Western Regional Research Project W-133

Benefits and Costs in Natural Resources Planning

Fourth Interim Report

June, 1991

Compiled by

Catherine L. Kling
Department of Agricultural Economics
University of California, Davis
Davis, California 95616

Benefits and Costs in Natural Resource Planning
Fourth Interim Report

CONTENTS

Lars Hultkrantz, "National Accounting of Timber and Forest Environmental Resources in Sweden"

Cindy Thomson, "Detecting Outliers and Influential Observations in Contingent Valuation Framework"

Linda Langner and Christopher Hansen, "Proposed Revisions to Forest Service Land Management Planning Regulations: Some Implications for Economic Analysis and Use of Nonmarket Values"

Frank Ward and John Fiore, "A Model of the Welfare Effects of Changes in Quality: New Mexico Fishing"

Renatte Hageman, "The SAGE Method in Endangered Species Management: Constructing Proxy Utility Functions to Measure Relative Values"

Minutes of W-133 Technical Committee Meeting

February, 1991, Monterey, California

The 1991 technical committee meeting of the W-133 regional research project was held February 27-28 in Monterey, California. W-133 members and associates attending the meeting are listed on the attached "Participants List".

The first day of the meeting was composed two invited paper sessions which were held jointly with the Western Regional Science Association (WRSA). These sessions provide an opportunity for W-133 members and special invited speakers to share state-of-the-art developments in theory and techniques for measuring benefits and costs of natural and environmental resource use, allocation, and management.

The first joint session, moderated by John Loomis (U. of California, Davis), was entitled "Measuring Nonmarket and Nonuse Values". Abstracts for the presentations in this session are presented below.

1. "The Theory of Measuring the Benefits of Quality Change", Michael Hanemann (U. of California, Berkeley) - The general topic of this presentation was the recovery of commodity preferences using indirect valuation methods. Michael was particularly concerned with the limitations and concerns posed by weak complementarity. He indicated that although weak complementarity does allow economists to estimate certain welfare measures, it may actually be of little practical value. Michael closed his presentation by making some observations and conjectures concerning the difference between willingness-to-pay and willingness-to-accept compensation welfare measures. Richard Bishop (U. of Wisconsin, Madison) commented on the paper. A question and answer period followed.

2. "Existence and Nonconsumptive Values for Wildlife: Application to Wolf Recovery in Yellowstone National Park", John Duffield (Montana State U.) - John Duffield began his presentation by reviewing some previous wildlife valuation studies and noting that very few had measured non-use values such as existence value. He then described the valuation problem faced with respect to wolf recovery in Yellowstone National Park. This valuation problem involves tradeoffs related to the loss of other wildlife (e.g., elk) and domestic livestock killed by wolves. The total economic value of wolf recovery was measured using the contingent valuation method. The components of total economic value (e.g., existence value) were separated out using a multivariate logistic model. Results showed relatively large existence values for wolf recovery, and positive net benefits for wolf recovery when the opportunity costs of other wildlife and domestic livestock killed were considered. Cathy Kling (U. of California, Davis) commented on the paper. A question and answer period followed.

3. "Cost-Benefit Analysis for Non-Market Resources", Trudy Ann Cameron (U. of California, Los Angeles) and Jeffrey Englin - Trudy Ann Cameron and Jeffrey Englin presented a paper which dealt with the develop and application of an utility theoretic approach for measuring option price,

option value, and expected consumer surplus. The study area was four northeastern states (New York, New Hampshire, Vermont, and Maine). Contingent valuation data on recreational fishing were used to estimate a Graham-type willingness-to-pay locus. This locus was then used in the estimation of option price, option value, expected consumer surplus, and the "fair bet" point. Results indicated that option value was very small. Jack Sinden commented on the paper. A question and answer period followed.

4. "Option Prices and Option Values from Market Data", Doug Larsen (U. of California, Davis) - In his presentation, Doug Larsen provided a conceptual and empirical analysis of option price. Option price was defined as an ex-ante compensating variation (CV) measure of welfare change. Using travel cost data, option price was derived from a Marshallian demand function. The conceptual and empirical results suggested that the sign of option value is sensitive to the source of uncertainty (e.g., own price vs. income). Option value estimates were quite small. John Stoll (Texas A&M U.) commented on the paper. A question and answer period followed.

The second joint invited paper session, moderated by John Keith (Utah State U.), was entitled "Nonmarket Valuation: Some Methodological Appraisals". Abstracts of the papers presented in this session are presented below.

1. "Valuation in a Vacuum: A Naive Perspective", Charles Harris (Colorado State U.) - Charles Harris, a behavioral scientist, provided a skeptical non-economist's viewpoint of the contingent valuation method (CVM). Chuck argued that economists who use the CVM should consider ideological, psychological, and specific valuation issues. Ideological issues included the importance of interdisciplinary research and skepticism of "hard economics". Psychological issues included social pressure and halo effects. Specific valuation issues Chuck discussed included framing effects and context and information effects. John Stoll (Texas A&M U) commented on the paper. A question and answer period followed.

2. "Self Reported Values and Observable Transactions: Is there a Trump in the Deck?", Alan Randall (Ohio State U) - Alan Randall began his presentation by arguing that nonmarket valuation techniques work well enough to merit further use and application of these techniques, particularly considering that market and nonmarket commodities are equally worthy of valuation. Alan then went on to critically examine the travel cost method (TCM) and the contingent valuation method (CVM). He argued that the TCM is limited conceptually by the Austrian view that costs (including travel costs) are subjective. With respect to the CVM, Alan discounted the notion that the CVM can be used to "uncover" a unique, fixed value of a non-market commodity. Rather, he argued, CVM values (like market values) are "conditional values" - that is, sensitive to the conditions of the valuation environment. Ted McConnell (U. of Maryland) commented on the paper. A question and answer period followed.

3. "Asymetric Valuation of Gains and Losses and Preference Order Assumptions", Jack Knetsch (Simon Fraser U.) - Jack Knetsch provided a summary of some experiments conducted to investigate the disparity between willingness-to-

pay (WTP) and willingness-to-accept compensation (WTA) welfare measures. In general, experimental results support "prospect theory" which claims that people value losses much more than commensurate gains. Jack pointed out that his experimental results may have implications for mitigation vs. compensation in damage assessment cases. He argued that it may be better to mitigate the problem (e.g., provide "in-kind" compensation) rather than provide money compensation (because, in the case of a loss, people may demand much more money compensation than they would in-kind compensation). Richard Bishop (U. of Wisconsin, Madison) commented on the paper. A question and answer period followed.

The second invited paper session ended about 5:00 p.m. The W-133 business meeting was then conducted. The business meeting was convened by Cathy Kling at about 5:10 p.m. The first order of business discussed was the location of the 1992 technical committee meeting. The discussion of this location decision centered around whether or not the W-133 group should continue to meet jointly with the Western Regional Science Association (WRSA). On the negative side, it was pointed out that meeting with the WRSA usually involves higher registration fees and hotel rooms. On the positive side, it was pointed out that meeting with the WRSA greatly simplifies the logistics of meeting organization, provides for greater participation in the meetings through enhanced travel justification (particularly for invited participants who are not regular members of W-133), provides for greater exposure for W-133 activities, and provides opportunities for papers presented at the W-133 meetings to be published in a refereed journal published by the WRSA (The Annals of Regional Science). It was decided by the group that the "benefits" of meeting jointly with the WRSA appeared to outweigh the "costs". Hence, the group voted to continue meeting jointly with the WRSA. The 1992 joint meeting of the WRSA and W-133 group will be held in South Lake Tahoe, California. A meeting date has not yet been set by the WRSA. In order to reduce some of the costs associated with meeting jointly with the WRSA, John Loomis was asked to assess the room costs of the hotel selected by the WRSA and if necessary, identify at least one alternative hotel in South Lake Tahoe as a "lower-cost" housing option for W-133 members and associates.

The second order of business was election of a new secretary-treasurer. Kevin Boyle nominated Rich Ready (U. of Kentucky). John Bergstrom (U. of Georgia) seconded the nomination. Rich was elected unanimously. Olvar Bergland (Oregon State U.) now moves to president, and John Bergstrom (U. of Georgia) moves to vice-president.

The final order of business was approval of new W-133 member states. Rhode Island and Massachusettes were approved as new members. Enoch Bell noted that Hawaii requested to be dropped from W-133, and Nevada did not apply. Enoch and John Meadows also informed the group that we needs a new Experiment Station administrative advisor. Any suggestions should be forwarded to Enoch or John immediately. John Meadows expressed preference for an administrator from a Western state.

The business meeting was closed by Cathy Kling at 5:45 p.m.

The second day of the meeting was devoted to a more informal "workshop" presentations by W-133 members of regional project research in progress or recently completed. Selected non-members of W-133 were also invited to make presentations of research or government policy and management issues of particular relevance to the goals and objectives of the W-133 regional project.

The first workshop session was moderated by Kevin Boyle (U. of Maine). Abstracts of the presentations are presented below.

1. "Preservation of King Mackeral Populations for Sportfishing: A Policy Referendum Approach", John Stoll and Robert Ditton (Texas A&M U) - John Stoll presented the results of a recently completed contingent valuation study of the value of King Mackeral for recreational fishing. Data on King Mackeral anglers and survey response rates were presented first. The format of the valuation question was then presented, and the difficulty of identifying an appropriate reference point for contingent valuation was discussed with input from the group. Some preliminary results were then presented.

2. "A Decision Theoretic Approach to Estimation in CVM", Olvar Bergland (Oregon State U.) - Olvar Bergland talked about the need for nonmarket valuation techniques to reflect the context of the policy decision. He suggested the use of loss functions in policy decisions. These loss functions would reflect the losses incurred with a "wrong" policy decision. The objective of policy decision-making is to minimize such losses.

3. "Polychotomous Choice Valuation Questions", Rich Ready (U. of Kentucky) - In his presentation, Rich Ready described some research in progress on the use of polychotomous choice (PC) questions in contingent valuation questionnaires. PC questions offer a range of possible responses to the typical valuation question: "Would you by $X for this commodity?" These possible responses, for example, include "definitely yes", "maybe yes", "maybe no", and "definitely yes". The PC questioning format was applied to the task of measuring willingness-to-pay for wetlands protection in Kentucky. Preliminary results suggested that PC questioning format generated higher valuations as compared to the traditional dichotomous choice questioning format.

4. "Visibility in the Grand Canyon Revisited", Richard Carson (U. of California, San Diego) - Richard Carson presented the results of a recent contingent valuation study of the economic value of visibility in national parks. Richard discussed key survey design issues including the type of visibility changes to value, number and size of photographs to use, description of haze properties, the scope of the policy context, and the survey population. Focus group and survey results were briefly presented.

5. "Context Effects in CVM", Bill Schulze (Colorado State U.) - Bill Schulze described concerns related to "hypothetical bias" in contingent valuation studies. He reported on the results of experiments which suggest that hypothetical valuation questions lead to skewed (to the left) bid distributions. Some methods for dealing with this skewed distribution were discussed. Bill also addressed the problem of "embedding" which occurs when respondents treat environmental commodities as joint products. The potential presence of embedding reinforces the need for careful survey design and implementation.

6. "Modelling and Testing for Effects of Complexity in Contingent Valuation

Surveys", Marisa Mazzotta and Jim Opaluch (U. of Rhode Island) - The presentation by Marisa Mazzota and Jim Opaluch focused on complex decision-making in contingent valuation surveys. Jim discussed alternative behavioral modes including perfect cognition, neoclassical complexity, and simplification (e.g., lexicographic simplification, enumerative simplification). Jim also described a contingent valuation survey designed to investigate complex decision-making. Marisa described the statistical tests used and summarized the survey results. Results tended to support the use of simplification by respondents. More support was found for enumerative simplification.

The afternoon "workshop" session was moderated by John Hoehn (Michigan State U.). Abstracts of the afternoon presentations are presented below.

1. "What Do Existence Value Estimates Really Mean?", Thomas Stevens (U. of Massachusettes) - Thomas Stevens discussed the results of a recent study of existence value of wildlife species. The wildlife species studied were bald eagles and wild turkeys. The contingent valuation method with a trust fund payment vehicle was used to measure existence value. A relatively high number of protest bidders was observed. "Embedding effects" also appeared to be present. The results suggested existence value appeared to represent a relatively large proportion of the total economic value associated with bald eagles and wild turkeys. Tom also discussed some of the ethical implications of his results.

2. "National Accounts for Timber and Forest Environmental Resources in Sweden", Lars Hultkrantz - Lars Hultkrantz presented a methodology for introducing services provided by environmental resources in GNP accounts. He termed the contribution of these resources "Green GNP". An application of estimating Green GNP in Sweden was discussed. Green GNP appeared to exceed traditionally measured GNP.

3. "Detecting Outliers in a Contingent Valuation Framework", Cindy Thompson (National Marine Fisheries Service) - Cindy Thompson discussed a number of statistical methods for identifying outliers in contingent valuation data. These methods were grouped into two major categories: 1) case studies for detecting a single outlier, and 2) procedures for diagnosing multiple outliers and influential observations.

4. "Observations on Nonmarket Valuation Research", Robert Davis (U. of Colorado) - Bob Davis presented some observations and comments on the future of nonmarket valuation research. He noted that the TCM needs to deal with the Austrian subjective cost problem, and the CVM needs to deal with context (information) effects, embedding effects, the disparity between WTP and WTA, and the scope of existence value. Bob also noted that CVM research is basically survey research, thus we need to bring the best of what survey research has to offer into nonmarket valuation studies.

5. "Forest Service Land Management Planning and Economic Analysis", Linda Langner and Chris Hansen (U.S. Forest Service) - Linda Langner presented an overview of the use of economics in U.S. Forest Service land management planning. She noted that the future role of economic analysis in land management planning is somewhat uncertain. Chris Hansen described the proposed revisions in forest plan regulations in more detail. In the

proposed revisions, the specific criterion to maximize "net public benefits" has been dropped. There is also a substantial reduction in explicitly stated requirements for economic analysis. The revisions give the regional forester much greater discretion with respect to the nature and extent of economic analysis related to forest plans.

6. "Optimally Managing Environmental Improvements: Southwestern Water", Frank Ward (New Mexico State U.) and Catherine Richards - Frank Ward described the develop and application of a regional value estimator model for southwestern water bodies. The model can be applied to simulate recreation demand at multiple sites. Application of the model to 130 sites was described. Frank concluded by discussing some of the advantages and disadvantages of the model.

7. "The SAGE Method in Endangered Species Management: Constructing Proxy Utility Functions of Measure Relative Values", Renatte Hagemann (San Diego State U) - Renatte Hagemann described a multiple-objective decision-making process (called SAGE) which she applied to evaluate an endangered species management plan at a Naval Weapons Station. She pointed out that the SAGE process may be useful in situations where estimation of WTP or WTA may not be appropriate. Five management plans for controlling non-native red fox populations were evaluated using the SAGE process. The capture and cage management alternative appeared to be preferred by respondents.

8. "Corps of Engineers Regional Recreation Demand Model", Jim Henderson (U.S. Army Corps of Engineers) - Jim Henderson described work currently being conducted by the U.S. Army Corps of Engineers to estimate a regional recreation demand model for Corps reservoirs. The objective of the model is to be able to estimate changes in recreation use and benefits resulting from changes in the quantity or quality of recreation resources, new project development, or changes in existing projects. Jim would like to recruit an economist to work with him on this project. Anyone interested should contact him at the Waterways Experiment Station in Vicksburg, Mississippi.

9. "Test-Retest Reliability of Contingent Values Using a Complete Experimental Panel Design" - Kevin Boyle (U. of Maine), Daniel McCollum (U.S. Forest Service), and Stephen Reiling (U. of Maine) - Kevin Boyle described a contingent valuation experiment designed to investigate test-retest reliability. The survey designed for the experiment was applied to resident Moose hunters in 1989 and 1990 (the re-test period). Preliminary results indicated that hunting values remained relatively constant over the two time periods.

After Kevin Boyle's presentation, the meeting was adjourned by Cathy Kling at about 5:00 p.m.

Minutes respectively submitted by:

John C. Bergstrom (U. of Georgia)

EXISTENCE AND NONCONSUMPTIVE VALUES FOR WILDLIFE:

APPLICATION TO WOLF RECOVERY IN YELLOWSTONE NATIONAL PARK

W-133/Western Regional Science Association Joint Session:

"Measuring Nonmarket and Nonuse Values"

Monterey February 27, 1991

John Duffield

Department of Economics

University of Montana

Missoula, MT 59812

TABLE OF CONTENTS

ABSTRACT

A total valuation model for wolf recovery in Yellowstone National Park is presented and used to define the potential welfare changes at issue. The application provides an estimate for existence values in the context of a total valuation framework, as first suggested by Randall and Stoll (1983). Welfare measures are estimated using dichotomous choice contingent valuation. Recent advances in the interpretation of covariate effects in these types of models (Cameron, 1988; Patterson and Duffield, 1991) are utilized to define a new method for identifying the relative share of existence versus other uses. The results of this method are compared to the Boyle and Bishop (1987) approach of using question sequences where the definition of potential uses is varied (e.g., with and without in situ use). The application is based on the responses of 612 YNP visitors surveyed in August-September 1990. Estimated benefits to visitors are compared in a benefit-cost framework to potential losses to area residents due to reduced hunting opportunites and livestock predation.

INTRODUCTION AND BACKGROUND

This study provides an economic analysis of proposed wolf recovery in Yellowstone National Park. The benefits of wolf recovery are the existence and nonconsumptive values associated with having wolves present in the Yellowstone ecosystem. Costs are associated with reduced ungulate populations, which would affect nonconsumptive use (viewing) in the park as well as hunting of animals migrating out of the park in fall and winter.

Most previous estimates of the nonmarket value of wildlife have been concerned with consumptive uses, such as hunting. Walsh, Johnson and McKean (1988) recently reviewed 120 separate studies providing 285 site and/or activity specific estimates of recreational value. However, there is also an emerging literature on the potentially considerable value associated with indirect uses and with nonconsumptive uses, such as viewing wildlife. As first articulated by Krutilla (1967), existence value is the value associated with knowing that a species or ecosystem exists, independent of actually visiting or using a given site. For example, it is possible that some individuals may place a high value on knowing that wolves exist in Yellowstone Park, independent of any expectation of ever seeing these animals. Recent studies of eagles in Wisconsin (Boyle and Bishop, 1987), whooping cranes in Texas (Bowker and Stoll, 1988) and an elk winter range study in Montana (Duffield, 1989) indicate that both nonconsumptive and existence values for wildlife may be considerable. The primary objective of this paper is to describe and apply methods for measuring the latter types of values.

A secondary but related objective is to investigate alternative methods 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. Alternativelyt, 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. Additionally, only a two-way split of total value is possible. An alternative approach to measuring the share of total valuation due to existence motives is introduced here. The basic idea is to examine covariate effects in a total valuation model rather than comparing welfare changes across a sequence of questions.

Before turning to the theoretical model, it is useful to summarize the expected physical and biological consequences of wolf recovery and the policy setting for the application.

Yellowstone National Park is one of three potential recovery sites for the northern Rocky Mountain wolf (Canis lupus) (U.S. Fish and Wildlife Service, 1984). As Singer (1988) has observed, many questions surround the prospects of Yellowstone as a recovery site. On the positive side, Yellowstone has large populations of potential ungulate prey species, especially elk and bison, the park and adjacent national forest wilderness exceed 3 million acres in size, and the wolf is the only missing element of Yellowstone's fauna. However, wolves could reduce big game harvests in the heavily used hunting districts that border the park. As Singer also notes, there are concerns about livestock predation, effects of wolves on ungulates in the park, and visitor perception of wolves and predation. Previous studies (YNP, 1990) provide a basis for understanding the physical and biological changes that may accompany wolf recovery. However, the question remains as to whether wolf recovery in Yellowstone National Park should proceed. Is the park, the region or the nation better off with or without wolf recovery? This question can be addressed through an analysis of the likely impacts of wolf recovery from a net social benefit accounting stance. Distributive issues, including regional economic impacts, are discussed elsewhere (Duffield, 1990).

An economic analysis of wolf recovery in YNP requires a model of the likely biological consequences. The following basic assumptions about wolf recovery are drawn primarily from a synthesis of the opinions of 15 North American wolf and wolf-prey experts (Koth, Lime and Vlaming, 1990). A viable wolf population of about a dozen wolf packs (totaling 150 individuals) would spend the majority of their time in YNP after the population has stabilized (20 years after reintroduction). Elk are expected to be the primary prey for wolves in all seasons. There should be moderate or little change in elk behavior and distribution. A reduction of the elk population of less than 20 percent is expected. Wolves may reduce the population of mule deer by 20 to 30 percent, moose by 10 to 15 percent and bison by less than 20 percent. Other species will be little affected and no species will become extinct in YNP due to wolf recovery. The experts are split over whether reduced hunting levels would be a necessary concession that comes with wolf restoration. Specific assumptions for the Gallatin, Sand Creek and Northern Yellowstone elk herds are detailed below based on Vales and Peek (1990) and Garton, Crabtree, Ackerman and Wright (1990). On average for these herds, elk harvest may be reduced by about 10 percent. No point estimates of the effect of wolf recovery on livestock predation in the GYA are available. However, Fritts (1990) provides a careful discussion of the issue. It appears that historical predation in Minnesota (with a population of 1500 to 1800 wolves and similar livestock populations to the GYA) may provide a "worst case scenario" for GYA depredation. Another possible comparison is Alberta (with a population of about 5000 wolves and 300,000 cattle in the wolf range).

Wolf recovery in YNP is in many ways of national, or even of international, concern. People from across the country, independent of whether they ever have or ever will visit the park, may have strong feelings about this program. Yellowstone is not only the world's first national park, but also perhaps the world's best known park. Nonetheless, the greatest impact of wolf recovery in Yellowstone will likely be on the people who go there - the park visitors. Accordingly, the focus of this study is on the park. Sampling regional or national households is recognized as infeasible given budget limitations. The only impacts that are examined outside the park are the potential effects on hunting and livestock predation in the Greater Yellowstone Area (GYA).

THEORY AND METHODS

Well-established markets do not exist for most of the resources and services at issue which are wildlife preservation, recreational hunting and wildlife observation. Accordingly, the basic problem is one of measuring nonmarket values. The method used in this study, contingent valuation, has been widely applied and is recognized by the U.S. Water Resources Council (1983) as an appropriate method. The essence of this approach is to ask individuals their willingness to pay contingent on a hypothetical situation. There are a number of important issues in the design of these surveys including choice of question format, payment vehicle, and range of offer bids . A discussion of these general issues is provided in Boyle, Welsh and Bishop (1988) and Duffield and Patterson (1991). Details of the specific methods utilized, dichotomous choice contingent valuation, are provided below.

A Model of Total Value for Wolf Recovery in YNP

The value YNP visitors place on wolf recovery was derived from responses to a hypothetical trust fund. A trust fund payment vehicle has been used successfully in a number of other studies related to wildlife valuation (Boyle and Bishop, 1987; Bowker and Stoll, 1988). In this section a simple model of total value for wolf recovery is described that includes both nonconsumptive (viewing and hearing) uses as well as existence. The conceptual basis for measuring existence values in a total valuation framework has been previously examined by Randall and Stoll (1983), Peterson and Sorg (1987) and Randall, Hoehn and Swanson (1989). Only modeling of the choice problem under conditions of certainty is examined; option values are not investigated. The model presented here 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 YNP visitors would experience with wolf recovery is a function of their level of nonconsumptive wolf viewing or hearing uses (Nw), the level of a viable restored wolf population (W) which provides them with existence value, the nonconsumptive use services they derive from seeing ungulate prey species such as elk, bison, moose and deer (S), the services they derive from hunting ungulates that summer in the park (H), and a vector of all other goods and services ($\tilde{Z}$) not expected to be affected by wolf recovery. An individual park visitor's utility function, assumed to have the properties required by consumption theory, is then given by:

$$U(N_w, W, S, H, \tilde{Z}) \qquad (1)$$

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,Ps,Ph,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 no wolves in the park (Nw, W = 0), the maximum attainable level of well-being for an individual is given by:

$$U(0,0,S^*,H^*,Z^*) = \bar{U} = V(P_w^m,0,P_s^0,P_h^0,P_z^0,Y) \qquad (2)$$

Where $\bar{U}$ is the reference or current level of utility. Note that the price of wolves, P_w^m, is a price sufficiently high to make wolf viewing services zero (or equivalently, since there are no wolves in YNP, the price is infinite). This model provides a compact way of describing the value associated with changes in the current situation. If wolves were present at some viable recovery level $\bar{W}$, and wolf viewing was possible at a finite price, then there is some amount, WTP^1, which would make an individual ambivalent between the current experience and one with wolves present in YNP:

$$V(P_w^1,\bar{W},P_s^1,P_h^1,P_z^0,Y-WTP^1) = V(P_w^m,0,P_s^0,P_h^0,P_z^0,Y) \qquad (3)$$

An assumption of this study is that existence values for wolves are not negative and that typical WTP^1 are positive. Given these assumptions, since 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 wolf recovery, since it includes both nonconsumptive (viewing and hearing) as well as existence value, but is net of changes in viewing or hunting ungulates expected by the visitor. WTP^1 can be estimated using dichotomous choice contingent valuation. From the perspective of a threshold motivation for these types of models, WTP^1 corresponds to the individuals true WTP in the model of equation 5 below. Details of the contingent valuation trust model used to implement this welfare measure are provided in the following section.

A second welfare change is also examined in this study:

$$V(P_w^m, \overline{W}, P_s^2, P_h^2, P_z^0, Y-WTP^2) = V(P_w^m, 0, P_s^0, P_h^0, P_z^0, Y) \tag{4}$$

In this case there is no possibility of seeing or hearing wolves, only the existence use of knowing wolves are present in the park. Accordingly, WTP^2 provides a measure of the existence value associated with wolf recovery net of any change in well-being associated with viewing or hunting ungulate prey species. Then WTP^1-WTP^2 equals the use value associated with wolf recovery, which in this case is viewing or hearing wolves.

The respondent's visit to YNP is the other resource for which net economic values are estimated in this study. A similar motivation to that provided in equations 3 and 4 defines the value of the respondents current trip. The value of YNP visits is used to estimate the influence of elk viewing on the value of the park visit experience. The payment vehicle chosen to identify the respondent's net willingness to pay is increased trip expenses. This is a payment vehicle that has been used in a large number of contingent valuation studies of outdoor recreation (Walsh, Johnson and McKean, 1988).

Dichotomous Choice Contingent Valuation

In dichotomous choice, individuals respond "yes" or "no" as to their willingness to pay a specific cash amount for a specified commodity or service. The advantages of this approach, as compared to open-ended or bidding game questions formats, have been discussed elsewhere (Boyle and Bishop (1988) and Bowker and Stoll (1988)). The disadvantage of this approach is that analysis and interpretation are relatively complex, since WTP is inferred rather than observed.

Hanemann (1984) has investigated the theoretical motivation for dichotomous choice models. He provides both a utility difference approach and an alternative derivation based on the relationship of the individual's unobserved true valuation compared to the offered threshold sum (see also Cameron 1988). In the latter, it is assumed that if each individual has a true willingness-to-pay (WTP), then the individual will respond positively to a given bid only if his WTP is greater than the bid. For example, suppose that an individual is confronted with an offered price (t) for access to a given resource or recreational site. The probability of accepting this offer $\pi(t)$, given the individual's true (unobserved) valuation WTP is then:

$$\pi(t) = Pr(WTP>t) = 1-F(t) \qquad (5)$$

where F is a cumulative distribution function of the WTP values in the population. In the logit model F(.) is the c.d.f. of a logistic variate and in the probit model F(.) is the c.d.f. of a normal variate. The specification of this model can be briefly illustrated for the case where the WTP values are assumed to have a logistic distribution in the population of interest conditional on the value of covariates. A statistical model is developed that relates the probability of a "yes" response to explanatory variables such as the bid amount, preferences, income, and other standard demand shifter type variables. The specific model is:

$$\pi(t;\tilde{X}) = [1 + \exp(-\alpha t - \tilde{\gamma}'\tilde{X})]^{-1} \quad (6)$$

where $\pi(t;\tilde{X})$ is the probability that an individual with covariate vector $\tilde{X}$ is willing to pay the bid amount t. The parameters to be estimated are α and $\tilde{\gamma}'$ (the constant term is included in $\tilde{X}$). The equation to be estimated can be derived as:

$$L = \ln[p/(1-p)] = \alpha t + \tilde{\gamma}'\tilde{X} \quad (7)$$

where L is the "logit" or log of the odds of a "yes" and p are observed response proportions. In application the logit and probit models are so similar that it is difficult to justify one over the other on the basis of goodness of fit. We choose to work with the logistic specification here because the probit model does not lead to closed-form derivatives. Maximum likelihood estimates of the parameters in equation 7 can be obtained with a conventional logistic regression program. We have utilized BMDP (1988) on a VAX mainframe.

Hanemann (1984) has shown that the linear specification in equation 7 is consistent with utility maximization based on his utility difference motivation. However Cameron (1988) argues that from the standpoint of the threshold motivation, any of a variety of WTP distributions are theoretically plausible. This implies that the choice of functional form for F(.) be based on empirical considerations. Some investigators (e.g., Boyle and Bishop (1988) and Bowker and Stoll (1988)) have found that WTP distributions are skewed to the right. In these cases, a better estimate may be obtained with a log-logistic model (replacing t in equation 7 with log t). We apply both forms of the model below.

Since with dichotomous choice contingent valuation we estimate the distribution of WTP values, the question remains as to which parameter of the distribution to use. A variety of welfare measures for dichotomous choice models have been proposed in the literature including a truncated mean (Bishop and Heberlein, 1979), the overall mean and percentiles of the distribution, including the median (Hanemann, 1984, 1989). In all cases the distribution of F is assumed to be continuous and nonnegative. As developed below, we utilize the truncated mean and several different percentiles in this application. The truncated mean is defined by:

$$M_T = \int_0^T [1 - F(x)]\, dx \tag{8}$$

where f(x) is the probability density function of the distribution. The truncated mean has the interpretation of being a mean, but with all values above the truncation point, T, set equal to T. Accordingly, the truncated mean is more conservative than the overall mean, but has a clear interpretation for purposes of aggregation. T is generally set equal to the highest bid offer; as a result the integrand in equation 8 is within the range of observed data. Previous applications indicate that the truncated mean is also much more precisely estimated than the overall mean (Patterson and Duffield, 1991).

The p^{th} quantile (100 p^{th} percentile) of the distribution is given by $F^{-1}(p)$. For the log-logistic model, the p^{th} quantile is given by:

$$\eta_p(\tilde{x}) = \exp(-\tilde{\gamma}'\tilde{x}/\alpha)\,[p/(1-p)]^{-1/\alpha} \qquad (9)$$

Of course when $p = .50$ equation 9 provides an estimate of the median. For the case where WTP values are skewed, as demonstrated in previous studies (e.g. Bowker and Stoll), the median and the truncated mean may differ considerably. As Hanemann (1989) has discussed, choice of the welfare measure is a value judgement in that there is an implicit weighing of whose values are to count. Hanemann has suggested using other percentiles, such as the 75th, as another alternative. For some models we report all three measures: the truncated mean, the median and the 75th percentile.

Methods have recently been developed to identify the precision of dichotomous choice based welfare estimates. Several different procedures are utilized in this study including bootstrapping (Efron 1982), simulation using repeated sampling from the estimated asymptotic distribution of the logit model parameters (Krinsky and Robb,1986) and analytical estimates using the delta method (Serfling, 1980). Details of the procedures for applying these methods to logistic models are described elsewhere (Park, Loomis and Creel, 1989; Duffield and Patterson, 1991).

Share to Existence Use

As previously noted, there is an extensive economics literature concerned with identifying the relative share of total valuation due to specific motives, such as existence versus in situ use. An approach using covariate effects in a total valuation model (rather than previous approaches that utilize a sequence of questions) is developed as follows. 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. A WTP relationship is provided by equation 9, which is basically Cameron's (1988) valuation function but with an explicit definition of the welfare measure being applied (following Patterson and Duffield, 1991). McConnell (1990) suggests this is a cost function. Social-psychology methods are used to develop a set of Lickert scaled attitude measures. A detailed discussion of the development of these types of measures is provided in Duffield, Butkay and Allen (1990). For our application, these measures indicate preferences for nonconsumptive use (viewing or hearing wolves) and existence values and are used to develop explanatory variables for the logistic model of total valuation of wolf recovery. For a welfare measure based on a percentile of the willingness to pay distribution, and when preference variables are specified with a log transformation, the welfare measure is homogeneous in preferences for a specification like equation 9. For a function $y = f(\bar{x})$ that is homogeneous of degree r, by Euhler's theorem:

$$\sum_{i=1}^{N} f_i x_i / ry = 1 \tag{10}$$

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 $f(\bar{X})$ due to the i^{th} factor. For the case at hand, if $f(\bar{X})$ is homogeneous degree r and is a functional measure of willingness to pay (as in equation 5), then equation 10 provides an analytical method for identifying the share of total valuation associated with the subset of explanatory variables that measure preference. Other explanatory variables in a specification like equation 5 (income or other socio-economic variables) are used to define a given population strata for application of the method.

For the case at hand, both the Boyle and Bishop (1987) method and the covariate approach were utilized. Respondents were asked to assume: 1) that a trust fund was essential for wolf recovery in the park, 2) that the respondent might personally get to see or hear a wolf in Yellowstone and 3) that donors would have the satisfaction of knowing that wolves would be present in YNP. Additionally, visitors were provided with a fact sheet summarizing the expected impacts of wolf recovery in greater detail. Following this description of the hypothetical situation, survey participants were asked "if you were contacted in the next month, would you purchase a lifetime membership in trust fund for $__(bid amount)__ to support wolf recovery in Yellowstone Park?". The bid amount varied randomly across surveys from $5 to $300. The location of bids and distribution of sample among bids followed procedures intended to minimize the standard error of the estimated truncated mean

(Duffield and Patterson, 1991). Two different versions of the trust fund question were used. In one, the motivation for the trust fund is the need "to compensate livestock owners for any wolf predation" and in the other the motivation is that "the dollar costs of recovery could be relatively high".

Responses to this trust fund question measure the net total valuation associated with wolf recovery including both direct use (viewing and hearing wolves) and existence values. Covariate effects can be examined for a model of these responses. A followup trust fund question intended to measure just net existence values was asked that excluded the possibility of the respondent ever personally hearing or seeing wolves. Comparison of the two trust fund responses provides an application of the Boyle and Bishop (1987) method.

Nonconsumptive Value of Ungulate Viewing

Nonconsumptive values related to elk viewing were estimated with a current trip payment vehicle. After a question to establish the respondent's actual trip expenditures, she is asked "Suppose that your share of total trip expenses to visit Yellowstone National Park increased, would you still have made the trip if your cost had been $ (bid amount) more?". The bid amount varied randomly across surveys from $10 to $2000. A model of respondent willingness to pay for the current trip can be estimated that includes variables to measure whether any elk were seen on this trip as well as the number of elk seen. The effect of changes in the visitor's experienced conditions on willingness to pay is estimated by computing welfare estimates at different levels of the covariates of interest. This provides an estimate of reduced nonconsumptive use in YNP that may be associated with wolf recovery. The estimates are for reduced value per trip and for elk viewing only.

Aggregate estimates of the net economic benefits of wolf recovery are derived under the assumption of zero value for nonrespondents. This conservative approach has been previously used by Bishop and Boyle (1985). Since the trust fund is for a lifetime membership, it is aggregated over the number of adult respondent visitors.

Value of Big Game Hunting

Wolf recovery may result in reduced big game hunting opportunities in the GYA. Because park visitors may be only a subset of individuals who hunt in the GYA, an estimate of the values associated with possible reduced big game hunting is developed separate from the trust fund analysis. This may entail some double-counting of hunting losses, which makes the estimated aggregate net benefits of wolf recovery more conservative. The net economic values per hunting trip and expenditures per trip are taken from previous studies. Some of these literature values are specific to Montana hunting districts utilized by the northern Yellowstone elk herd (Loomis, Cooper and Allen, 1988; Duffield, 1988). This analysis, as noted previously, needs to be closely tied to the underlying biology of wolf and ungulate interaction. Where there is some uncertainty in the biological outcomes (for example, whether wolves will migrate and the extent to which wolf populations will be suppressed at the park boundary), sensitivity analysis should be undertaken.

Survey Design and Procedure

This study utilized a printed questionnaire distributed to YNP visitors in late August/early September 1990. The focus of the survey was on two basic areas: 1) park visitor characteristics (attitudes, use, and socioeconomic characteristics) and 2) values associated with wolves. Because of the short time frame available for this study, it was necessary to utilize a handout/mailback procedure. A total of 1996 surveys were distributed by YNP entrance station personnel in late August/early September 1990. Surveys were distributed among entrance stations in proportion to historic use levels. By a cutoff date of 1 November, a total of 612 surveys were received for a response rate of 30.6 percent. This study also draws on a survey of park visitors undertaken in October, 1989 for Montana DFWP) (Duffield, 1989). A total of 2000 surveys were distributed in mid-October with 728 (36 percent) returned by mid-November. The response rate for these surveys is similar to that obtained for other handout/mailback park visitor surveys (Machlis and Dolson, 1988, report a 31 percent response on 2716 questionnaires distributed in the park in July, 1987.) These response rates are similar to those obtained for the first mailing of surveys using the Dillman (1976) total design procedure. While the reponse is relatively low, this is realistic for the trust fund payment vehicle. Real world trust fund mailings generally do not involve followup mailings. It is also realistic to assign a zero value to nonrespondents.

It would have been preferable to sample throughout the visitor season. Because the study was not authorized until July 1, 1990 and because of the time necessary to design and pre-test the survey instrument, this was impossible. Given the limitations of the survey data base, caution must be used in extrapolating the results to visitors at other times of the year or to nonrespondents.

Visitor Attitudes and Preferences

Visitor attitudes and preferences were examined on three general areas: attitudes toward wolves and wolf recovery, general environmental attitudes and preference for seeing specific animal species in YNP. It is beyond the scope of this paper to discuss these issues in detail (see Duffield, 1990). However, it may be noted that wildlife observation is the primary reason for visiting Yellowstone, and that 95 percent of all respondents report participating in this activity. A large majority (80 percent) of park visitors favor wolf recovery, although there are significant differences across population strata defined by hunting participation, place of residence and other socio-economic characteristics. These findings are consistent with the results of a previous YNP survey (McNaught, 1985 and 1987). Visitor preferences for viewing wildlife are surprisingly well-defined. Rankings of preference to see 21 specific species in Yellowstone were nearly identical across regional and out-of-region residents.

RESULTS AND DISCUSSION

Net Social Benefits of Wolf Recovery to YNP Visitors

This section provides an analysis of the net social benefits associated with wolf recovery for the YNP visitor population. The following topics are discussed in turn: overview of aggregated responses to the contingent valuation questions, choice of functional form for the logistic models, contingent valuation analysis for valuing wolf recovery based on trust fund responses, share of trust fund for hearing or seeing wolves as opposed to existence values, valuation of reduced elk viewing through a current trip payment vehicle and aggregate net social benefits to park visitors.

Aggregated responses to the dichotomous choice contingent valuation bid offers are shown in Table 1 for the total valuation trust fund question and the current trip valuation question. As one would expect, the share of respondents responding "yes" to a given bid offer generally declines as the bid level increases. For example, 60 to 70 percent of respondents would donate \$5 or \$10 to a wolf recovery trust fund, but only 11 percent (9 of 81 asked) would donate \$300. Simple bivariate logistic models with the log of bid as the only explanatory variable provide good fits to the data, with the difference between the observed and predicted probabilities not significant at the 10 percent level in either model (Table 2). Alternative functional forms (linear in bid or log transformation for this variable) for the bivariate logistic model are compared in Table 2. Based on the Pearson and the Hosmer-Lemeshow (Hosmer and Lemeshow, 1988) chi-square goodness of fit statistics, the logged model provides a much better fit to the data and is accordingly used in the remainder of this analysis.

Net economic benefits per respondent for the two trust fund questions related to wolf recovery are provided in Table 3 for a variety of welfare measures. As in many previous studies, the estimated willingness to pay distribution is skewed to (has heavier tails in) the upper range of values. Accordingly, the medians are much lower than the truncated means. The median is a typical value in that 50 percent of respondents would be willing to donate that amount. For total net valuation of wolf recovery (nonconsumptive use plus existence values) median values are from $15 to $20 per person for residents and nonresidents. The estimated mean truncated at the upper bid level ($300) is a better measure of average willingness to pay and will be used in the aggregation reported below; these values are from $60 to $75 per respondent. The average is obviously heavily influenced by a small share of the respondents who are willing to pay fairly high amounts. Estimated medians when nonconsumptive use is excluded are somewhat lower at $7 to $14 (Table 3).

The precision of these estimates is examined through several methods. Bootstrap estimates of welfare measures and associated standard errors following the procedures described in Duffield and Patterson (1991) are reported in Table 3. Analytical asymptotic standard errors were computed for several of the point estimates and tended to be larger than the bootstrap values. For example, the analytical standard error for the complete sample total valuation model is 3.56 for the median and 16.04 for the 75th percentile. The corresponding bootstrap values are 3.32 and 11.68 respectively. A 90 percent confidence interval for the complete

Table 1. Aggregate Responses to Dichotomous Choice Contingent Valuation Questions.

Bid Level	N	Yes Response	Actual Probability	Predicted Prob.
A. Trust fund response to wolf recovery total valuation.				
5	54	34	.63	.72
10	48	33	.69	.61
25	81	35	.43	.45
50	95	40	.42	.33
100	133	27	.20	.23
200	94	12	.13	.15
300	81	9	.11	.12
B. Value of current trip to YNP.				
10	28	26	.93	.96
25	28	24	.86	.91
50	41	36	.88	.85
100	100	78	.78	.76
250	98	60	.61	.60
500	103	47	.46	.45
1000	136	38	.28	.31
2000	57	13	.23	.20

Note: Predicted probability from bivariate model (log of bid) in Table 2.

Table 2. Comparison of Goodness of Fit for Different Functional Forms: Bivariate Logistic Dichotomous Choice Contingent Valuation Regressions.

	Trust Fund		Current Trip	
Parm./Stat.	Linear	Logged	Linear	Logged
Intercept (t-stat.)	.1914 (1.43)	2.123 (6.63)	1.145 (8.57)	5.08 (10.1)
Ln(BID)	-.01029 (-7.78)	-.7252 (-9.10)	-.00176 (-9.02)	-.8512 (-10.2)
Chi-Square	19.288	7.981	34.64	3.109
D.F.	5	5	6	6
P.	.002	.157	.000	.795
Hosmer-Lemeshow Chi-Square	19.921	8.185	36.384	3.334
D.F.	5	5	6	6
P.	.001	.146	.000	.766
Sample Size	586	586	590	590

sample estimates are on the order of plus or minus 30 percent of the estimate.

Share of Valuation to Existence Motives

Multivariate logistic models for the total valuation trust fund response are reported in Table 4. These models fit the data well and include a number of highly significant explanatory variables with the theoretically expected signs. This indicates that the responses are not random but are consistent with our model of economic behavior. As one would expect from economic theory, the odds of a yes response is a positive function of income and a negative function of bid level. The population strata of hunters is significantly less likely to contribute. There was no significant difference due to the two alternative motivations for the trust fund (fund for livestock damages versus high costs of recovery). Responses were highly correlated to two measures of preferences. The variable WOLFSEE is constructed by summing responses to questions related to nonconsumptive use of wolves including ranking of wolves in preference to see, desire to hear or see wolves in the wild and attitudes toward participation in interpretive programs. The variable EXIST is constructed by summing responses to the positive Lickert-scaled preference measures. These responses measure preferences for existence values. Alternative preference measures were examined; the reported models were selected on the grounds of goodness of fit and precision of the estimated coefficients.

Based on the previously described models, estimated net economic values per respondent for

Table 3. Estimated Net Economic Benefits Per Respondent for Bivariate Logistic Models[1] for Wolf Recovery Based on Trust Fund Responses (1990 dollars).

Welfare Measure	MT,ID,WY Resident	Out of Region Resident	All
(A) Trust Fund Responses for Wolf Recovery Total Valuation			
Median	15.38	20.27	18.68
(S.E.)[2]	(5.30)	(4.59)	(3.32)
Truncated Mean	59.04	74.51	69.97
	(8.77)	(6.85)	(4.84)
75th Percentile	62.27	96.76	84.97
	(16.78)	(20.36)	(11.68)
(B) Trust Fund Responses for Wolf Existence Value			
Median	6.64	14.20	11.50
(S.E.)	(2.68)	(2.92)	(2.16)
75th Percentile	44.94	88.73	74.37
	(33.92)	(22.70)	(15.48)

[1] Reported values are based on the following bivariate equations: (A) Resident 2.147-.7856ln(bid), Nonresident 2.115 - .7029ln(bid), All 2.123 - .7252ln(bid). (B) Resident 1.088 - .5746ln(bid), Nonresident 1.591-.5996ln(bid), All 1.438 - .5887ln(bid).

[2] Follows procedure described in Duffield and Patterson (1991) for 200 bootstrap repetitions.

wolf recovery in YNP are summarized in Table 5. Following the approach described in the theory section, the net total valuation associated with wolf recovery in YNP is $15 to $20 for the two residency groups using the median welfare measure. An estimate for the share of total valuation due to existence motives can be derived by comparing the two trust fund responses (net total valuation for wolf recovery versus just net existence value). This is similar to the method of Boyle and Bishop (1987). For the median welfare measure these shares are 43 percent and 70 percent for residents and nonresidents respectively.

The second method for estimating the share of existence value in total valuation for wolf recovery is also reported in Table 5. As described in the theory section, this method derives shares based on estimated coefficients for preference measures in a model of respondent willingness to pay. The models reported in Table 4 can be reparameterized (Cameron (1988); Patterson and Duffield (1991)) as a function of any specific percentile of the willingness to pay distribution including the median. The reparameterized model is homogeneous in preferences for any given population strata of income-hunter participation. The share of willingness to pay for the estimated model that is due to existence value is given by the coefficient on lnEXIST divided by the sum of the coefficients on lnEXIST and lnWOLFSEE. For the given models, this share is constant for all population strata and alternative percentiles of the willingness to pay distribution. By this method, the estimated share due to the existence motive is 46 percent of total valuation for residents but 74 percent for nonresidents. These shares are in the same range as those estimated by the method of comparing trust fund responses for with and without the opportunity to view or hear wolves.

Table 4. Multivariate Logistic Model of Wolf Recovery Trust Fund Response (Total Valuation).

