parties. In contractarian theories, rights are enforceable claims. Change occurs when all affected parties, endowed with enforceable rights, consent to it; without consent, the status quo prevails. While consent justifies change, the lack of consent for change is insufficient to justify the status quo. The starting point (or constitution) must itself be justified directly, typically by arguing that it was chosen by voluntary agreement among all concerned.

Contractarian approaches encounter great difficulties when taken literally. Should all life-forms count equally or, at the other extreme, should the interests of biodiversity be represented by (as yet unborn) humans who are ignorant as to which generation they will be born into? Norton's (1989) thought experiment considered a constitutional convention of the unborn who know neither what species nor what generation they will be born into. The substantial probability of being born nonhuman would lead to agreement on a constitution in which preservation of biodiversity is taken very seriously. But biodiversity would probably not be accorded trump status; participants would accept less than iron-clad guarantees for biodiversity if that would reduce the chances of being born into unrelievedly miserable circumstances. Thus, Norton's contractarian thought experiment identified the SMS constraint as a likely component of a just constitution.

Justifying the consideration of benefits and costs may seem more difficult from a contractarian perspective. Here, we invoke Mike Farmer's result (section 3, above): contractarians would agree on a default rule to take benefits and costs seriously. At least, such a rule assures that the contractarian game is positive sum. In the problem at hand, a plausible contractarian solution is to maximize net benefits (to satisfy preferences) subject to an SMS constraint (because participants in the "veil of ignorance" process such as Norton's would insist on it).

A "BC but always subject to the SMS" decision rule is thus admissible under contractarian thinking.

c. **Duty-based approaches.** Some authors (e.g., Ehrenfeld 1988) seek to place the claims of ecostability on a secure footing by asserting a moral duty of humans to avoid any action that would be threatening to ecostability. Ehrenfeld seems to be suggesting trump status for ecostability. But, without asserting trump status, one can make an interesting duty-based argument.

The case for the SMS is straight-forward. Assume that preserving the ecosystem and enhancing the life prospects of the worst-off people are both moral goods. However, the claims of humans trump those of non-humans. From these moral principles, it can be deduced that humans should make substantial, but not unlimited, sacrifices for the environment. This result endorses the basic idea of the SMS. It avoids claiming trump status for eco-stability, permitting some sacrifice of eco-stability in the face of intolerable costs. But it takes intolerable costs to justify relaxation of the SMS.

The duty-based justification of a BC rule is more subtle. While the SMS can be derived from moral reasoning, the decision rule was left incomplete. Upon what basis should people decide those many issues that do not threaten the SMS? As Hubin argued (section 2, above), it is hard to conceive of a plausible moral theory that does not, in the absence of overriding concerns, give a good deal of weight to the satisfaction of human preferences. Thus, we should take seriously a rule that policy issues be decided on the basis of benefits and costs, but always subject to constraints identified by moral reasoning. Net benefits are maximized because human preference satisfaction is morally worthy, and the constraints are imposed because they ensure that higher moral goods can trump preference satisfaction in the event of conflict.

7. Conclusion

Interestingly, we conclude, the same general kind of decision rule -- maximize net benefits subject to an SMS constraint -- is admissible under consequentialist, contractarian and duty-based reasoning.

Finally, the SMS provides the last missing link in our story. We have argued that, although the net present value rule seems indefensible to many conservationists (since it might sanction conscious choice of policies that would eventually exhaust essential resources), deliberate departures from standard discounting rules have little to recommend them. The problem, we argued, is not discounting per se, but the possibility that human-made capital may not substitute very well for certain kinds of essential natural resources. The SMS seems tailor-made for such natural resources.

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NOTE

1. This argument leaves open the door for some familiar objections that BCA provides a less than perfect account of preference satisfaction. For example, should society censor from its accounts those individual preferences that are obviously personally or socially destructive? Why does BCA evaluate preferences in terms of willingness to pay, which depends also on endowments? And, are we sure that BCA gets the interpersonal aggregation rule right?