Variable / Statistic	Entire Sample	Residents	Nonresidents
Constant	-31.39	-34.56	-32.48
(t-stat.)	(-7.18)	(-4.0)	(-5.98)
LNTRU1	-.9840	-1.314	-.9175
	(-8.53)	-(4.85)	(-7.13)
LNINC	.4631	.5481	.4836
	(2.61)	(1.59)	(2.25)
LNFAMTRUS	1.345	--	1.263
	(3.47)		(2.92)
LNWOLFSEE	3.589	7.594	2.764
	(4.36)	(2.85)	(3.07)
LNEXIST	7.300	6.573	7.989
	(5.96)	(2.95)	(5.28)
SEEPREY	-.3365	--	-.3362
	(-1.31)		(-1.25)
HUNT	-.5217	-1.615	--
	(-1.66)	(-2.69)	
Sample Size	524	158	366
Hosmer-Lemeshow			
Chi-Square	3.953	3.541	12.428
D.F.	8	8	8
P.	.860	.896	.133

Note: Variable definitions are as follows;

LNTRU1 = log of bid amount

LNINC = log of gross family income

LNFAMTRUS=log of 1-4 index of familiarity with trust funds

LNWOLFSEE =log of composite variable which sums yes-no (1 or 0) responses to a) would like to hear or observe wolves, b) would participate in interpretive programs, and c) ranked wolves in top 10 of animals they prefer to see.

LNEXIST = log of the sum of positively coded environmental attitudes in Section IV, Question 1 (a,d,e,g,h)(Appendix A)

SEEPREY = Dummy variable; 1 = ranked preference to see elk moose, bison or deer (Section I, Question 7) in top three or = 0 if not.

HUNT = Dummy variable; 1=hunts big game, 0=does not

Table 5. Share of Wolf Trust Fund Valuation Due to Existence versus Nonconsumptive Use (Viewing/Hearing) Motive.

Welfare Measure	All	Region	Out of Region
(A) Comparison of response to trust fund question with and without wolf viewing in YNP (median welfare measure, dollars per respondent)			
net trust total[1]	18.68	15.38	20.27
net trust existence[2]	11.50	6.64	14.20
wolf nonconsumptive[3]	7.18	8.74	6.07
(B) Share of total valuation to existence motive based on comparison of two trust fund questions (method 1) and logistic model coefficients (method 2).			
method 1	.62	.43	.70
method 2	.67	.46	.74

[1] Trust fund welfare measure for net total valuation (Table 3).
[2] Trust welfare measure for net existence value (Table 3).
[3] Derived as difference of net trust fund responses for wolf recovery with and without opportunity to see wolves.

Nonconsumptive Value of Elk Viewing

Note that the trust fund responses noted previously are provide net total valuation that includes the visitor's expected welfare change due to reduced elk viewing opportunities. However, it is of interest to estimate separately the magnitude of this expected loss. Given that the primary cost of wolf recovery to YNP visitors is likely to be reduced viewing opportunities of ungulate prey species, this cost was investigated through valuation of the respondents current trip. The analysis that follows is limited to elk, which are expected to be the primary prey species. Reduced elk populations (up to 20 percent) that may accompany wolf recovery could reduce YNP visitor satisfaction by reducing the number of elk seen and the probability of seeing elk. We examined the effect of the respondents reported elk viewing experience on current trip values, similar to the method of Bishop, Boyle, Welsh, Baumgartner and Rathbun (1987) for valuing the influence of experienced flow levels on float trips in the Grand Canyon. This analysis is best viewed as exploratory, in that bias may be introduced by not simultaneously examining the effect of other nonconsumptive activities (eg. viewing bison, moose, bear, etc.) on the visit experience.

Table 6 reports multivariate logistic models based on current trip valuation responses. It should be noted that to increase precision through larger sample sizes, these estimates are based on a combined October 1989 (Duffield, 1989) and August-September 1990 samples. The current trip valuation questions in the two samples are nearly identical. In the reported equations, the dummy variable for whether a visitor saw an elk or not (SAWELK) is not

Table 6. Parameter Estimates for Logistic Dichotomous Choice Model of Willingness to Pay for Current Trip Valuation, YNP.

Variable / Statistic	MT,ID,WY Residents	Out Of Region
Constant	3.4384	-.6469
(t-stat.)	(7.55)	(-.522)
LNBID	-.9664	-.8612
	(-10.1)	(-11.6)
LNDAYS	.6917	.4147
	(2.79)	(3.14)
LNINC	--	.5859
		(5.12)
LNED	--	-.4237
		(-2.15)
1990	.7796	--
	(2.70)	
SAWELK	.2312	.1988
	(.777)	(1.00)
Sample Size	435	791
Hosmer-Lemeshow		
Chi-Square	6.451	15.499
D.F.	8	8
P.	.597	.050

Note: Variable definitions are as follows:
LNBID = log of the bid amount
LNDAYS= log of the number of days spent in YNP
LNINC= log of gross family income
LNED= log of educational index (1 to 8)
1990= dummy for year of survey administration
SAWELK= dummy variable; 1=saw elk, 0=did not see elk

statistically significant at even the 80 percent level. However, when the variable lnDAYS is excluded, SAWELK is significant at the 90 percent level for nonresidents and at the 80 percent level for residents. As one might expect, the probability of seeing at least one elk and the length of the trip are multicollinear; in these situations the parameter estimate is unbiased but standard errors are not reliable. (Using the parameter estimates with lnDAYS excluded would lead to omitted variable bias). Models quadratic in a measure of the number of elk seen per trip were also estimated. Parameters for these models were significant at the 80 percent or less level, although the signs were what one would expect for diminishing values to seeing additional elk and the parameters were surprisingly stable across subsamples and alternative specifications. However, when the dummy variable SAWELK was included the significance level of the estimated parameters on the number of elk seen dropped to near zero.

Table 7 provides an estimate of the nonconsumptive elk viewing benefits that might be lost due to wolf recovery for the typical respondent (the welfare measure is the median). Most visitors (76 to 77 percent) report seeing elk, and for those who see elk, both resident and nonresident visitors report seeing an average of about 40 of these animals per trip (Table 7). If elk populations were reduced by 20 percent, numbers of elk seen might be reduced linearly to 30 to 33 elk per trip. However, the reduction in probability of seeing at least one elk is not likely to be linear. Even if the Northern Yellowstone herd was reduced to only a few animals, as long as some of these elk were near the entrance station at Gardner, the probability of seeing elk would remain high. Lacking a sophisticated model of how elk populations will affect the probability of seeing elk, the change in point estimates between the October 1989 and the August-September 1990 samples was used. Visitors in October reported seeing many more animals (50.4 versus 24.7) and were more likely to see at least one elk (81.1 percent versus 71.4 percent). The difference in numbers of elk seen in these samples is probably due to the additional activity and visibility of elk during the fall rut. Presumably the relationship between numbers of elk seen and probability of seeing one elk could hold whether the number of elk seen is changed due to activity levels or due to changed population levels. In any case, this is an area for further research.

Based on the comparison of the October and August-September samples, it is expected that a 20 percent decline in elk populations might reduce the probability of seeing elk from 77 to 74 percent for nonresidents and by a comparable amount for residents. This leads to a reduction in median trip value of $.63 for residents and $4.61 for nonresidents. A value per respondent over a year (given average number of trips per year) would be $2.63 for residents and $5.25 for nonresidents. These amounts are about one-fourth of the net trust fund donations reported above.

Reduced Hunting and Livestock Predation in the GYA

The preceding sections provide an estimate of net value to wolf recovery from the standpoint of park visitors. It is of interest to compare these net values to losses to regional residents associated with hunting and livestock predation. The estimates presented below are

Table 7. Effect of Potential Reductions in Elk Populations on YNP Current Trip Value.

Variable / Statistic	WY,MT,ID Residents	Out of Region Residents
(A) Baseline - from October 1989 and August/Sept. 1990 surveys.		
Baseline number of elk seen per visitor	37.7	41.0
Baseline probability of seeing elk	.761	.770
(B) With 20% reduction in elk population.		
Expected number of elk seen per visitor	30.1	32.8
Expected probability of seeing elk[1]	.733	.740
(C) Typical value of current trip to YNP (median welfare measure).[2]		
Baseline current trip (1990 dollars)	96.15	668.58
With reduced probability of seeing elk	95.51	663.97
Reduction in value	.63	4.61
(D) Value of current trip with and without seeing elk (median).		
Current trip value if see elk	101.81	705.04
Current trip value if don't see elk	80.15	559.70
Value difference	21.66	145.34

1 Based on relationship of number of elk seen and probability of elk seen from 1989 and 1990 samples.

2 Based on multivariate model, Table 6.

preliminary and only intended to show the general range of probable costs to regional residents.

Only limited estimates are available concerning the biological and physical impacts of wolf recovery on hunting in the GYA. Potential impacts of wolf recovery on elk hunting for the Gallatin and Sand Creek herds are summarized in Table 8 based on Vales and Peek (1990). A specific analysis of the impact of hunting on the Northern Yellowstone herd is not available, but Garten, Crabtree, Ackerman and Wright (1990) estimate that the population of this herd could be reduced by 10 percent with wolf recovery. It is assumed for purposes of this analysis that the effect on harvest is also a 10 percent reduction. Numbers of hunters and success rates are drawn from other sources summarized in Duffield (1989). These herds account for a total annual harvest of 3032 animals annually. Taking point estimates of probable reduction, harvest and presumably hunter participation would be reduced by about 10 percent overall for all three herds (Table 8). Using a point estimate obscures the considerable uncertainty concerning impacts on hunting. Additionally, it is beyond the scope of this study to investigate any qualitative changes in the hunt, for example from a antlerless to a bull-only regulation. Based on Singer (1990), there are a total of eight elk herds in the YNP area with a combined harvest of 8153 animals. It is not known if the other herds would or would not be affected by wolf recovery or the extent. The potential impact on hunting based on three herds and, for purposes of sensitivity analysis, a linear extrapolation to eight herds are both examined. The appropriateness of the this extrapolation has not been investigated. Obviously this is a preliminary analysis; note that effects on any other big game

Table 8. Preliminary Estimate of Potential Impacts of Wolf Predation on Hunting in Areas Adjoining YNP.

Area	Current Harvest	Reduced Level	Estimated Reduction	Reduced # of Hunters[3]
Gallatin[1]				
	436	300-400 (350)	86	478
Sand Creek[1]				
a) Wolves conf. to YNP	219	170-270 (220)	--	--
b)Wolves outside of YNP	738	640-770 (705)	33	183
Gardner area[2]				
General seas.	421	10%[2]	42	230
Late season	1218	10%[2]	121	170

1 Vales and Peek, 1990.

2 Duffield, 1989 and Garton, Crabtree, Ackerman and Wright, 1990. Statistics are for Montana hunting district 313. Expected reduction in population of 10% of the North Yellowstone Herd. Assumes a 10% decrease in harvest and hunters.

3 Assumes hunter success for Gallatin and Sand Creek is the same as for HD 313 general season (18%).

species (such as moose and deer) have not been addressed.

The net social benefits for elk hunting trips are based on estimates for elk hunting in Montana hunt district 313 (Duffield, 1988) of $84.33 per day (1989 dollars). The aggregate reduction in net social benefits for elk hunting in the GYA that may be associated with wolf recovery is $.4 to $1.1 million per year or a present value over 20 years of $4.5 to $12.1 million (Table 9).

The level of possible livestock predation in the GYA has not been quantified though it has been examined by Fritts (1990) and Weaver (USFWS 1984). Based on these authors, it appears that Minnesota may serve as a worst case scenario for the GYA. There are roughly comparable numbers of livestock in these areas, but Minnesota has 1500 to 1800 wolves compared to the 150 expected for a restored YNP population. An even worse case scenario might be Alberta where there is considerable ranching and a population of 5000 wolves. These two areas are convenient for comparison in that both have government sponsored programs of compensation for wolf predation. For the late seventies, annual compensation in Alberta was $50,832 per year and in Minnesota, $18,095 per year. Alberta pays about 73 percent of market value. When both estimates are corrected to market value and inflated to 1990 price levels from 1978 (a factor of 2.02), the annual compensation amount is $36,552 to $139,511 for the two areas. The inflation adjustment may be overgenerous as agricultural prices tend to lag behind the consumer price index. From the standpoint of net social benefits, only the loss in net income associated with livestock losses should be included.

Again to err on the high side, assume all of the loss is net income. This leads to a present value over 20 years of livestock predation in the GYA of $.5 to $1.74 million. It may be noted that Defenders of Wildlife has made a commitment to compensate ranchers for wolf predation losses and has a trust fund in place for this purpose (Fischer, 1990).

Net Social Benefits

Aggregate net economic benefits to park visitors associated with wolf recovery in YNP (assuming no change from current levels of visitation) are summarized in Table 9. The value per respondent is based on estimated truncated means from Table 3. These aggregated estimates require an estimate of the total number of adult visitors who would respond to a trust fund (nonrespondents are assumed to place zero value on wolf recovery). The total number of YNP visitors in 1990 assumed to place a value on wolf recovery is the response rate of .306 times current total annual visits divided by the sample average number of annual visits per respondent. Average visits per year are 4.17 for residents and 1.14 for nonresidents. These estimates are not corrected for the bias of oversampling individuals who visit more frequently. (The survey obtains information for the typical visit but not the typical visitor.) On the other hand, visitors were not sampled at the end of the year but in August-September. It is possible that some visitors would make additional trips in 1990.

For the most recent 12 month period, total visits are 2,859,971 (Varley, 1990). Additionally, this total is reduced by 25 percent, which is the share of visitors under the age of 18

(Machlis and Dolson, 1988). Accordingly it is estimated that in the most recent 12 month period there were 46,872 adult resident and 403,827 adult nonresident visitors who would participate in a trust fund questionnaire. The trust fund donation is for a lifetime membership. To derive a present value for wolf recovery over 20 years, it is necessary to estimate the additional first time visitors in future years and the share of repeat visitors from years other than 1990. No information is available on the latter, but first time visitors in 1990 were 35.4 percent of out-of-region respondents and 6.7 percent of Montana, Idaho and Wyoming visitors. No change in current visitation levels to YNP is assumed; this implies an additional 3,140 resident and 142,955 nonresident visitors who would respond to a trust fund in each year after the first year. Excluding repeat visitors from other years makes the estimate conservative.

The estimated net benefits to YNP visitors of wolf recovery at current levels of visitation is $33 million per year and a present value over 20 years of $157.6 million at a 5 percent real discount rate. Assuming the number of adult visitors used for aggregation purposes is a known constant and using the bootstrap standard errors reported in Table 3, a 95 percent confidence interval for first year benefits is $27 to $38 million. A 95 percent confidence interval for the present net worth over 20 years of wolf recovery is plus or minus 14 percent of the mean estimate or $134 to $180 million.

Expanding the analysis to take into account effects in the GYA on big game hunting benefits and the livestock industry, the net social benefits for the first year of wolf recovery are

Table 9. Preliminary Estimate of Regional Net Economic Benefit Associated with Wolf Recovery in YNP (Millions of 1990 dollars).

Regional Net Benefits	Annual/ First Year	20 Year Present Value
Value of Wolf Recovery to Current Park Visitors[1]	32.9	157.6
Value of Foregone Benefits to Hunters[2]	.4 - 1.07	4.5 - 12.06
Value of Livestock Losses[3]	.041 - .14	.50 - 1.74
Net Benefits of Wolf Recovery	31.7 - 32.5	143.8 - 152.6

1 Excludes potential benefits of increased use.

2 Lower end of range for hunting loss is for three herds identified in Table 8. Upper end of range assumes other elk harvest surrounding the park (8153 harvest total for all herds (Singer in YNP 1990)) would be reduced in same proportion as for the 3 herds listed in Table 8. Assumes no losses to hunting of other big game species.

3 Assumes worst case scenario based on actual payments and losses to wolves in Alberta and Minnesota. (Weaver in USFWS, 1984).

positive and on the order of $30 million. The estimated 20 year present value of wolf recovery in YNP at a 5 percent real discount rate is around $150 million (Table 9). In order for the net social benefits to be negative, hunting losses would have to be 14 times as high as the upper range of the estimate or (with hunting losses at the upper estimate), livestock predation losses would have to be 300 times those experienced in Minnesota or 85 times as high as losses in Alberta. This accounting is in the absence of the more speculative benefits associated with increased visitation, which may be on the order of several hundred million dollars present value. Additionally, no estimate has been made of the existence value that may be associated with wolf recovery on the part of the nonvisitor remainder of the U.S. population; these values could be very large. It appears safe to conclude that the net social benefits associated with wolf recovery are positive and on the order of $150 million for a 20 year horizon.

DIRECTIONS FOR FURTHER RESEARCH

There are a number of interesting methodological issues raised by this paper that are addressed in only a preliminary way. The two methods compared for identifying the share of existence values showed results in the same range. This finding does not confirm either model. Analytical work that develops testable hypothesis for comparison of these approaches is needed. To the extent that examining covariate effects in a total valuation model is a promising approach, it would be of interest to examine these issues for a less restrictive specification than that used here. The implication of different welfare measures for the comparison is not addressed.

Both bivariate and mulitivariate logistic models are presented. Use of the latter type of model results in measures of welfare change that are conditional on covariate values. The interpretation of these measures for purposes of aggregation are not obvious. For example, using multivariate models with covariates at the sample means can result in very different estimates for a given parameter, such as the median, compared to the simple bivariate model even when both models fit the data well.

Given the time and budget constraints of this study, there are a number of limitations specific to this application. One such limitation is that YNP visitors were only sampled at a point in time and nonresponse bias could not be investigated. This raises the general issue of the appropriate procedures and interpretation for trust fund payment vehicles. What is being measured by trust fund responses elicited through followup mailings? The analysis in several areas, including valuation of increased visitation and reduced viewing opportunities in YNP, is exploratory. In some cases the analysis is tentative because research on the underlying biological and physical impacts is still underway. This is true, for example, with regard to the impacts on hunting, livestock predation and impacts on extractive natural resource industries in the GYA.

Factors influencing the satisfaction visitors derive from a visit to YNP are poorly understood. Preliminary analysis indicates that visitors have strong and well-defined preferences for viewing wildlife. The influence of wildlife-related experiences needs to be measured and analyzed simultaneously with other factors such as congestion and frequency of visitation. A sample drawn continuously throughout the visitor season would be helpful for examining these issues. Next to nothing is known concerning the values associated with wolf recovery on the part of GYA and other U.S.residents who do not visit YNP. Existence values for these populations could be of a magnitude equal to those held by the YNP visitor population. A household regional or national survey would provide insight into these issues.

ACKNOWLEDGEMENTS

I am grateful to John Varley for his effort in making this project possible. Chris Neher and Susan Ehlers efficiently and patiently undertook the extensive computational work associated with this project. Susan also conducted the survey pretest and directed the data management effort. David Patterson's help and guidance during the survey design and analysis phase was invaluable. I am indebted to Anita Varley for coordinating the distribution of surveys in YNP. A number of individuals provided useful comments on the draft survey: Rob Brooks, Arnold Dood, John Varley and Norm Bishop. This paper has benefited from comments by Catherine Kling. None of these individuals is responsible for the interpretations made here.

LITERATURE CITED

Bishop, R.C., and T.A. Heberlein. 1979. "Measuring Values of Extra-Market Goods: Are Indirect Measures Biased?" American Journal of Agricultural Economics 61:926-30.

Bishop, R.C. and K.J. Boyle. 1985. The Economic Value of Illinois Beach State Nature Preserve. Final Report to the Illinois Department of Conservation. Madison, WI.

Bishop, R.C., K.J. Boyle, M.P. Welsh, R.M. Baumgartner, and P.C. Rathbun. 1987. "Glen Canyon Dam Releases and Downstream Recreation: An Analysis of User Preferences and Economic Values." Salt Lake City, UT: U.S. Bureau of Reclamation.

BMDP, 1988. BMDP Statistical Software, Inc. Los Angeles, CA.

Boyle, Kevin J. and Richard C. Bishop. 1987. Valuing Wildlife in Benefit-Cost Analysis: A Case Study Involving Endangered Species. Water Resources Research 23(5):943-950.

Boyle, K.J., and R.C. Bishop. 1988. "Welfare Measurements Using Contingent Valuation: A Comparison of Techniques." American Journal of Agricultural Economics 70: 21-27.

Boyle, K.J., M.P. Welsh and R.C. Bishop. 1988. Validation of Empirical Measures of Welfare Change: A Comparison of Nonmarket Techniques: Comment and Extension. Land Economics 64:94-98.

Bowker, J.M. and John R. Stoll. 1988. Use of Dichotomous Choice Methods to Value the Whooping Crane Resource. American Journal of Agricultural Economics 70:372-381.

Brookshire, David S., Larry S. Eubanks and Alan Randall. 1983. Estimating Option Price and Existence Values for Wildlife Resources. Land Economics 59(1):1-15.

Cameron, T.A. 1988. "A New Paradigm for Valuing Non-market Goods Using Referendum Data: Maximum Likelihood Estimation by Censored Logistic Regression." Journal of Environmental Economics and Management 15:355-379.

Cummings, R., D. Brookshire and W. Schulze. 1986. Valuing Environmental Goods. Totowa: Rowman and Allanheld.

Duffield, John. 1988. The Net Economic Value of Elk Hunting in Montana. Montana Department of Fish, Wildlife and Parks. Helena.

______. 1989. Nelson Property Acquisition: Social and Economic Impact Assessment. Montana Department of Fish, Wildlife and Parks. Helena.

______. 1990. An Economic Analysis of Wolf Recovery in Yellowstone: Park Visitor Attitudes and Values. National Park Service.

Duffield, John and Stewart Allen. 1988. Angler Preference Study Final Economics Report: Contingent Valuation of Montana Trout Fishing by River and Angler Subgroup. Montana Department of Fish, Wildlife and Parks. Helena.

Duffield, John, Susan Butkay and Stewart Allen. Economic Value of Recreation and Preservation Benefits of Instream Flow. USDA Rocky Mountain Forest and Range Experiment Station, Fort Collins.

Duffield, John and David Patterson. 1991. Inference and Optimal Design for a Welfare Measure in Dichotomous Choice Contingent Valuation. Land Economics (forthcoming).

Efron, B. 1982. The Jackknife, the Bootstrap and Other Resampling Plans. Philadelphia: Society for Industrial and Applied Mathematics.

Fischer, Hank. 1990. Personal communication.

Fritts, Steven H. 1990. Management of Wolves Inside and Outside Yellowstone National Park and Possibilities for Wolf Management Zones in the Greater Yellowstone Area. In YNP (1990).

Garton, Edward O., Robert L. Crabtree, Bruce B. Ackerman and Gerald Wright. 1990. The Potential Impact of a Reintroduced Wolf Population on the Northern Yellowstone Elk Herd. In YNP (1990).

Krinsky, I. and A.L. Robb. 1986. On Approximating Statistical Properties of Elasticities. Review of Economics and Statistics 68:715-719.

Hanemann, W.M. 1984. Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses. American Journal of Agricultural Economics 66:332-41.

Hanemann, W.M. 1989. Welfare Evaluations in Contingent Valuation with Discrete Responses: Reply. American Journal of Agricultural Economics 71:1057-1061.

Hicks, J.R. 1943. The Four Consumers' Surpluses. Review of Economic Studies 11:31-41 (1).

Hosmer, D.W. and S. Lemeshow. 1980. Goodness of Fit Tests for the Multiple Logistic Regression Model. Commun. Statis. 10:1043-1069.

Krutilla, John. 1967. Conservation Reconsidered. American Economic Review 57(4):77-86.

Littlejohn, M. 1990. Personal communication.

Loomis, John B. 1987. Broadening the Concept and Measurement of Existence Value. Northeast Journal of Agricultural Economics.

Loomis, John, Joseph Cooper and Stewart Allen. 1988. The Montana Elk Hunting Experience: A Contingent Valuation Assessment of Economic Benefits to Hunters. Montana Department of Fish, Wildlife and Parks. Helena.

Machlis, Gary E. and Dana E. Dolson. 1988. Visitor Services Project, Report 15. Yellowstone National Park.

McConnell, K.E. 1990. Models for Referendum Data: The Structure of Discrete Choice Models for Contingent Valuation. Journal of Environmental Economics and Management 18(1):19-34.

McNaught, David. 1985. Park Visitor Attitudes toward Wolf Recovery in Yellowstone National Park. Master of Science Thesis, University of Montana.

McNaught, David. 1987. Wolves in Yellowstone? - Park Visitors Respond. Wildlife Society Bulletin 15:518-21.

Patterson, David and John Duffield. 1991. Cameron's Censored Logistic Regression Model: Comment and Extension. Journal of Environmental Economics and Management.

Peterson, George L. and Cindy F. Sorg. 1987. Toward the Measurement of Total Value. U.S.D.A. Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-148.

Randall, Alan, John P. Hoehn, and Cindy Sorg Swanson. 1989. Estimating the Recreational, Visual, Habitat and Quality of Life Benefits of Tongass National Forest. U.S.D.A. Rocky Mountain Forest and Range Experiment Station. General Technical Report.

Randall, Alan, and John R. Stoll. 1983. "Existence Value in a Total Valuation Framework" in Robert D. Rowe and Lauraine G. Chestnut, eds., Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas (Boulder, Colo., Westview).

Serfling, R.J. 1980. Approximation Theorems of Mathematical Statistics. Wiley, New York.

Singer, Francis J. 1988. The Ungulate Prey Base for Large Predators in Yellowstone National Park. Research/Resources Management Report No. 1. Yellowstone National Park, Wyoming.

Singer, Francis J. 1990. The Ungulate Prey Base for Wolves in Yellowstone National Park.

In YNP (1990).

Stoll, J.R. and L.A. Johnson. 1984. Concepts of Value, Nonmarket Valuation and the Case of the Whooping Crane. Transactions of the Forty-ninth North American Wildlife and Natural Resources Conference 49:382-93.

Sutherland, Ronald J. and Richard G. Walsh. 1985. Effect of Distance on the Preservation Value of Water Quality. Land Economics 61(3):281-291.

U.S. Fish and Wildlife Service. 1984. Agency Review Draft Revised Northern Rocky Mountain Wolf Recovery Plan. Prepared by the Northern Rocky Mountain Wolf Recovery Team. USFWS, Denver, CO.

U.S. Water Resources Council. 1983. Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. Washington, D.C.: U.S. Government Printing Office.

Vales, David J. and James M. Peek. 1990. Estimates of the Potential Interactions between Hunter Harvest and Wolf Predation on the Sand Creek, Idaho and Gallatin, Montana, Elk Populations. In YNP (1990).

Varley, Anita. 1990. Personal communication.

Walsh, R., D. Johnson and J. McKean. 1988. Review of Outdoor Recreation Economic Demand Studies with Nonmarket Benefit Estimates. Colorado Water Resources Research Institute Technical Report No. 54. Colorado State University, Fort Collins.

Walsh, Richard G., John B. Loomis and Richard A. Gillman. 1984. Valuing Option, Existence and Bequest Demands for Wilderness. Land Economics 60(1):14-29.

Yellowstone National Park. 1990. Wolves for Yellowstone? A Report to the United States Congress. Volume II. Research & Analysis.

DATE: June 14, 1991

COST-BENEFIT ANALYSIS FOR NON-MARKET RESOURCES: A UTILITY-THEORETIC EMPIRICAL MODEL INCORPORATING DEMAND UNCERTAINTY

by

Trudy Ann Cameron
Department of Economics, University of California, Los Angeles, CA 90024

and

Jeffrey Englin
Pacific Northwest Laboratory, Portland, OR 97232

ABSTRACT

There exists a well-developed theoretical literature concerning the nonmarket value of public goods under uncertainty, but little research effort has been devoted to utility-theoretic empirical specifications. This paper develops an empirical model that employs the state preference model of consumer decision making. We use this model to assess willingness to pay for prevention of acid rain damage to lakes in the Northeast U.S. Our sample includes both resource users and non-users and we specifically model individual participation decisions, thereby allowing for individual risk (demand uncertainty) in the form of endogenous recreational participation probabilities. Controlling for user/non-user sample selection, we use responses to a referendum contingent valuation survey question to calibrate an indirect utility difference function. We then derive the corresponding cost-benefit quantities (individual expected consumer surplus, option price, option value, and individual willingness to pay loci) relevant to this application. Our method obviates the need for signing option value to ascertain whether the usual second-best welfare measure, expected surplus, is an upper or lower bound on option price, the preferred measure of welfare. As a by-product, it supplies an intuitively appealing means of estimating total "non-use" (existence and bequest) resource values.

Acknowledgements:

A large number of individuals contributed valuable input into the design and implementation of the survey utilized in this study. Robert Mendelsohn deserves particular credit. The majority of this research was supported by the National Acidic Precipitation Assessment Program (NAPAP), the EPA and DOE under contract #DE-AC06-76RLO-1830. The results described here are preliminary and have not been subjected to review by any government or private agency, and our findings certainly do not reflect the policies or opinions of any such agency. We have benefitted from the helpful comments of participants at the W-133 conference in Monterey, CA, February, 1991, and from seminar feedback at UC Irvine, UCLA, the University of New Mexico, Los Alamos National Laboratory and the RAND Corporation. Any remaining errors or omissions are solely the responsibility of the authors.

COST-BENEFIT ANALYSIS FOR NON-MARKET RESOURCES: A UTILITY-THEORETIC EMPIRICAL MODEL INCORPORATING DEMAND UNCERTAINTY

1. INTRODUCTION

At least since Wiesbrod (1964), economists have acknowledged that a public good has value above and beyond its current use value. While an individual may choose not to use the good this period, they may choose to use it in the future. Individuals would pay some amount (a contingent payment) for the right to use the good in the next period. For many private goods, rights to the use of a good in subsequent periods are sold in organized markets. This is rarely if ever true for public goods.

A general theoretical framework for cost-benefit analysis for a non-market good under uncertainty was first articulated clearly by Graham (1981). This framework is applicable in a wide array of circumstances, but we will concentrate on the implications of Graham's analysis for the estimation of the social value of environmental resources when individual demand uncertainty exists. Our example concerns individual willingness to pay (WTP) to prevent acid rain damage to 20% of all currently fishable high-altitude lakes in the Northeast United States. Intuition certainly suggests that the amount an individual would be willing to pay to prevent such damage will depend on the extent to which they participate in freshwater-based recreational activities in the affected area. In particular, recreational anglers will be impacted.

Much of the current empirical literature on the valuation of non-market environmental resources has focused exclusively upon user values, revealed ex post. Survey samples have concentrated upon current participants in activities that involve these resources, often intercepting respondents on location. For example, recreational fisheries valuation studies typically interview holders of fishing licenses or employ valuation surveys conducted in conjunction with fisheries management creel surveys at boat launch sites.

These studies develop estimates of total social value by taking one of two approaches. In the first, the analyst assumes that the proposed change in the resource will not affect the number of users, allowing sample weights to be used in a straightforward fashion to inflate the individual value estimates to a population total value. In the second approach, an aggregate participation function is used, relating the total number of participants to current conditions and forecasting the change in participation after some resource change occurs or some policy is implemented.

However, economic theory has characterized at least two main classes of demand in addition to use demand. "Option" demand reflects the fact that some potential users may not participate at present, and they are uncertain about whether or not they will participate in the future, but the resource has value to them because they derive utility from the option to participate. "Existence" demand (sometimes lumped together with "bequest" demand) acknowledges that some individuals have no intention whatsoever of using the resource themselves, but they derive utility from the fact that the resource continues to exist for others to use, or for later generations to enjoy.

Most empirical studies which consider non-use demands invite survey respondents to reveal their total value of the resource, and then to partition this value among use and non-use demands.[1] One problem with this approach is that survey respondents may have difficulty understanding the theoretical distinctions between these types of values. A second difficulty is the static nature of this approach. Without some way of forecasting the changes in the probability of using the resource under different circumstances, the analyst can only identify ex post measures of non-use values. Ex ante value measures are usually argued to be more relevant, since cost-benefit analyses of most policy measures and the attendant decisions must be made in advance of knowing the resolution of the uncertainty.

Any model designed to produce estimates of the use and non-use components of the social value of a non-market resource must explicitly feature uncertainty about the individual's user status.[2] Our study adopts a strategy of estimating the two structural equations underlying the standard state preference approach to modelling individual choice under uncertainty.[3] These structural equations include an equation describing the probability of

---

[1] Some representative papers on nonuse demand for nonmarket resources include Brookshire, Eubanks and Randall (1983), Greenley, Walsh, and Young (1981), Madariaga and McConnell (1987), McConnell (1983), Randall and Stoll (1983), Smith (1987a,b), and Walsh, Loomis and Gillman (1984). Additional aspects of the issue of non-use demands for extramarket goods are raised in surveys by Cummings, Brookshire, and Schultze (1986) and in Mitchell and Carson (1989).

[2] Uncertainty in the general context of cost-benefit analysis has received considerable attention over the last twenty years. Schmalensee (1972,75), Willig (1976), Chipman and Moore (1980), Hausman (1981), and McKenzie and Pearce (1982) all either touch on the subject or make it the centerpiece of their theoretical analyses.

[3] Another approach, advocated by Smith (1987a,b) is to develop "planned expenditure functions." However, since the expenditure function is a reduced form, it obscures the underlying relationships. Graham's original analysis is easier to interpret and to implement in the context of utility functions.

being a user and an equation describing the indirect utility functions of users and non-users. We take as our starting point the deterministic theoretical model offered by Graham (1981).[4]

This present research takes advantage of a unique survey of households in the Northeastern United States. Both users and non-users are included in the sample, and all respondents answer a common set of questions regarding their valuation of a set of environmental changes affecting freshwater recreational opportunities. These valuation questions employ the a closed-ended (or "referendum") contingent valuation method (CVM) for eliciting values. Additional survey questions collect sociodemographic information. An independent data set provides an inventory of water-based recreational opportunities.

This paper is organized as follows. Section 2 reviews Graham's model. Section 3 discusses the design of our survey and outlines the data it provides. In Section 4, we develop an empirical version of the theoretical model. Using this framework, we then derive several welfare measures relevant for cost-benefit analysis. These include both individual and social measures: expected consumer surplus, option price, option value, willingness to pay locus, and the expected value of the "fair bet" point. Section 5 presents our empirical results and a final section concludes the paper.

2. REVIEW OF THE THEORETICAL LITERATURE

One of the most frequently cited theoretical analyses of cost-benefit procedures in the presence of uncertainty is Graham (1981). We will

---

[4] Additional work has been done by Chavas, Bishop, and Segerson (1986), and by Chavas (1991).

paraphrase Graham's main points, using an analogous example appropriate to the types of "policies" addressed in this study.

Assume that there are two goods, "dollars" (income) and a proposed change in environmental quality. For each individual, there are also two possible "states of nature": being a user of the affected resource, or a non-user of the resource (with probabilities P_u and P_n, respectively). Following Arrow's state-preference approach, the consumer will have a claims to dollars dependent upon which state occurs. Using Hirschleifer's (1965, 1966) extension of the von Neumann-Morgenstern theorem, the individual's utility function can be represented as:

(1) $$V = P_n V_n(c_n, \delta) + P_u V_u(c_u, \delta)$$

where c_n and c_u are claims to dollars contingent upon user or non-user status, respectively, and δ represents the presence or absence of the proposed change in environmental quality. (In our survey, some of the hypothesized environmental changes were beneficial and some were adverse. For the example in this paper, the change is adverse, so we will assess willingness to pay to avoid the change.) Let δ=1 indicate that the change has occurred, and δ=0 indicate that it has not happened.

Following Graham, we make the standard assumptions of nonsatiation and risk aversion (conditions upon the first and second derivatives of the utility function). We can now define "expected surplus" and "option price." Let S_j, j=n,u, be defined by the condition:

(2) $$V_j(Y - S_j, 1) = V_j(Y, 0); \qquad j=n,u$$

The individual's expected surplus (expected equivalent variation in our application) is:

(3) $$E[S] = P_n S_n + P_u S_u$$

The second quantity, option price, is defined by the equality:

(4) $$P_n V_n(Y - OP,1) + P_u V_u(Y - OP,1) = V^*$$

where

(5) $$V^* = P_n V_n(Y,0) + P_u V_u(Y,0)$$

Option value is then defined as the difference: $OV = OP - E[S]$.

A concept which is crucial to cost-benefit analysis under uncertainty, however, is the "willingness-to-pay locus." This is a set of ordered pairs, (γ_n, γ_u) satisfying:

(6) $$P_n V_n(Y - \gamma_n,1) + P_u V_u(Y - \gamma_u,1) = V^*$$

where V^* is as defined in (5). A consumer facing "individual risk" regarding his usage status would be happy to make any of these contingent payments (γ_n if he turns out to be a non-user and γ_u if he turns out to be a user) rather than suffering the adverse environmental change (or doing without the desirable environmental change).

Once this locus has been identified, it is easy to see that (S_n, S_u) and (OP, OP) are two points which lie along it. The locus itself will be concave due to the assumption of risk aversion.[5] Figure 1 reproduces an

---

[5] Mendelsohn and Strang (1984) note that taking the total differential of equation (6) and rearranging produces the slope of the WTP locus:

$$\partial\gamma_u/\partial\gamma_n = - [P_n V_n'(Y - \gamma_n)]/[P_u V_u'(Y - \gamma_u)]$$

adaptation of Graham's helpful diagram. Two other interesting points on the locus are the "certainty" point and the "fair bet" points. The certainty point is defined as that point (γ_n^*, γ_u^*) along the willingness to pay locus such that:

$$V_n(Y - \gamma_n^*, 1) = V_u(Y - \gamma_u^*, 1) \tag{7}$$

In words, if the individual could contract for contingent payments (γ_n^*, γ_u^*), he would be indifferent as to whether he turned out to be a user or not. This would be a completely insured position against the individual's uncertain user status.

The fair bet point (fb) is that point (γ_n', γ_u') along the locus which has the largest expected value. Combinations of payments with the same expected value lie along a line with slope equal to $-P_n/P_u$. Maximizing expected value along the willingness to pay schedule involves seeking the highest iso-expected-value line just tangent to the curve in the positive quadrant. (The tangency point gives the fair bet combination of contingent payments.)

When there exist markets in which the individual can obtain actuarily fair insurance against the uncertainty involved, the expected value of the fair bet is occasionally advocated as an appropriate measure of social value. In our context, however, such an insurance market is unlikely to exist. Adverse selection would be a serious problem, since individuals would clearly have far better information about their probability of

---

where V_j' is the marginal utility of income. Diminishing marginal utility clearly produces the curvature in the locus.

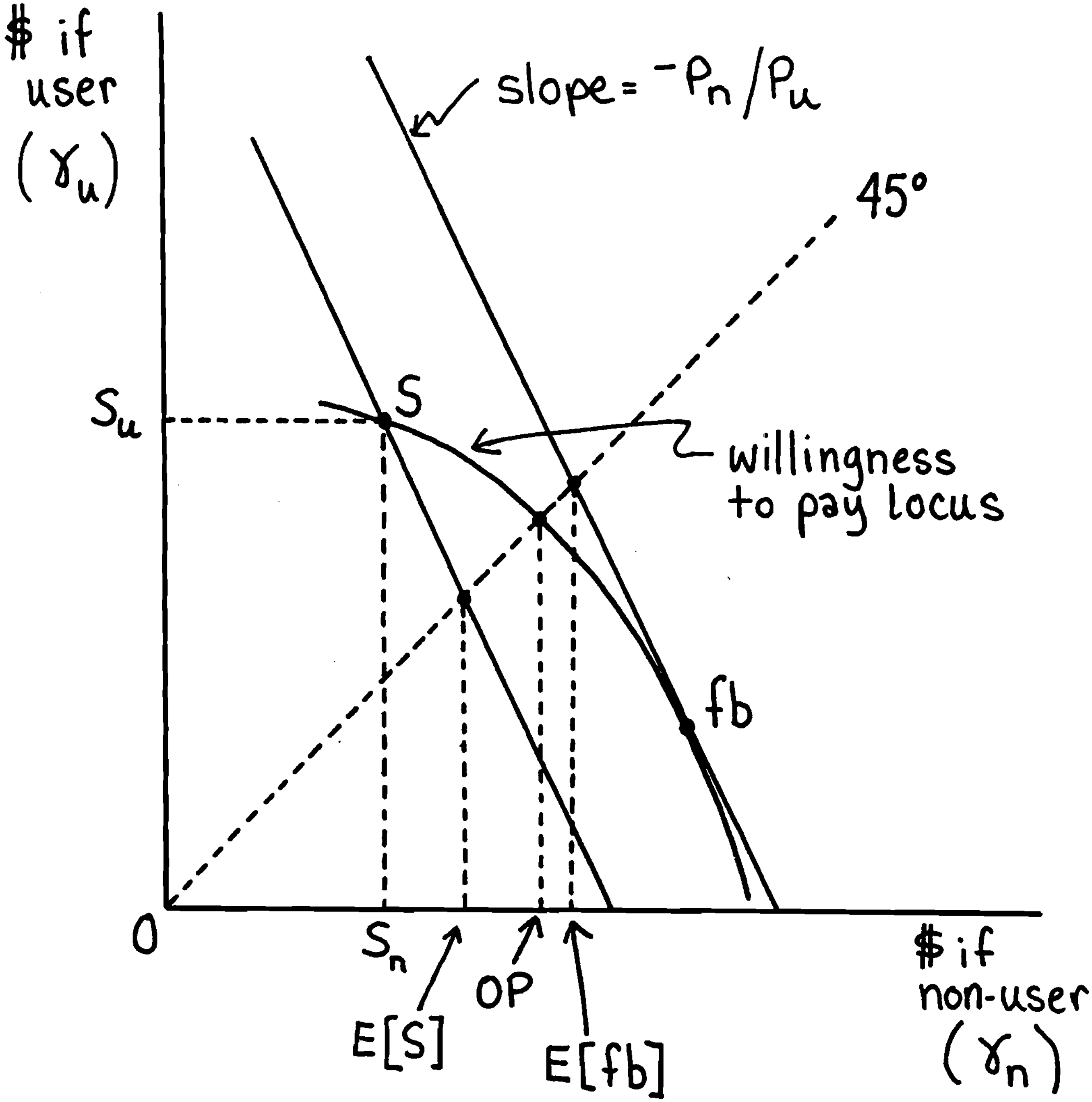


Figure 1: Reproduction of Graham's (1981) diagram depicting cost-benefit quantities which can be read off of an individual's WTP locus.

participating next period than could any potential insurer.

The expected values of various payment combinations along the individual willingness to pay locus are appropriate for determining individual valuations under most circumstances. However, when a researcher is attempting to determine the aggregate social value of some change in environmental quality, there will occasionally be scenarios under which the aggregate willingness to pay locus is an appropriate construct for analysis. The aggregate WTP locus is not appropriate in our specific example, but it would be readily attainable from a model similar to ours in a different application. The aggregate locus sums the individual WTP schedules so that each aggregate of contingent payments is defined where the slope of each individual's WTP locus is equal to the slope for all other people included in the aggregate group.

There has been considerable discussion in the literature concerning which of these quantities constitute first-best measures of value for cost-benefit analyses under different circumstances. Ex ante, option price, OP, is a more relevant measure of value than ex post expected consumer surplus. Most previous studies have had to make do by identifying, at best, the location of the (S_n, S_u) point and approximating the slope of the iso-expected value line $(-P_n/P_u)$ in order to locate the intersection of this line with the 45° line to determine the second-best welfare measure E[S]. The now-vast literature devoted to defining conditions under which option value will be positive or negative was motivated by the need to determine whether an empirical estimate of E[S] is an upper or a lower bound on option price (which would be the first-best measure if it were attainable). This paper demonstrates that the usual compromise second-best E[S] measures can be replaced by first-best OP measures.

3. AN OUTLINE OF THE AVAILABLE DATA

During the summer of 1989, the National Acidic Precipitation Assessment Program, in conjunction with the Office of Policy Planning and Evaluation of the Environmental Protection Agency, conducted a four-part survey in four states: Maine, New Hampshire, Vermont, and New York. The survey design included a screening survey of the general population and three subsequent panels of freshwater recreationists identified during the screening survey. The panels included anglers, swimmers and boaters.

The overall goal of the data collection effort was to develop a sample of recreationists which could (i.) be linked back to the general population, and (ii.) be used effectively to implement a variety of non-market economic models. In this paper we focus on the screening survey of the general population, and concentrate upon the contingent valuation questions on that survey.

The general population screening survey utilized a stratified sample. The probability of a county being drawn was proportional to the population of the county. The five counties comprising New York City were excluded from the survey because of the low freshwater recreation participation rate. A sample of forty of the ninety-seven counties in the sample area was drawn. For a given county, a random digit dialing procedure was used to generate potential interviews. All households were eligible to participate in the screening survey. Since the proportion of participants in freshwater recreation by county was unknown in advance, the size of the screening survey could not be predicted a priori. Eventual sample size depended on the rate of recruitment into the three panels. The goal of the recruitment was to enlist twenty-eight anglers, seventeen swimmers and seventeen boaters from each county. The final screening survey completed interviews with 5,744 individuals, of which 4319 had complete data for all of the variables considered in this analysis.

The questionnaire was developed in a multi-step process. Focus groups were conducted with freshwater recreationists in two parts of the study area. The questionnaire was also pretested before being fielded. Some features of the survey design merit comment. One is that the questionnaire includes a device to avoid a female phone answering bias. The device used is to ask for the individual over eighteen with the most recent birthday. This randomizes the respondents by gender. Additionally, the screening survey was intended to be the primary tool used to gather demographic characteristics for the full range of studies anticipated from the extended data set and so it contains a fairly broad set of demographic questions. These characteristics include: secondary residence, education, employment status (including retired), household size, number of children (and their ages), age, ethnicity, income, and gender. Acronyms and descriptive statistics for the subset of variables employed in this paper are presented in Table 1. A more detailed discussion of the data is provided in Appendix I.

There were four referendum contingent valuation questions posed to respondents during the screening interviews, but we will concentrate here on just the "acid rain" question:

> **"If acid rain damaged fishing in 20% of all currently fishable high altitude lakes in the Northeast, would you be willing to pay ____ per year to prevent this?"**

Table 1

Descriptive Statistics for Estimating Sample (n = 4319)

ACRONYM	Description	Mean (st.dev.) Full Sample	Mean (non-users) Mean (users)
USER	User this season? (1=yes, 0=no)	0.1706	0 1
t	Offered CV threshold (dollars)	25.33 (28.69)	24.98 27.05
WTP	WTP offered amount (1=yes, 0=no)	0.7326	0.7180 0.8033
Income (multiply imputed in estimation phase):			
MIDINC	income bracket (midpoint, $'000)	36.33 (27.54)	36.57 35.18
Schooling (omitted category is less than college graduate, non-trade school):			
TRSC	trade school is highest educ. attain.	6.483e-02	0.06086 0.08412
COLG	college graduate or higher degree	0.2936	0.2998 0.2632
Gender and Ethnicity:			
FEM	female (1=yes, 0=no)	0.5291	0.5592 0.3826
BLK	black (1=yes, 0=no)	0.01204	0.01396 0.002714
AMIN	American Indian (1=yes, 0=no)	0.02038	0.01759 0.03392
Life-cycle variables:			
AGE	age in years	42.06	42.83

		(15.90)	38.36
RETI	retired (1-yes, 0-no)	0.1475	0.1575 0.09905
Occupational status (omitted category is full-time employment):			
PART	employed part-time (1-yes, 0-no)	0.1236	0.1329 0.07870
NOEM	not employed (1-yes, 0-no)	0.08613	0.08961 0.06920
UNEM	unemployed (1-yes, 0-no)	0.05210	0.05221 0.05156
STUD	student (1-yes, 0-no)	0.01806	0.01843 0.01628
County attributes from NORSIS data base:			
CNTY	county area (millions of acres)	0.6632 (0.5457)	0.6490 0.7321
LILL	small lakes in county (acres <2 acres in size)	5.594 (4.503)	5.713 5.016
LILR	small rivers in county (acres <66 feet wide)	19.77 (22.23)	19.21 22.47
POP	county population (1985, millions)	0.2026 (0.3145)	0.2167 0.1344
State of residence (NY is omitted category):			
NH	New Hampshire (1-yes, 0-no)	0.09956	0.09548 0.1194
ME	Maine (1-yes, 0-no)	0.1466	0.1335 0.2103
VT	Vermont (1-yes, 0-no)	0.1401	0.1251 0.2130
Past general fishing experience:			
PAST	Past fishing trips? (1-yes, 0-no)	0.4987	0.5793 0.1072

YRS	Years of past fishing experience	7.738 (13.12)	5.195 20.09
Miscellaneous variables:			
SECR	secondary residence (1-yes, 0-no)	0.1533	0.1502 0.1683
URB	urban county (1-yes, 0-no)	0.3945	0.4082 0.3284

Different values between $1 and $100 were randomly assigned to each individual for each referendum contingent valuation question.

A supplementary source of data was the NORSIS database. Compiled by the U.S. Forest Service, Southeast Range Station (Athens, GA), this data base provides nationwide county-by-county inventories of outdoor recreational opportunities, from numbers of swimming pools to numbers of boat-launching ramps. The information is collected from a wide variety of federal and state sources. We use a subset of these data pertinent to the forty counties sampled in our survey.

4. AN EMPIRICAL SPECIFICATION

a.) The Participation Probability Sub-model

In the theoretical literature, it is quite clear that individual subjective probabilities determine individual expected utility. While it is certainly feasible in survey research to ask respondents directly about their participation probabilities, our survey did not attempt to elicit these probabilities.[6] For one thing, a relevant time horizon would have to be specified, and we would also have had to rely upon respondent comprehension of the notion of probability. Instead--as is often preferred in empirical research--we choose to rely upon current-period revealed

---

[6] Our survey asked respondents whether they planned any fishing trips at all between the time of the screening survey and September 30. A yes response, however, implies only that their participation probability exceeds zero. Of our 4319 respondents, 1816 indicated that they planned to fish during this subsequent period, but only 977 actually went fishing at any time during the entire April 1 to September 30 sampling period. Unfortunately, these questions pertained to fishing in general, rather than fishing in any of the high-altitude lakes that are susceptible to acid rain damage.

preferences for participation across our sample rather than the stated preferences of each individual.

Consistency of our empirical model with Graham's theoretical development requires that one accept fitted probabilities derived from observed participation as reasonable proxies for respondents' true but unobserved subjective participation probabilities. Certainly, if we adopt the usual interpretation that each observation in the sample represents a large number of essentially identical individuals in the population, these fitted probabilities would be useful estimates of typical subjective probabilities for that group. Since we have no alternative but to resort to stated preferences in the second (contingent valuation) phase of the modeling process, this choice anchors at least the participation submodel upon actual behavior.[7]

The participation probabilities that we infer from this first submodel deserve careful attention because these probabilities play three vital roles in our model. First, they are the pathway whereby demand uncertainty enters into the model--relative probabilities of use and non-use determine the slope of the iso-expected value lines ($-P_n/P_u$) used to convert any given pair of contingent payments to an expected value. Second, they are crucial to the process of correcting for selectivity bias in locating the true coordinates of point S, (S_n, S_u). Since respondents have freely chosen to be users or non-users of the resource in question, failure to correct for

---

[7] Even if individual subjective probability claims had been available, we would still have modelled these subjective probabilities using the same explanatory variables we employed to infer probabilities from observed participation behavior. Fitted probabilities are required for the forecasting and simulation phase of our analysis. For example, we will be curious about how a shift in the age distribution affects participation probabilities and thereby effects welfare.

the endogeneity of participation when estimating willingness-to-pay will locate point S incorrectly and therefore result in improperly positioned individual WTP loci and invalid inferences about option prices and other welfare measures. Third, these probabilities are an ingredient in constructing the individual WTP loci themselves. Each individual's locus passes through the point S, but its shape also depends on the probabilities P_n and P_u.

In our sample, we observe the discrete outcomes of participation or nonparticipation in freshwater recreational fishing during the current period. A maximum likelihood (MLE) probit algorithm is therefore appropriate for estimating fitted continuous participation probabilities for each individual. Let the individual's (latent) propensity to participate, W_i, depend systematically on a vector of variables, Z_i:

$$W_i = \theta' Z_i + \epsilon_i \tag{8}$$

where ϵ_i is distributed $N(0,\nu^2)$. The location and scale of measurement of W_i are unobservable, so we assume that if $W_i > 0$, participation is observed and if $W_i < 0$, the individual is a nonparticipant. Standard MLE probit techniques yield estimates of the parameter vector $\theta^* = \theta/\nu$, and each individual's fitted continuous probability of participation, P_u, is given by $\Phi(\theta^{*\prime} Z_i)$; of nonparticipation, P_n, by $[1 - \Phi(\theta^{*\prime} Z_i)]$. P_n/P_u will then be the absolute value of the slope of the iso-expected-value line for individual i.[8]

---

[8] If all of the Z_i variables were free from measurement error, the standard MLE probit parameters and their covariance matrix could be considered reliable. However, the income data we have available is in

Selectivity correction is another role for the results of the participation model. If unobservable factors which make individuals systematically more or less likely to participate also make them likely to exhibit higher- or lower-than-expected equivalent variations for the proposed environmental changes, our parameter estimates from the second-stage contingent valuation random utility probit model outlined in the next section will be biased unless we compensate for this tendency. To effect a correction, we will borrow from the literature on selectivity bias corrections in ordinary least squares regression models, adapting the procedure to our second-stage probit specification.[9]

In most selectivity correction models, the second stage is to be estimated only for one of the two outcomes over which the selection of the

---

bracket form, with an open-ended upper interval. Since income data figure prominently in a utility-theoretic specification, it is important to our analysis not to overstate the information in these data. Wherever the income variable appears in any of our estimations, the effective parameter point estimates and covariance matrices have been assessed for sensitivity using the technique of "multiple imputation" (Rubin (1987) and Brownstone (1991)). Grouped data estimation of the marginal log-normal distribution of income in the full sample produces a fitted distribution for log(income). Multiple imputations of the income vector are used to produce a range of point estimates and covariance matrices subject to the vagaries of our income variable. We use the means of the imputation point estimates as parameter values, and the average of the imputed covariance matrices inflated by a factor of $(1 + m^{-1})$ times the sample covariance of the m different vectors of point estimates as the parameter covariance matrix.

[9] Our primary results will be derived using simultaneous full information maximum likelihood estimation of the participation and contingent valuation joint probit models (i.e. LIMDEP, by Greene, 1990). However, for sensitivity analysis, the estimation must be simulated many times to accommodate our deficient income variable and the slowness of LIMDEP is a disadvantage. For our sequentially estimated results, we rely on the very fast single probit algorithms offered in SST (Dubin and Rivers, 1991) and correct the second stage contingent valuation probit covariance matrix.

sample takes place. In this study, however, we elicit contingent valuation responses from both users and non-users. Following the lucid exposition of selectivity correction given in Greene (1990, p. 744), the vector of regressors in our main contingent valuation model will be augmented by two constructed variables:

$$(9) \quad \lambda_i^u = \phi(\theta^{*\prime}Z_i) \,/\, \Phi(\theta^{*\prime}Z_i) \qquad \text{if } D_i = 1$$
$$= 0 \qquad \text{otherwise}$$

$$\lambda_i^n = -\phi(\theta^{*\prime}Z_i) \,/\, [1 - \Phi(\theta^{*\prime}Z_i)] \qquad \text{if } D_i = 0 \,.$$
$$= 0 \qquad \text{otherwise}$$

where $D_i = 1$ for current users and $D_i = 0$ for current non-users. These two variables will be included as explanatory variables in the valuation model described in the following section. In that model, the estimated coefficients on these two selectivity correction terms will reveal information about the correlation between the effects of unobservable variables which simultaneously affect participation and resource valuation.

b.) <u>A Random Utility Model for the Indirect Utility-Difference Function</u>

We will start with the simplest utility function that seems to allow non-zero option values to be estimated--one that is essentially Cobb-Douglas in form. Let indirect utility with and without the contingent valuation scenario be:

$$(10) \quad V_j^1 = \beta_j \log(Y-t) + \delta_j \log P + \omega_j \log(A) + \alpha_j^1 X + \eta^1, \quad j = \text{non-user, user;}$$

$$(11) \quad V_j^0 = \beta_j \log(Y) + \delta_j \log P + \omega_j \log(.8A) + \alpha_j^0 X + \eta^0, \quad j = n, u.$$

where V^1 implies the respondent's indirect utility with the hypothesized change in the resource (prevention of acid rain damage) and the loss of income (the payment, t) proposed in the contingent valuation question. V^0 implies the situation with no mitigation of acid rain and no payment. Y is income, P is the price of a day of access to the specific environmental resource under consideration, A is the attribute of the resource which is subjected to a hypothetical change (acid rain damage to 20% of all currently fishable high-altitude lakes, leaving the fishable proportion at 0.8 of the current number), and X is a vector of respondent sociodemographic characteristics, other resource attributes, and other prices. The assumed i.i.d. normal error terms are η^1 and η^0.

The respondent's answer to the contingent valuation question will depend on the relative magnitudes of these two utilities. They will be willing to pay the proposed amount if the utility difference (8)-(9) is positive:

$$(12) \quad V_j^1 - V_j^0 = \beta_j \log(\frac{Y - t}{Y}) - \omega_j \log(.8) + (\alpha_j^1 - \alpha_j^0)\, X + \rho_j \lambda^j + (\eta^1 - \eta^0) > 0, \quad j = n, u.$$

We will rename the $(\alpha^1_j - \alpha^0_j)$ coefficients as simply α_j (since we will be unable to identify their separate values). The term involving the ω_j parameter and the log of (.8) will be absorbed into the constant term among the α coefficients.[10] The λ terms are the selectivity correction variables defined in (9) in the previous section. If we assume that the error terms in the participation probit model and the upcoming contingent valuation probit model are distributed bivariate normal with parameters $[0,0,1,1,\rho]$, a simple analogy to the ordinary least squares case would imply that the coefficient on each λ variable should be a separate estimate of the correlation parameter ρ. This approach will produce two separate estimates of ρ: ρ_u and ρ_n, which can be examined for comparability.[11]

For current <u>users</u>, we must use our calibrated model to simulate their likely non-use value S_n, whereas for current <u>non-users</u>, we must use the model to simulate their likely use value, S_u. Only then can we locate the point $S = (S_n, S_u)$ for each individual and construct their WTP locus. If selectivity <u>is</u> occurring, and we ignore it, we will be plotting S in the wrong place.[12]

The specification in (12) follows that adopted by Hanemann (1984) in that the stochastic structure assumes that the <u>indirect utility difference</u> bears an additive $N(0,\sigma^2)$ error term, $\eta = \eta^1 - \eta^0$. We will subsume the non-user and user indirect utility functions within one model by allowing

---

[10] If our questionnaire had varied the hypothesized level of damage to high-altitude lakes across respondents, we could readily have determined a schedule of WTP a function of damage levels prevented. Since only the 20% damage level was addressed, we produce only a point on this curve.

[11] In the sequentially estimated model, the estimates of ρ can be constrained to be identical by summing the two separate λ variables to create a single selectivity correction term. The value of ρ is estimated directly by maximum likelihood in our bivariate probit model.

[12] For example, if ρ is positive so that unobservable factors make users systematically more likely to have high surplus and nonusers more likely to have lower surplus, our S points without a selectivity correction will tend to be placed too far to the northwest in Graham's diagram. If ρ is negative, they will be too far to the southeast.

each coefficient in the utility-difference function to differ systematically across the two groups. Thus, we modify our notation so that $\beta_j = \beta_n + \beta_\delta D_i$, where j = n, u, and D_i equals 0 for non-users and 1 for users. The coefficient β_δ therefore denotes the coefficient differential between the two groups. Likewise, we will have $\alpha_j = \alpha_n + \alpha_\delta D_i$. In its simplified form, for each individual i, the stochastic model is:

$$(13) \quad (V^1 - V^0)_i = (\beta_n + \beta_\delta D_i) \log((Y_i - t_i)/Y_i) + (\alpha_n + \alpha_\delta D_i)'X_i + \rho_n \lambda_i^n + \rho_u \lambda_i^u + \eta_i$$

Note that logP (the own-price term) disappears from the utility difference equation because price is presumed not to be affected by the hypothesized change. Likewise, prices of all other goods are also presumed to remain constant and these will not appear in the utility-difference function either.

Conventional packaged maximum likelihood probit models can be used to estimate this contingent valuation utility-difference model. The simulated (scaled) utility difference $(V^1 - V^0)_i$ in the absence of selectivity would be calculated by imposing $\rho_n = \rho_u = 0$, which is equivalent to ignoring the ρ and λ terms in any subsequent calculations involving $(V^1 - V^0)_i$.

The separate "true" values of β_n, β_δ, α_n, and α_δ are not identified, since in the likelihood function, they always appear in ratio to the unknown error variance, σ. We must be satisfied instead with estimating $\beta_n^* = \beta_n/\sigma$, $\beta_\delta^* = \beta_\delta/\sigma$, $\alpha_n^* = \alpha_n/\sigma$ and $\alpha_\delta^* = \alpha_\delta/\sigma$. Fortunately, this is not a limitation because the important quantities required for our welfare calculations involve only ratios of the β_n, β_δ, α_n and α_δ parameters. The implicit σ terms in the denominators of the maximum likelihood probit parameters will cancel.

c.) Calculating Expectations of Individuals' Cost-Benefit Quantities

A crucial complication in this specification concerns the transformations of the estimated parameters and the error term (all of these being random variables) that must be undertaken before we arrive at our estimates of the different welfare quantities calculated from the calibrated model that are necessary for cost-benefit analyses. We will assume that the maximum likelihood estimates of β_n^*, β_δ^*, α_n^* and α_δ^* are distributed approximately multivariate normal, with an asymptotic variance-covariance matrix produced from the expected Hessian evaluated at the optimal parameter values. Also by assumption, the standardized probit error term, $\eta^* = \eta/\sigma$, is N(0,1) and independent both across observations and from the estimated coefficients.[13]

The value of t which makes equation (13) exactly zero is the surplus (equivalent variation), S_j, associated with the proposed mitigation of acid rain damages. If we carry along the error term, η^*_i as we solve the estimated version of equation (13) for the value of $t_i = S_{ji}$ which makes the utility difference exactly zero for individual i, we pass through the following intermediate steps. Simplify the notation temporarily by letting $\beta^{*\prime}D_i = \beta_n^* + \beta_\delta^* D_i$. Then

[13] As noted previously, it is necessary in the sequentially estimated model to correct the second-stage parameter estimates and parameter covariance matrix to reflect the grouped income data and the estimated nature of the selectivity correction terms.

(14) $$f_j = \log[(Y_i - S_{ji})/Y_i] = (\alpha^{*\prime}X_i)/(\beta^{*\prime}D_i) + \eta^*_i/(\beta^{*\prime}D_i),$$

$$j = n, u.$$

Any linear combination of normal random variables is also normal, so $\alpha^{*\prime}X_i$ and $\beta^{*\prime}D_i$ and η^*_i will all be approximately normally distributed. However, to calculate S_j, we must exponentiate f_j. Each individual's fitted expected value of S_{ji} will be given by:

(15) $$E\{S_{ji}\} = Y - Y\,E\{\exp[(\alpha^{*\prime}X_i)/(\beta^{*\prime}D_i)]\exp[\eta^*_i/(\beta^{*\prime}D_i)]\},$$

$$= Y - Y\,E\{\exp(f_j)\}.$$

No analytical solution for this complicated expectation is available.

Instead, we use the simulation method suggested in another context by Krinsky and Robb (1986). Their technique suggests that we adopt a multivariate normal distribution for the estimated probit parameters, with variance-covariance matrix as produced by the maximum likelihood probit algorithm (and modified to account for the grouped income data and the estimated nature of the λ terms for selectivity correction.) Combined with this, we will assume an independent unit normal distribution for η^*. A large number of "random draws" for (β_n^*, β_δ^*, α_n^*, α_δ^*, η^*) will be produced and, in conjunction with the observed data, <u>simulated distributions</u> for S_{ji} (and subsequently, for all of the other cost-benefit quantities to be discussed) will be calculated for each individual. The means of these simulated values will be taken as the expected value of S_j for each individual. Note that these two expected values are inputs into the calculation of E[S] for the individual, which is a different entity since the expectation is taken not across the randomness of the parameters and errors, but across the two uncertain outcomes for that individual: use or non-use.

The fitted (expected values of) S_n and S_u for each individual are not the final objective of this study. For example, in the computation of option value, we must carry the stochastic properties of the estimates through the our derivations of both E[S] and OP, calculate their individual expectations for each respondent, and then compute the difference for each person.

The individual consumer's <u>expected</u> equivalent variation from the proposed acid rain mitigation, E[S], also depends on the respondent's probability of using of the resource. We will employ fitted probabilities of participation and non-participation from our first-stage participation probit model. These fitted probabilities are also random variables because they are constructed as nonlinear functions of the estimated probit θ^* parameters: $P_u = \Phi(\theta^{*\prime} Z_i)$ and $P_n = [1 - \Phi(\theta^{*\prime} Z_i)]$. In addition to the Krinsky-Robb simulations for the S_j values, we must employ the same types of simulations for P_j. Expected surplus across user and non-user states of the world, substituting the formulas derived above for S_u and S_n and simplifying, will be:

$$(16) \qquad E[S] = Y \{ 1 - (P_u \exp[f_u] + P_n \exp[f_n]) \}$$

In words, E[S] is a specific fraction of income determined by a probability weighted average of the exponentiated f_j functions.

To determine the option price associated with the proposed change in the resource attribute, we need to work in the environment of utility differences, as in equation (12). Option price, OP, solves:

(17) $$P_u V_u^0 + P_n V_n^0 = P_u V_u^1 + P_n V_n^1$$

or, equivalently:

(18) $$P_u (V_u^1 - V_u^0) + P_n (V_n^1 - V_n^0) = 0.$$

From equations (13) and (14), we have expressions which can be substituted for the utility difference terms in parentheses in (18).

(19) $$(V_j^1 - V_j^0) = \beta_j \log[(Y-t)/Y] - \beta_j f_j, \quad j = n,u.$$

where the β_j parameters are random and the f_j terms are random variables involving the estimated random utility CV probit parameters and the standard normal error term from that model as in equation (14). We can now rewrite equation (18) as:

(20) $$P_n\{ \beta_n \log[(Y-S_n)/Y] - \beta_n f_n\} + P_u\{ \beta_u \log[(Y-S_u)/Y] - \beta_u f_u\} = 0.$$

We then solve for the value of option price $OP = S_n = S_u$ that makes this equality true:

(21) $OP = Y \{ 1 - \exp[(P_n\beta_n + P_u\beta_u)^{-1} \{P_n\beta_n f_n + P_u\beta_u f_u\}] \}$

Whereas E[S] was a fraction of income determined by a probability-weighted average of the exponentiated f_j functions, OP is a fraction of income determined by the exponentiated value of a probability- and β coefficient-weighted average of the same f_j functions. (Note the difference in the order of the exponentiation and the averaging.) Like the other cost-benefit quantities, the expected value of OP for each respondent will be simulated from a set of Krinsky-Robb draws from the joint distribution of (β_n*, β_δ*, α_n*, α_δ*, η*) for the f_j and β_j terms and an analogous set of draws from the joint distribution of the θ* parameters for P_j, j = n, u.

Even if $\beta_u = \beta_n$ in this model, E[S] and OP will differ systematically. Making this assumption for the moment, recall that option value is defined as OV = OP - E[S]. In this simple case, we will have:

(22) $OV = Y \{ [P_n\exp(f_n) + P_u\exp(f_u)] - \exp [P_n f_n + P_u f_u] \}$

The sign of option value will depend upon the relative magnitudes of the two terms inside the braces. Of course, $P_u + P_n = 1$, so in this case, we are comparing a weighted average of two exponentiated quantities with the exponentiated value of their weighted average, with the same weights used. Since the function exp(z) is convex when viewed from below, the first term will always exceed the second term, regardless of the values of the two f_j functions. Thus if $\beta_u = \beta_n$, option value will be positive.

Only if the weights used in the expression for OP (i.e. in equation (21)) differ from the simple probability weights in the expression for E[S] is it possible for option value to be negative for some or all consumers.

Suppose that $\beta_u = \beta_n + \Delta$. We can substitute this expression for β_u wherever it appears in equations (16) and (21), set E[S] = OP and solve for the value of Δ that makes the equality true:

$$(23) \qquad \Delta = -\beta_n \{ 1 + P_n[\log((Y-E[S])/Y) - f_n]/P_u[\log((Y-E[S])/Y) - f_u] \}.$$

The threshold Δ will differ across individuals due to differences in P_j, f_j and Y. If $\Delta_i < \beta_u - \beta_n$, individual i's option value will be positive; if not, it will be negative.

Of course, option value is not a distinct component of value, and OV estimates have limited relevance. OV is merely the difference between an ex ante value measure (option price) and an ex post measure (expected consumer surplus). The only time option value may be useful is for assessing the error introduced when using an available E[S] estimate as a proxy for the desired OP measure (see Smith, 1987a, p. 289). Nevertheless, the issue of option value was a preoccupation in the literature for some time, so we will provide empirical estimates of option value in our discussion of the results.

Having shown how the various welfare measures are derived, we are now in a position to examine one of the limitations of our current specification. Our model makes explicit the endogeneity of participation status in the contingent valuation indirect utility-difference equation. We also allow for unobserved heterogeneity to affect both the utility difference and the participation decision through their correlated error terms. The next generation of specifications will explore more general functional forms for indirect utility and will seek to make resource values an explicit endogenous variable in the participation equation as well.

Making values a determinant of participation appears to be non-trivial in the present case because the contingent valuation questions in our survey use a referendum format. The discrete contingent valuation response explained by the random utility model cannot be used analogously in the participation equation due to its dependence on the offered threshold. For our indirect utility function, each individual's option price, for example, is not an observed or directly estimated variable but an expected value inferred through simulations with no simple analytical formula that could be substituted into the participation equation for general FIML estimation. Generalizing our model to one where valuation and participation are jointly determined will be an important undertaking in subsequent research. Our present formulation is a recursive model with a non-diagonal error covariance matrix rather than a fully simultaneous, dependent-error specification.[14]

d.) Empirical Formulas for Individual WTP Loci and Useful Quantities

For our specification for indirect utility, each individual's WTP locus will be given by (γ_n, γ_u) pairs which satisfy the following equality:

$$(24) \quad \gamma_u = Y - Y \exp\{ (P_n\beta_n f_n + P_u\beta_u f_u)/(P_u\beta_u) - (P_n\beta_n/P_u\beta_u) \log[(Y-\gamma_n)/Y] \}$$

---

[14] A naive simultaneous formulation of our two equations incorporates both the contingent valuation discrete response and the offered threshold value as explanatory variables in the participation probit model. Estimating the participation model by itself, the threshold variable is strongly significant and the discrete response to the valuation question is significant at the 10% level. However, when the two equations are estimated jointly using the bivariate probit algorithm, the estimated correlation between the two equation errors persists in moving outside the admissible range and the algorithm does not converge. This outcome is common in simultaneous bivariate probit models.

In most theoretical analyses, the individual WTP locus is depicted with pronounced concavity (following directly from the assumption of risk aversion on the part of consumers). Nonsatiation requires that $\partial V_j/\partial Y > 0$ for $j = n, u$. Risk aversion requires $\partial^2 V_j/\partial Y^2 < 0$ for $j = n, u$. For our simple utility functions, the first derivative with respect to income is just β_j/Y; the second derivative is just $-\beta_j/Y^2$. Thus the conditions will be met globally as long as $\beta_j > 0$ for $j = n, u$. Furthermore, the Arrow-Pratt measure of absolute risk aversion in our case reduces to simply $1/Y$ (a very tiny number) which is independent of the parameter estimate for β_j. While the correct sign on the β coefficients will guarantee concavity of the WTP locus, it is important to appreciate that the curvature of the locus in our empirical examples will be very slight.[15]

Consider the algebraic formula for the slope of the WTP locus:

$$(25) \qquad |\partial\gamma_u/\partial\gamma_n| = [Y/(Y - \gamma_n)]\ (P_n\beta_n/P_u\beta_u) \cdot \exp[\ (P_n\beta_n f_n + P_u\beta_u f_u)/(P_u\beta_u) - (P_n\beta_n/P_u\beta_u)\ \log[(Y - \gamma_n)/Y]$$

This derivative is clearly increasing in γ_n, but in our application, the contingent payments (γ_n, γ_u) are typically very, very small relative to income Y. Thus $[(Y - \gamma_n)/Y] \approx 1$ and the slope will be almost a constant (relative to γ_n) given by:

---

[15] Graham (1984) rebuts Mendelsohn and Strang (1984) by asserting that their claim that "...projects which entail individual risks and "small" changes in the marginal utility of income across states give rise to linear WTP loci..." is incorrect. Our empirical findings suggest that linear WTP loci are a rather good approximation, at least under our specification for indirect utility. However, this approximately constant slope is not equal to P_n/P_u.

(26) $$|\partial\gamma_u/\partial\gamma_n| = (P_n\beta_n/P_u\beta_u) * \exp\{ (P_n\beta_n f_n + P_u\beta_u f_u)/(P_u\beta_u) \}$$

Anticipating future efforts to use models of this genre to estimate resource values, it should be emphasized that it is crucial to have data on participation in an activity which is as closely matched as possible to the resource change described in the contingent valuation question being analyzed. The shape of the individual WTP loci depend crucially upon the odds of being a non-participant (P_n/P_u); if these odds are misrepresented by an inappropriate match between the definition of participation and the CV scenario to be examined (e.g. participation defined too broadly), the loci will be incorrect (in this case, too flat).

We have already noted that the expected value of the fair-bet point is probably not appropriate in this particular context as a measure of welfare because it is unlikely that actuarily fair insurance against the use/non-use contingency would ever be offered to individuals. However, if this insurance market did exist, we could readily calculate this welfare measure. Once each individual's WTP locus is identified, their fair bet point is found by setting the absolute value of the slope of the WTP locus equal to the individual's current relative probability of non-use, P_n/P_u. This yields the fair bet coordinates (γ_n', γ_u'), where

(27) $$\gamma_n' = Y - Y \exp\{ (P_n\beta_n f_n + P_u\beta_u f_u)/(P_n\beta_n + P_u\beta_u) + (P_u\beta_u)/(P_n\beta_n + P_u\beta_u) \log(\beta_n/\beta_u) \}$$

and γ_u' satisfies equation (24) for the WTP locus. These formulas apply providing that the tangency of the iso-expected value line with the WTP curve is interior. Corner solutions are frequent, however. For j = n, u, if $\gamma_j' < 0$ according to the above formulas, we substitute $\gamma_j' = 0$ and

$$(28) \qquad \gamma_j' = Y - Y \exp \{ (P_n\beta_n f_n + P_u\beta_u f_u)/(P_j\beta_j) \}$$

The expected value of the fair bet point for each consumer employs the individual fitted participation probabilities for that person:

$$(29) \qquad E[fb] = P_n \gamma_n' + P_u \gamma_u'$$

The "certainty point" along the WTP locus would be an interesting curiosity, since this combination of contingent payments allows the respondent to be fully insured against risk involving his user/non-user status. However, this particular welfare quantity is not available given the specification used in this study. Given that the parameters of the indirect utility function in this application must be estimated from the indirect utility-difference equations, we cannot recover all the information necessary to identify these coordinates. Referring back to section 2, and using the indirect utility functions outlined at the beginning of this section, the certainty point is the pair of contingent payments (γ_n^*, γ_u^*) along the WTP locus that satisfies:

$$(30) \qquad 0 = V_u^1 - V_n^1 = \beta_u \log[Y - \gamma_u^*] - \beta_n \log[Y - \gamma_n^*] - (\omega_u - \omega_n) \log(0.8A) + (\alpha_u^1 - \alpha_n^0) X$$

While point estimates of the β coefficients are available, as are data for Y and the X variables, it is not possible to solve this equality for (γ_n*, γ_u*).[16]

5. EMPIRICAL RESULTS

a.) The participant/nonparticipant probit submodel

Many hundreds of individual lakes in the Northeast U.S. are susceptible to acid rain damage, but the state of the science does not allow researchers to pinpoint precisely which lakes would be among the first 20% to be affected. Hence our contingent valuation question did not list specific lakes which would allow us to select only users of those particular lakes as "participants" for purposes of the first probit model in our analysis. However, acid rain is far more likely to adversely affect higher altitude, shallow bodies of water. In order to match users as closely as possible with the lakes addressed in the CV question, we limited our definition of participants to include only those individuals who actually went fishing at least once during the sample period and who also listed one of the five categories of trout as one of their three most frequently targetted species. Anglers who target bass exclusively are not members of the intended user group, for example.

Table 2 thus describes parameter estimates and asymptotic t-ratios for our probit model of participation in fresh-water recreational fishing in

---

[16] For this functional form, no distinct estimates of the usage-status-specific α parameters are available (we estimate only ($\alpha^1_u - \alpha^0_u$) and ($\alpha^1_n - \alpha^0_n$)). Second, the level of the environmental amenity, A, enters in log form so that its magnitude conveniently drops out of the utility difference function that is estimated. This is fundamentally necessary because no data on the absolute level are available. The constant $-\omega_j \log(0.8)$, j = n, u, is absorbed by the constant term in each utility difference function in the estimation process, so neither term in the second line of the formula can be recovered.

Table 2

Fishing Participation Probit Model

Estimated both as (i.) one equation in a joint probit specification, and (ii.) derived from ordinary probits using 50 multiple imputations of the income variable)

Dependent variable: USER

Value	Label	Count	Percent
0	no	3582	82.94
1	yes	737	17.06

	Bivariate Probit Model (with CVM response)		Single Probits on 50 imputations of income	
Independent Variable	Est. Coef.	t-Stat.	Est. Coef.	t-Stat.
INTERCEPT	-0.5242	-1.663	-0.5309	-1.815
AGE	-0.02803	-1.966	-0.02726	-2.115
AGE2	1.346e-04	0.827	1.265e-04	0.878
INC	0.002899	0.651	0.002760	0.621
INC2	-8.031e-06	-0.745	-8.147e-06	-0.708
AGE*INC	-5.200e-05	-0.585	-5.191e-05	-0.587
SECR	-0.09645	-1.241	-0.09473	-1.210
FEM	-0.1461	-2.339	-0.1474	-2.425
RETI	0.1174	0.770	0.1169	0.827
BLK	-0.5797	-1.415	-0.5922	-1.566
AMIN	-0.02276	-0.139	-0.01498	-0.088
PART	-0.1891	-1.840	-0.1892	-1.924
NOEM	0.1365	1.239	0.1352	1.264
UNEM	0.04550	0.332	0.04386	0.342
STUD	-0.07536	-0.366	-0.07028	-0.339
URB	0.06184	0.797	0.06373	0.813
CNTY	-0.1161	-1.359	-0.1150	-1.372
LILL	0.01218	1.698	0.01247	1.707
LILR	0.0010	0.572	0.001078	0.602
POP	-0.2543	-1.884	-0.2648	-1.921
VT	0.5877	6.677	0.5893	6.961
NH	0.3297	3.302	0.3278	3.436
ME	0.5192	4.750	0.5133	5.001
PAST	-0.9230	-13.132	-0.9297	-13.66
YRS	0.08637	15.493	0.08588	15.79
YRS2	-0.001112	-10.076	-0.001106	-9.429

high-altitude lakes in the Northeast U.S. Two sets of point estimates and standard errors are provided. The first set is for the participation portion of a bivariate probit model where the participation outcome and the contingent valuation response are estimated jointly. The second set gives point estimates and modified standard errors that result from 50 multiple imputations of the grouped data income variable. Most coefficients bear the anticipated sign. Three categories of variables are employed in calibrating the participation submodel. First, we use characteristics of the individual respondent. The model is fully quadratic in AGE and INC (income), but only the linear term in AGE is individually statistically significant.

There are also several dummy variables: ownership of a secondary residence (SECR) decreases participation and retired status (RETI) increases participation, although neither effect is significant. Participation is insignificantly lower for blacks and American Indians. It is significantly lower for females (FEM), however.

Part-time employment, relative to full-time employment, results in an almost significant decrease in participation. Being unemployed, or out of the labor force (as opposed to retired), both increase participation, although not significantly. Student status produced a negligible decrease in participation.

The second category of variables attempts to capture the extent of water-based recreational opportunities available in the respondent's home county. Participation is insignificantly lower for residents of urban counties (URB). CNTY is the total county area, in acres. LILL is acres of water in bodies less than two acres, LILR is acres of water in rivers or streams less than 66 feet wide, and POP is the county population estimate for 1985. Only the acreage of small lakes comes close to having an individually significant effect among the water area variables. Being from a more densely populated county, controlling for county area, has a negative effect upon participation.

Relative to New York State (the omitted category), participation by residents of the states of NH, ME and VT all exhibit statistically significantly higher probabilities of participation.

The last set of variables attempts to control for past fishing participation of any type. Whether or not an individual has fished in the past, and how intensively, is an important indicator of the probability that they will participate in the current year. The past participation dummy alone bears the opposite sign from that anticipated, but one must bear in mind that the effect of past participation is captured by all three of the variables (PAST, YRS, and YRS2) if PAST is not zero. All three variables are highly significant.

The sociodemographic factors must be included in addition to these past participation variables because we discriminate between "fishing in general" and "fishing in high-altitude lakes." While the inclusion of this lagged, partially endogenous variable renders our specification dynamic, which complicates our forecasting exercises, it has the potential to dramatically increase the accuracy of our probability estimates.

b.) <u>The Referendum Contingent Valuation Probit Model</u>

Table 3 gives the contingent valuation random utility probit parameter estimates and asymptotic standard errors for the jointly estimated bivariate probit participation and valuation models. It also gives analogous results

Table 3

Indirect Utility-Difference Function Parameter Estimates

Referendum CV Question: WTP to Prevent Acid Rain Damage to 20% of all Currently Fishable High-Altitude Lakes in the N.E.

Dependent variable: WTP offered amount?

Value	Label	Count	Percent
0	no	1155	26.74
1	yes	3164	73.26

Independent Variable	From Bivariate Probit (with participation) β_n^*, α_n^* Coef. (t-ratio)	From Bivariate Probit (with participation) β_δ^*, α_δ^* Coef. (t-ratio)	From 50 imputations of Y and the selectivity terms β_n^*, α_n^* Coef. (t-ratio)	From 50 imputations of Y and the selectivity terms β_δ^*, α_δ^* Coef. (t-ratio)
log[(Y-t)/Y]	140.89 (13.92)	-23.86 (-0.763)	142.78 (9.218)	-21.88 (-0.586)
INTERCEPT	0.9889 (10.77)	0.1645 (0.675)	1.030 (10.52)	4.139e-02 (0.155)
SECR	0.1534 (2.288)	-0.1673 (-1.011)	0.1577 (2.372)	-0.1673 (-1.042)
TRSC	0.1786 (1.733)	-0.2561 (-1.141)	0.1827 (1.829)	-0.2560 (-1.161)
COLG	0.1947 (3.867)	-0.1054 (-0.778)	0.1940 (3.855)	-0.1078 (-0.8111)
AGE	-9.237e-03 (-4.741)	5.336e-03 (0.926)	-9.455e-03 (-4.742)	5.273e-03 (0.9553)
RETI	-0.1132 (-1.328)	-0.1334 (-0.533)	-0.1161 (-1.379)	-0.1340 (-0.5518)
UNEM	-0.2103 (-2.015)	0.5950 (1.952)	-0.2156 (-2.092)	0.5984 (2.010)
NOEM	-0.1242 (-1.480)	0.3259 (1.239)	-0.1258 (-1.519)	0.3225 (1.264)
BLK	-0.3387 (-1.807)	a	-0.3493 (-1.893)	a
FEM	0.1555 (3.271)	-2.462e-02 (-0.190)	0.1498 (3.147)	-3.549e-02 (-0.271)
ρ	-0.07858 (-1.069)	-	-	-
λ^n	-	-	5.310e-03 (0.1504)	-
λ^u	-	-	3.815e-02 (0.2395)	-

[a] The very small number of black respondents in this category made it inappropriate to estimate a coefficient differential for this group

for the sequentially estimated model that reflects the deficiency in the income variable, with all estimates corrected for both the grouped income data and the estimated selectivity correction terms. These estimates of the indirect utility difference function warrant attention primarily because they show how the user and non-user indirect utility functions differ. The basic theory behind the model allows for systematically different utility functions for users and nonusers, and our model retains this feature.

In Table 3, the first column of estimated coefficients in the pair of columns for each estimation method pertains to the non-user indirect utility function (i.e. β_n^* is the coefficient on log[(Y-t)/Y] and the α_n^* are the coefficients on the remaining variables). The second column of point estimates in each pair contains the differentials β_δ^* and α_δ^* to be added to the first column to yield the estimated indirect utility parameters for users (β_u^* and α_u^*). The coefficient ρ is the estimated error correlation for the bivariate probit model. The estimated coefficients on λ^u and λ^n are ρ_u and ρ_n, respectively, for the sequential method.

The coefficient β_n^*, the marginal utility of log income for non-users, is very strongly statistically significantly different from zero at about 141 to 143. The corresponding marginal utility for users bears a point value smaller by 22 to 24, but is not significantly different from the value for non-users.

Classes of explanatory variables in the "X" category (sociodemographic shifters of the indirect utility function) include ownership of a secondary residence, educational attainment (omitted category is less-than-college graduate), age, and dummy variables for race, gender, and employment status. For non-users, the utility difference increases with education level. AGE is individually significant and the point estimate implies that the utility difference is declining with age over the ages represented in our sample. Retired status decreases the utility difference, although not significantly. The utility difference is higher if a secondary residence is maintained. Utility is statistically significantly lower for blacks (at the 10% level), but higher for females. The latter result is somewhat surprising because Table 2 shows that women are less likely to participate in fishing. While the state dummies had a dramatic effect on participation, the had uniformly small and insignificant effects in the valuation portion of the model.

The second column in each pair in Table 3 shows that few of the user utility-difference parameters is individually significantly different from the corresponding non-user parameter at the 5% level. The major exception is UNEM, unemployed status. For non-users, unemployment decreases the utility-difference significantly, but for users, unemployment has a statistically significant positive effect. The results for the not employed dummy variable are similar, although not statistically significant.

In this particular example, the selectivity problem does not appear to be as important as it is in the analysis of some of the other three contingent valuation questions posed on our survey.[17] In the bivariate probit version of the model, the single point estimate of the error correlation ρ is very small, negative and insignificant. In the sequentially estimated version, neither constrained nor unconstrained estimates of the ρ parameter on the λ terms were statistically significantly

---

[17] The researcher cannot know the impact of selectivity ex ante. The selectivity correction terms must be constructed and included in the estimation of the utility-difference parameters whenever participation might be endogenous. Alternately, joint probit models should be used.

different from zero. These results, however, contrast with the implications from a sequentially estimated model without recognition of the estimated nature of the selectivity correction terms. Since our example is intended as a prototype for future applications, it is important to emphasize that selectivity bias cannot be ruled out universally in models of this type because it does not appear to be statistically significant in this particular example. It will need to be assessed in every application.

c.) Empirical Cost-Benefit Quantities

For cost-benefit purposes, we are less interested in the bivariate probit coefficients (or in the two sets of ordinary probit parameter estimates from the sequential model) and more interested in particular functions of these estimated parameters and the data. For all of these quantities, we employ the means for each individual across a set of Krinsky-Robb simulations. Table 4 presents comprehensive descriptive statistics for the marginal distributions across our entire sample of 4319 respondents of the individual average cost-benefit quantities calculated from 50 Krinsky-Robb simulations (including mean, standard deviation, minimum, maximum, skewness and kurtosis). Recall that we are treating these individual simulation means as analogous to point estimates of the individual values, had analytical formulas for their expectations been tractable.

Our estimated option price (the ex ante measure) for acid rain damage to 20% of all currently fishable high altitude lakes is roughly $253. The ex post measure, expected consumer surplus, is very little different at about $258. The expected value of the fair bet, however, is approximately $289. These quantitative results are dependent upon the definition of a "user" adopted in the estimation process. These particular values focus on

Table 4

Descriptive Statistics across Estimating Sample (n = 4319) for Means (over 50 Krinsky-Robb simulations) of Selected Cost-Benefit Quantities (using bivariate probit parameter estimates)

Measure	Mean (Std. Dev.)	Minimum Maximum	Skewness Kurtosis
S_n	\$ 234.62	\$ 13.74	4.51
(non-user surplus[a])	(200.45)	3069.68	41.38
S_u	375.92	31.39	4.32
(user surplus)	(304.56)	4407.29	37.53
E[S]	258.16	14.46	4.51
(expected surplus)	(217.48)	3076.81	41.00
OP	252.89	14.26	4.51
(option price)	(212.97)	3074.16	41.06
OV	-5.27	-121.63	-4.047
(option value)	(7.73)	-0.000409	36.13
E[fb]	288.53[b]	16.82	4.46
(expected fair bet)	(244.24)	3259.89	39.85

[a] Interpreted as "existence and bequest value"

[b] Interior fair bet points occurred for only 24.5% of the Krinsky-Robb simulations, on average. At most, 72% were interior, but for some individuals, none were. This stems from the near-linearity of the individual WTP loci.

anglers who target trout and who have been fishing this season. (We might, instead, consider anyone who has ever been fishing as a "user," so that participation characterizes just over 80% of the sample. The resulting option price is just less than \$280, expected consumer surplus is just over \$280, S_n is \$158 and S_u is \$306.)

For each individual in our sample, our estimate of S_n can be translated as ex post non-user equivalent variation and S_u is total ex post user equivalent variation. Each individual's WTP locus passes through the point S, but its shape depends crucially on the individual's perceived participation probabilities P_n and P_u (see equation (24). What is the effect of reducing someone's use probability to zero?

For any individual, as P_u approaches zero and P_n approaches one, their WTP locus becomes steeper and steeper (see equations (24-26)) until, in the limit, its intercept with the γ_n axis in Figure 1 goes to S_n. So S_n is the value each individual would place on the resource if we chose to simulate circumstances wherein it was impossible for him or her to use the resource. We interpret S_n as "existence and/or bequest value." By similar reasoning, $S_u - S_n$ can be considered the incremental value of the resource that comes with use. This analysis therefore suggests that non-use values are a very substantial component of total user value.

Assuming diminishing marginal utility for fishable lakes, the sample average S_n value, \$235, can be interpreted as an estimate of the per-capita existence value of "the last" 20% of all currently fishable high-altitude lakes. Five times this dollar figure might therefore be considered a lower bound on the per-capita existence value of the fishability of all high-altitude lakes in the Northeast. If the represented population consists of roughly 13 million people, a crude estimate of the total dollar value is $15.3 billion annually ($235 * 5 * 13 million).

Our sample median individual option price is roughly $ 213, indicating that a majority of our sample would be willing to vote in favor of a policy to prevent the damage that resulted in uniform costs of $ 213 to each person. The types of individuals who are likely to be willing to pay more, or less, are also revealed by our model. This information could be very useful to either the government or to industry for identifying and mobilizing their respective constituencies for a referendum on this issue.[18]

Our analysis has focused upon option prices under the assumption that only a common "sure" payment for acid rain mitigation would be implemented, despite identifiable differences in user/non-user contingent payments for each individual. In practice it is possible to go part way towards usage-contingent payments with a crude mixed payment strategy. The uniform component might consist of cost to everyone (for example, via higher product prices) equal to the mean existence and bequest value. Users could then be "taxed" (through user fees) an amount necessary to match the total use/non-use differential for current users. This tax would probably have to be larger than the current average use/non-use differential because of the effect of such a tax on participation. In a somewhat richer specification, the participation elasticity with respect to annual fees can be approximated from a participation model. At present, omitted variables leave income with an apparent negative effect on participation, so this payment scenario

[18] The lower quartile of option prices in our sample is $125 and the upper quartile is $318. A thorough analysis of the sensitivity of value estimates to the presence of influential observations would perhaps include a re-estimation of the model using only respondents having option prices, say, in the inter-decile range according to this basic model.

cannot be simulated reliably.

As was mentioned in the discussion of the stochastic specification, the individual WTP loci in this example are almost linear, having little curvature because (Y-S)/Y is so close to unity. Plots of the WTP locus for every individual could readily be generated, and there is great variability in the slopes and locations of these curves across respondents. Option price, expected consumer surplus, and option value can easily be computed for each individual in the sample.

The aggregate WTP locus is not relevant in this application because the points from which it is assembled are determined under the assumption of identical "community" uncertainty (P_n/P_u) for each individual. Individual probabilities of use and non-use will always differ. The only time they would be identical would be if the resource was eliminated so that all probabilities fell to zero.

d.) <u>Using the Calibrated Model for Forecasting and Simulation</u>

The estimated structural parameters for freshwater fishing participation probabilities and for the indirect utility difference function associated with our acid rain CV question are interesting in their own right. So are the estimates of <u>current</u> cost-benefit quantities: individual option prices, expected surpluses, option values, and individual WTP loci. However, because we have been careful to control for a wide range of factors which can influence participation and resource values, our model is well-suited for forecasting and simulation.

In the most general case, we can consider a unilateral permutation of a variable that appears both among the Z variables in the participation probability model and among the X variables in the CV indirect utility model. For example, the age distribution in the US is expected to shift upwards over the next twenty years due to the "graying" of the baby-boom generation. By 2010, the average U.S. citizen will be roughly 5 years older. We can retain the calibrated parameters of our participation submodel and our main CV indirect utility difference model and counterfactually simulate a crude approximation to this change by arbitrarily adding 5 years to the age of every respondent in the sample.[19]

The change in ages will change fitted participation probabilities in each of the five subsequent years, due to the dynamic nature of our participation model. These altered participation probabilities will directly affect three components of the model: the slope of the iso-expected value line facing each individual, the location of each individual's S point, and the shape of each individual's WTP locus. But each person's S point and WTP locus are also determined by point estimates produced by the second-stage CV indirect utility function model, and a permutation of age for each person will change all of the estimated f_j quantities as well. Figure 2 illustrates the flow of effects from permuting the values of the age variable.

Rather than detailing the effects of our simulated age change at each stage in Figure 2, we summarize the overall effect in Table 5 by showing how the distributions of each of the candidate welfare measures change when all ages are permuted upwards by 5 years (Simulation 1). The effects are very little different if we additionally force into retirement (RETI=1) all

---

[19] Our cross-sectional data set does not allow this important distinction between age effects and cohort effects. Information from a panel-type survey would be required for this. This simulation therefore ignores cohort effects but still illustrates the forecasting technique.

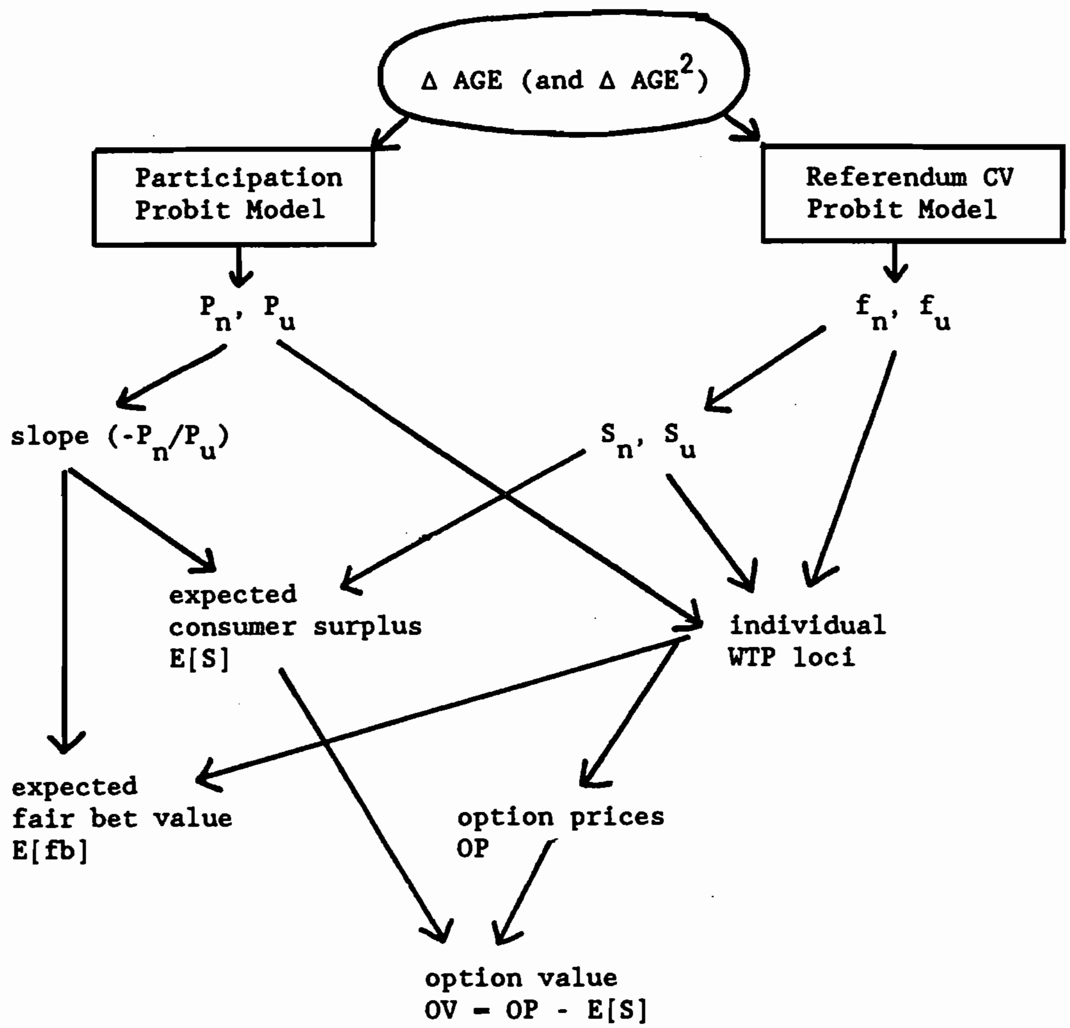


Figure 2: Pathways for Effects of Counterfactual Simulations

Table 5

Descriptive Statistics across Estimating Sample (n = 4319) for Means (over 50 Krinsky-Robb simulations) of Selected Cost-Benefit Quantities

Measure	SIMULATION 1 Increase AGE by 5 years: Mean (Std.Dev.)	SIMULATION 2 Increase AGE and impose retirement[a] Mean (Std.Dev.)	SIMULATION 3 Increase Y by $4000: Mean (Std.Dev.)
S_n (non-user surplus[b])	$ 225.88 (193.63)	$ 224.81 (193.19)	$ 259.75 (202.71)
S_u (user surplus)	370.12 (300.36)	366.98 (298.95)	416.82 (306.86)
E[S] (expected surplus)	246.43 (208.14)	245.27 (207.75)	285.99 (220.04)
OP (option price)	241.57 (204.04)	240.44 (203.64)	280.13 (215.41)
OV (option value)	-4.86 (7.49)	-4.83 (7.46)	-5.86 (8.19)
E[fb] (expected fair bet)	273.82[c] (232.88)	272.69 (232.57)	319.65[d] (247.27)

[a] Retire everybody who is 65 or older (after the simulated age increase).

[b] Interpreted as "existence and bequest value."

[c] Interior fair bet points occurred for only 26.6% of the Krinsky-Robb simulations, on average. At most, 72% were interior; in some cases, none were. (Very similar results for Simulation 2.)

[d] Interior fair bet points occurred for only 24.6% of the Krinsky-Robb simulations, on average. At most, 72% were interior; in some cases, none were.

respondents older than 65 after this age change (Simulation 2). Simulation 3 is a $4000 increase in real income for all respondents. This real income increase is also approximately consistent with forecasts for the year 2010. The separate effects of the age increase and the income increase are partially offsetting. If only the age increase took place, acid rain damage prevention would be a potential Pareto improvement if per-capita costs were less than about $ 241 (instead of $ 253). If only the real income increase took place, prevention would remain potentially Pareto-improving even if costs were as high as than $ 280.

It is important to note that our model makes it perfectly feasible to simulate simultaneous shifts in any or all of the exogenous variables which enter our participation and/or indirect utility-difference models. The overall effects of these simultaneous changes can then be assessed using any of the re-calculated cost-benefit quantities or the new WTP loci.

6. CONCLUSIONS

This paper develops a utility-theoretic empirical implementation of Graham's (1981) deterministic theory of cost-benefit analysis under uncertainty. Respondents' revealed behavior is used to infer their likely subjective participation probabilities. This information is then combined with a basic indirect utility function calibrated using responses to a referendum contingent valuation question concerning acid rain damage to freshwater resources in the Northeast United States. Participation probabilities are specifically recognized to be endogenous in our model of individual resource values. We are able to attain most of the interesting alternative measures commonly considered in cost-benefit analyses in the presence of uncertainty.

As was shown by Graham (1981) and recently reiterated by Smith (1990), in the absence of individually insurable risks, the best measure of individual welfare for ex ante cost-benefit analysis is the option price associated with the project for each individual. This measure is unambiguously identified in our model and is very easy to calculate, as are other measures developed in the theoretical literature and relevant to our application, (with the sole exception of the "certainty point"). Our model even allows different welfare concepts to be used for different groups of individuals in a sample, if so desired, since all measures are available for everyone.

Several issues keep re-emerging in the literature on cost-benefit analysis under uncertainty: (i.) how do changes in the likelihood of participating change the value of the good? and (ii.) how important is the existence or nonexistence of actuarially fair insurance markets affect the social value of a project (or, here, an environmental change)? (iii.) what about option value? and (iv.) how should existence values be measured empirically?

The first issue can be addressed in a perfectly straightforward manner in the framework of our model. The calibrated first-stage probability model and second-stage indirect utility model can readily accept counterfactually simulated changes in any of the wide range of variables which drive the model. These simulations produce new probabilities and new individual willingness-to-pay loci for each respondent in the sample. New values for the alternative welfare measures produced by our model are then available.

Since endogenous participation probabilities are explicitly modelled in this study, we can examine the factors which influence demand uncertainty. To our knowledge, no other empirical study had yet adopted this strategy. Purely exogenous changes in participation probabilities can also be readily simulated. If some purely arbitrary factor is expected to change only the individual probabilities, without affecting the utility function(s), these new probabilities can also be "cranked" through the model to provide our full array of valuable information about anticipated welfare consequences. Factors which uniformly influence community risk, as opposed to individual risk, could also be modelled in this fashion.

The second issue concerns welfare measurement when individuals are, or are not, able to obtain fair insurance against their uncertainty about whether or not they will be participants. Without actuarily fair insurance for individuals against their user/non-user status, no expected value measure of welfare is relevant (neither the expected surplus, E[S], nor the expected value of the fair bet point, E[fb]). If such insurance is available, the fair bet point has the largest expected value of all pairs of contingent payments along the individual WTP locus and therefore it conveys the most appropriate measure of benefits. The fair bet point is easily solved-for from each individual's willingness-to-pay locus in our empirical model.

Our response to the third issue, option value, succinctly summarizes one of the main contributions of this paper. The considerable debate over the sign and size of option value has been motivated by the need to quantify the difference between the first best and second best measures of welfare. The earlier work was based on the premise that first best measures often cannot be estimated. The development of a modelling strategy and an empirical technique which allows researchers to directly estimate first best measures has been our goal in this project. By estimating the parameters of a well-defined indirect utility-difference function and deriving the corresponding individual willingness-to-pay loci, each of the potentially first-best measures of welfare become available to the researcher.

Finally, our methodology illustrates an intuitively appealing derivation of existence and bequest (non-use) values for environmental resources. Non-use value is, on the one hand, value accruing to non-users, but the mean value to this group may be an inappropriate statistic because of self-selection into this group. On the other hand, non-use values also accrue to current users of the resource, so that total value must be decomposed into non-use value and the increment to value that comes with use. In order to achieve this decomposition, it is necessary to be able to simulate, for users, what their individual values would be if they had been non-users. Our framework readily accommodates these tasks.

REFERENCES

Brookshire, D.S., L.S. Eubanks, and A. Randall (1983) "Estimating Option Prices and Existence Values for Wildlife Resources," Land Economics (59) 1-15.

Brownstone, D. (1991) "Multiple Imputations for Dynamic Econometric Models," working paper, Department of Economics, U.C. Irvine.

Cameron, T.A. (1988) "A New Paradigm for Valuing Non-market Goods Using Referendum Data: Maximum Likelihood Estimation by Censored Logistic Regression," Journal of Environmental Economics and Management (15) 355-379.

Cameron, T.A. and M.D. James (1987) "Efficient Estimation Methods for 'Closed-Ended' Contingent Valuation Surveys," Review of Economics and Statistics (69) 269-276.

Chavas, J.-P. (1991) "On Welfare Analysis under Temporal Uncertainty," Land Economics (67) 37-48.

Chavas, J.-P., R.C. Bishop, and K. Segerson (1986) "Ex Ante Consumer Welfare Evaluation in Cost-Benefit Analysis," Journal of Environmental Economics and Management (13) 255-68.

Chipman, J.S. and J.C. Moore (1980) "Compensating Variation, Consumer Surplus and Welfare," American Economic Review (70) 933-49.

Colby, B.G., and D.C. Cory (1989) "Valuing Amenity Resources under Uncertainty: Does the Existence of Contingent Claims Markets Matter?" Journal of Environmental Economics and Management (16) 149-55.

Cory, D.C. and B.C. Saliba (1987) "Requiem for Option Value," Land Economics (63), 1-10.

Cummings, R.G., D.S. Brookshire, and W.D. Schulze (1986), Valuing Environmental Goods: An Assessment of the Contingent Valuation Method, Totowa, New Jersey: Rowman and Allenheld.

Freeman, A.M. III (1989) "Ex Ante and Ex Post Values for Changes in Risk," Risk Analysis (9), 309-17.

Goldfeld, S., and R.E. Quandt (1986) GQOPT. Princeton, NJ: Princeton University.

Graham, D.A. (1981) "Cost-Benefit Analysis under Uncertainty," American Economic Review (71) 715-725.

Graham, D.A. (1984) " Cost-Benefit Analysis under Uncertainty: Reply" American Economic Review (74) 1100-1102.

Greene, W.H. (1990a) Econometric Analysis. New York: Macmillan.

Greenley, D.A., R.G. Walsh, and R.A. Young (1981) "Option Value: Empirical Evidence From a Case Study of Recreation and Water Quality," Quarterly Journal of Economics (96) 657-683.

Hammond, P.J. (1981) "Ex-Ante and Ex-Post Welfare Optimality Under Uncertainty," Economica (48) 235-50.

Hanemann, W.M. (1984) "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses," American Journal of Agricultural Economics (66) 332-341.

Hausman, J.A. (1981) "Exact Consumer Surplus and Deadweight Loss," American Economic Review (71), 662-76.

Hirshleifer, J. (1965) "Investment Decision under Uncertainty: Choice-Theoretic Approaches," Quarterly Journal of Economics (79), 509-536.

Hirshleifer, J. (1966) "Investment Decision under Uncertainty: Applications of the State-Preference Approach," Quarterly Journal of Economics (80), 252-275.

Krinsky, I, and A.L. Robb (1986) "On Approximating the Statistical Properties of Elasticities," Review of Economics and Statistics (68) 715-719.

Krutilla, J.V. (1967) "Conservation Reconsidered," American Economic Review (57) 777-786.

Madariaga, B., and K.E. McConnell (1987) "Exploring Existence Value," Water Resources Research (23) 936-942.

Maddala, G.S. (1983) Limited-dependent and Qualitative Variables in Econometrics. Cambridge: Cambridge University Press.

McConnell, K.E. (1983) "Existence Value and Bequest Value," in R.D.Rowe and L.G. Chestnut, eds., Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. Boulder, CO: Westview Press.

McKenzie, G.W. and I.F. Pearce (1982) "Welfare Measurement: A Synthesis," American Economic Review (72) 669-82.

Mendelsohn, R. and W.J. Strang (1984) "Cost-Benefit Analysis under Uncertainty: Comment," American Economic Review, (74) 1096-1099.

Randall, A. and J.R. Stoll (1983) "Existence Value and a Total Valuation Framework," in R.D. Rowe and L.G. Chestnut, eds., Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. Boulder, Co: Westview Press.

Rubin, D.B. (1987) Multiple Imputation for Nonresponse in Surveys, New York: Wiley.

Sanders, Larry D., Richard G. Walsh, and John B. Loomis (1990) "Toward Empirical Estimation of the Total Value of Protecting Rivers," Water Resources Research (26), 1345-1357.

Schmalensee, R. (1972) "Option Value and Consumer Surplus: Valuing Price Changes Under Uncertainty," American Economic Review (62), 813-24.

Shankle, S.A., J.E. Englin, W.H. Monroe, D.M. Beck, M.F. Casinelli, H. Saunders, and S.E. Grover, (1990) "Freshwater-Based Recreation in the Upper Northeast: Data Collection Documentation," Battelle Memorial Institute, Pacific Northwest Laboratory, USDOE, prepared for National Acid Precipitation Assessment Program, November.

Smith, V.K. (1987a) "Uncertainty, Benefit-Cost Analysis and the Treatment of Option Value," Journal of Environmental Economics and Management (14) 283-292.

Smith, V.K. (1987b) "Non-Use Values in Benefit-Cost Analysis," Southern Economic Journal (54) 19-26.

Smith, V.K. (1990) "Valuing Amenity Resources under Uncertainty: A Skeptical View of Recent Resolutions," Journal of Environmental Economics and Management (19) 193-202.

Walsh, R.G., J.B. Loomis, and R.A. Gillman (1984) "Valuing Option, Existence, and Bequest Demands for Wilderness," Land Economics (60) 14-29.

Weisbrod, B. (1964) "Collective-Consumption Services of Individual-Consumption Goods," Quarterly Journal of Economics (78) 471-77.

Willig, R.D. (1976) "Consumer's Surplus without Apology," American Economic Review (66) 589-97.

APPENDIX I

Distillation of the Survey Data

a.) Geographical Information

The forty randomly selected counties belong to individual states as follows: counties 1 to 6 (Maine), counties 7 to 10 (New Hampshire), counties 11 to 34 (New York), and counties 35 to 40 (Vermont).

Maps of the Northeast were used to determine whether each county contains or is adjacent to a major urban area. This information is captured by the rough dummy variable URB.

Counties were matched with their corresponding FIPS codes so that data could be spliced in from the NORSIS data files.

If the age of the respondent is unavailable, observations were dropped from the data set.

If the person has taken a freshwater fishing trip in the relevant area since April 1 of the current year, the participation dummy variable is set equal to 1. If not, the dummy is set equal to zero. An alternative assumption also assumes current participation if any trips are planned between now and the end of the current year.

The contingent valuation questions are all of the "closed-ended" or "referendum" contingent valuation variety. Possible responses include: YES, NO, DON'T KNOW, and REFUSED. Initial analyses will focus on the YES and NO responses, but attention will also be devoted to the determinants of the ambiguous responses. (Furthermore, interviewers were asked to circle question numbers which they believed that the respondent had difficulty answering. This additional information could also potentially be utilized at a later date.)

The dollar amounts entered on the questionnaires were randomly assigned in advance from a predetermined list of values between $1 and $100. The full set of CV questions was:

Q-5: "If the abundance of trout could be doubled in lakes and streams in the Northeast, would you be willing to pay ____ per year for this benefit?"

Q-6: "If algae growth from sources such as agricultural runoff could be reduced so that you could see twice as deep into lakes and rivers would you be willing to pay ____ per year for this benefit?"

Q-7: "If acid rain damaged fishing in 20% of all currently fishable high altitude lakes in the Northeast, would you be willing to pay ____ per year to prevent this?"

Q-8: "Suppose half of all lakes in the Northeast were unfit for swimming due to pollution would you be willing to pay ____ per year to prevent this?"

If the respondent owns a secondary residence, the dummy variable SECR equals one, otherwise it is zero.

The available ten categories of educational attainment (highest level of education completed) are coded as a set of six dummy variables. The omitted category is "High School Graduate". "No Formal Education" and "Grade School" are combined as GRSC=1 due to the small number of individuals in the first category. SOMH is "Some High School." The omitted category of highschool graduate includes individuals with some college education. COLG is "College Graduate" or "Some postgraduate education." MAST is "A Master's Degree" and DOCT is "A Doctoral Degree." TRSC is trade school.

The respondent's current employment situation is summarized in six categories. The omitted category is "Employed Full Time." Other dummy variables are PART (Employed Part Time), NOEM (Not Employed Outside the Home), RETI (Retired), STUD (Student), and UNEM (Unemployed).

Racial and ethnic background information was also solicited from respondents. The omitted category is WHITE. Dummy variables indicated American Indian (AMIN), Mexican American (MEXA), Asian American (ASIA), and Black (BLK).

As is typical in these surveys, income data are only available at a very coarse level. The household's total income before taxes in 1988 was requested and intervals were implied by the respondent's answers. Representative values (MIDINC) were assigned somewhat arbitrarily as follows:

less than $ 10,000	coded as	7	($ '000)
$ 10,001 to $ 20,000		15	
$ 20,001 to $ 30,000		25	
$ 30,001 to $ 40,000		35	
$ 40,001 to $ 50,000		45	
$ 50,001 to $ 60,000		55	
$ 60,001 to $ 70,000		65	
$ 70,001 to $ 80,000		75	
$ 80,001 to $ 90,000		85	
$ 90,001 to $ 100,000		95	
$ 100,000 to $ 250,000		150	
more than $ 250,000		300	

If comprehensive error bars are required for the ultimate empirical implications of a study based on these data, sensitivity analysis with respect to these representative values would have to be constructed.

The gender dummy variable is FEM, equal to one for female respondents and zero for males.

For the initial estimates, we deleted respondents with incomplete data for any of the prospectively important explanatory variables. Observations were deleted if there were no data for: SECR, UNEM, PART, NOEM, RETI, STUD, GRSC, SOMH, TRSC, COLG, MAST, DOCT, URB, AGE, AMIN, ASIA, BLK, MIDINC, and FEM.

Some 285 variables are available, by county FIPS code, in the so-called NORSIS data set. The level of disaggregation of these variables is astonishing, and previous users have some reservations about the reliability of some of these data. However, it is helpful to extract some basic information from this data set on the relative availability of water-based recreational opportunities within each county.

The variables presently used in the models are:

POP85 = county population estimates for 1985 (census 1984)
CNTYACRE = total county area (census)
LILLAKE = Acres of water in bodies <2 acres
LILRIVER = acres of water in rivers/streams <66 feet wide

APPENDIX II

Robustness of the Utility Parameter Estimates

As we have noted in the body of the paper, we had responses to three other contingent valuation questions in addition to the acid rain question. We initially estimated entirely separate indirect utility difference function parameters for each of these questions. One of the other questions concerned a reduction in algae growth that would allow visibility to twice current depths (amenity level from A to 2A); a second concerned controlling pollution that would prevent swimming in half of all lakes (amenity level from A to .5A).[20] Across these three models, an interesting result emerged. Our point estimates of the marginal utility of log(income) to users and to non-users were virtually identical for the three cases!

By estimating the indirect utility difference separately for each question, we were allowing several different point estimates for what ought to be the same the same utility function parameters. This observation suggested that all three contingent valuation scenarios could be embedded in one model. Equations (10) and (11) in the body of the paper can be replaced by a set of four extended equations:

(31) $$V_j^0 = \beta_j \log(Y) + \delta_j \log P + \alpha_j^{0\prime} X + \omega_{j1}\log(A_1) + \omega_{j2}\log(.8A_2) + \omega_{j3}\log(.5A_3) + \eta^0, \quad j = n, u$$

(32) $$V_j^{11} = \beta_j \log(Y-t_1) + \delta_j \log P + \alpha_j^{1\prime} X + \omega_{j1}\log(2A_1) + \omega_{j2}\log(A_2) + \omega_{j3}\log(A_3) + \eta^{11}, \quad j = n, u$$

(33) $$V_j^{12} = \beta_j \log(Y-t_2) + \delta_j \log P + \alpha_j^{1\prime} X + \omega_{j1}\log(A_1) + \omega_{j2}\log(A_2) + \omega_{j3}\log(A_3) + \eta^{12}, \quad j = n, u$$

(34) $$V_j^{13} = \beta_j \log(Y-t_3) + \delta_j \log P + \alpha_j^{1} X + \omega_{j1}\log(A_1) + \omega_{j2}\log(A_2) + \omega_{j3}\log(A_3) + \eta^{13}, \quad j = n, u$$

---

[20] For one question, regarding WTP for doubling the abundance of trout, fitted values were extremely tiny relative to income (on the order of $10) and we have deemed the estimates for this question to be unreliable.

where A_1, A_2, and A_3 are now three distinct environmental amenities. The corresponding indirect utility-difference functions to be estimated using probit techniques become:

$$(35) \qquad V_j^{11} - V_j^0 = \beta_j \log[(Y-t)/Y] + \alpha_j'X + \omega_{j1}\log(2) + \rho_n \lambda^n + \rho_u \lambda^u + \eta'^1$$

$$(36) \qquad V_j^{12} - V_j^0 = \beta_j \log[(Y-t)/Y] + \alpha_j'X - \omega_{j2}\log(.8) + \rho_n \lambda^n + \rho_u \lambda^u + \eta'^2$$

$$(37) \qquad V_j^{13} - V_j^0 = \beta_j \log[(Y-t)/Y] + \alpha_j'X - \omega_{j3}\log(.5) + \rho_n \lambda^n + \rho_u \lambda^u + \eta'^3$$

where j = n, u in all three equations. This means that the probit intercept term among the α_j coefficients will have a different constant term added to it depending upon which question is being analyzed and upon the user/non-user status of the respondent. We cannot identify $\omega_{j1}\log(2)$, but we can estimate the difference between $\omega_{j1}\log(2)$ and $\omega_{j2}\log(.8)$, and the difference between $\omega_{j1}\log(2)$ and $\omega_{j3}\log(.5)$ by appropriate use of question-indicator dummy variables with the pooled data.

If we are willing to assume that η'^1, η'^2 and η'^3 have independent and identical normal distributions, each answer in a person's set of three responses to the CV questions can then be treated as a separate observation. This gives us three glimpses of their indirect utility function. For the exploratory models we have examined, we chose a subset of respondents who answered all three CV questions, yielding a sample of size 3349. Constraining the corresponding coefficients to be the same across all three responses involves stacking the data set to produce (3*3349) = 10047 "observations."[21]

For our pooled model, we conform the specifications by creating a set of X variables (individual attributes) consisting of the union of all X variables previously employed for the analysis of each individual contingent valuation question. We estimated three separate models, attaining individual maximized log-likelihood values of -1980.9, -1794.8 and -1507.2. When summed, the implied log-likelihood across all three questions for the pooled data and no restrictions is -5282.9. Pooling the data involves 78 parameter restrictions and produces a maximized log-likelihood of -5309.9. The value of the LR test statistic is therefore 54.0. The 5% critical value of a $\chi^2(78)$ is on the order of 100, so we cannot reject the restrictions.

Another important test concerns the necessity of allowing all of the parameters of the indirect utility-difference function to vary across users and non-users of the resource. One obvious alternative that would

---

21 Of course, there may be unique individual fixed effects that could be recognized in a more elaborate specification. However, panel data techniques in the case of probit models are not as straightforward as they are in OLS models with continuous dependent variables.

substantially reduce the dimensionality of the parameter space would be to suppress all of the user-dummy interaction variables to leave only an intercept shift dummy for users. This hypothesis involves 17 restrictions and produces a likelihood ratio test statistic of 44.8. The 5% critical value in this case is only 27.58, so we reject these restrictions.

If we were to pursue more elaborate specifications, we would clearly choose to rely upon the indirect utility parameters and the resulting cost-benefit quantities derived from the pooled data on all three questions. However, since our mission in this paper is to illustrate the empirical implementation of Graham's theory, we will use the inferences from the pooled data model merely to support the robustness of our utility-difference parameter estimates.

APPENDIX II

Discussion of Some More-Generally Related Literature

McConnell (1983) emphasizes that travel cost and hedonic property value methods are inappropriate for measuring existence value and that contingent valuation schemes are necessary. He also notes that any attempt to measure existence value must sample both users and non-users. One of the important contributions of the empirical model described in this paper is its ability to produce estimates of existence value for both non-users and users. Our data set contains identical valuation and covariate information for both users and non-users of the recreational fishing resource in question. Few previous data sets have this feature.

Existence (combined with bequest) value is generally understood to be the value that an individual would place on a particular resource if he or she was a non-user. For current non-users, this is the only component of value. For users, it is some portion of total value. What fraction of total user value can be ascribed to existence and bequest value is extremely difficult to ascertain if only a sample of users is available. In the process of calculating expected surplus E[S], we must calculate non-user and user values for each individual. It is enlightening to examine the selectivity-corrected estimates of average non-use values for both current non-users and current users. Average estimated S_n for non-users is larger than for current users. This difference also reflects the systematic differences in characteristics across the two groups, however. In particular, it undoubtedly conveys the negative effect of income (the opportunity cost of time) on participation rates.

Sanders, Walsh, and Loomis (1990) use 163 responses to an open-ended format contingent valuation mail survey regarding total value for a set of scenic rivers in Colorado. They ask respondents first for their total value and then attempt to elicit the percentages of this total value that the respondent would allocate to preservation, option, existence, bequest, and recreation use values. Atheoretic ordinary least squares regression models are used to explain each of these components as a function of individual attributes.[22] The effects of demand uncertainty could be assessed in the Sanders et al. study because respondents were asked directly to report how likely it was that they would visit any of the study rivers during the next year. However, these researchers simply tabulated resource values by three probability categories. Oddly, existence and bequest values for the zero probability group averaged $22, for the 1.0 probability group averaged $56, while for the 0.1 to .99 probability group they averaged $90. In contrast, our approach explicitly models participation probabilities (inferring them from actual participation behavior) and embeds these probabilities in a fully utility-theoretic model of consumer preferences.

Smith (1987b) notes that empirical efforts to quantify components of

---

[22] The approach is similar to that developed in Walsh, Loomis, and Gillman (1984).

non-use value "...have not been clear in specifying or attempting to determine the individual's perceptions concerning the term of access to the resource and the time horizon for future uses." Smith notes that individuals are usually able to adjust to uncertainty, and these limitations are particularly serious when estimates derived from these models are used to measure the value of changes in either attributes of the resource in question or in uncertainty itself. Smith concludes by advocating that before the relationship between measures of use and non-use values can be correctly assessed, better information is required regarding perceptions of uncertainty. Our study takes a big step toward the explicit modelling of demand uncertainty (using revealed participation choice) as a component of a comprehensive use and non-use value model in the tradition of Graham (1981). Future surveys should certainly be designed to allow both revealed <u>and</u> stated participation probabilities to be modelled.

Our approach to calculating existence values also differs systematically from that used in most previous theoretical analyses. McConnell (1983) and Freeman (1988) develop analytical models capturing existence values in the case of certainty, working from the individual consumer's expenditure function. Smith (1987a,b) argues in favor of using the "planned expenditure function," an analogous concept that defines the ex ante counterparts to the McConnell and Freeman measures. By adapting Graham's (1981) model to the case of endogenously determined individual risks, we believe our approach to be very similar in spirit to Smith's theoretical endeavors, even though we have found it more convenient and tractable to anchor our analysis upon a model of individual state-dependent indirect utility functions rather than planned expenditure functions. As Smith (1987a) argues, it is very important to develop a consistent ex ante perspective for cost-benefit analyses "...when a policy changes resources, the conditions of access to them under uncertainty, or the nature of the uncertainty itself."

Option Prices and Option Values from Market Data
Recreational Use of Old Growth Forests

Douglas M. Larson*

January 1991

Presented at the Joint WRSA/W-133 Session
on Measuring Nonmarket and Nonuse Values
Monterey, California
February 27-28, 1991

*Department of Agricultural Economics, University of California, Davis, CA 95616. I would like to thank Jonathan Rubin for providing the data used in this analysis, and Paul Flacco, Yu-Lan Chien, members of the UC Davis Natural Resources Workgroup, and participants in the W-133/WRSA meetings for helpful comments.

Option Prices and Option Values from Market Data
Recreational Use of Old Growth Forests

I. Introduction

Option value continues to be a colorful concept in environmental economics, in large part perhaps because of its elusiveness as a component of benefits measured under uncertainty. Early proponents of option value (Weisbrod [29]; Cicchetti and Freeman [8]) argued that when consumers face uncertainty, the expected value of their consumer's surplus (or more precisely, compensating variation) associated with use of nonstorable public goods services would understate their true willingness to pay for continued availability of those services. The reason for this, it was argued, is that risk-averse individuals would pay a premium (the option value) above and beyond expected consumer's surplus simply to be assured the services were available, even if they ultimately ended up never using them.

While Weisbrod's original discussion of option value and other early treatments (Long [20]; Lindsay [21]) were intuitive or qualitative in nature, papers by Byerlee [6] and Cicchetti-Freeman represented the first efforts to mathematically formalize the idea of option value, and in particular to consider risk aversion as an explanation for its sign. In particular, the Cicchetti-Freeman definition of option value as the difference between "option price," a nonstochastic payment that equates expected (indirect) utility with and without the public good, and expected consumer's surplus from having the good, has come to be widely used. Unfortunately, subsequent work (Schmalensee [27]) showed that within this framework the sign of the premium, option value, can be either positive or negative. More recent work (e.g., Smith [28]) has shown that option price can be interpreted as an *ex ante* compensating variation, which means that option value is the difference between an *ex ante* measure of welfare change and an *ex post* measure. This points out that option value, as defined by Cicchetti and Freeman and still commonly used, is not a distinct component of value *per se*, but rather the difference between two measures of welfare change under risk which differ in their temporal perspective.

This does not necessarily diminish the potential importance of option value. It remains an important question to what degree the *ex post* certainty measure, which can easily be calculated from empirical models, adequately mimics the *ex ante* compensating variation which is needed under uncertainty. There is a broad concensus among practitioners that when valuations must be made of goods for which future demand is uncertain, the *ex ante* compensating variation (or option price) is a more appropriate measure of welfare change than is the expectation of compensating variations which may actually be realized *ex post* (Schmalensee; Helms [17]; Graham [12]; Cicchetti and Freeman; Smith). Few studies have attempted to seriously grapple with the complexities raised by uncertainty for either measure.[1] Thus, what is commonly calculated in environmental benefit studies is a certainty welfare measure *ex post*, namely the individual's realized compensating variation. But as sample size increases, the expectation of *ex post* compensating variations across all individuals in the sample will approach the expected consumer's surplus. Thus, option value is important as a guide to the bias incurred when there are behaviorally important sources of uncertainty that are ignored in the calculation of benefit estimates.

Relatively few studies have attempted to measure option value empirically. Those studies which have been conducted have elicited individuals' option values through direct questioning techniques such as contingent valuation (e.g., Greenley *et al.* [13]; Brookshire *et al.* [5]; Desvousges *et al.* [9]; Edwards [10]). Not surprisingly perhaps, these efforts, while timely, are not without controversy or ambiguity concerning interpretation (Mitchell and Carson [23]; Greenley *et al.* [14]).

A central purpose of this paper is to demonstrate an alternative means for determining option prices and option values for environmental amenities, using market-related data such as that used in travel cost demand models. What is required for the approach is knowledge of the utility-theoretic structure implied by the empirical demand specification, along with knowledge of the (possibly joint) probability distributions of the random variable(s) which comprise the consumer uncertainty in the model. The link between empirical demand specifications and preferences is, by now, well-known, and it is possible to recover the indirect utility functions corresponding to a variety of commonly-used functional forms (Bockstael *et al.* [4], Hausman [16]; LaFrance and Hanemann [18]). In the literature on option value, both option price and expected surplus are defined in terms of the conditional indirect utility function, which is a construct from the theory of consumer choice under certainty. The situation addressed by option value is therefore one where consumers must provide a valuation *ex ante*, when some key parameter(s) (such as prices, income, or quality) are uncertain, knowing that they will be able to make their consumption choices optimally *ex post* when the uncertainty is resolved. The Marshallian demand functions typically estimated in demand studies are just this type of *ex post* choice function, which relate quantity consumed to (realized values of) prices, income, and shifters such as quality.

To implement the approach empirically, information about the probability distributions of variables that are random *ex ante*, when the valuation is needed, must be incorporated. Under the maintained hypothesis that individuals do face uncertainty in key parameters such as prices or income, one can interpret the actual values reported by individuals with similar characteristics as realizations of what were random variables *ex ante*. By looking across the sample at individuals with similar characteristics (e.g., miles travelled to the site), the variation in variables such as price may provide some evidence of the magnitude of uncertainty individuals faced *ex ante*.

Section I explains the theoretical framework for option price and option value, for the case of a semilog demand function. Section II briefly describes the data used in an illustration of the approach, which are from a sample of recreationists who visited forests with substantial old-growth timber in Washington state. These data, while not collected as part of the present study, provide an interesting case study for measuring option values, because of substantial nationwide publicity devoted to the plight of old-growth forests in the Pacific Northwest and elsewhere in the West. Thus, the issue of preserving old-growth forests, and the uncertainty surrounding their survival, might be expected to give rise to substantial option values for preservation of the forests. Section III develops a moment-based approach for modelling potential uncertainty faced by consumers, following the approach of Antle [1]. The results of the empirical illustration of the approach are presented and discussed in Section IV, and Section V concludes.

I. Some Theoretical Background

This section briefly sets the stage for the analysis by defining the concepts to be measured and deriving expressions for option price and option value which follow from the assumption that demand for a good can be represented in semilog or linear form. As mentioned earlier, option value has been defined and interpreted in the literature as the difference between two welfare measurement concepts. The definitions used here follow the usage of Cicchetti-Freeman and Schmalensee, though notation differs slightly to accomodate general risks with continuous probability distribution functions.

Option value has been defined in the literature (e.g., [8]) as the difference between option price (OP) and expected consumer surplus [$E(\tilde{s})$]; i.e., as

$$OV \equiv OP - E(\tilde{s}). \tag{1}$$

The tilde in $\tilde{s}$ indicates that the surplus is an *ex post* measure, which varies with outcomes of the random variables that comprise the consumer uncertainty in the model, and therefore is random itself. (The way in which it varies will be made clear below.) In contrast, option price is an *ex ante* compensating variation, a nonstochastic payment made before an individual's uncertainty is resolved. It reduces income so as to equate expected indirect utility when the good of interest is available with certainty to expected indirect utility when it is unavailable. Implicitly, option price OP is written

$$Ev(\tilde{p}, \tilde{q}, \tilde{m} - OP) \equiv Ev(\hat{p}, \tilde{q}, \tilde{m}) \tag{2}$$

where v(p,q,m) is the (conditional) indirect utility function from neoclassical consumer choice and $Ev(\cdot)$ is its expectation over the joint density of random variables; p is the price of the good of interest, which will be referred to as x, and $\hat{p} \equiv \min\{p: x(p,q,m)=0\}$ is its (Marshallian) choke price; m is income;

and q is a shifter that can represent prices of other goods, quality levels, or tastes[2]. In (2), the fact that uncertainty may come from any of the arguments p, q, or m is represented by a tilde beneath the variable (e.g., $\underset{\sim}{m}$). Also, $\hat{p}$ will vary randomly if any non-price variable is random, since it is a function of the non-price variables in the model.[3] The problem is formulated so that the option price is the maximum amount the individual will voluntarily pay for availability (with probability 1.0) of the good, since preservation versus removal of a good is often a central case where option values are thought to be important. With slight modifications, the model can also be used to determine option values corresponding to any price (or other parameter) change; one example of this setup can be found in Hartman and Plummer [15].

The expected surplus $E(\underset{\sim}{s})$ is obtained as the mean of compensating variations $\underset{\sim}{s}$ that satisfy

$$(3) \qquad v(\underset{\sim}{p}, \underset{\sim}{q}, \underset{\sim}{m} - \underset{\sim}{s}) \equiv v(\hat{p}, \underset{\sim}{q}, \underset{\sim}{m});$$

that is, for each realization of the random variables in the problem, the surplus $\underset{\sim}{s}$ equates indirect utility given the good is available to indirect utility given it is not. Conditional on specific realizations (say p^0, q^0, and m^0) of $\underset{\sim}{p}$, $\underset{\sim}{q}$, and $\underset{\sim}{m}$, (3) simply defines a compensating variation s^0 for removal of x: implicitly, $v(p^0, q^0, m^0 - s^0) = v(\hat{p}^0, q^0, m^0)$, where $\hat{p}^0 \equiv \hat{p}(q^0, m^0)$.[4] Thus, as noted above, this is an *ex post* welfare measure, and is random because it is defined by identity (3) as a function of other random variables. Solving (3) explicitly for $\underset{\sim}{s}$, one obtains

$$(4) \qquad \underset{\sim}{s} = \underset{\sim}{m} - e(\underset{\sim}{p},\underset{\sim}{q},v(\hat{p},\underset{\sim}{q},\underset{\sim}{m})),$$

where as noted above, $\hat{p}$ is also random since it depends on q and m: $\hat{p} = \hat{p}(\underset{\sim}{q},\underset{\sim}{m})$. Taking expectations, expected surplus is

$$(5) \qquad E(\underset{\sim}{s}) = E(\underset{\sim}{m}) - E\{e(\underset{\sim}{p},\underset{\sim}{q},v(\hat{p},\underset{\sim}{q},\underset{\sim}{m}))\}.$$

At this point it is worthwhile to make an observation about the difference in the welfare measures in (2) and (5). The uncertainty involved in both is identical; however, that doesn't mean that $E(\underset{\sim}{s})$ in equation (5) is equal to OP in (2). One could take expectations of (3), and note that the right hand sides of (3) and (2) are equal, which means that $Ev(\underset{\sim}{p}, \underset{\sim}{q}, \underset{\sim}{m} - OP) = Ev(\underset{\sim}{p}, \underset{\sim}{q}, \underset{\sim}{m} - \underset{\sim}{s})$. Since indirect utility is a nonlinear function, it does not follow that $OP = E(\underset{\sim}{s})$. OP just translates the random income distribution leftward, since it is a number, whereas $\underset{\sim}{s}$ modifies the income distribution in more complicated ways, based on the transformation in (3). Thus, there are two different utility distributions induced by OP and the state-dependent payments $\underset{\sim}{s}$, whose expectations are equal.

It is important to note that option value as conceptualized in the literature [and as represented in equations (1) to (5)] considers a situation where people have uncertainty about key parameter(s) they face, but they make their consumption choices *after* the uncertainty is resolved; i.e., after a value of random income and/or prices is known. In (2) and (3), both option price and the surpluses $\underset{\sim}{s}$ are defined in terms of neoclassical indirect utility functions v(p,q,m). Were consumption choices made *ex ante*, the relevant objective functions in (2) and (3) would be *expected* utility, and the indirect objective function would be indirect expected utility (*not* expected indirect utility).[5] The implication of these facts for empirical specification is clear: the choice variable (quantity demanded) depends on *realizations* of what to the individual are random variable(s) *ex ante*. Therefore, the demand function relevant for option value analysis is the usual Marshallian demand, which depends on prices, income, and other shifters, not on the distributions of variables that are random *ex ante*. Furthermore, there is a well-known link between Marshallian demands and preferences which can be recovered by integrating back (see, e.g., Hausman, LaFrance and Hanemann, or Bockstael *et al.* [4]). Thus, equations (2) and (5) suggest that option price and option value can be measured if one has knowledge of the preferences underlying the demands which are estimated econometrically, and the (joint) density of the source(s) of randomness individuals face.

A. Option Prices for Empirical Demand Specifications

While it is difficult in general to solve equation (2) explicitly for option price, it is clear that option price depends on the indirect utility function and the nature of uncertainty the individual faces. When one speaks of measuring option prices, though, specific empirical models must be employed, and it turns out that some commonly-estimated functional forms for demand, it is possible to derive explicit expressions for option price. The two common demand functions which will be used in the empirical analysis of this paper are the semilog and linear functional forms. This section will briefly develop the logic behind development of the option price expression corresponding to the semilog demand function, and will simply report the analogous expression for the linear functional form. More detail on these derivations can be found in Larson and Flacco [19].

Semilog Marshallian Demand

Suppose it is postulated that the good of interest has a semilog demand function, estimated with the dependent variable in natural log form as

(6) $$\ln x_i = \alpha + \beta p_i + \gamma q_i + \delta m_i + \epsilon_i.$$

In (6), x_i is quantity demanded and ϵ_i is the regression error for individual i[6], which represents unobservable influences uncorrelated with the variables in the systematic part of the model, while α,β,γ, and δ are the intercept term and price, quality, and income slopes, respectively. (The subscript i to index individuals will be suppressed in further derivations except as needed for clarity.) It is well-known that the implied expenditure function obtained by integrating back is, for $\delta \neq 0$,

$$\text{(7)} \qquad e(p,q,u) = (-1/\delta)\ln\left\{-\delta[u+(1/\beta)e^{\alpha+\beta p+\gamma q+\epsilon}]\right\}$$

where the constant of integration has been taken as the utility index u. The indirect utility function corresponding to (7) is

$$\text{(8)} \qquad v(p,q,m) = -(1/\delta)e^{-\delta m} - (1/\beta)e^{\alpha+\beta p+\gamma q+\epsilon}.$$

A requirement for integrability is $\beta+\delta x \leq 0$ (i.e., $e_{pp} \leq 0$), and it is assumed that x is not a Giffin good (i.e., $\beta<0$). The option price for this model is defined implicitly using (2) and (8), which results in

$$E\left\{-(1/\delta)e^{-\delta(\tilde{m}-OP)} - (1/\beta)e^{\alpha+\beta\tilde{p}+\gamma\tilde{q}+\epsilon}\right\} \equiv E\left\{-(1/\delta)e^{-\delta\tilde{m}} - (1/\beta)e^{\alpha+\beta\hat{p}+\gamma\tilde{q}+\epsilon}\right\}$$

and in this case option price can be solved for analytically as

$$\text{(9)} \qquad OP = (1/\delta)\ln\left\{1-\frac{(\delta/\beta)E\left\{e^{\alpha+\gamma\tilde{q}+\epsilon}\left(e^{\beta\tilde{p}}-e^{\beta\hat{p}}\right)\right\}}{E\left\{e^{-\delta\tilde{m}}\right\}}\right\}.$$

From (6) it is apparent that for $\beta<0$, $x \to 0$ as $p \to \infty$, so $\hat{p} = \lim_{p\to\infty} p$. Substituting this into (9) gives the expression for option price for this model in terms of observables:

$$\text{(10)} \qquad OP = (1/\delta)\ln\left\{1-\frac{(\delta/\beta)E\left\{e^{\alpha+\beta\tilde{p}+\gamma\tilde{q}+\epsilon}\right\}}{E\left\{e^{-\delta\tilde{m}}\right\}}\right\}.$$

Linear Marshallian Demand

If, instead, the Marshallian demand function is estimated as

$$\text{(11)} \qquad x_i = \alpha + \beta p_i + \gamma q_i + \delta m_i + \epsilon_i,$$

the expression for option price which results from applying the logic of the previous subsection to (11) is

$$(12) \quad \mathrm{OP} = \frac{(1/\delta)\mathrm{E}\left\{[\alpha+\beta \underset{\sim}{p}+\gamma \underset{\sim}{q}+\delta \underset{\sim}{m}+\epsilon+\beta/\delta]e^{-(\delta/\beta)(\gamma \underset{\sim}{q}+\beta \underset{\sim}{p})}\right\}-(\beta/\delta^2)\mathrm{E}\left\{e^{(\delta/\beta)(\alpha+\delta \underset{\sim}{m}+\epsilon)}\right\}}{\mathrm{E}\left\{e^{-(\delta/\beta)(\gamma \underset{\sim}{q}+\beta \underset{\sim}{p})}\right\}}.$$

Provided the (possibly joint) uncertainty which makes $\underset{\sim}{p}$, $\underset{\sim}{q}$, and/or $\underset{\sim}{m}$ random is known, an individual's option price for the availability of the resource can be calculated from (10) or (12), using the demand coefficients and the values of the exogenous variables for that person.

B. Option Values For the Empirical Specifications

Some of the later results of this paper will concern option value, and this section develops expressions for option value corresponding to the empirical specifications (6) and (11). Before proceeding, though, it is appropriate to reflect on why we might wish to be concerned about option value. As noted in the introduction, a number of recent authors have argued that option value, being simply the difference between *ex ante* and *ex post* value measures, is not a distinct component of value and therefore is of secondary concern (if it is of concern at all). It would seem that if it is possible to measure the theoretically-preferred option price directly from market data (as suggested in this paper), option value is indeed irrelevant.

However, it is undoubtedly clear to all that incorporating uncertainty into benefit-cost analysis in a realistic and correct manner is not easy. Since both option price and expected surplus (whose difference is option value) are benefit measures based on uncertainty, it is not obvious how a conclusion that option value is irrelevant helps us in evaluating conventional benefit-cost practices in the face of behaviorally-important uncertainty. With all the difficulties of measuring and incorporating uncertainty, the usual practice is to ignore it and calculate compensating variation for each individual in a sample based on the actual values of the variables, averaging across individuals to come up with an average compensating variation. The crucial question would seem to be, "What is the effect of ignoring the uncertainty on the benefit estimates so obtained?" This implies a comparison of the average compensating variation calculated when ignoring uncertainty to the average of option prices across individuals in the sample.

It turns out that option value answers this question, because the average compensating variation (ignoring uncertainty) and expected surplus (which accounts for uncertainty) are identical in the large sample. To see this, consider for simplicity the case where a single variable, say income, is random.

The usual practice would be to calculate compensating variation for person i, using that person's actual values of income and the other variables; that is to say, based on the person's *realized* income.

This is simply an *ex post* compensating variation as described in (4) for the single value of income actually realized. It is clear from (4) and (6) or (7) that the compensating variation so obtained depends both on income and on the regression error ϵ, which represents the unobservables specific to each person. Therefore, it is convenient to represent this actual (*realized*) compensating variation as $s(m,\epsilon)$, where both income and the unobservables are random, varying across the individuals in the sample.

Now the expected compensating variation computed in usual practice would be the average of the $s(m,\epsilon)$ across individuals i in the sample, which is a small sample estimate of the expectation of compensating variation as both income and unobservables vary across the population. This population expectation can be expressed formally as

$$\overline{CV} = E\left\{s(m,\epsilon)\right\} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} s(m,\epsilon)\ f(m,\epsilon)dm d\epsilon, \tag{13}$$

where $f(m,\epsilon)$ is the joint probability density function of m and ϵ. By Bayes' Theorem, this can also be written as

$$\overline{CV} = \int_{-\infty}^{\infty}\left\{\int_{-\infty}^{\infty} s(m,\epsilon)\ f(m,\epsilon|\epsilon)dm\right\}f_\epsilon(\epsilon)d\epsilon$$

where $f(m,\epsilon|\epsilon)$ is the conditional distribution of m given ϵ and $f_\epsilon(\epsilon)$ is the marginal distribution of ϵ. Performing the integration indicated within the brackets, what results is

$$\overline{CV} = \int_{-\infty}^{\infty} E_m\left\{s(m,\epsilon)|\epsilon\right\}f_\epsilon(\epsilon)d\epsilon \tag{14}$$

where $E_m\left\{s(m|\epsilon)\right\}$ is the conditional expectation of compensating variation given ϵ. Recognizing that the remaining integration in (14) is also an expectation as ϵ varies, the average compensating variation can also be written as an example of iterated expectations, namely as

$$\overline{CV} = E\left\{s(m,\epsilon)\right\} = E_\epsilon\left\{E_m\left\{s(m,\epsilon)|\epsilon\right\}\right\}. \tag{15}$$

Now consider expected surplus in the option value literature. For a specific individual (with fixed ϵ) it is defined formally by (5), and can be written equivalently in terms of $s(m,\epsilon)$ as

$$E(\underset{\sim}{s}) = E_m\left\{s(m,\epsilon)|\epsilon\right\}, \tag{16}$$

that is, as the conditional expectation of surplus taken over random income, given the individual's ϵ. Comparing with (15), it can be seen that

$$\overline{CV} = E\left\{s(m,\epsilon)\right\} = E_\epsilon\left\{E(\underset{\sim}{s})\right\},$$

or in words, the population mean compensating variation calculated ignoring uncertainty is the expectation across unobservables ϵ in the population of the expected surplus measure under uncertainty. Thus, if the expected surpluses $E(\underset{\sim}{s})$ calculated for each individual are averaged across all individuals in the sample (i.e., averaged across ϵ), this is also a sample estimate of the average compensating variation.

The point here is that the *certainty* welfare measure (average compensating variation) calculated by ignoring uncertainty is, for the population, the same measure obtained by averaging the expected surplus under *uncertainty* across individuals. In small samples they will differ due to sampling error, of course, but conceptually they measure the same thing. This is important because it means that option value can be interpreted not only as the difference between two welfare measures under uncertainty, but also as the difference between the desired option price and the welfare measure calculated ignoring uncertainty. It is a guide to the consequences of ignoring uncertainty in calculating welfare measures. If we have some understanding of how important option value is, we have information about the appropriateness of the current practice of ignoring uncertainty and calculating a point estimate of the welfare measure for each person.

Option Value in the Semilog Demand Model

To analyze option value within the framework of semilog demand, the expression for expected surplus is needed, since by (1) option value is the difference between option price and expected surplus. For this empirical model, surpluses $\underset{\sim}{s}$ are defined using (4) and (6):

$$\underset{\sim}{s} = \underset{\sim}{m} - (-(1/\delta))\ln\left\{-\delta[-(1/\delta)e^{-\delta \underset{\sim}{m}} - (1/\beta)e^{\alpha+\beta\hat{p}+\gamma\underset{\sim}{q}+\epsilon} + (1/\beta)e^{\alpha+\beta\underset{\sim}{p}+\gamma\underset{\sim}{q}+\epsilon}]\right\}$$

and substituting in for the choke price $\hat{p}$ and taking expectations, one gets

$$E(\underset{\sim}{s}) = E(\underset{\sim}{m}) + E\left\{(1/\delta)\ln\left(e^{-\delta\underset{\sim}{m}} - (\delta/\beta)e^{\alpha+\beta\underset{\sim}{p}+\gamma\underset{\sim}{q}+\epsilon}\right)\right\},$$

which is the version of equation (5) specific to the semilog demand model.

Option Value in the Linear Demand Model

For the linear model, the same logic can be used as for the semilog model, with equations (4) and (11), to obtain an expression for $\underset{\sim}{s}$ as follows:

$$\underset{\sim}{s} = (1/\delta)[\alpha+\beta\underset{\sim}{p}+\gamma\underset{\sim}{q}+\delta\underset{\sim}{m}+\epsilon+\beta/\delta] - [\beta/\delta^2]e^{(\delta/\beta)(\alpha+\delta\underset{\sim}{m}+\epsilon)}e^{(\delta/\beta)(\gamma\underset{\sim}{q}+\beta\underset{\sim}{p})} . \tag{17}$$

Taking the expectation of both sides of (17), one obtains the specific expression for expected surplus for the linear model.

II. The Data and Demand Models

To illustrate the approach for obtaining option value and option price in empirical studies, recreational use of several national parks and forests in Washington is used as a case study. These forests contain substantial acreages of old-growth timber which provide a habitat for spotted owls. Because of the prominence of the debate over preservation of owl habitat versus commercial timber harvest in the Pacific Northwest, this seems be a good case study for assessing the potential impact of option values on the debate over forest use. Old-growth timber set aside for owl habitat also provides opportunities for recreational use and activities, with an opportunity cost of foregone timber harvests.[7] Decisions made now about forest uses will affect the course of future recreational opportunities and should, to the extent possible, be based on the best and most accurate measures of net economic value in different uses.

If consumers' uncertainty about factors such as future income or prices is relevant to their recreational use of old-growth forests, the welfare measure needed for incorporating recreational values into today's decisions about forest policy is option price, the *ex ante* compensating variation associated with continued availability of old-growth forests for recreation purposes. If these forests provide services not readily found elsewhere, due to rare or unique features such as the old-growth timber, one might expect that individuals who are uncertain about future prices or income would be willing to be a substantial premium for retaining the option of using the forests recreationally at a later time.[8] If this premium, option value, is large in magnitude relative to the usual consumer's surplus measures, then good cause exists to consider uncertainty and its effect on valuation measures.

To evaluate this question of the magnitude of option value with market information, travel cost data collected in a survey of randomly selected Washington state residents were analyzed (a description of survey procedures can be found in Rubin *et al.* [25]). The questionnaire concerned individuals' recreation use, during 1986, of Rainier National Park, Olympic National Park and Forest, and Wenatchee, Gifford-Pinchot, Okanogan, and Mt. Baker-Snoqualmie National Forests. Individuals were asked about the frequency of their use of all forests, and several detailed questions regarding the forest most recently visited. While the survey was not designed for the present purpose of assessing option values, it contains enough information to assemble a rudimentary travel cost model of forest use.

Before discussing the empirical analysis, it is important to note several limitations of the data set that make it inappropriate to generalize beyond what hopefully will be an interesting examination, for a sample of people, of option value for a prominent natural resource. The response rate overall was low (about 24%), and the fraction of questionnaires usable for this analysis (about 12%) was even lower. Thus, inferences to the population made from this sample may be especially fragile. Also, some of the questions asked were somewhat imprecise, and the distinction between individual and household behavior was not always clear. The total trips variable was trips taken by household members to any of the forests, and money income was household income, while the price and time budget questions pertained more to the individual respondent. Nevertheless, these deficiencies are not all that uncommon in data on recreation choice, and the data set represents one of the better opportunities for examining behavior with respect recreational use of old-growth forests, which is an important national resource.

People making choices involving outdoor recreation can be fruitfully thought of as choosing trips to various areas subject to both money and time constraints. Time constraints can be quite important since the consumption of recreation frequently involves large amounts of time as well as the expenditure of money. In a two-constraint model, optimal demands will depend on both time and money prices and the amounts of each available. Both types of variables were available in the data set and were included in the analysis. Briefly, they were: *TRIPS*, the total number of trips taken by all household memebers to forests in the study area within the previous twelve months; *TRAVTM*, the travel time in hours per trip to the most recently visited site; *TRAVCOST*, the money cost of travel in dollars per trip; *OTRPS*, the number of trips to forests outside the study area within the previous twelve months; *HHSIZE*, the number of people in the household; *TOTIME*, a measure of the total number of hours of discretionary non-work time available; and INCOME, the household income in dollars per year. The only variable which did not come straight off the questionnaire is *TOTIME*, which is the sum of vacation days (obtained from the survey) plus 104 (the number of weekend days in a typical working year), converted to hours using a factor of 24. This is a crude measure of the time constraint, and measures discretionary time rather than total time, so the labor-leisure choice is taken to be exogenous. The variable *OTRPS* is included as an indicator of intensity of preferences for forest-based recreation, and *HHSIZE* is included because the dependent variable is trips taken by members of the household. The values of these and other variables relevant to the analysis are summarized in Table 1.

Linear and semilog demand functions were fit to the above variables, and are reported in Table 2. The models (#1 and #3) show strong significance of variables in the time constraint (*TRAVTM* and *TOTIME*), which are statistically significant at the 5% level and conform to expectations about signs (negative and positive, respectively.) The money constraint variables (*TRAVCOST* and *INCOME*) also have the expected signs, but are not statistically significant, possibly due to multicollinearity with the time variables. Both *OTRPS* and *HHSIZE* have positive signs, as would be expected, but are not statistically significant. The models suggest that time constraints are more binding than money constraints, though they explain only a small portion of the overall variation in trips. For the semilog model (#3), the hypothesis of no association cannot be rejected at the 10% level. When the insignificant money constraint variables were dropped (models #2 and #4), both models were significant at the 5% level.

The demands reported in Table 2 are price-inelastic and income-elastic. As noted previously, loglinear or Cobb-Douglas functions were also estimated and were also price inelastic, but surplus measures are not well-defined under price-inelasticity in this model. (It means the good is essential and surplus measures are infinite.) Because of this undesirable implication of the Cobb-Douglas specification when demand is price-inelastic, this specification was abandoned in further analysis of option price and option value.

III. A Moment-Based Approach to Assessing Consumer Uncertainty

In order to judge the impact of consumer uncertainty on value estimates, some means of assessing it must be devised. As mentioned earlier, the crux of the option value question is that at a point in time when consumers are uncertain about future prices or income, the worth to them of a natural resource facility must be determined. Data which are collected *ex post* do not directly reveal the influence of this uncertainty on the *ex ante* value estimates. However, *ex post* data may be meaningful and useful in assessing consumer uncertainty if they are viewed as outcomes of random variables. This section suggests an approach for modelling the moments of random variables for which data on outcomes are available. Own price and income have been of the most interest in the option value literature, so these are the focus in the empirical illustration. In the case at hand, since the time price and budget variables were highly significant while money price and budget were not, the focus will be on randomness in travel time (TRAVTM) and total recreation time (TOTIME). Uncertainty in each variable will be considered separately and the effects of the randomness on option price will be examined.

To motivate the approach, suppose that the price of a trip, in particular the amount of time required to access the site (TRAVTM), is random to the individual consumer. It seems quite likely that this variable would be random *ex ante* (that is, before the consumer visits the site the first time) if the scenery, road conditions, congestion, or even the number of miles to the destination are not known exactly. Once the travel time becomes known to the consumer, by acquiring better information from travel books, friends, or even by taking a first trip to the area, a choice of number of trips can be made. (As with many demand functions in general and with recreation demand in particular, this is a somewhat stylized description of the choice process.) When contacted *ex post*, the person will provide the *ex post* realization of travel time and the corresponding optimal number of trips taken.

If travel time is viewed as random along the preceding lines, the responses obtained in the data set can be viewed as outcomes from a probability density function of random travel time, and the moments can be modelled along conventional lines. At the simplest level, the overall sample mean and variance provide information about the *unconditional* distribution of travel time in the population. However, to take these unconditional moments as an approximation of each individual's uncertainty about travel time might well overstate the case. It is likely that the mean and variance of uncertain travel time depend on certain key factors, such as how far away the individual's home is from the site: one would perhaps expect that both increase with miles travelled. What is perhaps more relevant, therefore, for purposes of assessing consumer uncertainty is the *conditional* distributions; e.g., the mean and variance of travel time conditional on miles travelled. By considering individuals who are alike in key characteristics such as miles travelled, reported travel times can be interpreted as outcomes from conditional, rather than unconditional, probability distributions.

The process can be formalized by specifying and estimating a conditional moment model, which states explicitly how the moments of the random variable change with a set of exogenous factors. While several moment-based approaches are available, one due to Antle proves convenient and is used here. The conditional moment model extends the basic logic of the least-squares regression framework, which specifies how a set of variables X affect the conditional mean of a dependent variable Y, to the question of how X affects higher moments. If only the second moment, or variance, of Y is of interest, a heteroskedastic error model results. The conditional moment approach can easily be used to model the dependence of moments beyond the variance on exogenous factors, though in the problem at hand just the mean and variance are used.

The conditional moment approach begins with the specification of the conditional mean,

$$Y = f(X,\alpha) + \epsilon, \tag{18}$$

where α is a parameter vector[9], and $E(\epsilon) = 0$ and the other classical assumptions about ϵ hold, which is the usual linear or nonlinear regression model. Antle shows that the i^{th} power of the sample residuals $\hat{\epsilon}$ is a consistent estimate of ϵ^i, the ith moment of the true population error, so that the regression equation

$$\hat{\epsilon}^i = g(X,\beta) + \nu \tag{19}$$

provides a consistent estimate of the i^{th} moment of Y. The error ν is known to be heteroskedastic from the structure of the model (and of course ϵ is heteroskedastic by (19)), so generalized least squares (GLS) regression is needed to obtain efficient estimates for α and β. In general, for efficient estimation of moment i consistent estimates of moment 2i are needed; in the case of the variance, the feasible GLS weights can be shown to be $[h(X,\hat{\gamma})\text{-}g(X,\hat{\beta})^2]^{-0.5}$, where $h(X,\hat{\gamma})$ is a consistent estimate of ϵ^4 (Antle). The weights for feasible GLS estimation of (18) are $g(X,\hat{\beta})^{-0.5}$.

This approach was used to specify the conditional mean and variance of both travel time (TRAVTM) and total recreation time (TOTIME). Miles travelled (MLS) seemed to be the best available variable in the data set to explain differences in mean and variance of TRAVTM. There was no variable that seemed *a priori* would provide a good explanation for differences in vacation time, but one hypothesis is that this varies in a systematic way with money income level. Thus, INCOME was used as an explanatory variable in the moment equations for TOTIME.

Results of feasible GLS estimation of consistent and efficient α and β for the two random variables, TRAVTIME and TOTIME, are given in Table 5. A simple Cobb-Douglas functional form for $f(X,\alpha)$ and $g(X,\beta)$ was used to introduce nonlinearity parsimoniously. The method used in estimation was weighted nonlinear least squares using maximum likelihood with the MINIMIZE command in LIMDEP. The problem of negative values for the predicted variances needed in feasible GLS estimation, which Antle notes can occur in application of the approach, did not occur with this simple specification. Miles travelled is a significant influence on the mean of travel time, but its influence on the variance of travel time is not statistically significant at the α=.05 significance level. In the nonlinear regression of TOTIME ($x10^{-2}$) on INCOME ($x10^{-2}$), INCOME did not have a significant effect on either the mean or variance of income, though the constant terms were highly significant. The implication of this is that the unconditional mean and variance of TOTIME is the best assessment of individual uncertainty about total time available. This model is interesting in that it illustrates one extreme case: where, as best as can be determined, the mean and variance of total time available are the same for all individuals in the sample.

IV. Calculating Option Prices

When one has a representation of the uncertainty each individual faces over relevant parameters, that person's option price for removal of the resource can be calculated from equation (10). In the previous section a moment-based approach to assessing individual uncertainty was discussed, and if the conditional moment equations are correctly specified consistent estimates of the mean and variance of this conditional uncertainty can be obtained. Since the approach as developed thus far considers only the *marginal* distributions of individual explanatory variables, the discussion of option prices and option values will consider only univariate uncertainty arising from different sources.[10] (In particular, the focus will be on time price and time budget uncertainty, represented by the variables *TRAVTM* and *TOTIME.*) If $\hat{\mu}_i$ and $\hat{\sigma}_i^2$ denote these estimates of mean and variance for individual i, respectively, then by Slutsky's theorem $CV_i \equiv \hat{\sigma}_i/\hat{\mu}_i$ is a consistent estimate of the individual's coefficient of variation.

The coefficient of variation provides a convenient means of constructing random variables for each individual in the sample. In this study, the truncated normal distribution was used for convenience and realism. The truncated normal was used instead of the normal because in economic models the price and income variables are always non-negative. The idea is to sample from a normal distribution which is centered about each person's actual value of the random variable and which has variance equal to the estimated value for that person. The lower tail of the sampling distribution is truncated at zero so only strictly positive values of price or income are sampled. Each person's coefficient of variation can be used to define the point of truncation for sampling from a standard normal pdf (written N(0,1)), and for scaling the draws from a N(0,1) variate to obtain strictly positive values from a $N(\hat{\mu}_i,\hat{\sigma}_i^2)$ distribution.

For each of the 120 individuals in the sample, several welfare measures were calculated for both certainty and uncertainty. For purposes of comparison, Hicksian compensating variation and Marshallian consumer surplus measures were calculated using the individual's actual values of the explanatory variables and trips taken. Since the price and income variables are measured in time units (i.e., hours), the welfare measures represent surpluses measured in hours. As Bockstael *et al.* [3] note, in two constraint models economic surplus can be calculated can be computed in terms of the variables in either constraint, holding the other constant. Because of the high significance of the time variables and insignificance of the money constraint variables, it seems most appropriate to define welfare measures in time units. For each individual, one could in principle easily convert back and forth between money-denominated and time-denominated welfare measures if that person's marginal time-money tradeoff were known; the difficulty is often in identifying that tradeoff from observable information. In the data set at hand, the labor-leisure choice is assumed to be exogenous, so rather than attempting a time-money conversion the welfare measures are expressed in time units.

In adddition to the Hicksian and Marshallian certainty welfare measures, the option price was calculated from (10) for each individual, taking expectations over the 100 draws from the random variable. Also, for each individual, the "surplus" for each draw (which is a compensating variation) was calculated, and these were averaged to obtain the "expected surplus" referred to in the option value literature (and in equation (11)).

Results of the option price and option value simulations are presented in Tables 4 (linear model) and 5 (semilog model), for the cases where travel time is presumed uncertain and, separately, where total recreation time is presumed uncertain. It is interesting to note several features of these tables. First, the Hicksian and Marshallian certainty measures of welfare change for removal of the recreation opportunity (*HICKSCV* and *MARSHCS*, respectively) are presented. In the linear model the compensating variation under certainty is roughly 300 hours on average, whereas the consumer's surplus is about 360 hours. For the semilog model, estimates are somewhat higher: compensating variation is 411 hours while consumer's surplus is 527 hours, on average. The difference of about 25% between the Hicksian and Marshallian measures in the semilog model is large, but given the demands are highly income elastic (income elasticity in the vicinity of 1.7-2.1 at the means), this divergence is well within the Willig [30] bounds. While according to these models recreation is a (time-) normal good, the Marshallian welfare measure is larger than the Hicksian measure, which might seem puzzling at first until it is remembered that the compensating variation is defined for *availability* of the recreation good (i.e., for a price decrease).

Next in Tables 4 and 5 the results of the welfare measure calculations under uncertainty are presented, first for price (*TRAVTM*) uncertainty, then for budget (*TOTIME*) uncertainty. The moment models in Table 3 were used to predict a coefficient of variation for each person in the sample, which is given as CV in Tables 4 and 5. The predicted coefficients of variation for *TRAVTM* average about 1.2, the same as the unconditional CV (standard deviation of *TRAVTM* divided by its mean) for the whole sample. The estimated CV's for *TRAVTM* have a standard deviation of .18 and a range from about .9 to about 2.4. The predicted coefficients of variation for *TOTIME* averaged .09, the same as the unconditional CV for the whole sample for this variable, with a standard deviation of .01, with a range between .07 and .14.

Finally, Tables 4 and 5 present the uncertainty welfare measures, option price (*OPTPR*), expected surplus (*EXPSURP*), and option value (*OPTVAL*). Two things are notable about these estimates: first, the option price and expected surplus measures fall very close to the Hicksian certainty measure, and second, they are very close to each other; that is, option value is negligible. For price (travel time) uncertainty, both option price and expected surplus are close to, but slightly less than, the Hicksian certainty measure, which in turn is less than the Marshallian certainty measure (because a price decrease is being evaluated). For budget (total time) uncertainty, the pattern differs somewhat: in the linear model both uncertainty measures are slightly higher than the Hicksian certainty measure, whereas in the semilog model option price is less than, while expected surplus is greater than, the Hicksian certainty measure.

One final thing to note for the linear model is that for some high draws of random price or low draws of random income, quantity consumed may be choked off at zero. This doesn't pose any problems for the calculations, but it is interesting to note where this occurs and whether it makes any difference in the pattern of results obtained. The variable *NUMBER* in Table 4 represents the percentage of the draws for which this occurred, which on average was quite small (2-3% of the time), but for some few individuals it occurred as much as 30% or 40% of the time. This phenomenon made no difference to the option price or value estimates under *TOTIME* uncertainty, as all option values were zero. For the few individuals with *NUMBER* greater than, say, 10%, for *TRAVTM* uncertainty, option values were somewhat larger than the overall mean of .78 hours, but there was no clear pattern of variation in option value with *NUMBER*. This is potentially interesting because one way of representing ***supply-side*** uncertainty is by specifying availability of a good as a probability that the price will be lower than the choke price. Thus the ***demand-side*** uncertainty over own price has elements of the supply-side problem when the random price will be higher than the choke price some positive fraction of the time. This issue does not arise in the semilog model, for which demand approaches the price axis asymptotically, and there is not a finite choke price.

The option values in all these models are very small. For each type of uncertainty and model, the sign of option value is the same for all individuals in the sample. The sign of option value varies from model to model and with the type of uncertainty, however. The signs are consistent with predictions for normal goods in these models: option value is positive for price uncertainty, zero for income uncertainty in the linear model, and negative for income uncertainty in the semilog model. But in both empirical demand models, with uncertainty represented by an average coefficient of variation of 1.2, the option value associated with own price uncertainty amounts to about one- to two-tenths of a percent of the Hicksian and Marshallian certainty measures. In the linear demand model, for budget uncertainty option value is effectively zero (ranging from a minimum of -.0002 hours to a maximum of +.0002, with a mean of .00004 hours), as the theory would predict. The largest option values, in absolute terms, are for the semilog model with budget uncertainty, where all values are negative as would be expected and the mean value is -11 hours, some 2.5 percent of the mean option price and expected surplus for the sample.

V. Conclusions

This paper has shown how one might go about estimating option prices from market data. This requires two crucial pieces of information, a link between observable demands and option prices through the implied preferences corresponding to the estimated demands, and an assessment of the uncertainty which consumers face. The link from estimated demands to underlying preference structure is well-established and preferences corresponding to a variety of simple, and commonly estimated, demand functions can be easily recovered. The link between indirect utility functions corresponding to these demand specifications and the measurement of option price, or *ex ante* compensating variation, has apparently not been made previously but is straightforward once the indirect preferences are known.

The other crucial piece of information, on what the scope and magnitude of uncertainty people face *ex ante*, is a challenging one to obtain. One way of attempting to assess this, which could be built into the design of future surveys, would be to attempt to elicit the magnitude of uncertainty through a series of questions. However, there are at least two reasons why this might be very difficult: first, the fact that many surveys interview people about activities which have already taken place, so that whatever uncertainty might have existed has already been resolved, and choices made, at the time of the survey. Second is the generic problem of validating or corroborating peoples' responses to direct questions, which contingent valuation approaches generally share.

This study approaches the assessment of consumer uncertainty differently. Under the assumption that the data do represent the outcomes of variables which were uncertain *ex ante*, a moment-based approach was used to predict the conditional mean and variance of the uncertain variables of interest, as they depend on exogenous factors. This approach seems reasonable at an intuitive level, because if a variable (such as time price) is random, by grouping people who are as similar as possible across a set of characteristics (such as miles travelled), the outcomes observed provide some information about the density function of the random price. This line of reasoning suggests that in future surveys more attention should be given to identifying and collecting data on exogenous variables that affect the density of random variables of interest.

The empirical approaches outlined in the paper were applied to a data set on recreational use of seven National Forests and Parks in the state of Washington which contain substantial amounts of old-growth timber. Because of recent national concern over protecting old-growth forests, uncertainty by potential future users of the forests about their incomes or prices might give rise to substantial option values, or premia above expected willingness to pay for forest recreation, to ensure that the forests remain available in the future. It was found that option value in this particular setting is negligible. This finding of negligible option value is not new *per se*. Others (e.g., Freeman [11]) have simulated option value, though from a slightly different perspective: beginning with simple specifications of indirect utility, hypothetical risk distributions are added to assess the magnitude of option value as a potential adjustment to expected consumer's surplus. This paper differs in that it illustrates a means for doing the calculations directly from data sets on recreation activities, using the types of Marshallian demand functions which are commonly estimated.

The data set on forest recreation provides an excellent opportunity to consider the question of option value for a prominent environmental resource, but despite the concordance of the findings here with results from other studies, it is important to exercise caution in interpreting, and especially in generalizing from, the results of the analysis. The empirical results are, if anything, suggestive rather than definitive. A low response rate, imprecise wording on some questions, and the generally low overall explanatory power of the empirical demand models (despite highly significant time budget and time price coefficients) prevent meaningful generalizations of the specific empirical findings. Nevertheless, the study illustrates the possibility of directly estimating the theoretically-preferred option prices directly from market-related data.

The prospect of measuring option prices directly from empirical models should improve the ability to assess welfare costs and benefits under uncertainty, and stimulate the search for a broader set of models which permit direct measurement of option price. Further work is warranted both in applying the approach to other demand models and in studying further the range of parameter values and risk distributions for which the conclusions about option value are robust. An area that deserves further thought, too, is how to most effectively obtain measures of the consumer uncertainty that gives rise to option value.

Perhaps the most interesting point suggested by this paper's results is that the usual "average consumer's surplus," obtained by calculating a point estimate of compensating variation for each individual and averaging across all individuals in the sample, is a very good approximation for option price when there is consumer uncertainty. In the motivation of why we care about option value at all, it was argued that the "expected consumer's surplus" of the option value literature and the "average consumer's surplus" just described are essentially equivalent, especially in large samples. The empirical results, while proving nothing, suggest the same thing: comparing the compensating variation to option price (or expected surplus) for each source of uncertainty in Tables 4 and 5, one finds the percentage difference between the two is less than 3.5% in every case. (It is interesting to further note that Marshallian consumer's surplus does not approximate option price nearly so well.)

The implications would seem to be two-fold. First, if we collect large enough, representative samples of people whose outcomes of random variables (or vectors) are uncorrelated, the average (across people) of point estimates of compensating variation, calculated for each person's realizations of the random variables, is a very good approximation of option price. This is very advantageous given the likely difficulty in incorporating uncertainty into benefit measures in an accurate and meaningful way. Second, Willig-type bounds could be developed for the approximation error involved in using this "average consumer's surplus" in place of option price, or perhaps even for using average Marshallian consumer's surplus in its place. This would provide formal justification for the much-easier approach of ignoring uncertainty, in cases where it is known the approximation error will be small.

Footnotes

1. One reason for this, germane to the valuation of environmental commodities, is that data is commonly collected from people after they have made their choices (i.e., *ex post*). It is very difficult at that point to assess the presence or magnitude of *ex ante* uncertainty about factors (such as prices and income) which could have affected would have affected the person's valuation *ex ante* of the corresponding goods.

2. This implicit definition of option price is a slightly more general expression for the "compensating option price" OPE defined by Schmalensee ([27], equation (14)). He considered random incomes with a discrete pdf, whereas the present formulation can accomodate randomness in all variables, with discrete or continuous joint pdfs. The notion of a choke price ($\hat{p}$ in this notation) to represent the case where the good of interest is not available is also used by Schmalensee.

3. The fact that choke price varies randomly does not pose a problem for the welfare analysis. The price $\hat{p}(\underset{\sim}{q},\underset{\sim}{m})$ always represents the state where the good of interest is not available (with certainty), though of course the minimum price that chokes off demand will vary as other variables change. In contrast, the potentially random variable $\underset{\sim}{p}$ can represent a variety of situations: availability of the good with certainty at a fixed price, say $p^0 < \hat{p}(q,m)$, if $\underset{\sim}{p}|q,m$ is degenerate at p^0; availability with certainty but with a random price $\underset{\sim}{p}$, if all values in the conditional distribution $\underset{\sim}{p}|q,m$ are less than $\hat{p}(q,m)$; or availability some specified fraction of the time $\pi \equiv \text{Prob}(\underset{\sim}{p}<\hat{p}|q,m)$ if some (but not all) outcomes of $\underset{\sim}{p}|q,m$ exceed the choke price $\hat{p}(q,m)$.

4. As formulated, this is a variation measure because quantity consumed is changing as the price changes, from some positive level(s) at current prices to zero at the choke price. One could define a surplus measure, where once compensated for the removal of the good the individual could not consume the good. However, compensating variation is more appealing because it measures the amount of monetary payment that would make the individual voluntarily willing to change quantity consumed.

5. For an alternative treatment, where individuals make choices in the first period of a two-period model subject to uncertainty about prices, income, or preferences and balance the budget in the second period, see Chavas et al [7]. However, they point out their "correction factor" (the difference between *ex ante* option price and expectation of *ex post* compensating variations) is

conceptually different from option value.

6. The regression error ϵ is retained in this and the following derivations, so that the measures developed are for individuals who will differ not only in their values of the regressors but in the estimated ϵ. The regression error is not treated as a random variable for purposes of defining option price or expected surplus, however, since it represents errors in observing the individual's choice process rather than uncertainty the individual faces over the values of key variables. It is assumed that ϵ is uncorrelated with the random variables that represent the consumer's uncertainty, but this is not an additional assumption if one takes the estimated parameters from the demand specification as having been estimated consistently. The problem is one of stochastic regressors, which must be uncorrelated with the regression error for single equation estimation methods to yield consistent parameter estimates.

7. This specific tradeoff is evaluated, using these same data, in Rubin *et al.* [26].

8. One might also suspect there is considerable consumer uncertainty over whether, and to what extent, old-growth timber stands will be sustained as public policy is determined. This consumer uncertainty about whether or not a good will be provided (or available) is often referred to as *supply-side* uncertainty (see, e.g., Bishop [2], Freeman [11], Plummer [24], Smith). In contrast, this paper is concerned with the provision or elimination of old-growth forests for recreational uses when consumers are uncertain about their future demands for those services. The related public policy decision is whether or not to provide those services (each with probability 1.0); thus the comparison is between the value to consumers when the services are available and the value when they are not. In this context consumer uncertainty about provision of the good could only be interpreted as an information problem.

9. Antle explicitly considers a linear moment model, where $f(X,\alpha) = X\alpha$ and $g(X,\beta) = X\beta$. However, as he notes, the results of Malinvaud [22] on consistency of nonlinear least squares regressions assure the consistency of nonlinear $f(X,\alpha)$ and $g(X,\beta)$.

10. The Antle moment-based approach could be applied to the estimation of covariances as well as to variances, would would in principle allow one to consider the effect of multivariate uncertainty on welfare measures.

11. Proofs about the signs of option value under price and income uncertainty for linear, semilog, and Cobb-Douglas demand models can be found in the Larson-Flacco paper.

References

1. Antle, John M., "Testing the Stochastic Structure of Production: A Flexible Moment-Based Approach," *Journal of Business and Economic Statistics* 1(3): 192-200 (1983).

2. Bishop, Richard. "Option Value: An Exposition and Extension," *Land Economics* 58 (1982):1-15.

3. Bockstael, Nancy E., Ivar E. Strand, and W. Michael Hanemann. "Time and the Recreation Demand Model." *American Journal of Agricultural Economics* 69(1987): 293-302.

4. Bockstael, Nancy E., W. Michael Hanemann, and Ivar E. Strand. Measuring the Benefits of Water Quality Improvements Using Indirect or Imputed Market Methods, Report to EPA, 1986.

5. Brookshire, David S., Larry S. Eubanks, and Alan Randall. "Estimating Option Prices and Existence Values for Wildlife Resources." *Land Economics* 59(1983):1-15.

6. Byerlee, Derek. "Option Demand and Consumer Surplus: Comment." *Quarterly Journal of Economics* 85(1971): 523-527.

7. Chavas, Jean-Paul, Rchard C. Bishop, and Kathleen Segerson. "Ex Ante Consumer Welfare Evaluation in Cost-Benefit Analysis." *Journal of Environmental Economics and Management* 13(1986):255-268.

8. Cicchetti, Charles J., and A. Myrick Freeman. "Option Demand and Consumer Surplus: Further Comment." *Quarterly Journal of Economics* 85(1971):528-539.

9. Desvousges, William H., V. Kerry Smith, and Ann Fisher, "Option Price Estimates for Water Quality Improvements: A Contingent Valuation Study for the Monogahela River," *Journal of Environmental Economics and Management*,14(1987):248-267.

10. Edwards, Steven, "Option Prices for Groundwater Protection," *Journal of Environmental Economics and Management* 15(1988):475-487.

11. Freeman, A. Myrick III. "The Sign and Size of Option Value." *Land Economics* 60(1984):1-13.

12. Graham, Daniel. "Cost-Benefit Analysis Under Uncertainty." *American Economic Review* 71(1981):715-725.

13. Greenley, D. A., R. G. Walsh, and R. A. Young. "Option Value: Empirical Evidence From a Case Study of Recreation and Water Quality." *Quarterly Journal of Economics* 96(1981):657-673.

14. Greenley, Douglas A., Richard G. Walsh, and Robert A. Young, "Option Value: Empirical Evidence from a Case Study of Recreation and Water Quality," *Quarterly Journal of Economics* 100 (1985): 295-299.

15. Hartman, Richard, and Mark L. Plummer. "Option Value Under Income and Price Uncertainty." *Journal of Environmental Economics and Management* 14(1987):212-225.

16. Hausman, Jerry A. "Exact Consumer's Surplus and Deadweight Loss." *American Economic Review* 71(1981)662-676.

17. Helms, L. Jay. "Expected Consumer's Surplus and the Welfare Effects of Price Stabilization." *International Economic Review* 26(1985):603-617.

18. LaFrance, Jeffrey T., and W. Michael Hanemann. "On the Integration of Some Common Demand Systems." Dept. Agr. Econ. and Econ. Staff Paper No. 83-10, Montana State University, 1983.

19. Larson, Douglas M.,and Paul R. Flacco, Empirical Measurement of Option Price and Option Values from Market Behavior, Working Paper, UC Davis, Sept. 1990.

20. Lindsay, Cotton, "Option Demand and Consumer Surplus," *Quarterly Journal of Economics* 83 (1969): 344-46.

21. Long, Millard, "Option Demand and Consumer Surplus," *Quarterly Journal of Economics* 81 (1967): 351-52.

22. Malinvaud, E. "The Consistency of Nonlinear Regressions." *The Annals of Mathematical Statistics* 41:956-969 (1970).

23. Mitchell, Robert Cameron, and Richard T. Carson, "Option Value: Empirical Evidence from a Case Study of Recreation and Water Quality: Comment," *Quarterly Journal of Economics* 100 (1985): 291-293.

24. Plummer, Mark L., "The Sign and Size of Option Value: Comment," *Land Economics* 61(1985): 76-77.

25. Rubin, Jonathan, Melissa Cheney-Steen, and W. Ashley Ahrens, "The Measurement of Non-Market Benefits: The Northern Spotted Owl and Recreational Delights," Unpub. paper, Department of Economics, University of Washington (1987).

26. Rubin, Jonathan, Gloria Helfand, and John Loomis, "A Benefit-Cost Analysis of the Northern Spotted Owl: Results from a Contingent Valuation Survey," Working paper, Department of Agricultural Economics, University of California Davis (1991).

27. Schmalensee, Richard. "Option Demand and Consumer's Surplus: Valuing Price Changes Under Uncertainty." *American Economic Review* 62(1972):813-824.

28. Smith, V. Kerry. "Uncertainty, Benefit-Cost Analysis, and the Treatment of Option Value." *Journal of Environmental Economics and Management* 14(1987):283-292.

29. Weisbrod, Burton A. "Collective-Consumption Services of Individual-Consumption Goods." *Quarterly Journal of Economics* 78(1964):471-477.

30. Willig, Robert, "Consumer's Surplus Without Apology," *American Economic Review* 66 (1976): 589-97.

Table 1. Some descriptive statistics for the variables used in the analysis.

Variable	Mean	Std. Dev.	Minimum	Maximum	Cases
TRIPS	6.7000	6.1187	1.000	30.00	120
TRAVCOST	20.050	24.746	1.000	150.0	120
TRAVTM	6.6000	8.4718	1.000	72.00	120
OTRPS	3.0500	5.5259	.0000	30.00	120
HHSIZE	2.9083	1.7489	1.000	10.00	120
INCOME	37188.	22969.	2500.	.1250E+06	120
VACDAYS	20.625	11.780	2.000	75.00	120
TOTIME	2991.0	282.71	2544.	4296.	120
MLS	117.50	81.283	2.000	500.0	120

Table 2. Least Squares Estimates of the Demand for Trips.

Model Number	1	2	3	4
Dependent Variable	TRIPS	TRIPS	ln(TRIPS)	ln(TRIPS)
	Linear Model		Semilog Model	
Variable	Coefficient (Student's-t)	Coefficient (Student's-t)	Coefficient (Student's-t)	Coefficient (Student's-t)
ONE	-6.40443	-6.14800	-.858625	-.770439
	(-1.09)	(-1.04)	(-.92)	(-0.81)
TRAVCOST	-.976107E-02		-.522973E-03	
	(-.47)		(-.16)	
TRAVTM	-.112965***	-.114196***	-.155941E-01**	-.126918E-01**
	(-2.97)	(-2.96)	(-2.35)	(-2.14)
OTRPS	.184442	.178613	.126040E-01	.122171E-01
	(1.06)	(1.04)	(0.63)	(0.63)
HHSIZE	.656113	.674506	.579409E-01	.678537E-01
	(1.37)	(1.43)	(0.92)	(1.09)
INCOME	.971557E-05		.393189E-05	
	(.40)		(0.95)	
TOTIME	.374914E-02**	.370954E-02**	.708371E-03**	.708618E-03**
	(2.00)	(1.99)	(2.27)	(2.28)
Number of Observations	120	120	120	120
R^2	.108	.106	.078	.070
Adjusted R^2	.061	.075	.029	.038
F(df,df)	2.28** (6,113)	3.42*** (4,115)	1.59 (6,113)	2.1721**(4,115)

* (**, ***) denotes significance at the 10% (5%, 1%) level.

Table 3. Nonlinear Least Squares Estimates of the Conditional Moment Functions.

a) The first two moments of travel time, as a function of miles travelled

First moment: $TRAVTM = e^{\alpha_0}MLS^{\alpha_1} + \epsilon$

Second moment: $\epsilon^2 = e^{\beta_0}MLS^{\beta_0} + \nu$

Dependent Variable:	TRAVTM		$\hat{e}^2$	
	Parameter	Value (Asymptotic t)	Parameter	Value (Asymptotic t)
	α_0	-1.933139***	β_0	-1.827116
		(-2.79)		(-.43)
	α_1	.8075516***	β_1	1.246058
		(5.65)		(1.55)
Number of Observations		120		120
R^2		.698		.215
Adj R^2		.696		.208
Log-L		-354.3		-868.6

b) The moments of total time available, as a function of income level.

First moment: $TOTIME = e^{\alpha_0}INCOME^{\alpha_1} + \epsilon$

Second moment: $\epsilon^2 = e^{\beta_0}INCOME^{\beta_0} + \nu$

Dependent Variable:	TOTIME		$\hat{e}^2$	
	Parameter	Value (Asymptotic t)	Parameter	Value (Asymptotic t)
	α_0	3.353679***	β_0	5.156072**
		(23.80)		(2.27)
	α_1	.0042860	β_1	-.3011090
		(0.32)		(-1.31)
Number of Observations		120		120
R^2		.057		.035
Adj R^2		.049		.027
Log-L		-291.0		-536.1

* (**, ***) denotes significance at the 10% (5%, 1%) level.

Table 4. Option Price and Option Value Calculations for the Linear Demand Model with Travel Time and Total Time Uncertainty.

Variable	Mean	Std. Dev.	Minimum	Maximum	Cases
TRIPS	6.7000	6.1187	1.000	30.00	120
VACDAYS	20.625	11.780	2.000	75.00	120
OTRPS	3.0500	5.5259	.0000	30.00	120
HHSIZE	2.9083	1.7489	1.000	10.00	120
Certainty Welfare Measures					
HICKSCV	302.00	516.35	4.331	2920.	120
MARSHCS	359.10	667.46	4.378	3941.	120
Travel Time Uncertainty					
TRAVTM	6.6000	8.4718	1.000	72.00	120
CV	1.2091	.17802	.8806	2.439	120
OPTPR	292.61	506.99	3.056	2871.	120
EXPSURP	291.83	506.71	3.003	2870.	120
OPTVAL	.78283	2.0197	.3095E-02	15.16	120
NUMBER	2.5500	7.5502	.0000	46.00	120
Total Time Uncertainty					
TOTIME	2991.0	282.71	2544.	4296.	120
CV	.93610E-01	.10794E-01	.7481E-01	.1371	120
OPTPR	304.96	516.06	4.956	2935.	120
EXPSURP	304.96	516.06	4.956	2935.	120
OPTVAL	.40143E-04	.10819E-03	-.2104E-03	.2359E-03	120
NUMBER	3.2083	6.8377	.0000	30.00	120

Table 5. Option Price and Option Value Calculations for the Semilog Demand Model with Travel Time and Total Time Uncertainty.

Variable	Mean	Std. Dev.	Minimum	Maximum	Cases
TRIPS	6.7000	6.1187	1.000	30.00	120
VACDAYS	20.625	11.780	2.000	75.00	120
OTRPS	3.0500	5.5259	.0000	30.00	120
HHSIZE	2.9083	1.7489	1.000	10.00	120
Certainty Welfare Measures					
HICKSCV	411.93	310.27	76.65	1388.	120
MARSHCS	527.88	482.06	78.77	2364.	120
Travel Time Uncertainty					
TRAVTM	6.6000	8.4718	1.000	72.00	120
CV	1.2091	.17802	.8806	2.439	120
OPTPR	403.74	306.05	72.84	1372.	120
EXPSURP	403.41	305.83	72.74	1370.	120
OPTVAL	.32807	.89881	.3439E-03	8.037	120
Total Time Uncertainty					
TOTIME	2991.0	282.71	2544.	4296.	120
CV	.93610E-01	.10794E-01	.7481E-01	.1371	120
OPTPR	405.14	305.72	71.74	1358.	120
EXPSURP	416.21	312.04	76.02	1382.	120
OPTVAL	-11.069	8.3825	-64.67	-1.184	120

VALUATION IN A VACUUM? A NAIVE PERSPECTIVE

An Assessment of the State of the Knowledge about the Contingent Valuation Method

Charles C. Harris[1]

1 Associate Professor, Department of Resource Recreation and Tourism, University of Idaho, Moscow, 83843.

Paper presented at the 1991 W133 Meeting, Monterey, CA, Feb. 28 - March 1, 1991.

I see my task in preparing this paper as that of being a somewhat naive -- in the sense of being indoctrinated in the theoretical dogma and disciplinary mindset of the economics discipline -- critic: literally, one who critiques valuation methods; and that the organizers of this session would like me to be provocative and controversial, so I hope to be challenging and perhaps even somewhat confrontational. Here goes.

I've done a lot of reading and thinking, and some empirical research and writing, on topics relating to human preferences and values, so I wanted to provide another perspective: a naive perspective, based on my knowledge of social psychology as well as economics, on key concerns with nonmarket valuation. I'm a behavioral scientist who's done multi-disciplinary studies of nonmarket valuation that have not only built upon theory and research from economics but also from social psychology and sociology: these studies include my doctoral research assessing validity of economic methods for estimating sport fishery values (Harris 1983), donations to nongame wildlife and comparisons of these with CVM (Miller et al. 1989), and preliminary development and testing of a computer-based knowledge-based system (KBS) for evaluating people's existence values for bald eagles (Harris 1988, Harris and Swanson 1990).

Time is growing shorter on the many pressing resource-related public policy decisions, as increased global warming, other forms of pollution due to the disposal of resource process wastes, and losses in the Earth's biodiversity threaten its life systems and the prospects for the welfare of future generations of *homo sapiens*. Economic analyses (BCA) of public policy problems confronting us will be done and considered, and their accuracy thus must be of concern. The validity of CV measures, which seek to value the benefits of environmental protection actions, is directly a measurement, and thus a methodological, issue; but as I've noted before, validity involves ideological and theoretical issues.

Phillips and Zeckhauser (1989), writing about same time as my (1989) article, note "efforts to refine CVM surveys have been carried out largely in a vacuum" -- ironically, I came up with my title without having yet read or had knowledge of their article. I'll be looking at vacuum of valuation from several perspectives and in terms of several categories of issues.

Ideological Issues:

ISSUE 1. The continuum of valuation science as a human endeavor poses important ideological issues: Society <--> scientists <--> social scientists <--> economists <--> resource economists <--> neoclassical economists <--> nonmarket valuation economists. These issues can be represented with questions. Are some CVM economists losing sight of forest for trees? Are they too specialized, both in perspective and methods -- losing sight of larger context of knowledge, problem-definition, research methods from other social sciences? I do see more interdisciplinary research efforts, and these appear to be providing the significant advances in benefit evaluation.

Still, the danger of the organizational culture of economics discipline persists through the socialization and learning/education processes with which economists are trained, as Kuttner (1985) warned with his concern about students who stay or are weeded out of the field.

ISSUE 2. The skepticism of "hard economists" vs. "soft." Phillips and Zeckhauser (1989) have echoed the concern I expressed in my dissertation research 10 years ago of expressed vs. revealed preferences. Even many non-resource economists are suspicious of surveys and CVM; it "has active support of small number of applied economic practitioners, but probably has raised quiet doubts among most economists exposed to it...A low level of support...often enough for technique to become established in academic world." One economist I know who's dropped in on W133 meetings has called them "awe-inspiring," and didn't mean that exclamation in a positive sense.

Phillips and Zeckhauser (1989) also express concern that the CVM has "leapfrogged the testing process." These concerns are not without basis: For example, in a 1987 *Science* article, Bradburn et al. report results that cast further doubt on people's information gathering, recall, data processing and inferential abilities: because of limits on human beings' ability to recall information about past events, respondents have trouble answering questions that require them to remember and enumerate specific autobiographical episodes, and they resort to inferences based on partial information from memory to construct a numerical answer.

Nisbett and Ross (1980) discuss their findings that because people overrely on intuitive, inferential judgment strategies and underutilize more formal, logical and statistical strategies, they make "profound, systematic, fundamental errors in judgments;" not only may these errors be characteristic of market behavior (Schoemaker 1982, Thaler 1980), they could be even more critical in nonmarket settings where normal cues and signals that guide people in market valuation decisions -- or decisions about typical policy referendum issues -- are lacking, and where decisions can be major, irreversible or at least long-term. (We're talking valuing components of healthy, sustainable environments here, folks -- not toothpaste or property taxes!)

ISSUE 3. Major point here: Very basic ideological and ethical issues -- what is right way of behaving, right way of decisionmaking, right way of thinking (Daly's link of "intermediate ends" and "ultimate ends"?) Is efficiency (relation to perfectionism?) the "rightminded" goal (Buddhism); what is the relation of social efficiency (the "simple/happy peasant") to economic efficiency (prosperity of capitalist/growth-oriented/present-value-oriented society) in pursuit of social welfare? To what extent is this theory and its basic assumptions a reflection of the comparatively time-poor, neurotic pursuit of materialism that characterizes lifestyle of the capitalist system in the U.S. (and is the "model" for the rest of the world) vs. quality-time/leisure lifestyle of hunters/gatherer, more simpler modern cultures characterizing some Third World societies now?

Is there a mixing of "ways of knowing" (empiricism, faith, etc.) here? Doesn't CVM implicitly require leaps of faith that noneconomists/nonresource-economists have not taken? To what extent are social learning (new spin on equity?) and informed policy debates and decisions foregone in pursuit of more easily derived, technically "clean" measures of benefit maximization (Reich 1985, Sagoff 1988) -- and to what extent is this a reflection of economists and policy analysts' desires than the ethically and empirically correct way of making decisions.

Critique of implications of Power's (1990) position: No longer can we trust market economy to ensure that all societal members get necessities: government and social policy, not economic policy, ensures survival, with economy freed to focus on quality of life beyond survival; importance of this trend is that it reverses common perception of what economic activity all about: pursuit of quality of life (QOL), not survival. Social scientists and the policy analysts they inform need to start addressing what Daly (1980) has termed "ultimate ends" and "ultimate means to those ends," while CVM may embody (at its most extreme) a perpetration of focus on intermediate ends and means. (TAKE, FOR EXMPLE, THE PERSIAN GULF WAR, IN WHICH THERE WAS NEVER ANY EFFICIENCY ANALYSIS OF OPERATION DESERT STORM. THE ALLIES SIMPLY TOOK AN ETHICAL POSITION WITH ITS "JUST, RIGHT" STAND IN IRAQ. WHY CAN'T -- INDEED, SHOULDN'T -- THE U.S. TAKE AN EQUALLY STRONG MORAL POSITION ON ENVIRONMENTAL PROTECTION: CARTER'S "MORAL EQUIVALENT OF WAR"?)

Scitovsky provides part of the answer with his concern with America's pursuit of pleasure/comfort (QOL) implicit in our economic policy vs. necessity of determining policy leading to equity long-term stability of our social system and our survival and planet as we know it (Daly's focus on steady-state economy).

Theoretical Issues:

Psychological Theories. I was surprised to learn through my research that some of my presumptions and concerns (as presented in Harris et al. 1988, 1989) may be invalid: but some issues and problems clearly persist.

Social Psychological Phenomena -- General methodological issues raised by findings of social psychological research:

1.) Experimental work -- Concerns long have been raised by social psychologists over the significance of the findings of laboratory vs. field experiments (questions of internal and external validity or generalizabilty); and these are similar to concerns over CVM measurement in experimental lab versus field settings (which measure expressed preferences through questionnaire responses) versus behavioral economics (whose measures are of revealed behavior) very recognized problem with laboratory work stemming from its artificiality and possible lack of generalizability to real world phenomenon (with all apologies to Brookshire and his colleagues 1987, In process).

2.) Social influence. To what extent are social desirability phenomena (Asch 1958, Sherif 1961, 1966) at work in people's responding to CVM surveys? To what extent are the 70 percent of respondents who do respond to CVM surveys doing so out of their unwillingness to confront researchers (i.e., their desire to please) or their failure to appreciate the significance of disenfranchisement that willingness to pay (WTP) questions represent (Sagoff 1988)? Also, is "herd effect" in effect (i.e., effects on perceptions are swayed, magnified and distorted by very raising of an issue or "problem")? These phenomena are especially pertinent to the internal validity and interpretation of the findings of lab experiments as is the social psychological research on the influence of reference groups in conflict, which suggests that people's attitudes and behaviors are very susceptible to group pressures and influences (Kelley and Woodruff 1956, Newcomb 1943).

However, I don't buy Phillips and Zeckhauser's (1989) concern over an "anxiety factor" (awareness of environmental damage assessment may set off "anxiety" that itself increases people's perception of dangers of environmental damage; this is an important influence on all market behavior and pricing (e.g., property values at Love Canal after publicity about environmental damage there) -- not just nonmarket evaluation.

3.) Halo effect from focusing valuation on particular resource or environmental good: by focusing on single problem (eagle KBS study), CVM respondents may be overfocusing on the good in question, given that they are not reminded of countless others (Schulze et al. 1983, Phillips and

Zeckhauser 1989). One spin-off of this that continues to get attention but does not appear to pose any real problems is strategic, intentionally-untruthful responses; the much-discussed strategic bias that would result for these kinds of responses continues to be discussed in the literature, even though, since the earliest studies (Bohm 1972) on this kind of bias, no one has ever found any evidence this bias to be a significant problem, leading Dawes and Thaler (1988) to wonder if anyone actually ever behaves strategically in surveys, except perhaps economists!

4.) Framing effects. These refer to subtle cues in questionnaire description can determine values, and I discuss them in detail later.

Specific valuation issues

How many researchers who have done CVM studies have sat down with subjects and talked through process of valuation? My tally is very few. I'm reporting reflections based on my discussions with respondents, as well as my reading of current literature and the studies I've conducted (see, in particular, issues raised in Phillips and Zeckhauser 1989 and Harris et al. 1988, 1989).

1.) Stress effect. Some good news is that findings of eagle KBS study are that 1st, in course of debriefing, people don't report being stressed by CVM problem; they can readily give values (at least in case where payment vehicle is something they can relate to in actual experience: some pointed out that payment vehicle similar to that in private sector, as in paying to see wildlife in an African or American preserve or zoo);

2.) Ability to value: respondents' capacity to adequately process information. What's extent of valuation experience effect?

Cases where market experience is relevant:

The nongame study's (Miller et al. 1989) WTP results: no relation of reported WTP to actual $ contributions to nongame checkoff reported. Also, in eagle KBS study, the results of CVM vs. tradeoff of management budget as reflection of relative importance or worth of various resource uses revealed much higher values for eagles in terms of opportunity costs foregone than actual values given in response to payment vehicle reflected.

Major questions here are: Are people valuing environmental goods on basis of their market or charity-donation experience, and should they be? These answers are especially important in the case of existence values of endangered and threatened species of wildlife: if answers are yes, why not just use average revenues from cases of charity donations to The Nature Conservancy, World Wildlife Fund, other groups, as well as entrance/guide fees, as basis for estimating values.

There are complicating factors and concerns raised by current CVM techniques. For me, first concerns were raised with my 1983 dissertation research on use values of sport fisheries as reflected in WTP for last trip to Colorado fishery, when I found a large number of zero CV bids depending on wording of question. In that study, I examined results of two formats (pre-policy referendum) for CVM: "iterative valuation format" and "direct valuation format." The iterative format indirectly obtained the amount of each respondent's consumer surplus (as measured with WTP) by asking the respondents what the maximum amount of increased costs over and above their actual trip costs they could incur and still be able (and willing) to take the fishing trip. In contrast, the direct format represented an alternative approach that sought to directly present respondents with concept of net WTP, wherein they were asked to judge the worth of their trip above and beyond the expenses incurred on the trip. When questioned about WTP with iterative format before trip expenses recorded, only 16 percent of respondents responded that they had not obtained any consumer surplus ($0 response) from their trip, while for those reporting net WTP, mean value was $35. With direct format, when questioned about how much trip was worth relative to what actually expended, a majority of fishermen (64%) said trip worth exactly what paid (implicitly, a $0 WTP bid); the 33 percent who responded worth more reported mean WTP of $108, and 3 percent actually responded worth less. Clearly, the problem set (the way the problem is presented as well as the actual wording used) to which survey respondents are responding significantly influences the values obtained with CVM questions.

In eagle KBS study, I've found that respondents definitely are thinking in real $ terms: this may reflect the influence of market experience, but no sign of hesitation, confusion was found. Nonetheless, a major concern here persists: are respondents thinking simplistically, with little thought to context and the full ramifications, constituencies representing, etc.? My initial assessment is that it appears that they are representing selves only, not long-term ramifications -- even when information about these ramifications is provided.

Another issue raised by eagle KBS study concerns wide variance in responses; I would say WTP responses have little to do with value people place on eagles, either on a species or a per-eagle basis. One respondent bid $5 as his WTP for an entrance-fee (all that he could afford given distance), but he strongly took exception to idea that this means that he values the 300 eagles (600 eagles) on the reserve at $0.02 ($0.01) per eagle. Is there gap between theory (which is what is conceptually "right") and reality (which is "way things really are")? Bids ranged from "can't afford," to $5 entrance fee, to $500 lifetime membership, with median WTP of $100: exactly the amount originally suggested in the WTP policy-referendum question (a result similar to that found in my sport fishery valuation research). The mean WTP was $135, although the value of eagles explicitly presented in the information provided in terms of the opportunity costs for a private good (commercial salmon) foregone was approximately $670,000 times a factor (based on respondents tradeoff analysis between the two goods) ranging form 1.2 to 100, after adjusting for responses suggesting no comparison was possible.

This raises the larger question of what hidden assumptions, if any, people are making about nature of the good and their relation to it. This question is related to context effect: In eagle KBS study, the proximity of respondents to the eagle preserve site and the respondents' assumptions about the relevance of their current personal income (ability to pay) were major influences on WTP value. A significant proportion of respondents reported in debriefing that they made "erroneous" assumptions about their own situation (i.e., personal context) that significantly influenced their WTP, including their location in relation to the eagle refuge (i.e., they assumed they lived near the eagle refuge) and their ability to pay (i.e., they based their WTP on what they projected their future income might someday be, not on what their actual present income was).

Cases where no market experience (nonuse values in particular):

Phillips and Zeckhauser (1989) note people's failure to understand and respond to situations rationally; their behavior is significantly responsive to perceptions (including increased risk: N.Y. Times poll and lability of values), not merely actual consequences or outcomes.

Phillips and Zeckhauser (1989) have addressed the issue of inconsistent, contradictory results:

> some preferences can be shown to be self-contradictory and thus objectively unreasonable. In market situations, nonrational preferences and valuations may be reduced through market pressure, or they may prove irrelevant: One need pay no more than the market price,however much one values an object. However, CVM surveys take place outside a market context. (p.525)

Researchers have long expressed concerns concerning many CVM data that include WTP bids that are either extremely low (zero) or high (up to 25% of reported household incomes; Kahnemann and Knetsch Forthcoming, Harris 1983), posing significant methodological issues, as do nonrespondents who might be treated as people censoring themselves and/or concealing their bids. Edwards and Anderson (1987) and Randall and his associates (1981) have discussed methods for "culling" outliers and adjusting bid estimates to account for selection bias. But a critical issue here is the extent to which respondents' self-censoring reflects protest bidding against their concerns over the personal disenfranchisement and subversion of political and legal processes possibly represented by the CVM (Sagoff 1988). Heckman's (1979) procedure for testing selection bias from censorship of outliers is clearly inadequate for cases where self-censorship of nonrespondents has a political or ethical basis, and the results of McClelland et al.'s (In process) recent efforts to empirically examine the soundness of applying the selection bias model, regardless of its conceptual appropriateness, have led them to "advocate caution" in doing so.

Further assessment is needed of validity (in terms of accuracy) of people's expressed contingency values, motivations of persons valuing: e.g., people are accustomed to being price-takers (responding to set prices) rather than responding to open-ended WTP questions about nonuse values (Harris et al. 1988); in case of environmental damages, I question if people's responses are a reflection of their "strength of ideology about pollution," as much as a valid indicator of their WTP for cleanup (Kahnemann 1986)? Evidence on embedding effects, time frame in payment suggests very real possibility of arbitrariness of WTP values obtained (Kahnemann and Knetsch Forthcoming) must be furthered considered and researched.

Harris (1983, Harris et al. 1989) first raised concerns about the quality of expressed preference measures of value obtained with the CVM. Gregory et al.'s (Forthcoming) study followed up on suggestions he made with specific tests. They found that open-ended WTP measures may systematically underestimate value of social programs relative to private goods, and that a precise value for programs is not captured monetarily: (1) Different methods of value elicitation provide significant different measurements in evaluation of public vs. private goods; and (2) People have precise values for personally beneficial goods important to them even when they can't express that value in monetary terms.

3.) Commodity specification: Embedding and joint production effects. My research, as well as that of others, has confirmed the importance of these special cases of influences on WTP measurements due to variations in commodity specification. They were first discussed by Hoehn and Randall (1982) with reference to the appropriateness of aggregating WTP for several commodities from different samples into a WTP estimate for the entire commodity package; serious problems for summating across values for related programs noted by have been Schulze et al. (1983). Most recently, Loomis et al. (In process) have found empirical evidence suggesting error of independent valuation and summation of related programs (i.e., reducing agricultural drainage contamination and improving wildlife management) when performing BCA, and that a more correct approach is to have respondents value "packages" of related programs.

Most recent research results indicate serious problems for CVM with respect to both embedding and joint production effects. Embedding effect, also termed disaggregation effect and symbolic effect (Cummings et al. 1986), refers to the phenomenon wherein a good is assigned a lower value if its WTP is inferred from the WTP for a more inclusive good than if it is valued on its own. Kahnemann and Knetsch (Forthcoming) found a "robust" embedding effect for a well-defined good that has personal use value (improved availability of equipment and personnel for rescue operations) and for which the answer is interpretable as a quantity choice. They reported that "WTP is approximately constant for different levels of inclusiveness in definition of a public good, and estimates for a particular good differ by a factor of 25 for medians (or 9 for means) depending on the inclusiveness of the initial question" (p.12).

In the case of joint production effects, first discussed by Fischhoff and Furby (1987), evidence also supports its influence on WTP bids. In the eagle KBS study, debriefing discovered that many respondents were, not surprisingly, jointly valuing the eagles and the area being protected to preserve the eagle population wintering there. One additional, important result is that the majority aren't giving higher bids for 600 eagles over 300, which may have major implications for measuring marginal value.

Likewise, the research reported by McClelland et al. (In process) found that some respondents reported viewing health and visibility improvements as joint products, and further that the proposed tax payments used to fund air quality improvements (the payment vehicle) were viewed as providing a much larger package of public goods. This hypothesis was formally tested and not rejected.

4.) Context/information effects. When talking about major elements of context, McClelland et al. (In process), Bergstrom et al. 1989, and my eagle KBS research all produced results consistent in their determination that information about context of the valuation problem had little effect in terms of resource being valued. This surprises and concerns me. Shouldn't this make a difference; again, do we want measures of just atomistic, short-term value based on monetary value (Gregory et al. In process, also my tradeoff analysis in eagle KBS study), or should policy be based on more complex judgment? Are what we're getting now still simplistic, short-cut CV decisions as cited in 1989 paper despite the detailed information provided with the KBS. Are subtle framing effects playing a role here?

The attributes and components of good being valued need to be clearly defined: One related issue is that people are valuing the experience of being able to "see eagles" as the good they're valuing, as opposed to valuing eagle protection or eagles themselves (which suggests that people assign their own meaning to the good being valued, regardless of what they're told that good is).

Another issue is raised by Boyce et al.'s (In process) research on the role of intrinsic moral values as value component. Their elegant experimental research affirms suggestion I made in 1986, 1990 papers (Harris and McGown 1986, Harris and Brown In process) that the assignment of property rights implicit in the welfare measures researchers use can shift the allocation of moral responsibility for preserving good. As they note,

> If a commodity has an intrinsic value, we show that a kinked or inflected indifference curve may result because intrinsic values may be included in the WTA measure of value but at least partially excluded from the WTP measure of value. This can occur if the assignment of property rights implicit in the two measures of value shifts the allocation of moral responsibility for preserving the commodity. Thus, if intrinsic values are introduced, a disparity between WTA and WTP might be created or increased. (p.7)

An additional issue raised by our eagle KBS study is whether people are responding with attention to their income-constraints. Bergstrom et al. (1989) found that providing respondents with information about the relation of their bid (for the public good of access to a recreational river) either to the respondent's income, to other possible sources of income, or to relative sizes of expenditures on other typical consumer expenditures, had no meaningful effect on their bid. In contrast, the eagle KBS study found that consideration of income makes a major difference.

The relation of the location of the good being valued to the residence of the respondents should also be examined, this region of concern relates directly to the constituency that should be represented: locals, region, state, nation, world. Phillips and Zeckhauser (1989) note the case of "counting" those "nonusers" who discover they'd be willing to pay for cleanup even if they are ignorant of, unaffected by, or unconcerned about it prior to being surveyed. The opposite case is one wherein people greatly value the good, but live sufficiently far enough away to be willing to register only small WTP in terms of the payment vehicle provided. Respondents in the eagle KBS study reported they would have expressed a much greater WTP in terms of buying lifetime membership if they lived near the eagle preserve, but given their distance from it, they don't live close enough to bid more than amount for entrance fee, in all practicality).

Phillips and Zeckhauser (1989) note the difficulties of specifying a complex good to be valued in a complex context, commenting that "a CVM value for one level of improved [environmental] quality ...not convertible if another is actually relevant."

Also, attitudinal issues can be raised, especially given that the feelings of respondents may vary depending on source of payment (payment vehicle, e.g., source of payment: direct billing, general fund monies, other parties or particular segments of society; Phillips and Zeckhauser (1989). No data currently exist on this issue for payment vehicle, but some results based on variations in time period specified suggest this is critical: Kahnemann and Knetsch (Forthcoming) found no difference in mean $ WTP when payment was expressed in terms of a one-time payment versus a long-term commitment to a series of annual payments over five-years.

5.) Frame of reference effects, and the WTP-WTA discrepancy as a subset of framing effects. These effects were first raised as concern with Tolley and Randall's (1983) finding that WTP for improved visibility in Grand Canyon differed significantly depending on where this WTP was asked in the survey; as Kahnemann and Knetsch (Forthcoming) note, "the effects of order and embedding observed in assessments of value for public goods are difficult to reconcile with "standard value theory" (p.6). Additional concerns have been raised by research based upon prospect theory and concerns over property rights and logic of selling, relation to policy referendum; see, for example, the results of Knetsch and Sinden 1984, Cummings et al. 1986, Gregory 1986, and Gregory and Bishop 1988).

In their comparison of field and laboratory research, Brookshire and Coursey (1987) found discrepancy between WTP and WTA to hold for CVM, both in the field study of the Smith auction process (a WTA/WTP ratio of 75:1) and, to a lesser but still significant, extent in the laboratory study of Smith auction (a WTA/WTP ratio of 5:1); the persistence of the discrepancy may reflect the influence of social desirability factors rather than, as the authors suggested, a functioning of market as "strong disciplinarian" with more complete revelation of responses in repetitive market-like environment. Phillips and Zeckhauser (1989) express concern, and Coursey et al.'s (1987) findings suggest that, under laboratory conditions where respondents learn in repeated bidding situation, although the discrepancy decreased, but still some difference persisted. Given above results, I'd suggest just using WTP because close enough to WTA is not satisfactory.

One explanation of the discrepancy between WTA and WTP may be the major but previously unappreciated: role of "moral responsibility." It is significant but not surprising that a number of researchers have discovered and focused on this phenomena independently. Boyce et al.'s research suggests that the disparity between WTA and WTP may be due largely to intrinsic "moral" values inherent in nonmarket goods; the results of their research are predicated on the premise that the "WTA measure of value of preserving an endangered species "clearly assigns moral responsibility" to respondent valuing it, while "WTP measure makes a much clear assignment:" "that is, the framing effect caused by ..."As they point out, this issue of intrinsic value as represented by moral responsibility is not insignificant given the Federal court ruling modifying U.S. DEPARTMENT OF THE INTERIOR rule-making based on CERCLA; its decision stated that "option and existence values...reflect utility derived by humans from a resource, and thus, prima facie, ought to be included in a damage assessment" (U.S. Court of Appeals 1987, p.67, as cited in Boyce et al. In process).

Kahnemann and Knetsch (Forthcoming) also found evidence of what they call the "purchase of moral satisfaction:" they tested the hypothesis that moral satisfaction exhibits an embedding effects and found strong support for the hypothesis.

In a similar vein, our nongame research (Harris and Brown In process) has found that when Idahoans are offered the policy choice of who should pay for a "major reduction of nongame wildlife and endangered species" from among variety of plausible options (i.e., all Idaho taxpayers should pay, only those people to whom these wildlife are important should pay, only those people responsible for the loss of these wildlife should pay, or the loss of wildlife is of no concern), the majority (53%) of these citizens believe that the state of Idaho should pay with tax dollars from all taxpayers. In similar vein, Gregory and colleagues (Gregory et al. Forthcoming) found that judgments of benefits obtained with rating scale were unrelated to WTP, suggesting that WTP for social programs even when don't benefit directly.

McClelland et al. (In process) found that 71.8 percent of the sample of people asked to value air quality responded with infinite WTA responses, which also supports the view that $0 WTP bids represent "protest" bids (only 35% of respondents gave $0 WTP bids). In contrast, people don't perceive they have the same ability to challenge the abrogation of their rights presented by CVM researchers with their WTP questions. Again, these findings are related to Sagoff's (1988) concerns: what is and should be the role of information -- are decisions being made with methods that base judgments on situations that represent a sufficient abstraction from reality that the results obtained have little external validity?

Phillips and Zeckhauser (1989) also note that attempts to minimize bias and ensure consistent results can result in the suppression of real heterogeneity in values, as subjects are induced to ignore some relevant issues and only consider certain others.

6.) Validity as accuracy of CVM estimates: Convergent validity most recently was assessed by Duffield (1990) with some of most up-to-date valuation methods and extensive surveying. He obtained TCM/CVM ratios ranging from 0.57 to 1.88 from a comparison across 17 segments of MT rivers and a total of 2171 survey respondents; if assume a mid-point in this range of 1.23 represents some indicator of accuracy (a big assumption), the plus/minus 50% bounds of error around the estimates obtained don't suggest high degree of accuracy (a result similar to that in Cummings et al. 1986).

Also, methodological issues first raised in 1986 discussion assessing adequacy of research methods for nonmarket valuation (Harris et al. 1988) need to be further addressed. Validity depends on methodological soundness and reliability of estimates: (1) Sensitivity of WTP mean estimates to sample design and functional form chosen to derive these estimates, lack of consensus over how deal with statistical complexity of dichotomous choice CVM necessary for policy referendum, and ultimate dependence on researcher judgment (Bowker and Stoll 1988, Cooper and Loomis In process, Johansson et al. 1989); (2) low test-retest reliability coefficients for readministering of CV questions over a nine-month period (Loomis 1988); (3) initial comparison of mail vs. in-person survey method resulted in higher response rates for questions on sensitive (income) and complex, future-oriented (CVM) issues on mail than in-person survey (Mannesto and Loomis 1991); (4) use of computer programs for laboratory experimentation in consumer decisionmaking and valuation judgment have major advantages (see Harris 1988; Brucks 1990) -- ongoing research is taking advantage of computerized knowledge-based systems (Harris 1988, Harris and Swanson 1990).

Pragmatic Issues (Praxis):

What are some major conclusions? And what's the "so what," the practical implications, of where research on CVM now stands?

CONCLUSION 1. Need to further address issue: How and how much is this analysis used now? Someone needs to conduct BCA of research and applications of CVM:

Are some BCA analyses done to justify ad-hoc preordained policy choices, as has been charged in case of many water development projects?

What's the efficiency of valuation research (opportunity costs of alternative uses of $, time, expertise, given political nature of public policy decisionmaking and preordained decision outcomes)? High cost of CVM research and ENVIRONMENTAL PROTECTION AGENCY cut-back, concerns over credibility of values obtained as indicated by the recent review of USFS forest planning regulations (USDA Forest Service 1990). Unfortunately, are some states supporting research with less quality control on ensuring validity of findings and appropriateness of its use?

CONCLUSION 2. A look at other social behaviors and theories about them is needed: along with the adoption of psychological paradigms called for in Harris et al. (1989) -and those others already mentioned, further attention to attitude theory (e.g. Gregory et al.), ramifications/applications of attribution theory, and exploration of decisionmaking and valuation issues with more sophisticated and efficient technology.

Broader issue of halo-effect and why higher values are obtained because of a focus on particular good like eagles needs greater scrutiny.

Another major issue is whether WTP with a policy referendum approach is appropriate or defensible after damage is done. This may not be a major problem, as Phillips and Zeckhauser (1989) note, in efficiency analyses where error in true value minimally affects results -- but it is a problem for assessing a potentially responsible party's liability, as in the case of Exxon and AK oil spill (Implicat.s greater with CERCLA; see Grigalunas and Opaluch 1988).

One conclusion of the eagle KBS study is that the KBS is an interesting heuristic tool, but doesn't contribute to improved valuation; it's use in clarifying context, however, is critical -- especially that of the respondent and his/her ability to pay. KBS provides an important prompting devise for understanding the decision process people go through in their evaluation of a nonmarket good: debriefing of what they responded and why they responded the way they did proved very enlightening.

CONCLUSION 3. Related issue investigated by Gregory and colleagues (Gregory et al. Forthcoming): can value be defined, measured with single, monetary indicator? Their research results reaffirm what no. of us have been saying for decade: benefits, costs, WTP and importance may represent different dimensions of value relating in different ways to attributes associated with set of goods -- concept of value is multi-faceted, many dimensions raised in debates over public policy issues.

Kuttner's (1985) concern about freshman students and contrived way of thinking is again relevant here, same with my naive but sophisticated social science students -- are we talking descriptive or prescriptive theory, its relation to real world, and what is reality..."Perception is reality:" our perceptions defined by questions we ask (Far Side cartoon): role of disciplinary (e.g., economic discipline) culture.

CONCLUSION 4. Reality of criticalness of efficiency vs. equity issues: Need to redefine perceptions, social and economic reality -- redivert resources from sports, TV/entertainment, cars, defense and subsidization of special interests (industries like agriculture, timber; elderly) to environmental protection and revitalization of cities -- Basic value judgment being made about survival: Kuwait invasion non-negotiable (where was the efficiency analysis here?!) vs. greenhouse, which is?

Sagoff's (1988) basic message: Efficiency moot point when some things are non-negotiable -- gap between social value of endangered and threatened species (Legislative cap on loss: not incremental but all-or nothing -- or have we reached margin where social costs=benefits?) and economic value (as indicated by WTP/opportunity cost BCA). Fischhoff's concern that economists' techniques may implicitly present responds with

> "abrogation of own rights..." when aren't offered response option "a clean environment nonnegotiable"...anesthesiz. moral feeling (Fischhoff as cited in Harris et al. 1989; p.222)

Second aspect of equity issue: assume for moment those personal. types with greatest propensity to value nonmarket good are middle-class (individuals who are educated but have consciously chosen lower-paying, public service types of jobs) -- Equity issue large if these, who place greatest priority on public goods, are constrained by ability to pay due to lower incomes.

Perhaps, though, the major issue is whether economic efficiency should be basis for assessing damages, as presently practiced with WTP per CERCLA regulations (Grigalunas and Opaluch 1988)? First, what can we summarize about state of art/knowledge of nonmarket valuation? Not great:

doubted by other resources in your own discipline, and work of those researching this area raises doubts.

Also issue in case of using CVM to compensate for damages of these limited to values from use, even though natural resources also deliver nonuse values (e.g., spiritual, biodiversity, etc.) that may represent significant portion of total value -- is there an ideological basis of these? Also, conflicting arguments can be made over use of WTA (Boyce et al.'s arguments) and WTP (Harris and Brown In process): RMFRES results suggest that WTA valid welfare measures given certain property rights structure, and Harris results suggest that WTP most socially acceptable because people willing to accept state's assumption of damage coverage.

CONCLUSION 5. Finally, the results of research on WTP and WTA using both CVM surveys and laboratory experiments are starting to raise issues that should be encouraging economists to rethink some basic microeconomic theory. Research results and conceptual reflections of scientists whom I respect greatly, including Jack Knetsch, Robin Gregory, George Peterson, Tom Brown, Gary McClelland, Bill Schulze, Dan Kahnemann and Amos Tversky, are suggesting that some of microeconomics' premises about the characteristics of indifference curves should be changed, including kinked or inflected nature of these curves (either because of loss aversion as posited by prospect theory or because intrinsic values may be included in WTA measures that are excluded from WTP measures) and the irreversibility of indifference curves because of the endowment effect. This a major contribution of CVM research: promoting interdisciplinary work with cross-over of economics and psychology that may be contributing to changing basic economic theory.

Debates continue over most of points, issues, questions I've discussed here -- but in talking to people in preparation to come back to the economics fold (or pack?), so to speak, and after presenting this paper, I must confess I'm wondering if I'm hearing new element of stridency in the debate. This concerns me, in light of Kuhn's perspective on scientific revolutions: This especially critical when have situation when a field may become (albeit unintentionally) self-censoring. While scientists are supposed to declare values at outset, then lay them at doorstep of lab to extent possible, is research on

CVM a political process: are arguments over theory and empirical findings being directed and taken personally, are critics of method being treated with hostility and unsubstantiated rebuff (because careers and reputations built on this work) that stifles dissent and critique on which scientific process and method depend, and is there the receptiveness to persuasive arguments in midst of inter-paradigm conflict, or the modesty of experts, that Maxwell and Randall (1989) call for in their piece on economic model in a pluralistic, participatory society?

I closed my talk with a FAR SIDE cartoon: the central questions for CVM research may not even be whether we're getting different theoretical perspectives on same question, or some confusion about which perspective is right; but rather whether we're asking the right questions, and whether people are actually giving us answers to the questions we think we're asking. Obviously, you might guess from my remarks that I don't think we know enough yet about the answers to these critical questions to be basing public policy decisions on the results of CVM research. Contrary to the maxim that making decisions with some information better than none at all, I hold that no info is better than bad info. I trust I've fulfilled my charge to be sufficiently provocative.

References

Asch, S.E. 1958. Effects of group pressure upon modification and distortion of judgments. In E.E. Maccoby, T.M. Newcomb and E.L. Hartley (eds.), *Readings in Social Psychology* (3rd ed.). Holt, Rinehart and Winston, New York.

Bergstrom, J.C., J.R. Stoll and A. Randall. 1989. Information effects in contingent markets. *Amer. J. Agr. Econ.*, 685-691.

Bohm, P. 1972. Estimating demand for public goods: An experiment. *Europ. Econ. Rev.*, 3, 2:111-130.

Boyce, R.R., Brown, T.C., McClelland, G.H., Peterson, G.L., and W.D. Schulze. In process. An experimental examination of intrinsic environmental values. Draft manuscript.

Bowker, J.M., and J.R. Stoll. 1988. Use of dichotomous choice nonmarket methods to value the whooping crane resource. *Amer. J. Agr. Econ.*, 372-381.

Bradburn, N.M., Rips, L.J., and S.K. Shevell. 1987. Answering autobiographical questions: The impact of memory and inference on surveys. *Science*, 236, 157-161.

Brookshire, D.S., and D.L. Coursey. 1987. Measuring the value of a public good: An empirical comparison of elicitation procedures. *American Economic Review*, 77(4): 554-566.

Brookshire, D.S., Coursey, D.L., and D.B. Redington. In process. Special interests and the voluntary provision of public goods. Photocopy manuscript.

Brucks, M. 1990. Computer-controlled experimentation in consumer decision making and judgment. *Advances in Consumer Research*, 17, 905-909.

Carlin, A. 1991. Personal communication. Feb. 20, 1991.

Cooper, J., and J. Loomis. In process. Sensitivity of willingness to pay estimates to bid design in dichotomous choice contingent valuation models. Photocopy manuscript. University of California, Davis.

Cummings, R.G., Brookshire, D.S., and W.D. Schulze. 1986. *Valuing environmental goods: An assessment of the contingent valuation method.* Rowman and Allanheld, Totowa, New Jersey.

Coursey, D.I., Hovis, J.J., and W.D. Schulze. 1987. The disparity between willingness to accept and willingness to pay measures of value. *Quart. J. of Econ.*, 52, 679-690.

Daly, H.E. (ed.) 1980. *Economics, ecology, ethics: Essays toward a steady-state economy*. W.H. Freeman and Co., San Francisco.

Dawes, R.M., and R.H. Thaler. 1988. Cooperation. *Journal of Economic Perspectives*, 2(3): 187-197.

Duffield, J. 1990. Economic valuation of fisheries: Nonmarket studies in the Clark Fork Basin. Paper presented at Clark Fork River Symposium, Missoula, MT. Dept. of Economics, Univ. of MT, Missoula.

Edwards, S.F., and G.D. Anderson. 1987. Overlooked biases in contingent valuation surveys: Some considerations. *Land Economics*, 63, 2:168-178.

Fischhoff, B. and L. Furby. 1987. Measuring values: A conceptual framework for interpreting transactions with special reference to contingent valuation of visibility. *Journal of Risk and Uncertainty*, 1, 147-184.

Freeman, M.F. Forthcoming. Welfare measurement and the benefit-cost analysis of projects affecting risks. *South. Econ. Journal.*

Gregory, R. 1986. Interpreting measures of economic loss: evidence from contingent valuation and experimental studies. *Journal of Environmental Economics and Management*, 13: 325-337.

Gregory, R., and R.C. Bishop. 1988. Willingness to pay or compensation demanded: issues in applied resource valuation. In: G.L. Peterson, B.L. Driver and R. Gregory (Editors), *Amenity Resource Valuation: Integrating Economics with Other Disciplines*. Venture Publishing, Inc., State College, PA, pp. 135-142.

Gregory, R., D. MacGregor and S. Lichtenstein. In press. Assessing the quality of expressed preference measures of value. *Journal of Economic Behavior and Organization*.

Grigalunas, T.A., and J.J. Opaluch. 1988. Assessing liability for damages under CERCLA: A new approach for providing incentives for pollution avoidance? *Natural Resources Journal*, 28, 509-533.

Harris, C.C. 1983. *Assessing the validity of economic methods for evaluating sport fishery benefits: A behavioral approach*. Unpublished doctoral dissertation. The University of Michigan, Ann Arbor.

Harris, C.C., H.E.A. Tinsley and D. Donnelly. 1988. Research methods for valuing public amenity resources: Issues and recommendations. In: G.L. Peterson, B.L. Driver and R. Gregory (Editors), *Amenity Resource Valuation: Integrating Economics with Other Disciplines*. Venture Publishing, Inc., State College, PA, pp. 201-218.

Harris, C.C. 1988. Development of a knowledge-based system for improved amenity-resource valuation. Research proposal submitted to USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO. Department of Wildland Recreation Management, University of Idaho, Moscow.

Harris, C.C., B.L. Driver and W.J. McLaughlin. 1989. Improving the contingent valuation method: A psychological perspective. *J. of Environ. Econ. and Management*, 17, 213-229.

Harris, C.C., and M. McGown. 1986. The propriety of applying economic methods to the allocation of public amenity goods: Paradigms, property rights and progress. In R. Johnson and G. Johnson (eds.), 1990, *Economic Valuation of Natural Resources: Issues, Theories and Applications*, pp. 51-65. Westview Press, Boulder, CO.

Harris, C.C., and C. Swanson. 1990. Developments in modelling choice using the public policy referendum format. Paper presented at the Outdoor Recreation Trends Symposium III. March 29-31, 1990. Indiana University, Indianapolis.

Harris, C.C., and G. Brown. Forthcoming. Gain, loss and personal responsibility: The role of motivation in resource valuation decisionmaking. *Ecolog. Econ.*

Heckman, J.J. 1979. Sample selection bias as a specification error. *Econometrica*, 49, 153-61.

Hoehn, J.P., and A. Randall. 1982. Aggregation and disaggregation of program benefits in a complex policy environment: A theoretical framework and critique of estimation methods. Paper presented at the American Agricultural Economics Association meetings, Logan, UT.

Johansson, P., B. Kristrom and K.G. Maler. 1989. Welfare evaluations in contingent valuation experiments with discrete response data: Comment. *American Agric. Econ. Assoc.*, 1054-1056.

Kahnemann, D., and J. Knetsch. Forthcoming. Valuing public goods: The purchase of moral satisfaction. *Journal of Environmental Economics and Management.*

Kelley, H.H., and C.L. Woodruff. 1956. Members' reactions to apparent group approval of a counternorm communication. *J. of Abnorm. and Soc. Psych.*, 52:67-74.

Knetsch, J., and J. Sinden. 1984. Willinness to pay and compensation demanded: Experimental evidence of an unexpected disparity in measures of value. *Quarterly Journal of Economics*, 507-521.

Knetsch, J.L. 1989. The endowment effect and evidence of nonreversible indifference curves. *Amer. Econ. Rev.* 79(5):1277-1284.

Kuhn, T. The Structure of Scientific Revolutions.

Kuttner, R. 1985. The poverty of economics. *Atlantic Monthly*, 225:74-80, 82-84.

Loomis, J., Hoehn, J., and M. Hanemann. In process. Testing the fallacy of independent valuation and summation in multi-part policies: An empirical test of whether `too many proposals pass the benefit cost test.'

Mannesto, G., and J.B. Loomis. Forthcoming. Evaluation of mail and in-person contingent value surveys: Results of a study of recreational boaters. *Journal of Environ. Managem.*, 32.

Maxwell, J.A., and A. Randall. 1989. Ecological economic modeling in a pluralistic, participatory society. *Ecological Economics*, 1, 233-249.

McClelland, G., Schulze, W., Waldman, D., Irwin, J., and D. Schenk. In process. Sources of error in contingent valuation. Draft manuscript.

Miller, T., C.C. Harris, and K. Reese. 1989. A survey of taxpayers' opinions about Idaho's nongame wildlife and tax checkoff program. Unpublished report submitted to the Idaho Department of Fish and Game. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow.

Newcomb, T.M. 1943. *Personality and social change*. Dryden Press, New York.

Phillips, C.V., and R.J. Zeckhauser. 1989. Contingent valuation of damage to natural resources: How accurate? How appropriate? *Toxics Law Reporter*, 10-4-89, 520-529.

Power, T.M. 1988. *The economic pursuit of quality*. M.E. Sharpe, Inc., Armonk, NY.

Randall, A., J.P. Hoehn and G.S. Tolley. 1981. The structure of contingent markets: Some results of a recent experiment. Paper presented at the 1982 Amer. Econ. Assoc. meetings, Washington, DC.

Reich, R.B. 1985. Public administration and public deliberation: An interpretive essay. *Yale Law Journal*, 94, 1617-1641.

Sagoff, M. 1988. Some problems with environmental economics. *Environmental Ethics* 10: 55-74.

Schoemaker, P.J.H. 1982. The expected utility model: Its variants, purposes, evidence and limitations, *J. Econ. Lit.*, 20, 529-563.

Schulze, W.D., R.G. Cummings and D.S. Brookshire. 1983. *Methods development in measuring benefits of environmental improvements*, Vol.II. Report to the U.S. Environmental Protection Agency, Washington, DC.

Scitovsky, T. 1976. *The joyless economy*. Oxford University Press, Oxford.

Sherif, M., O.J. Harvey, B.J. White, W.E. Hood, and C.W. Sherif. 1961. *Intergroup conflict and cooperation: The Robber's Cave experiment*. Univ. of OK. Book Exchange, Norman, OK.

Sherif, M. 1966. *In common predicament: Social psychology of intergroup conflict and cooperation*. Houghton Mifflin, Boston.

Thaler, R. 1980. Toward a positive theory of consumer choice. *J. Econ. Behav. Organ.*, 1, 39-60.

USDA Forest Service. 1990. Resource pricing and valuation procedures for the recommended 1990 RPA program. Appendix B of *The Forest Service Program for Forest and Rangeland Resources: A Long Term Strategy*. Washington, DC.

SELF-REPORTED VALUES AND OBSERVABLE TRANSACTIONS: IS THERE A TRUMP IN THE DECK?*

Alan Randall
The Ohio State University

For many most nonmarket valuation problems, the choice of method must seem like an exercise in the applied economics of second-best. The ideal is usually taken to be interpersonally-verifiable values, but the choice is typically between self-reported values (as in the contingent valuation method, CVM) and inference from observable transactions (as in the travel cost method, TCM). My purpose this afternoon is to explore some of the implications of this choice among alternatives that seem less than ideal.

But, before I do that, let me say just a few words to those who would dismiss the whole controversy with "A plague on both your houses!"

WHY DO NONMARKET VALUATION, AT ALL?

It is nigh impossible to obtain philosophical support for the proposition: The Good Society is, uniquely, that society which maximizes the excess of benefits over costs. None of us ever really believed such a proposition, and we get a little tired of people who are all too willing to point out just how shallow we must be, to believe it.

* Invited paper, W-133 and Western Regional Science Association, Monterey, CA, 2/27/91.

However, I have been surprised to learn just how broad is the philosophical support for the proposition that actions that are beneficial (in the benefit cost sense) are morally worthy. This, of course, is a much less sweeping philosophical position. Claims based on benefits may be trumped by more powerful moral considerations. Nevertheless, I find it quite helpful in clearing the mind.

- We seek to identify beneficial actions because doing beneficial things is morally worthy.

Doing beneficial things is morally worthy, it turns out, because preference satisfaction is morally worthy. If follows rather directly that:

- Beneficial market and nonmarket things are equally worthy because the ethical justification for doing beneficial things is independent of market institutions.

Market institutions are merely means, whereas preference satisfaction is an end. Nonmarket goods and market goods are, in principle, equally valid for preference satisfaction.

One could argue that some worthy things are, under the most favorable conditions, done so badly that they are best not attempted. Some philosophers, some ecologists, and some economists have claimed that benefit cost analysis and, especially, nonmarket valuation are among these things. Today, I will simply deny that claim. Preaching, as I am, to the choir, I can probably get away with that. Elsewhere, I might be obligated to attempt a genuine argument.

THE SCOPE OF NONMARKET VALUATION METHODS

For most purposes, the choice among nonmarket valuation methods narrows rather quickly to two groupings of methods: survey and experimental methods including CVM, and methods that rely on weak complementarity or implicit price theory including TCM. The advantages of CVM, with respect to scope, are now rather widely known. It can be applied to:

- new kinds of policies.
- policies that would extend policy-goods beyond the experienced range.
- policy-goods with no obvious prospects for using weak complementarity or implicit price methods.
- multi-part policies.
- policy-goods with nonuse values.
- valid total valuation frameworks.

This is the easy case to make for CVM, but it leaves some of us uneasy since it seems to claim little more than that, for a large set of important valuation tasks, CVM is the only game in town. Not that this is an unimportant consideration; it's just that it amounts to less than a ringing endorsement.

And that is the way it sometimes comes out in the various official and semi-official pronouncements about what methods of nonmarket valuation are sanctioned for benefit cost analysis, damage assessment, etc.: TCM, for example, is preferred where it is applicable, and CVM is acceptable elsewhere.

IS THERE A TRUMP AMONG NONMARKET VALUATION METHODS

I could have quit while ahead, having made the easy case that CVM has broader scope of applicability than the weak complementarity methods. But there is a case to be made that, in situations where they compete head to head, CVM is at least as promising as, say, TCM.

a) Is TCM a Trump?

The trump claim for TCM emerges typically from its empirical basis in observable transactions. But the analytics of TCM have always been a problem. Over the last generation or so, the following analytical issues have arisen:

- zonal *vs*. household observations?
- the treatment of substitute sites or activities.
- multi-site trips.
- multi-purpose trips.

- the cost of travel time.
- choice of functional form.
- are we dealing with normal or censored distributions; and should we use regression or maximum likelihood estimation methods?

The estimated benefits are sensitive -- some studies report, alarmingly sensitive -- to analytical choices on the part of the researcher. Some of these problems have been resolved; some methodological progress has been made. But many of these problems remain.

Let's look at fundamentals. TCM is not based on observable values but observable transactions. Specifically, it is observed that visitation rates diminish as distance increases. This is the genuinely robust empirical basis of TCM. Assume distance is costly and we can deduce that visitation rates diminish as the cost of visiting increases. This is clearly a testable hypothesis and its robustness corroborates and tends to confirm an essentially economic explanation of a class of behavior that some might otherwise be tempted to claim is fundamentally non-economic. This is an important contribution.

The next and, for nonmarket valuation, crucial step is to infer the value of access to the site from the observable use decision and the concomitant costs. It seems that problems abound. What does travel really cost? Consider that:

- automobile-related costs are largely fixed and independent of the particular trip, once the vehicle is chosen. But there is always the troubling possibility that preferences concerning outdoor recreation may have influenced the choice of motor vehicle.
- distance traveled suffers the same kind of ambiguity. Recreation preferences may be a consideration when choosing one's place of residence.
- lodging and subsistence expenditures have a large discretionary component; so, how does one determine the amount that is a necessary complement to site visitation?
- the cost of travel time remains essentially a mystery to TCM researchers despite some rather ingenious attempts to model the time allocation decision and estimate the cost of time.
- the appropriate set of substitute sites and/or activities to include in the model remains pretty much a mystery; and I include that problem under the general heading of costs. We care about substitute sites and activities because we want some sense of the opportunity costs of selecting the chosen site.

The really bad news is that we cannot reasonably expect to make much more progress in determining what travel really costs. Important components -- probably, the largest components -- of travel cost are simply not third-party observable. TCM methodologists and practitioners are about to hit the wall: in this instance, the Austrian wall. Cost is opportunity cost and opportunity cost is not third-party observable.[1] Without reliable observations of travel cost, there remains an impenetrable gulf between the observable visitation decision and the value of recreation.

Let me be clear. TCM has been valuable, and will continue to be, in confirming the robust relationship between distance and participation, and corroborating the hypothesis that participation declines as the cost of so-doing increases. I believe it should be possible to develop conventions for doing TCM in such a way that we can be sure that the results unambiguously understate the value of site access. This would be a genuinely useful contribution. But, I believe the research program to estimate the value of site access from observable participation decisions and travel costs is about to hit the Austrian wall of subjective costs.

Observable participation decisions or not, TCM is no trump.

---

[1]For those unfamiliar with the controversity between neoclassical and Austrian economists concerning the concept of cost, perhaps a brief summary of the key points is in order.

Neoclassicals argue that cost is uniquely determined by technology and factor prices and therefore third-party observable. Austrians argue that cost is opportunity cost and entirely subjective. What counts as an opportunity is subjective, as is the sacrifice entailed in choosing one opportunity rather than another. Furthermore, opportunity cost is always ex ante; it is the subjective expectation of sacrifice that drives the decision.

The Austrian concept of cost is correct, and the neoclassical concept is wrong. Sometimes, a wrong theory can nevertheless be serviceable for particular uses (e.g., it is often argued that Newtonian physics is good enough for most civil engineering tasks). However, the abject failure of the neoclassical program to base farm price-policy on objectively determined cost of production should give us pause.

While the neoclassical concept of cost is always wrong, it is grievously wrong in the case of travel cost. Travel is a nonhomogeneous activity produced by the household. Characterizing its cost in terms of observable technologies and factor costs is a forlorn hope. It follows that those who seek, by using TCM, to avoid the problem of directly observing preferences will fail: it is necessary to observe preferences directly in order to observe the cost of travel.

b) Is CVM a Trump?

CVM generates data sets of values, WTP or WTA as the case may be, as equalities or -- in the econometric worst case of discrete choice data -- as unidirectional inequalities. Since value data is what is needed, this is an advantage that should be taken seriously.

However, as has been widely remarked, the value data is self-reported in the context of contingent responses to contrived choice situations. This has engendered a skepticism about data quality that has taken a variety of forms. Specifically:

- respondents would answer strategically; it would be to their advantage to send false signals about WTP (WTA).
- respondents would answer carelessly, since the cost to oneself of a wrong decision in a CV exercise might be small.
- responses might be sensitive to a variety of artifacts of the contrived choice situation: whether the alternative situation (that which one is asked to pay for, or accept compensation for) is framed as a gain or a loss relative to the baseline situation; the payment vehicle; the starting price or value; whether the respondent is asked to pay for a menu of other items before, or simultaneously with, the item of direct interest; etc.

It seems that the first two of these concerns no longer attract quite the attention they once did. I have (along with John Hoehn) clearly stated my view on these matters elsewhere. So, I plan to pay them no further attention here. I do want to discuss at some length the sensitivity of CVM responses to conditions built into the choice situation.

For almost as long as CVM has existed -- and, certainly, for longer than it has been known by that name -- authors have been reporting that CVM responses are sensitive to this or that artifact of the questionnaire. Sometimes the tone is one of concern and perhaps a little embarrassment (as one might feel when a skeleton is exposed in the family closet). Sometimes the tone is one of exultation, as though the author believed that his empirical result was the Popperian crucial experiment that would refute the entire CVM research program.[2]

I suspect that there are relatively few potential empirical laws about CVM responses, and that very few paradoxical results will ever achieve the status of empirical laws. Rather, the body of empirical CVM research is a large group of exercises each a little different from the others, and each to be evaluated on its own merits. There are many choices made by the researcher and these choices often have consequences for the CVM responses. The standard for evaluation is first, whether the particular exercise conforms to the highest standards of theory, method, and practice, and only then, what new insights it may suggest about CVM in general.

[2]Incidently, I never have understood the sense of achievement that some feel when reporting a paradoxical result: surely the ancient maxim among computer jocks, "garbage in, garbage out," applies with equal force to survey research in general and CVM in particular. The challenge is to do it right, not to demonstrate that you too can find yet another way to screw it up.

Nevertheless, some findings that CVM responses are sensitive to experimental conditions do seem to be recurrent and perhaps even persistent and replicable. Some studies that appear to be well-done report these kinds of sensitivities. How do we interpret these reports of persistent sensitivities? First, we need to abandon something that seems to have a visceral hold on us, even if we'd never accept it as a scientific proposition: the fixed-point theory of value, the idea that each item on the menu has a single, true value.

Market prices and asset values are conditional. That is, they depend on institutions, supply and demand conditions, and expectations about both. Those skeptical about regarding market prices as informative about "more fundamental" values often raise the issue of price volatility. Prices seem to fluctuate "too much"; they are too hard to predict; they are prone to "speculative bubbles," etc. Was the notorious Van Gogh original really worth the less-than-$10 million that appraisers thought in the early 1980s, the more-than-$50 million that Mr. Alan Bond paid for it in the late 1980s, or the less-than-$30 million for which he sold it a couple of years later? Recently, economists have converged on an answer to that vexing question: "all of the above." That is, the rational markets hypothesis posits that the market price at any moment in time reflects all of the information available at that moment. Each of the prices for the Van Gogh was right for its time, given all that was known at that time. Price is conditional.

Observed prices come in time series: a series of prices, each the result of the "natural experiment" that generated the conditions unique to its moment in time. But that moment will never be repeated, so the natural experiment can never be exactly replicated. The fact that we observe (under ideal conditions) a single price at a given moment must not obscure the principle that market price is conditional.

Contingent values are like market values in this respect. They, too, are conditional. Contingent valuation provides an opportunity to induce cross-sectional variation in WTP (WTA), as a purposeful experimental strategy. The truism that one may change the pattern of responses to a survey by changing the wording of the questions is in no way damning for survey research. Changing the wording of a question changes its meaning, which should change the responses. The most competent survey researchers do not deny that responses are sensitive to wording; rather, they work hard to find the appropriate wording. After the obviously inappropriate question structures have been eliminated, there may be a considerable set of candidates remaining. Where there seems no basis for choosing among candidate question structures, the responsible approach is to set-up experiments testing the effects of alternative wording, i.e., to explore the range of conditional responses.

This process, applied to contingent valuation surveys, does not suggest a search for Popperian refutations of the proposition that "CVM works". Nor does it suggest a search for the one best way to ask WTP (WTA). Since WTP (WTA) is conditional, a program of deliberate experimentation to systematically relate reported valuations to variations in relevant conditions is appropriate.

Such a research program would permit us to map the relationship between reported WTP (WTA) and various conditions that might influence it.[3] It would, per se, cast very little light on whether a particular CV exercise, or the CV method in general, is valid. The conditionality of contingent values precludes such an interpretation of evidence that WTP is not invariant to alternative experimental treatments.

To identify which of a set of conditional contingent values is "right" for policy purposes requires identifying the conditions that are "right" for policy purposes. Theory and methodology of welfare change measurement and survey research will be helpful in eliminating many candidate conditions. Nevertheless, once the conditionality of contingent values is fully understood, it becomes apparent that some conscious decisions must be made, on less than certain grounds, as to what are the "right" conditions for

---

[3]It might be useful to offer a partial but illustrative list of the kinds of conditions that I would recommend be researched systematically, to map their affects on reported WTP (WTA). Value may be conditioned on:

a. alternative descriptions of the status quo and whether the proposed program is framed as a gain or loss. Sometimes the status quo is, in reality, ambiguous.

b. the details of baseline and proposed scenarios. Real-world controversy may pertain to the facts of the situation. In addition, research should be addressed to testing whether discretionary aspects of scenario communication (long or short, what kinds of visuals (etc.) are used) influence WTP (WTA).

c. what else is to be valued, bought, voted-for, etc., prior to or simultaneously with the proposal of direct interest.

d. external conditions not under the control of the researcher. For example, are CVM results about oil spills sensitive to information flows about events in the Gulf?

e. any "baggage" that may be deliberately or inadvertently introduced into the scenarios or CVM format. Payment vehicle is one notorious example, but plenty of others can be imagined.

f. the starting price (if any) offered by the researcher.

g. whether payments are one-time-only or periodic and repeated.

valuation. But, observed market prices are also conditional, and benefit cost analysts working with market data are obliged to make some of the same kinds of choices.

Now, I return to the question raised at the start of this section: Is CVM a trump among nonmarket valuation methods? No; it is at best premature to make that claim. Nevertheless, I believe CVM has, at this moment, more growth potential than TCM. If either of these methods is ever to achieve trump status, I suspect it will not be TCM.

For too long, empirical CVM research was done mostly by people somewhat removed from the mainstream of survey research. Mainstream survey researchers had too little interest in, and understanding of, welfare change measurement. The current mini-boom in CVM research, under the harsh light focused by institutions as influential as the US judicial system and Australia's Resources Assessment Commission, is likely to stimulate a long overdue merger of the best in welfare measurement theory and survey research practice.

POLYCHOTOMOUS CHOICE VALUATION QUESTIONS

Richard C. Ready, John Whitehead, and Glenn Blomquist*

* Authors' affiliations are, respectively, Department of Agricultural Economics, University of Kentucky; Department of Economics, East Carolina University; and Department of Economics, University of Kentucky.

Polychotomous Choice Valuation Questions

Since Bishop and Heberlein's (1979) study on the value of a goose hunting permit, the dichotomous choice (DC) question format has gained wide popularity among contingent valuation (CV) practitioners. Application of the DC format includes both referendum approaches (see Mitchell and Carson 1989) and the original "take-it-or-leave-it" hypothetical market approach of Bishop and Heberlein. In both forms, respondents are faced with a choice between two options. In the baseline option, the respondent's income remains the same, and the resource to be valued is set at some baseline level. The alternative option takes one of two forms. In a willingness-to-pay (WTP) question, the resource is enhanced, and the respondent's disposable income is decreased. In a willingness-to-accept (WTA) question, the resource is degraded relative to the baseline, and the respondent's income is increased. In either case, the respondent is asked to compare his or her own utility under the baseline with utility under the alternative option. It is hoped that if utility is higher under the alternative option than under the baseline, the respondent will so indicate, either by stating that he or she would vote "yes" in the hypothetical referendum, or that he or she would make the hypothetical transaction.

With the DC format, the hypothetical decision situation in which the respondent is placed closely resembles an actual market transaction or an actual voting situation, and so should be familiar to the respondent. For this reason, DC questions are believed to be easier to answer than open-ended questions. The DC format does not suffer from starting point bias, though poorly chosen bid amounts can limit the analysis, and provides no incentives for strategic responses (Hoehn and Randall 1987). The DC format is easier to administer than iterative approaches, and makes fewer demands on the respondent's time and patience. The DC approach has the disadvantages, relative to open-ended questions or iterative bidding approaches, that less information is collected from each respondent, and that statistical analysis is more complicated and requires rather strong assumptions about the statistical distribution of values among respondents (Hanemann 1984, Cameron 1988).

One aspect of the DC approach that has received little attention is the form that the question should take. Standard practice has been to offer respondents two choices, "yes" and "no". The respondent is asked to indicate which option, the baseline or the change, is more desirable. However, the hypothetical scenario presented will be deliberately constructed such that neither choice dominates the other in all respects. In a WTP question, for example, a "yes" response would gain the respondent an increase in the amenity, a desirable change, but a decrease in disposable income, an undesirable change. The respondent is therefore guaranteed to have ambivalent feelings about the choice. The polar extremes of "yes" and "no" may not accurately describe the way in which the respondent views his or her own preferences in the hypothetical situation being posed. Rather, the respondent may prefer to think of the action in probabilistic terms, such as "I probably would vote yes" or "I might vote no" or in terms of the strength of preferences, such as "I strongly prefer the baseline" or "I slightly prefer the alternative option." Valuation questions that provide a range of possible responses that vary according to the probability or intensity of preference might be less stressful for the respondent, because they allow a more accurate description of the respondent's preferences. Such a question format might be called polychotomous choice (PC).

Use of a PC format should not materially affect whether a respondent answers yes or no. If expected utility is higher under one option than the other, the respondent should indicate preference for that option, whether or not he or she is given the opportunity to express mixed feelings about the trade-off involved. Thus, the proportion of total yes responses should not differ between the DC and PC formats, and the two formats should provide similar estimates of the value of the amenity or resource in question. However, expressing preferences along a scale of relative probability or relative strength may seem more natural to the respondent than forcing an answer that implies certainty, perhaps resulting in lower item non-response rates and lower protest rates, yielding a larger usable sample.

The equivalence of the two formats in terms of item non-response rates and protest rates and in terms of estimated willingness-to-pay was empirically tested in two separate studies, one estimating the external costs of wetland destruction by coal mining, the other estimating the benefits of horse farm preservation.

Survey Methods

Detailed accounts of the two studies discussed here are available in Blomquist and Whitehead (1990) and Ready (1990). Sampling was done by the same method for both studies. First, households were contacted by phone using random digit dialing in target counties. Persons answering the phone were asked to participate in a mail survey. Those that gave the interviewer their name and address were sent questionnaires in the mail with one follow-up postcard according to Dillman (1978). Non-respondents were sent one additional copy of the questionnaire.

In the wetlands study, respondents were told to imagine that a wetland in Western Kentucky was threatened by coal mining. Alternative versions of the questionnaire gave different descriptions of the wetland, including different wetland types with varying characteristics. Respondents were told that the wetland could be preserved if the respondent would donate a specified amount to a wetlands preservation fund. Bids were chosen based on a presurvey with an open-ended valuation question, and ranged from $3 to $49. In DC questionnaires, respondents were asked whether they would be willing to make the specified donation in order to preserve the wetland. Respondents were given only YES and NO as possible responses. PC questionnaires were identical to the DC questionnaires, except that respondents were given six responses to choose from, DEFINITELY YES, PROBABLY YES, MAYBE YES, MAYBE NO, PROBABLY NO, and DEFINITELY NO.

In the horse farm study, respondents were asked to suppose that the number of horse farms in Kentucky would decrease over time, due to a continuing decline in the profitability of horse farming in Kentucky relative to other states. Different questionnaires presented different levels of reduction, ranging from a 25% decrease in the number of horse farms to a complete loss of horse farms in Kentucky. These scenarios were credible to the respondents, at least for the lower decrease levels. 72% of the respondents indicated that they believed that the number of horse farms in Kentucky is currently declining. Respondents were told that this decrease could be avoided with a package of incentives to horse farm owners, but that the package would result in higher state and local taxes. Bid amounts were based on an open ended valuation question in a presurvey and ranged from $5 to $500. In DC questionnaires, respondents were asked which they would prefer: implementation of such a program, or the decrease in horse farming. Possible responses were limited to PREFER PROGRAM and PREFER NO PROGRAM. Again, PC questionnaires were identical to DC questionnaires, except that respondents were given six responses to choose from; STRONGLY PREFER PROGRAM, PREFER PROGRAM, SLIGHTLY PREFER PROGRAM, SLIGHTLY PREFER NO PROGRAM, PREFER NO PROGRAM, and STRONGLY PREFER NO PROGRAM.

In both the wetland study and the horse farm study, a small number of PC questionnaires were mailed that included five response categories, rather than six. In these, the two middle response categories were combined to create a MAYBE category in the wetland study, and a NO PREFERENCE category in the horse farm study.

Response and Protest Rates

A total of 641 wetland questionnaires and 626 horse farm questionnaires were mailed out. The response rates for the three different question formats are presented in Table 1. Incomplete surveys are those that were returned, but were unusable, typically due to item non-response for the valuation question. Protest responses were determined by follow-up questions to the valuation question. Too few "five response" surveys were included in either study to draw conclusions about the performance of that format. The discussion that follows concentrates on comparisons between the "six response" format and the "two response" format.

It was postulated that the PC format might result in higher return rates, lower item non-response rates, and lower protest rates than the DC format. These would combine to yield higher rates of usable surveys. The results of the two studies are suggestive, but not conclusive. In both studies, the PC format did result in a higher rate of usable responses than did the DC format (67.0% versus 60.0% for the wetland study, 58.0% versus 53.5% for the horse farm study). Logit estimation was used to analyze factors influencing the probability of a particular survey being returned and being usable, to determine whether these differences are statistically significant. For both studies, factors investigated included the particular scenario described in the survey (percent loss of horse farm, size and type of wetland involved, etc.) and whether the valuation question was of the DC or PC format. For both surveys, none of the scenario variables significantly affected the probability of a survey being returned and being usable. For the wetland survey, the coefficient on the dummy variable for question format was positive, indicating that PC format surveys were more likely to be returned and usable, and was significant at the 0.05 level (asymptotic t=2.159). For the horse farm study, the coefficient on the dummy variable was again positive, but was not significant (asymptotic t=1.014).

We can offer no explanation for why the two surveys would generate different response patterns. Our belief is that question format did have a real effect on the proportion of usable responses in both studies, but that the effect is slight.

Valuation Results

The DC format asks the respondent to indicate the direction of his or her preference. The PC format allows the respondent to indicate both the direction of preference and the intensity or probability of preference. If respondents are able to answer DC questions accurately, then expansion to a PC format should not influence the direction of the response. This assertion is a testable hypothesis in the context of the two studies. Specifically, we tested whether the question format affected the probability of a "yes" response.

Logit estimation was used to investigate factors influencing the probability of a respondent giving a "yes" response. Table 2 describes the independent variables used in both the wetland and horse farm regressions. Table 3 presents the results of logit estimations for both studies. A log-linear specification (log in bid) was used for the wetland study, while a linear specification was used for the horse farm study. Variables used in the regressions reflect both the characteristics of the household surveyed, characteristics of the scenario presented in the survey, and a dummy variable, PC, for the question format used in the survey. The coefficient on PC indicates the impact of question format on the probability of a "yes" response. In both studies, the coefficient on PC was positive, and significant at the 1% level. In other words, respondents are more likely to say yes to a bid if the question is asked using a PC format than if asked using a DC format.

This result was unexpected. It would imply that the values respondents place on the amenity estimated using data from a PC question would be higher than those estimated using data from a DC question. To investigate the impact of question format on estimated amenity values, the full sample for each study was split into two subsamples, one for each question format, and logit regressions were run on each subsample. The results of these four regressions, transformed according to Cameron (1988) are presented in table 4.

The regression results presented in table 4 can be used to estimate the value that a household places on a wetland or on the existence of horse farms in Kentucky. Estimated WTP to preserve a wetland with different characteristics is shown in figure 1 for a typical Kentucky household. As would be expected from the logit analysis of the full sample, estimated WTP is higher for the PC subsample than for the DC subsample. Also, both subsamples showed a positive relationship between WTP and the characteristics index.

Households place a higher value on wetlands with higher index values. However, that positive relationship is significant only for the DC subsample. As can be seen from Table 4, the coefficient on the characteristics index for the PC subsample is positive, but insignificant.

Estimated WTP to preserve horse farms is shown for both subsamples in figure 2. Again, estimated values are higher for the PC subsample than for the DC subsample. Here, however, the relationship between WTP and the scenario presented is slightly more complex. For the DC subsample, WTP increased from the 25% level to the 50% level, and from the 50% level to the 75% level, but then dropped off sharply at the 100% level. These differences were statistically significant at the 10% level (χ^2 with 3 d.f.= 7.445). A similar pattern was seen in the open-ended valuation question used in the survey pretest. There, mean WTP to avoid a 25% loss was \$23.21 (n=14), WTP to avoid a 50% loss was \$52.31 (n=13), WTP to avoid a 75% loss was \$97.92 (n=12), while WTP to avoid a 100% loss was only \$68.55 (n=31).

If respondents place a value on the existence of horse farms in Kentucky, the value of avoiding a loss in the number of horse farms should logically increase as the number of farms threatened is increased. Thus, the increase in WTP from the 25% level to the 75% level is expected. The dropoff in WTP at the 100% level is unexpected however. It is most likely due to a problem with the credibility of that scenario. Focus group participants indicated that they were willing to believe that the number of horse farms in Kentucky has been declining in recent years. However, many respondents were unwilling to believe that the horse industry might leave Kentucky completely. A respondents might respond "no" to the valuation question because he or she does not believe the scenario being presented, not because his or her WTP is below the bid price.

In contrast, estimated WTP for the PC subsample, while higher at each loss level than for the DC subsample, did not vary from loss level to loss level. The slight decrease in value with increasing loss level is statistically insignificant (χ^2 with 3 d.f.=0.2142). As with the wetland study, the scenario presented seems to have less impact on responses with the PC format than with the DC format.

Discussion

To summarize, we found three results that were consistent between the two studies. First, the PC format tends to result in slightly higher rates of usable responses, and therefore slightly higher sample sizes, than does the DC format. Second, the PC format results in much higher rates of "yes" responses, and therefore much higher estimated WTP's than does the DC format. Third, respondents seem to be less influenced by the scenario being presented when answering a PC format valuation question than when answering a DC format question. These results were consistent between two studies that valued different amenities (wetlands and horse farms), used different payment vehicles (voluntary contributions vs. taxes), and motivated the six PC responses differently (by probability vs. by intensity of preference).

Is there a single model of respondent behavior that motivates all three of these results? Use of PC type questions was motivated by the belief that respondents would be more comfortable answering valuation questions if they were given the opportunity to express their ambivalence, rather than being forced to state their preferences unequivocally. This implies that there may be some loss of utility associated with answering a DC format question, that does not occur with a PC format question. An ambivalent respondent who is forced to state YES or NO may feel that neither answer is completely correct.

Such a respondent may experience disutility from choosing either answer, and may instead choose to not answer the question or to not return the survey. Likewise, the disutility associated with answering a DC question may increase the tendency for a respondent who is unhappy with the hypothetical scenario being presented to enter a protest response.

But why would question format influence the probability of a "yes" response? It could be that a respondent with mixed emotions about the trade-offs involved in the hypothetical situation views the loss associated with answering YES differently from the loss associated with answering NO. Consider a respondent who is unsure of his or her true preferences. Answering YES is incorrect, since with more thought or more information, the respondent might conclude that NO is the correct response. Similarly, NO is an incorrect answer since the respondent believes that there is a chance the true answer is YES. However, the cost of being wrong is not symmetric. The respondent may feel that it is worse to say YES when the true answer is NO, then to say NO when the true answer is YES. The respondent may view the former as a lie, since it involves a commitment to undertake some specific action (vote yes or pay money), but view the latter as only a mistake. Such a respondent will tend, therefore, to answer "no." To use a market analogy, if you are unsure whether you want to buy something, and you are risk averse, you will tend to not buy it.

This effect is less pronounced with a PC format question. A respondent who chooses MAYBE YES or SLIGHTLY PREFER YES is indicating that there is uncertainty over the true answer. It is impossible to be wrong with such a response. If the respondent answers MAYBE YES, when the true answer is NO, the respondent has not told a lie. The cost associated with such a response is therefore very low, and is symmetric with the cost associated with "maybe no". The tendency for a higher proportion of yes responses with the PC format is therefore due to a combination of ambivalence over the choice being made and an asymmetry in the utility loss from giving the wrong answer to a DC question.

Higher losses associated with an incorrect DC response would also explain the third result, that respondents pay less attention to the scenario presented when answering a PC question than when answering a DC question. If the cost of giving an incorrect answer to a DC question is high, the respondent will spend time and effort thinking about his or her true WTP, including giving attention to the specifics of the scenario being presented. In contrast, the loss associated with an incorrect answer to a PC question may not be large enough to provide the incentive to think hard about the question. It may be too easy for a respondent to say MAYBE YES, so that respondents choose this answer without giving enough consideration to the specifics of the scenario being presented. Thus, respondents answering a PC question may pay less attention to the specifics of the scenario because the utility cost associated with being wrong is so low.

Which, then, is the preferred format for CV studies? The PC format yields higher usable sample sizes, which is desirable, but respondents show less care in answering PC questions, which is undesirable. Outweighing either of these considerations, however, is the higher tendency for "yes" responses with the PC format. The difference in estimated WTP from the two formats is strikingly large, and can have important policy implications. Here, the difficulty is that we do not know whether the DC format underestimates true WTP by making it too hard to say YES, or whether the PC format overestimates true WTP by making it too easy to say MAYBE YES, or whether both formats give answers that are systematically biased. Here, comparisons with simulated or actual markets could help resolve which format is preferred.

References

Bishop, Richard C., and Thomas A. Heberlein. 1979. "Measuring Values of Extramarket Goods: Are Indirect Measures Biased?" American Journal of Agricultural Economics 61(5):926-930.

Blomquist, Glenn C., and John C. Whitehead. 1990. the Effect of Alternative and Reclaimed Areas on the Value of Wetlands. Final Report to the Office of Surface Mining, Reclamation, and Enforcement.

Cameron, Trudy Ann. 1988. "A New Paradigm for Valuing Non-Market Goods Using Referendum Data: Maximum Likelihood Estimation by Censored Logistic Regression." Journal of Environmental Economics and Management 15:355-379.

Dillman, Don A. 1978. Mail and Telephone Surveys: The Total Design Method. New York. Wiley.

Hanemann, W. Michael. 1984. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses." American Journal of Agricultural Economics 66:332-341.

Hoehn, John P., and Alan Randall. 1987. "A Satisfactory Benefit Cost Indicator from Contingent Valuation." Journal of Environmental Economics and Management 14(3):226-247.

Mitchell, Robert C., and Richard T. Carson. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington, D.C. Resources for the Future.

Ready, Richard C. 1990. The Value to Kentuckians of the Kentucky Equine Industry: A Contingent Valuation Study. Preliminary Report to the Lexington Chamber of Commerce.

Table 1. Response rates, item-nonresponse rates, protest rates, and ultimate sample sizes for the wetland and horse farm studies.

WETLANDS STUDY

	TWO RESPONSES	SIX RESPONSES	FIVE RESPONSES
# of surveys mailed	368	233	40
# of surveys returned	294	172	25
(% of total mailed)	(79.9)	(73.8)	(62.5)
# of incomplete surveys	40	1	0
(% of total returned)	(13.6)	(0.6)	(0.0)
# of protest responses	33	15	2
(% of completed surveys)	(13.0)	(8.8)	(8.0)
final sample size	221	156	23
(% of total mailed)	(60.0)	(67.0)	(57.5)

HORSE STUDY

	TWO RESPONSES	SIX RESPONSES	FIVE RESPONSES
# of surveys mailed	282	281	63
# of surveys returned	202	205	41
(% of total mailed)	(71.6)	(73.0)	(65.1)
# of incomplete surveys	8	9	4
(% of total returned)	(4.0)	(4.4)	(9.8)
# of protest responses	43	33	7
(% of completed surveys)	(22.2)	(16.8)	(18.9)
final sample size	151	163	30
(% of total mailed)	(53.5)	(58.0)	(47.6)

Table 2. Variables used in logit regressions.

WETLAND STUDY

CHAR	index of wetland characterisitics - ranges from 7 to 18
MALE	= 1 if male
AGE	age of respondent in years
EDUC	education of respondent in years
CHILD	number of children in household
WAGE	hourly wage
MEMBER	= 1 if member of a conservation organization
DISTANCE	household distance from wetland
PC	= 1 if survey uses polychotomous choice format

HORSE FARM STUDY

25%LOSS	= 1 if horse industry would decline by 25%
50%LOSS	= 1 if horse industry would decline by 25%
75%LOSS	= 1 if horse industry would decline by 25%
FEMALE	= 1 if female
AGE	age of respondent in years
EDUC	education of respondent in years
INCOME	household income; = 0 if question not answered
INCTELL	= 1 if income question not answered
RACE	= 1 if respondent visited race track in past year
PROX	index of distance to closest horse farm, ranges from 1 to 9
BG	= 1 if household located in bluegrass region
POPDENS	population density of county of residence
FARMS	number of horse farms in county of residence
PC	= 1 if survey uses polychotomous choice format

Table 3. Logit coefficients for both studies, including PC and DC responses.

WETLAND STUDY n=377

VARIABLE	COEFFICIENT ESTIMATE	STANDARD ERROR	ASYMPTOTIC T
CONSTANT	-2.1679	0.9590	2.26
LOGBID	-0.5996	0.1286	4.66
CHAR	0.0908	0.0370	2.45
MALE	0.2790	0.2417	1.15
AGE	-0.0125	0.0077	1.63
EDUC	0.1115	0.0502	2.22
CHILD	0.1253	0.1250	1.00
WAGE	0.0376	0.0145	2.60
MEMBER	1.0066	0.3215	3.13
DISTANCE	0.0035	0.0019	1.85
PC	0.9349	0.2498	3.74

HORSE FARM STUDY n=314

VARIABLE	COEFFICIENT ESTIMATE	STANDARD ERROR	ASYMPTOTIC T
CONSTANT	0.6200	1.0973	0.56
BID	-0.0043	0.0009	-4.60
25%LOSS	-0.1962	0.3647	-0.54
50%LOSS	0.3324	0.3694	0.09
75%LOSS	0.3859	0.3596	1.07
FEMALE	-0.2746	0.2656	-1.03
AGE	0.0106	0.0079	1.33
EDUC	-0.0010	0.0522	-0.02
INCOME	0.0135	0.0063	2.15
INCTELL	0.5715	0.5891	0.97
RACE	0.3672	0.2903	1.27
PROX	-0.1900	0.0853	-2.23
BG	-0.7661	0.5042	-1.52
POPDENS	-0.0000	0.0003	-0.04
FARMS	0.0031	0.0022	1.37
PC	0.6971	0.2617	2.66

Table 4. Transformed logit coefficients for split samples of both studies.

WETLAND STUDY

VARIABLE	DC SURVEYS ONLY n=221 COEFFICIENT ESTIMATE	STANDARD ERROR	ASYMPT T	PC SURVEYS ONLY n=156 COEFFICIENT ESTIMATE	STANDARD ERROR	ASYMPT T
CONSTANT	-2.4131	2.0313	-1.19	-3.4779	2.3382	-1.49
CHAR	0.2270	0.1117	2.03	0.0643	0.0898	0.72
MALE	0.0821	0.5435	0.15	1.0071	0.6558	1.54
AGE	-0.0260	0.0189	-1.38	-0.0187	0.0193	-0.97
EDUC	0.0572	0.1061	0.54	0.3838	0.1957	1.96
CHILD	0.0099	0.2775	0.04	0.2474	0.3275	0.76
WAGE	0.0833	0.0394	2.12	0.0028	0.0414	0.07
MEMBER	1.5754	0.8740	1.80	1.7838	1.1297	1.58
DISTANCE	0.0035	0.0041	0.85	0.0101	0.0063	1.62
k	1.7135	0.4846	3.54	1.4510	0.4499	3.22

HORSE FARM STUDY

VARIABLE	DC SURVEYS ONLY n=151 COEFFICIENT ESTIMATE	STANDARD ERROR	ASYMPT T	PC SURVEYS ONLY n=163 COEFFICIENT ESTIMATE	STANDARD ERROR	ASYMPT T
CONSTANT	-4.7532	342.8172	-0.01	512.2832	413.2789	1.24
25%LOSS	-85.6516	107.6128	-0.80	51.0533	143.2484	0.36
50%LOSS	65.8593	115.6324	0.57	-23.1601	125.9667	-0.18
75%LOSS	190.1766	115.8700	1.64	1.2695	128.7523	0.01
FEMALE	-28.7212	80.1135	-0.36	-121.1467	105.1476	-1.15
AGE	1.8040	2.4201	0.75	2.9206	2.9085	1.00
EDUC	8.5372	15.6405	0.55	-7.1698	18.5492	-0.39
INCOME	1.3716	1.8267	0.75	4.2652	2.5913	1.65
INCTELL	98.3841	170.1216	0.58	198.0218	239.8455	0.83
RACE	118.0060	87.1146	1.35	45.2371	100.2002	0.45
PROX	-35.2711	26.4762	-1.33	-58.7232	35.9937	-1.63
BG	-123.0461	145.3058	-0.85	-266.2008	196.8066	-1.35
POPDENS	-0.0827	0.1006	-0.82	0.0445	0.1109	0.40
FARMS	0.7523	0.6665	1.13	0.8304	0.8622	0.96
k	209.4784	58.2493	3.60	244.2637	84.3606	2.90

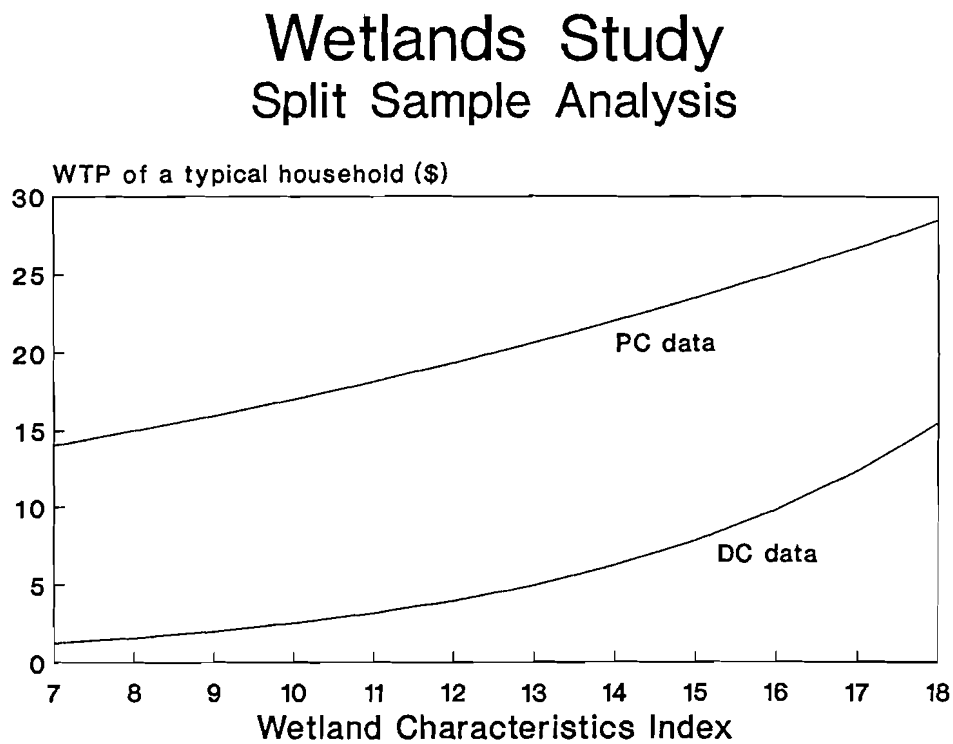


Figure 1. Willingness to Pay of a typical household to preserve wetlands with varying characteristics.

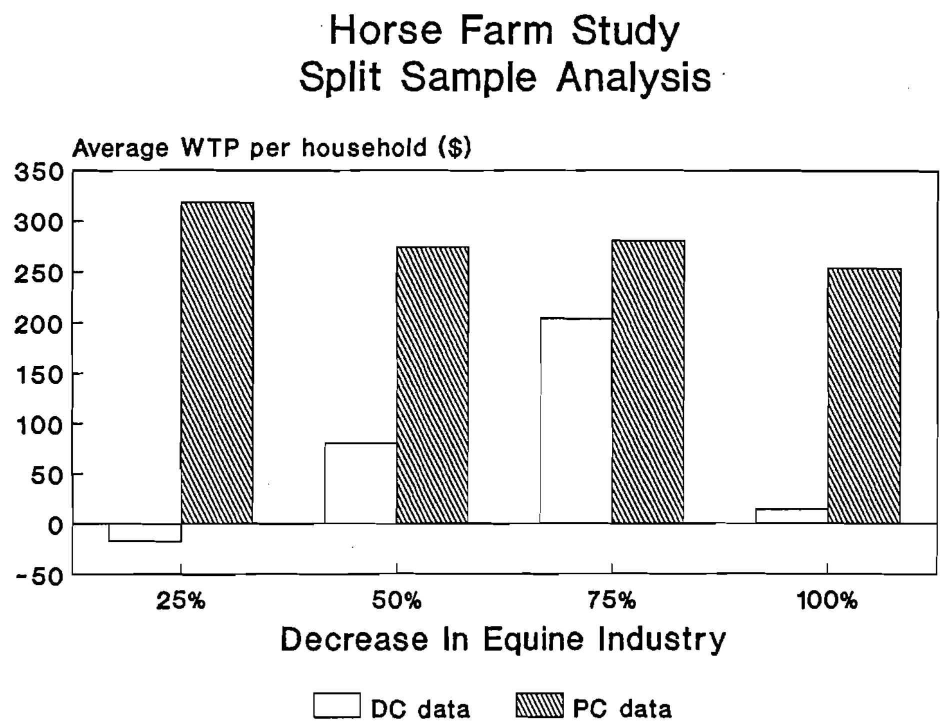


Figure 2. Average Willingness to Pay per household to avoid different levels of loss of horse farms.

THE GRAND CANYON VISIBILITY BENEFITS STUDY

William E. Balson, Richard T. Carson, Michael B. Conaway, W. Michael Hanemann, Annette Hulse, Raymond J. Kopp, Kerry M. Martin, Robert C. Mitchell, Stanley Presser, and Paul A. Ruud*

*Authors' affiliations are, respectively, Decision Focus, Inc.; Department of Economics, University of California, San Diego; Natural Resource Damage Assessment, Inc.; Department of Agricultural Economics, University of California, Berkeley; Decision Focus, Inc.; Resources for the Future; John F. Kennedy School of Government, Harvard University; Graduate School of Geography, Clark University; Department of Sociology, University of Maryland; Department of Economics, University of California, Berkeley. The opinions expressed in this paper are solely the responsibility of the authors and should not necessarily be taken to be those of the Salt River Project. A number of individuals and organizations assisted in various phases of the research reported here, including Baruch Fischoff, John Molenar, and Greg Witherspoon. They too should remain blameless for any errors we have made.

INTRODUCTION

The general context for this paper is a major policy controversy over the steps to be taken to limit visibility impairment at national parks. The particular context is the debate over whether the Navajo Generating Station (NGS) should install scrubbers to lessen its contribution to visibility impairment at the Grand Canyon National Park. The U.S. Environmental Protection Agency (EPA) has recently proposed a Best Available Retrofit Technology (BART) action which would require the NGS to cut its emissions by 70-90%, depending on the final rule. Action of this magnitude would require the NGS to spend more than a billion dollars to install scrubbers. This issue pits the EPA, the National Park Service (NPS), and the Environmental Defense Fund against the various owners of the NGS, namely, the Bureau of Reclamation and several large public utilities, including the Salt River Project (Phoenix) and the Los Angeles Department of Water and Power.

This paper describes our work, the Grand Canyon Visibility Benefits (GCVB) Study (Balson *et al.*, 1990), to value visibility changes of the type which might result from EPA's proposed BART action. Our work was sponsored by the Salt River Project. EPA and NPS have also sponsored a contingent valuation survey by Chestnut and Rowe (1990) (hereafter CR Survey) to value visibility benefits in the Southwestern Parks and an effort by Rowe, Chestnut, and Skumanich (1990) (hereafter RCS Report) to extrapolate the results of that survey to obtain a benefit estimate for Grand Canyon visibility improvements which might result from an NGS BART action. Much of the design of the GCVB study was motivated by what we considered flaws or weaknesses in earlier drafts of the CR Survey and RCS Report. As a result, this paper frequently compares and contrasts the design of the GCVB study with that of the CR Survey and the RCS Report. We believe that this approach will help clarify many of the key issues surrounding the valuation of visibility improvements in national parks.

MEASURING VISIBILITY BENEFITS

Contingent Valuation

Environmental amenities like air and water quality can not be bought and sold in the open market. Economists have developed several techniques for measuring the value of these so-called non-marketed goods. When the primary value of the non-marketed good comes from its direct use by the public, a number of different techniques can be used. When there are thought to be substantial nonuse values, then contingent valuation (Mitchell and Carson, 1989) is the only economic valuation technique capable of correctly, from the perspective of economic theory, measuring both use and nonuse benefits of visibility improvements. Contingent valuation (CV) is a survey based approach which sets up a market in which a respondent can make purchase decisions involving the environmental amenity of interest. The respondent is queried about his or her willingness to pay (WTP) for this environmental amenity. The choice is often placed in the context of how the respondent would vote if the cost to them of providing the amenity was $x. Both the CR Survey and the GCVB Study use the contingent valuation method. The method is increasingly accepted by economists and the courts (Kopp, Portney, and Smith, 1990) as a valid way to measure the public benefits of natural resources.

Design Choices

As with any research method, the validity of any individual CV study depends on the degree to which the potential sources of bias and error are controlled. In the case of contingent valuation, careful attention must be given both to economic theory issues and to a number of survey research issues. These issues include the wording of the questionnaire, the size, the design, and the selection of the sample, the execution of the survey, including the method of administration, and the analysis of the data. The wording, which involves the choice of scenario elements, the sequence of their introduction, and the language used to convey this framework to the respondent and to pose the valuation questions, is of obvious importance because it will influence the respondents' answers, including their willingness-to-pay amounts. The wording choices therefore require justification and, for studies used in policy purposes, must survive scrutiny by professionals and policy-makers.

In the course of designing a contingent valuation survey suitable for use in benefit/cost decision-making, the researcher inevitably must make and justify a number of design decisions which often have no obviously correct answers. Many of these decisions involve the scenario. The scenario is the market framework within which the respondent is asked to value the good. It includes such things as the payment vehicle, the duration of the payments, the nature of the good and how it will be provided, the method used to elicit the willingness-to-pay (WTP) amount, such as a payment card or an open-ended question, and conditions under which the good will be provided, such as the time of the year. The scenario used in a contingent valuation survey should be consistent with applied welfare theory and the nature of the good being valued. It must also be plausible and understandable to the ordinary respondent for whom the experience of stating a dollar value for a non-marketed good may be a novel experience.

Previous Work

The RCS Report estimated the economic benefits from winter visibility improvements in the Grand Canyon National Park that might result from a BART action requiring air pollution controls on the NGS. That report based its benefit estimates on the earlier CR Survey. The benefit estimates presented in the RCS Report are flawed because they are inappropriately derived from the CR Survey through questionable analytical assumptions and appear to substantially overstate the benefits of a possible BART action.

The CR Survey questionnaire was mailed to 3,345 households selected in five states: Arizona, California, Missouri, New York, and Virginia. A total of 1,647 responses were received. An insert contained 3 x 5 inch color photographs of four levels of visibility conditions during the summer at one or more of three national parks. The four levels were the reference level, one decreased visibility level, and two improved levels. The good was described as changes in average annual visibility range. Photographs for the reference level showing a range of 135 miles were described as illustrating the current annual range. Respondents valued large improvements to 200 and 250 miles and the prevention of deterioration to 115 miles. The study used a higher prices and taxes payment vehicle, a payment card elicitation method, and an annual payment in perpetuity.

Three versions of the instrument obtained WTP amounts for improving visibility in all the Southwestern national parks. Willingness to pay for the Grand Canyon was obtained by asking respondents to say what percentage of these WTP amounts they would allocate to the Grand Canyon. Although these three versions differ in the information provided to the respondents, Chestnut and Rowe say they found no statistically significant differences in responses for the three versions and therefore combined the results for these treatments, using those results in the RCS Report to EPA which estimates Grand Canyon visibility benefits. The Grand Canyon estimates are based on approximately 700 usable cases from the three different treatments.

Two major problems with the CR Survey bear mention here. That study does not at any point specifically value the type of visibility change envisioned as a result of a Navajo BART action, *i.e.*, a decrease in winter event days. Rather, the CR Survey values the aggregate of large changes in average annual visibility levels at all Southwest parks with the result that statistical techniques and a long chain of unverifiable assumptions must be used to impute a value for the visibility change that EPA projects will occur in the Grand Canyon due to a Navajo BART action. The primary source of proposed visibility change, a coal-fired power plant, is never mentioned to respondents. Furthermore, region-wide improvements -- the Southwestern Parks -- were the primary focus of the CR Survey, not the Grand Canyon. Respondents were asked for a single "percentage" to allocate their WTP amounts to Grand Canyon visibility.

A second problem concerns what respondents in the CR Survey were actually valuing. The intent of that study was to value visibility; the issue is whether their respondents were also valuing other presumed effects of air pollution such as health effects, harm to wildlife, harm to plants, and harm to geologic formations, *in addition to* visibility. The problem of separating visibility benefits from other types of benefits is driven by consideration of provisions of the Clean Air Act and has long been recognized as a difficulty by contingent valuation researchers working in the area of air pollution. Two approaches have evolved for dealing with this separability issue. One approach is to take an aggressive tact to informing respondents that they are only buying visibility improvements and that the health of plants, animals, and humans is not at risk or affected by the policy in question. The second is to take a statistical approach to separating the values of different types of benefits using an explicit hedonic pricing equation (Carson, Mitchell, and Ruud, 1990). The CR Survey did neither of these, and a substantial part of the benefits they attribute to visibility may in fact come from the respondents' wrongly believing that they will get other types of benefits if the visibility is improved.[1]

A number of other survey-related problems weaken the CR Survey as a basis for a NGS BART decision. These include:

- The results were extrapolated to the entire U.S. population despite the fact that the CR Survey was administered in only five states and was based on an inadequate sampling frame within those states.

- The study does not adequately address the problems in using a mail survey to administer a visibility contingent valuation study. One is the high level of illiteracy and semi-literacy in the United States (Mitchell and Carson, 1989); 10 to 20 percent of the population would find it hard or impossible to understand a questionnaire as complex as the CR instrument. Another is the possibility of selection bias inherent in mail surveys where those who look at it and choose to answer it may be more interested in the subject matter and have higher values for the good it describes than those who examine the questionnaire and choose not to answer it. A third is the lack of control over who fills the questionnaire out and how it is administered. A self-administered questionnaire may or may not be given the amount of serious attention necessary to arrive at a meaningful value for the good.

[1]The CR Survey instrument told their respondents to give only their willingness to pay for visibility improvements. However, in a follow-up question (Q17), only 32% of their respondents indicated that their WTP amounts were "basically for the stated changes in visibility at national parks". Even this 32% is in doubt though, as 115 out of 449 respondents who gave this response did not follow instructions and later indicated that the average percentage of their WTP amounts which should be attributed to visibility was slightly less than 50%. Further, the CR Survey only made an attempt to separate visibility from a general "help other needs at the national parks" and did not make an attempt to separate "visibility" from several other phenomena such as acidic clouds damaging rock formations which our focus group work suggests many people initially see as closely intertwined with visibility degradation.

THE GCVB STUDY

By building on the knowledge gained from previous CV studies of visibility improvements, including our own work on Eastern air visibility (Carson, Mitchell, and Ruud, 1990) and the CR Survey, a draft instrument was developed which was then tested and revised repeatedly until threats to its validity had been identified and satisfactorily addressed. In the course of the research reported here, we conducted focus groups, two telephone surveys, two survey pretests, and a pilot study of 202 persons. This series of research activities was designed to assess whether our initial critique of the CR Survey was correct and to help us understand the problems that would have to be overcome in designing a valid visibility contingent valuation study for the Navajo BART case (Balson, 1990). The focus groups explored the participants' basic assumptions about visibility improvements in general and the Grand Canyon in particular. Later focus groups paid particular attention to the Grand Canyon photographs to be used in the in-person surveys. The telephone surveys were conducted with random samples of Phoenix and Chicago residents. The questions in the telephone surveys were used to assess the representativeness of our focus group findings and to begin developing the structure of an in-person survey. While telephone surveys do not permit the use of photographs, they are quick to implement and proved to be very useful for the exploratory purpose for which they were used. The final activity during the preliminary assessment phase of our research was a small in-person survey we conducted in Provo, Utah. The instrument for this survey was an adaptation of the phone instrument modified for use with Grand Canyon visibility photographs. The results of this work suggested that a successful in-person survey based on days of visibility change in different seasons with a fairly extensive set of photographs was possible.

We also began to develop an instrument specifically for a larger in-person survey starting from the questionnaire developed during the assessment phase of our work. This instrument went through numerous drafts, a couple of small three-person focus groups, and a series of test interviews. We contracted with the National Opinion Research Center at the University of Chicago, one of the nation's leading survey research organizations, to conduct a pretest and pilot study.

The pretest took place at the end of June. After a day long interviewer training session for four NORC interviewers and their supervisors, the interviewers carried out a 22 respondent in-person pretest in four Chicago area neighborhoods under field conditions. A day spent debriefing the NORC interviewers and working with NORC staff resulted in substantial modifications that made administration of the survey more manageable and improved the clarity of the questions and the flow of the interview. The pilot instrument was administered to subsamples in St. Louis and San Diego during late July and early August. The average interview length was approximately 35 minutes.

Comparison of Questionnaires

The GCVB pilot instrument and the CR instrument both ask an extensive set of questions about park visits, awareness of visibility, and willingness to pay for changes from one level to a greater level of visibility. Both studies have respondents examine a series of photographs which depict different changes in visibility levels. The language of the two surveys for several of these questions is identical.

However, the GCVB pilot instrument differs from the CR instrument in a number of important respects. One obvious respect is the survey methodology; the pilot instrument is for an in-person survey whereas the CR Survey was a mail survey. In comparison with mail surveys, in-person administration offers the researcher a greater amount of flexibility in the kinds of questions that can be asked, the skip patterns[2] that can be managed, and the types of visual aids that can be employed to communicate complex information to the respondent. It also permits the researcher to control the pace and sequence of the interview whereas the mail survey respondent has control of these factors. Among the various differences in the wording of two survey instruments, three are particularly important.

[2]Skip patterns refer to directions in the questionnaire to control the flow of questioning by directing the respondent to the next question; which question is the next question depends on the response to the current question.

First, the pilot instrument focuses strictly on willingness to pay for visibility improvements in the Grand Canyon whereas the CR Survey focuses on all Southwest parks. The CR Survey had respondents value visibility improvements in a number of Southwest parks *including* the Grand Canyon while the pilot instrument focuses entirely on the Grand Canyon. The only question specifically on the Grand Canyon in the CR Survey asked respondents what percentage of their willingness-to-pay to improve visibility in Southwest parks should be spent on the Grand Canyon. We believe the CR Survey's method for ascribing values to Grand Canyon visibility improvements is too casual for use in making an important policy decision since the respondents were not informed they would be required to give the percentage of their allocation to GCNP and they were not required to allocate their overall valuation among the several parks in the Southwest. If the Grand Canyon and the other Southwest parks are substitutes (Hoehn and Randall, 1989) as we believe they are, then concentrating on the Grand Canyon exclusively, rather than on all the Southwest parks and apportioning some fraction of that willingness to pay to the Grand Canyon, other things being equal, should result in higher values for Grand Canyon visibility improvements.[3]

Second, the pilot instrument uses a conceptual framework and visual aids that approximate to a greater extent the type of Grand Canyon visibility improvement that may result from a BART action; the CR Survey limits itself to improvements described by relatively small photographs that depict large changes in average yearly visibility. This difference has two components. The first is the framework used to describe the changes. The CR Survey employed the concept of changes in average annual visibility. Respondents were shown a set of four photographs which they were told represented the current average yearly visibility level for the Southwest Parks and three other visibility levels, one worse and two better.

---

[3]At this point, we are not making any judgement as to whether a larger Southwest Parks policy should have been offered to respondents, only that by not doing so our estimates, if anything, should be higher than that of the RCS Study.

Our previous research on visibility values and our Grand Canyon focus groups and other survey development research lead us to reject the average annual visibility change approach. Although it has the apparent advantage of simplicity -- one photograph or number represents the visibility level of an entire year -- people do not find the average annual visibility level concept very meaningful. In addition, it tends to convey the erroneous impression that most days in the Grand Canyon have similar visibility conditions. The Grand Canyon is particularly unsuited to the notion of a change in average visibility because of its natural extremes in visibility and because of the strong influence of weather on visibility. Yet the average person may harbor preconceptions that the Grand Canyon does not ever suffer weather-caused visibility degradation; the pictures that most people see of the Grand Canyon rarely exhibit any visibility impediments. The visibility impairments attributed to NGS occur during times of high humidity, the same conditions during which weather-caused visibility degradation occurs. Thus the two cannot be separated in a questionnaire designed to elicit WTP values.

To arrive at the optimal balance between a simplicity which seriously distorts reality and a complexity which overwhelms the cognitive capacity of human respondents is very difficult. The pilot instrument attempts, without overloading the respondents, to convey a greater level of complexity by conveying three types of distinctions: (1) two seasonal periods, winter and summer, (2) three kinds of visibility conditions, and (3) individual days. Combining the first two distinctions yields six types of days -- summer high visibility, summer medium visibility, summer low visibility, winter high visibility, winter medium visibility, and winter low visibility. One of six photographs exhibits each of these types of days. While six types of visibility days necessarily simplifies reality a great deal, they nevertheless describe a much greater range of variation than does the CR Survey which describes change in terms of average annual visibility. Our respondents are also informed about the distribution of these different types of visibility days over the two seasons. Care was taken to ensure that the pictures shown for comparison were for the same times and same seasons, eliminating another problem in the CR Survey. We believe that, in spite of the additional complexity of our approach, respondents find it more plausible and therefore easier to understand.

The respondent is shown two photoboards, one for the distribution of three levels of visibility during the seven-month summer and one for the distribution of three visibility levels of the five-month winter. Each photoboard contains two sets of photos. The left set shows the current visibility levels, each photograph representing a certain number of days of the year. For each photograph of the left set, a photograph in the right set, the improved set, shows the improvement in visibility if most sources of pollution could be controlled. Those facts are presented to the respondents on the photoboards and in the text of the survey. Figure 1 displays a winter photoboard.

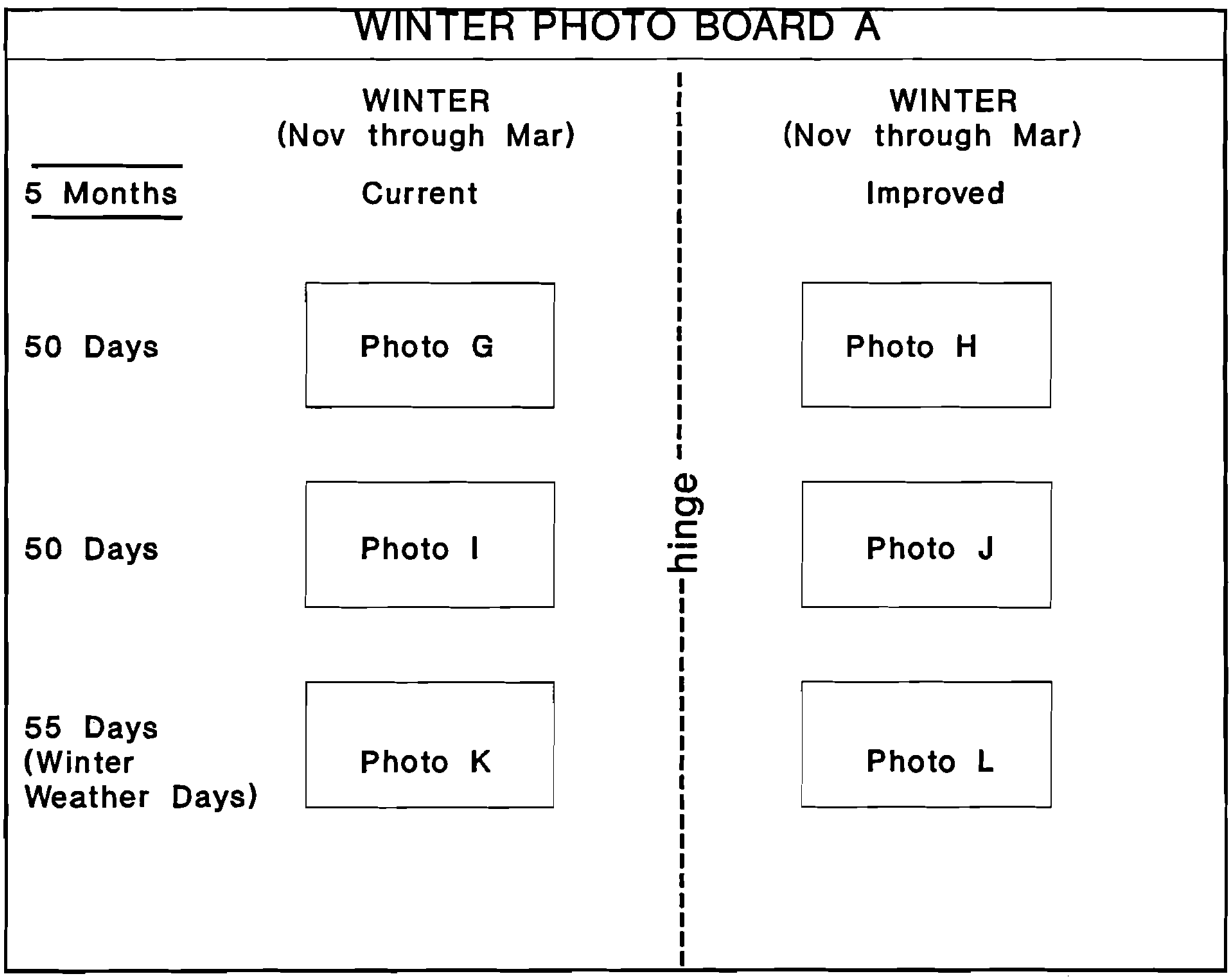


Figure 1

For the summer photoboard, the upper two photographs illustrate the current and improved visibility for 120 days; the center two photographs illustrate the current and improved visibility for 70 days; and the bottom two photographs illustrate the current and improved visibility for the remaining 20 days of the seven-month summer. The top pair of photographs illustrate the highest level of visibility and the bottom level the worst visibility. These relationships are illustrated in Table 1.

For the winter photoboard, the upper two photographs illustrate the current and improved visibility for 50 days; the center two photographs illustrate the current and improved visibility for 50 less clear days; and the bottom two photographs illustrate the current and improved photographs for the remaining 55 days of worst visibility. One of two versions of the pair of 55 worst day photographs were assigned to respondents to control for the possible effect of cloudiness and thereby avoid biasing the results in the event respondents reacted to the particular types of clouds shown in those photographs.[4] These relationships are illustrated in Table 2.

While both the CR and GCVB pilot instruments use photographs, they differ in focal length, size, and finish. The CR Survey used photographs 3 x 5 inches in size which were reproduced by a color printing process. They were taken by a camera with a 135 millimeter telephoto lens which focuses attention on distant details rather than presenting the view that a visitor might see. The GCVB photographs are 8 x 12 inches in size, printed on glossy photo paper. They were taken by a camera with a focal length of 50 mm and depict the view a visitor would see. These characteristics of the GCVB photographs make them superior for communicating visibility levels. Our focus group participants and pretest interviewers strongly supported the use of photographs this size in preference to the same photographs in a 7 x 10 inch format because they thought the larger photographs did a much better job of showing Grand Canyon visibility.

---

[4]The visibility ranges for the 55 winter weather days are weighted averages of the ranges of two sets of pictures each of which was shown to half the sample. Statistical tests showed no significant differences in willingness to pay responses to any of the five programs due to the version of the winter weather day shown to the respondent.

Table 1 COMPARISON OF CURRENT AND IMPROVED SUMMER VISIBILITY			
Number of Days	Current Visibility (km)	Improved Visibility (km)	Average Daily Improvement
120	205	325	59%
70	111	243	119%
20	48	170	254%

Table 2 COMPARISON OF CURRENT AND IMPROVED WINTER VISIBILITY			
Number of Days	Current Visibility (km)	Improved Visibility (km)	Average Daily Improvement
50	355	435	22%
50	98	205	109%
55	16	92	475%

Many of the respondents to the CR Survey may have had difficulty perceiving the visibility differences they were asked to evaluate. If so, the respondents would have been very sensitive to cues conveyed by the wording of the questionnaire. This may explain, for example, the otherwise puzzling fact that the CR Survey respondents were willing to pay a sizeable amount more for the visibility improvement from photograph C to photograph A than they were for the visibility improvement from photograph C to photograph B, even though the light extinction coefficient for picture B was slightly smaller than that of picture A.[5] In spite of being told that they were being shown summer pictures, they were effectively asked to value going from a hazy summer day to a clear winter day. Because winter colors are strongly preferred, this change in lighting conditions due to the season may have provided an upward bias to the resulting WTP values.

[5]The CR Survey showed respondents pictures A, B, C, and D, of which C represented current average annual visibility. They asked respondents to value changes from C to B, C to A, and to value preventing the change from C to D.

A third important difference is that the GCVB pilot instrument makes a much greater effort to get respondents to restrict their valuations to visibility changes. Indeed, the CR Survey took an opposite tack by suggesting to respondents in an earlier question that air pollution was responsible for damage to vegetation and historic structures and the acidification of lakes and streams. Furthermore, in the preamble to the valuation questions, the respondents are told that others would be asked to value the reduction of air pollution related effects on health, vegetation, and visibility.

Several additional differences between the GCVB pilot instrument and the CR Survey instrument deserve comment because they may have the effect of lowering the willingness to pay in the GCVB Study. In each case, design choices in constructing the pilot instrument were made on the basis of what seemed to be compelling reasons that this was a more correct design choice than the alternatives.

First, instead of using the CR Survey language which informed respondents that the visibility improvement would last forever, the pilot instrument informs respondents that the power plants responsible for the visibility impairment which is being corrected are scheduled to be in operation for 20 years. Thus, they are buying a good for 20 years after which time any visibility impairment due to the plants would end with the operation of the plant, and the visibility improvement would then be free. To the extent that respondents in the CR Survey thought they were buying a permanent visibility improvement and, more importantly, that these programs were the only opportunity to buy that improvement for future generations, our willingness to pay numbers should be smaller.

Second, we have changed the payment vehicle from higher prices and taxes to higher utility bills. If the policy being implemented is closely tied to a particular payment vehicle, as in the case of a NGS BART action, that payment vehicle should be used. The use of a higher prices and taxes vehicle is justified when there are a multitude of ways in which respondents would actually pay for the good as in the case of national water quality. Such a payment vehicle would be appropriate in the Grand Canyon case only if a more comprehensive policy was being considered. Since any improvement in visibility resulting from an NGS BART action would be financed by higher electric bills, an electric bill payment vehicle should be used. It is possible that its use, rather than that of the higher prices and taxes payment vehicle, might lower the willingness to pay responses because of the immediate and direct impact of higher electric bills and because of resentment toward electric utilities. However, a rough comparison between the two payment vehicles in Phoenix and Chicago telephone surveys did not reveal any substantial differences between the two payment vehicles. Most respondents were unwilling to pay anything through either payment vehicle.

Third, unlike the CR Survey which begins with questions about national parks, our survey instrument begins with a set of questions that put the visibility improvements into a larger context by asking respondents about a set of issues, several of which are unrelated to the Grand Canyon. This type of opening question is frequently used by survey researchers to put respondents at ease and to encourage them to realize that the particular good that is the subject of the survey is but one of a much larger group of public goods. This approach mitigates to some extent the tendency of some respondents to assume that the good being valued must be valuable since so much money and trouble is being expended to get his or her views about it; this "importance bias" should be avoided in any study that attempts to obtain a credible benefits estimate using the CV methodology.

A fourth difference concerns the elicitation methods used in the two surveys. The CR Survey instrument uses the payment card method which, in their case, has the respondent choose one amount from a list of 28 amounts ranging from $0.00 to "More than $750." Ninety percent of the amounts on the CR Survey payment card are larger than the amount needed to justify the NGS BART decision. The configuration of this card is likely to have put pressure on the respondent who does not have any value for the improvement to circle a positive amount. In the pilot survey we use the open-ended method in which the respondent arrives at a dollar value with no prompting of any kind from the interviewer. While we have been strong proponents of the payment card method, its use requires that most respondents be willing to pay something. Its use also assumes that the willingness to pay amounts are distributed over a reasonable range rather than concentrated at a single value, such as zero.

The GCVB visibility valuation exercise consisted of several steps. The respondent was first asked to rank their preferences for the five different programs without considering costs. Then the respondent was asked which of those programs they would be willing to pay something extra for each year. This amounts to a dichotomous choice for willingness to pay of zero versus more than zero. If the respondent was unwilling to pay for any of the programs, he was given a chance to reconsider. Respondents not willing to pay anything for any program were asked to explain. For those respondents who would vote for any of the programs, the next step was to ask how much that the program could cost them before they would vote against it. Respondents who gave non-zero amounts were reminded that they were only obtaining visibility improvements and asked if that would influence the amount that they gave. Those respondents who said yes were asked to give revised amounts for just visibility. However, our focus group work and the Chicago pretest indicate that some respondents will not accept that the only effect of decreasing haze is to improve the visibility. Therefore, some willingness-to-pay responses may be biased upward. Respondents who were willing to pay non-zero amounts for programs were asked to explain what about those programs made them worth it; and respondents not willing to pay anything for programs were asked what about those programs made them not worth anything. This multiple step, yes/no, open-ended valuation, and explain format is appropriately sensitive to small values while avoiding the obvious threat of compliance bias (Mitchell and Carson, 1989: 237).

PILOT STUDY RESULTS

A pilot study using the developed instrument was conducted at two sites, St. Louis and San Diego, from July 20 to August 2, 1990 (Balson *et al.*, 1990). Since the intention of the pilot was to test the instrument under the type of field conditions that would prevail in a national survey, those sites were chosen to provide two diverse settings. We used an economical sampling frame based on random assignment of blocks and a quota scheme based on age and sex. Our quota-based sampling plan resulted in a random sample which looks reasonably representative of the population. We do not suggest, however, that our results should be extrapolated to the national population, merely that unlike the CR Survey, we measured the relevant visibility changes and that our results differ very substantially from those of the RCS Report.

In any telephone or in-person survey, interviewers necessarily play a key role in motivating respondents to cooperate and in eliciting information. This role must be carefully prepared and monitored to ensure the interviewers play their role in a neutral manner. At the conclusion of the interviewing, one of the researchers and the NORC staff conducted full day debriefing sessions in St. Louis and San Diego, attended by the interviewers and the local NORC supervisors. NORC headquarters personnel also attended the St. Louis debriefing. The debriefing probed the interviewers' experiences with the instrument, the problems encountered, and their suggestions for changes. Every portion of the instrument was systematically discussed.

The interviewers recorded all comments made by the respondents on the instrument itself. These verbatim responses are an important part of the survey results. They provide insight to what respondents were thinking and allow a much deeper interpretation of the quantitative findings. In some instances they suggest ways in which particular survey questions should be changed to avoid misinterpretation or confusion.

A large number of the respondents in our sample had visited the Grand Canyon: 38% in St. Louis and 54% in San Diego. Of the respondents who had been to the Grand Canyon, over half had only made one visit. As one might expect, San Diegans were more likely to have made multiple trips. Less than 20% in both samples had made more than two trips. If the respondent had visited the Grand Canyon, their last trip was on average a little over 10 years ago and the distribution of last trips was fairly uniform across years. Most trips appear to have been made in June, July, and August with only 3% of the last trips made by respondents in our St. Louis sample taking place in the five month November-March winter period and with only 10% of the last trips made by San Diego respondents taking place in that period. About 45% of the respondents from both samples rated visibility during their last visit to the Canyon as very clear. A little over 15% suggest that visibility was somewhat clear or not clear. Only 3% of the respondents had not visited the Grand Canyon or seen pictures of it. Approximately 30% of the St. Louis sample and 55% of the San Diego sample indicated that they were very likely or likely to visit the Grand Canyon in the future.

Virtually all of the respondents were able to chose the summer photograph with the best visibility; the correct visibility ordering on the picture boards had to be pointed out to only 4 respondents. Strong support was expressed for the environmental movement in both samples with the suburban St. Louis sample being somewhat more supportive (30% active; 61% sympathetic) compared to the San Diego sample (24% active and 46% sympathetic).[6] San Diego had a larger percentage of respondents who were neutral or unsympathetic toward the environmental movement. Roughly 40% of both samples thought of themselves as outdoor people.

Valuation of Visibility Improvements

Estimation of willingness to pay for each of the programs requires a number of steps. For any particular program a respondent could give a zero, a positive amount, or a don't know. If they gave a zero, a determination must be made if it is a "protest zero". If a positive amount is given, one must check to see if a revision of that amount was made in Q28, where the respondent was reminded that the programs would only improve visibility. In a few cases, a respondent failed to give an amount for a program that was ranked higher, or should logically have been ranked higher, than a program they gave an amount for. In these cases, the value for this program was set to the amount given for the lower ranked program.

Don't knows tended to be of two types. One type consists of respondents who basically have no idea how much a visibility improvement program is worth to them and have no idea how to consider the issue; these responses are typically from the elderly and less well-educated. The other type of don't knows comes from the those respondents who say that they can not make the decision without more

[6]Question 33 of our pilot study instrument used a four point scale: actively supports, sympathetic, neutral, and unsympathetic.

information, typically more information than could be provided in a contingent valuation survey. These responses tend to come from the better-educated and from specific occupations. This percentage of don't knows is low by comparison to most contingent valuation studies. The don't knows are excluded from our analysis of willingness to pay amounts here.

Classification of the zero responses into true zeros and protest responses is always a difficult and somewhat subjective exercise. If actually given the opportunity to vote on any of the visibility programs, many of these respondents would likely vote "no" so that removing all of these zero responses from the sample may artificially inflate the willingness to pay observable in an actual referendum context. We divided the zeros into four types. Those individuals who indicated that they did not have any real desire for the visibility improvement or that financially they could not afford to pay anything for the program were classified as true zeros. The other zeros were classified into three types: clear protests, possible protests, and likely true zeros. A clear protest was an individual who indicated that they wanted one or more of the visibility improvements but thought that it should be paid for in some other fashion. We classified as possible protests those respondents whose verbatim answers indicated that they did not like some aspect of the scenario but whose verbatim answers did not address whether they thought that one or more of the visibility improvement programs should be undertaken. Typically, these respondents indicated that the government wastes money, that the program should be paid from cuts in defense or the space program, or that the electric utility company could not be trusted. Likely true zeros look like possible protests in their complaints about the government and electric utilities. They differ in that they also included comments which suggest that they did not find the visibility improvement programs to be important relative to other problems faced by the government.

Of the 16 respondents who revalued their amounts after being reminded that they were only getting a visibility improvement, about one-third changed their amounts to zero, about a third reduced their amounts by half, and the other third changed their amounts in a somewhat erratic manner including one respondent who revalued upward and one who changed to a don't know. Eight respondents did not change their amounts but indicated that they believed that they had to be getting other types of benefits in addition to Grand Canyon visibility improvements. Thus only 12% of the sample appear to have not understood or believed the statements earlier in the questionnaire explaining that they would only be getting visibility improvements in the Grand Canyon; this percentage is a dramatic reduction from that of the CR Survey where at least 58% of the sample allocated part of their willingness to pay for something other than visibility improvements.

The result is a set of yearly WTP estimates for the five programs. Table 3 displays the median, two frequently used robust estimators, the 5% trimmed mean and the 10% trimmed mean (Huber, 1981), the mean, the standard deviation, the range, the percent of zero responses, the number of valid bids, the number of clear protest zeros, and the number of don't knows. Using the 5% trimmed mean as a crude upper bound and the 10% trimmed mean as a crude lower bound on the point estimate for the true unobserved willingness to pay, the combined summer and winter program falls into the range $16-$20, the summer program $8-$11, the winter program $1-$3, the 20 winter day program $0.02-$0.50, and the 10 winter day program $0.00-$0.49. However, these estimates are significantly lower than those of the RCS Study, by a factor of 2 to 3 for the combined programs and by at least an order of magnitude for the 10 and 20 winter weather day programs. Formal confidence intervals show the willingness-to-pay amounts for the 10 and 20 winter day programs to be virtually indistinguishable from zero.

A major issue in this analysis is the choice of correct summary statistic of willingness to pay for each program. The median is the statistic of choice if one adopts a majority voting rule. In this case, the combined winter and summer visibility program receives a median value of $10. All of the other visibility programs have a median value of $0, and therefore none of these programs would seem likely to receive majority approval for implementation.

The mean is the correct statistic under traditional welfare economic theory if one is willing to ignore distribution consequences, that is, if one is willing to accept a program of which all the benefits may be enjoyed by a few and the costs borne by the rest of society. However, the raw sample mean

Table 3 VISIBILITY VALUES - PILOT STUDY					
Program	Summer and Winter	Summer Only	Winter Only	20 Winter Weather Days	10 Winter Weather Days
Number of Valid Bids	183	182	182	181	181
Range	$0-360	$0-300	$0-150	$0-100	$0-100
Median	$10.00	$0.00	$0.00	$0.00	$0.00
10% Trimmed Mean	$16.15	$8.11	$1.25	$0.02	$0.00
5% Trimmed Mean	$20.20	$10.51	$2.92	$0.50	$0.49
Mean	$27.78	$15.71	$6.34	$2.38	$2.28
Standard Deviation	$50.04	$33.82	$18.89	$10.32	$10.08
Percent Zero	40%	58%	79%	89%	90%
Total Sample Size	202	202	202	202	202
Clear Protest Zeroes	10	10	10	10	10
Don't Knows	9	10	10	11	11

*18 outliers trimmed off each end of the distribution; **9 outliers trimmed off each end

WTP should not be used as measure of benefits for any of the Grand Canyon visibility improvement programs. In contingent valuation studies which elicit continuous WTP payments, this statistic is known to be biased upward, sometimes by an order of magnitude or more. No major contingent valuation researcher has ever used or proposed the use of the raw sample mean WTP as a measure of the benefits of a program[7]. The reason is straightforward: like all data from surveys, a certain percentage of the

[7]For discussions in early studies see, for instance, Brookshire, Ives and Schulze (1976) or Rowe, d'Arge, and Brookshire (1980). For more general discussions see Mitchell and Carson (1989) or Smith and Desvousges (1986). Note that the CR Survey discusses possible invalid WTP responses in their data set and adopts an extensive set of *ad hoc* procedures to identify and remove these observations. Carson and Ruud (1991) provided an extensive discussion of this issue.

data is "bad". By "bad", we mean that an observation's value for a variable is "missing", at variance with known facts, or inconsistent with behavioral models based on responses to other questions or economic theory. Government agencies such as the Census Bureau which collect vast amounts of data routinely use a variety of imputation techniques and consistency checks before the data is summarized and released as official statistics. The ordinary mean can be grossly distorted by a very small number of outliers such as the case here. A few outliers cause the ordinary mean to be anywhere from 1.5 to 8 times the size of the 5% trimmed mean, the larger distortions coming in the winter visibility improvement programs. Furthermore, because the gross errors on the small side are bounded by zero, the use of the sample raw mean WTP will almost always overstate the actual population WTP, often grossly so, by an order of magnitude or more.

We have taken several different approaches to estimating the mean WTP for the 10 and 20 winter day programs for the population sampled for the GCVB study. *All* suggest mean benefit values for the 10 and 20 winter weather day programs of $0.50 or less per household, and most suggest values substantially less than $0.50.[8] The results of this analysis is summarized below in Table 4.

One approach is using a α-trimmed mean for which the α percent smallest and largest observations are deleted and the mean is based on the remaining observations. The 10% trimmed mean, the mean based on the central 80% of the distribution, and the 5% trimmed mean, the mean based on the central 90% of the distribution are provided in Table 3. In many types of data sets, trimmed means are more reliable statistical estimators of the true expected value than is the ordinary mean (Stigler, 1977; Huber, 1981). Contingent valuation surveys have a pattern of gross errors which make the α-trimmed mean, particularly attractive. This family of estimators can be thought of as implementing the notion due to Alan Randall that contingent valuation surveys provide a solid core of usable responses. Continuous, or nearly continuous, contingent valuation WTP data from an open-ended question such as we used in

[8]For extended discussions concerning different approaches to estimating mean willingness to pay from this data set see Carson and Ruud (1991) and Carson *et al.* (1991).

Table 4		
Estimator	20 Winter Days	10 Winter Day
Median	$0.00	$0.00
Mean	$2.38	$2.28
5% Trimmed Mean	$0.50	$0.49
10% Trimmed Mean	$0.02	$0.00
Huber	$0.01	$0.01
Welsch	$0.00	$0.00
Biweight	$0.00	$0.00
Belsley, Kuh, and Welsch Outlier Deletion	$0.15	$0.13
Conditional Regression (Huber)	$0.19	$0.15
Box-Cox Proportional Errors Correction	$0.02	$0.01
Theoretical Consistency Check Only	$0.41	$0.37

our pilot study, from a payment card such as the CR Study used, or from a bidding game tend to have a very distinct type of gross error pattern first noted by Brookshire, Ives and Schulze (1976): some zeroes which are not true zeroes and some very large stated WTP amounts which the respondent is not really willing to pay. These zeroes tend to reflect a rejection on the part of respondents of the scenario proposed and, in particular, the belief (possibly strategic) that there is some responsible party which should and will instead pay. Very large WTP amounts may in some instances reflect a desire to please the sponsor of the survey or the interviewer, a perception by the respondent that he is getting something more than the scenario is actually representing, or the opposite strategic view that a high stated WTP will help the program to be implemented but that some or all of the cost will not actually be passed on.

It is possible to raise some legitimate objections to the use of an estimator which symmetrically trims off some predetermined percentage of the largest and smallest data values. These objections usually take three forms. The first is the simple objection to predetermined "symmetric" trimming. Those holding this objection usually contend that one of the two tails of the distribution is not likely to contain a high percentage of gross errors. To meet this objection, we have looked at the results of several univariate robust estimate techniques, the Huber, the Welsch, and Tukey's biweight. These techniques do not impose the symmetric trimming like the trimmed least squares estimators, nor do they automatically drop or downweight observations. They all result in lower estimates for the 10 and 20 winter day programs than the 5% trimmed mean and are essentially identical to the 10% trimmed mean estimates. These estimates are lower because the zero WTP amounts do not look like gross errors to these estimators while the α-trimmed means are automatically trimming off α percent of these zero WTP amounts at the same time they are trimming off α percent of the high WTP amounts.

The second objection is that very large WTP amounts may not still look like potential gross errors after one has taken account of covariates which may indicate that these amounts belong to respondents with high incomes, high concerns about national parks and visibility, and a likelihood of visiting the Grand Canyon in the future. This possibility is usually examined in the context of a regression on the available covariates. We look at three different regression approaches. The first is the standard econometric approach proposed by Belsley, Kuh, and Welsch (1980) which has been used in previous contingent valuation studies such as Smith and Desvousges (1986). This approach effectively drops observations with large studentized residuals. When these observations are dropped, most of predictor variables have the expected signs, and many are quite significant even in a data set of our size. The second regression approach is a (Huber, 1981) robust regression which conditions on the WTP amount for the combined winter and summer visibility program when predicting the WTP amounts for the 10 and 20 winter day programs. The strength of this approach is that as long as the same covariates predict the strength of preferences for the year round visibility program it is not necessary to have measured those covariates in our contingent valuation survey in order to determine whether a large WTP amount for the 10 or 20 winter day program is likely to be a gross error. The third regression approach we have examined is the Box-Cox proportional errors correction method suggested by Irwin *et al.* This approach allows for the possibility that respondents may make errors in giving their WTP amounts which are proportionate to the magnitude of the WTP amounts rather than errors which are independent of the size of the WTP amounts they give. This approach results in lower estimates of WTP if the error distribution is estimated to be right skewed such as the log-normal and the model indicates that there is a large random component to the WTP amounts. All three of these regression approaches give estimates which fall between the 5% and 10% trimmed mean estimates.

The third objection is to taking a mostly statistical approach to identifying gross errors rather than looking instead at whether the WTP amounts respondents give are consistent with simple tests of consistency with economic theory. The simplest of these tests is to require that a respondent with a positive willingness to pay amount for one visibility program is willing to pay more for another visibility program which clearly dominates it in the sense of providing more of those visibility benefits. What we find here is that a substantial fraction of the raw sample mean WTP is due to a very small number of respondents whose gave the same positive WTP amount for the entire winter program (and typically also for the combined winter and summer program) as they did for the 10 winter day program.[9] Dropping these respondents also results in WTP estimates for the 10 and 20 winter day programs between the 5% and 10% trimmed mean estimates.

[9]We find the fact that over 40% of the respondents to the CR Survey contingent valuation gave the same amount to all of the visibility improvements very strong additional grounds to recommend rejecting their estimates as having little bearing on Grand Canyon visibility benefits. In contrast, only 4% of the respondents to the GCVB study exhibit this type of inconsistent behavior.

CONCLUSION

We believe our Grand Canyon visibility research (Balson, 1990, Balson *et al.*, 1990, Carson *et al.*, 1991) leads to a simple conclusion. The CR Survey is *not* capable of providing any evidence on the benefits of this BART action. The estimates in the RCS Report are driven by unverifiable and highly questionable assumptions and not by any empirical data. A decision with sunk costs (Viscusi, 1988) of the order of magnitude of this proposed BART action should not be made on such a basis.

This may seem to be an extreme position. However, summarizing the problems with the CR Survey as we will do here should cause anyone to ask how reasonable it is to base a major BART action on a single study which has the following characteristics: (1) it asked respondents to value an irrelevant average visibility change from hazy summer conditions to clear winter conditions while incorrectly telling respondents the pictures were of summer days, (2) it gave respondents a one time chance to buy a permanent improvement in Grand Canyon visibility, (3) it displayed small 3" x 5" photographs to respondents and did not reveal that a telephoto lens was used to focus attention on distant canyon details rather than presenting the view that a visitor might see, (4) less than 1/3 of the respondents indicated that their WTP responses were only for visibility, (5) over 40% of the respondents gave the same positive dollar amount to all of the visibility changes they were asked to value, (6) the allocation of willingness to pay for visibility improvements in all Southwest parks to improvements in just the Grand Canyon is based on a single question and not directly tied to the visibility change being valued, (7) that bequest motivations appear to play a large role in the values given even though the BART action concerns a single plant with a finite and reasonably short life span, and (8) that a mail survey (with either a bad sampling frame or bad response rate, depending on how one wants to define the problem) of four states, is used to represent the U.S. population. Add to this list of discomforting characteristics, the RCS Report's inability to theoretically justify going from willingness to pay for small annual average visibility change to willingness to pay for large visibility changes on a small number of winter days and the fact that the value for a small annual change in average visibility is determined almost entirely from the functional form assumed for the valuation rather than any actual data in that region.

The GCVB Study is a less substantial basis for making a major BART decision than we feel comfortable with. Its limitations stem from its pilot study nature and from continuing uncertainty over what visibility improvement would result from the proposed NGS BART action. It does, however, value the type of change which might occur from a BART action through its use of large well-defined photographs presented to respondents in in-person interviews conducted by one of the country's most respected survey organizations. On most of the criteria by which contingent valuation surveys are typically judged, the GCVB Study can be judged quite successful. If the GCVB Study results had been based on a large sample of the U.S. population using a full probability sampling design rather than a quota sample of 202 respondents at two sites, we would have no hesitancy in making a concrete statement on the magnitude of the benefits of the visibility improvements valued. Even so, at this time, the GCVB Study provides the best and, indeed, the only reliable estimate of the benefits to the public of a change in Grand Canyon winter visibility event days.

REFERENCES

W.E. Balson, R.T. Carson, M.B. Conaway *et al.*, (1990), *Development and Design of a Contingent Valuation Survey for Measuring the Public's Value for Visibility Improvements at the Grand Canyon National Park*, Report to the Salt River Project,(Los Altos, CA, Decision Focus, September.)

W.E. Balson (1990), *A Review and Critique of the Applicability of Visibility Studies to a Navajo Power Plant BART Decision*, Report to the Salt River Project (Los Altos, CA: Decision Focus).

A. Belsley, E. Kuh, and R.E. Welsch (1980), *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity* (New York: John Wiley).

D.S. Brookshire, B.C. Ives, and W.D. Schulze (1976), "The Valuation of Aesthetic Preferences", *Journal of Environmental Economics and Management*, 3: 325-346.

R.T. Carson, M.B. Conaway, and W.M. Hanemann *et al.* (1991), Comments on the Benefit Analysis in the U.S. Environmental Protection Agency's Proposed Navajo Generating Station BART Action. Submitted to U.S.E.P.A.

R.T. Carson, R. C. Mitchell, and P. A. Ruud, (1990) "Valuing Air Quality Improvements: Simulating a Hedonic Pricing Equation in the Context of a Contingent Valuation Scenario," in C. V. Mathai, ed., *Visibility and Fine Particulates* (Pittsburgh: Air and Waste Management Association).

R.T. Carson and P.R. Ruud (1991), Grand Canyon Visibility Benefits Calculations. Memo To William E. Balson of Decision Focus, Inc.

L.G. Chestnut and R.D. Rowe (1990), *Preservation Values for Visibility Protection at the National Parks*. Report prepared for the U.S. Environmental Protection Agency and the National Park Service. (Boulder, CO: RCG/Hagler, Bailly Inc.)

J.P. Hoehn and A. Randall. (1989) "Too Many Proposals Past the Benefit Cost Test", *American Economics Review* 79(3):544-551.

P.J. Huber (1981), *Robust Statistics* (New York: John Wiley).

J. Irwin, W. Schulze, G. McClelland *et al.* (1990), *Valuing Visibility: A Field Test of the Contingent Valuation Method* (Report to U.S.E.P.A).

R.J. Kopp, P.R. Portney, and V.K. Smith (1990), "Natural Resource Damages: The Economics Have Shifted after Ohio v. United States Department of Interior, *Environmental Law Reporter* 20:10127-10131.

R.C. Mitchell and R.T. Carson (1989), *Using Surveys to Value Public Goods: The Contingent Valuation Method* (Baltimore: Resources for the Future/Johns Hopkins University Press).

R.D. Rowe, L.G. Chestnut and M. Skumanich (1990), *Controlling Wintertime Visibility Impacts at the Grand Canyon National Park: Social and Economic Benefit Analysis*. Prepared for the U.S. Environmental Protection Agency. (Boulder, CO: RCG/Hagler, Bailly, Inc.).

R.D. Rowe, R. d'Arge, and D.S. Brookshire (1980), "An Experiment on the Economic Value of Visibility," *Journal of Environmental Economics and Management*, 7:1-19.

V.K. Smith and W.H. Desvousges (1986), *Measuring Water Quality Benefits* (Boston: Kluwer/Nijhoff Publishing).

S.M. Stigler (1977), "Do Robust Estimators Work with Real Data," *Annals of Statistics*, 5:1055-1077.

W.K. Viscusi (1988), "Irreversible Environmental Investments with Uncertain Benefit Levels", *Journal of Environmental Economics and Management*, 15:147-157.

CVM Wildlife Existence Value Estimates:
Altruism, Ambivalence and Ambiguity

T.H. Stevens*

INTRODUCTION

The increased use of benefit-cost analysis in environmental management decisions has stimulated considerable debate abut wildlife valuation. Wildlife are now thought to produce two types of economic value; (1) "use values" derived from hunting, fishing and viewing, and; (2) nonuse or existence values accruing to both users and to those not actually "using" wildlife but who, nevertheless, have an interest in it. Attention has recently focused on the existence category, and although preliminary estimates suggest that this might be the most important component of total value, CVM existence value estimates are often viewed skeptically. Kellert (1981), for example, argues that "...we are stymied by the dilemma of generating prices for the priceless and for quantifying the unquantifiable."

This paper examines several questions about the meaning and validity of CVM wildlife existence value estimates. For example, what type of decision making strategy do CVM respondents use? Do decisions about the existence of wildlife involve altruism and moral principles not readily amenable to the pricing scheme used in the CVM?

A CVM case study of the value of bald eagles and wild turkeys in New England is used to facilitate discussion of these issues. We found that the behavior of most respondents was inconsistent with the neoclassical model of tradeoffs between money and wildlife. One explanation is

*Department of Resource Economics, University of Massachusetts, Amherst, MA. This research was sponsored, in part, by the Forest Service, U.S. Department of Agriculture.

that questions about existence value created ambivalence which resulted in protest and lexicographic behavior. Another possibility is that individual decisions about monetary commitment were made primarily on the basis of social and ethical considerations falling outside the neoclassical model.

CONCEPTUAL CONSIDERATIONS

An interdependent individual utility function of the type suggested by Loomis (1988) depicts one possible structure of individual preferences giving rise to existence values:

$$U_a = F_a\ (f_{1a}(X_a,R_a) + f_{2a}(Q_a,(R_b,Q_b)))$$

Where U_a is a weakly separable function relating the utility of individual a to a's own consumption of a bundle of private goods, X_a; a's use of the wildlife resource, R_a; knowledge that other people (represented by b) are able to use the wildlife resource, R_b; personal satisfaction from knowing that wildlife exists, Q_a; and the knowledge that others derive satisfaction from knowing that wildlife exist, Q_b. Since existence is a pure public good, $Q_a = Q_b$.

The total economic value of wildlife in this formulation consists of several self-interest and altruistic components which can be held simultaneously by each individual. These components can be aggregated into three main categories; (1) personal use values (which might include option value), (2) use by others (including bequest value), and (3) nonuse values. The condition of weak separability means that the marginal rates of substitution between goods purchased in the market, X, are independent of Q and consequently contingent valuation is the only technique capable of measuring existence values. However, there is substantial debate about the validity of this approach.

Decision-Making Quality

Harris, et al. (1989) question the nature of decision making within the CVM and suggest criteria for judging decision making quality. For example, do survey respondents adequately consider the prices of other market or non market goods? Do they consider their income as a realistic constraint? Decision making is often stressful--does the CVM provide too much or too little stress? Are respondents familiar with the resource being valued? A related concern is that decisions made in the context of the CVM might be viewed by respondents as having little consequence. Freeman (in Cummings, Brookshire and Schulze, 1986) argues that "...in CVM there is no cost to being wrong, and therefore no incentive to undertake the mental effort to be accurate" (p. 50). Cummings, Brookshire and Schulze (CBS , 1986) suggest that CVM accuracy is increased when participants have had experience with making choices about the commodity and when there is little uncertainty, but neither of these conditions hold for most wildlife species.

Moral/Ethical Issues

A more difficult issue is that decisions about wildlife existence involve ethical or moral considerations (Kneese and Schulze, 1985; Sagoff, 1988 and Edwards, 1986). Harris, et al. (1989) remind us that wildlife are often viewed as:

> "either priceless or beyond market-like transactions because of spiritual or other factors, including perceptions that moral rights rather than exchangeable property right should predominate..." (p. 222).

Choices involving moral principles are likely to produce psychological conflict and ambivalence. Consequently, many people may attempt to avoid making such decisions and, in the CVM, this can result in nonresponse, protest bids and outliers (Harper, 1989 and Opuluch and Segerson, 1989). These problems are likely to be particularly prevalent when people believe the stakes are high, as in the case of wildlife existence.

Ambivalence arising from moral or ethical concerns about wildlife may also result in incomplete and/or inconsistent individual preference orderings. Respondents may employ simple "rules of thumb" such as lexicographic, when making decisions about monetary commitment. Edwards (1986), for example, argues that many CVM respondents may be motivated by "genuine altruism" which reflects an ethical commitment to wildlife "...rooted in what one thinks as being right or wrong from a moral or ethical point of view regardless of how one's own welfare might be affected" (p. 147). These respondents might therefore state preferences according to a lexicographic rule whereby indifference and tradeoffs between money and wildlife are undefined.[1] One possibility is depicted by the lexicographic preference map in Figure 1 in which Y^* represents a minimum level of income below which more income is always preferred to wildlife and above Y^* wildlife are always preferred to income. If the initial situation is at point A this individual is willing to pay the same amount (Y_0-Y^*) to avoid any reduction in the wildlife population. On the other hand, willingness-to-pay is undefined at point B. In either case willingness-to-pay does not measure equivalent surplus.

<u>Markets for Public Goods</u>

Wildlife existence is a pure public good; once provided it is indivisible in consumption and no one can be excluded from enjoying it. Decisions about public goods are normally made in the political arena and CVM structures should therefore be based on political (as opposed to private) markets. This may imply a different set of operating conditions for the CVM. For example, in the political markets for public goods outliers do not influence the results unduly and respondents can abstain (see Mitchell and Carson in CBS, 1986).

---

[1]Kunreuther and Easterling (1990) found that respondents to a nuclear waste facility siting study refused to make tradeoffs between risk and income until a minimum threshold level of safety was assured.

A more basic concern, however, is that neoclassical economic theory frequently fails to adequately explain individual preferences and choices about public goods: "In the presence of public goods, the behavior of a self interested 'economic man' conflicts with everyday observation" (Margolis, 1982, p. 17). A familiar illustration is the inability of neoclassical theory to explain why many people vote or make contributions to nonprofit organizations. Why should an individual expend effort and money when there is very little chance that her action will actually make a difference?

According to neoclassical theory rational individuals will fail to contribute because they are caught in a Prisoner's Dilemma. However, as noted by Holländer (1990) "...the empirical extent of cooperation (or contribution) is in marked contrast to the one expected from standard theory" (p. 1157). Several explanations of individual cooperation and voluntary contribution for the provision of public goods have been suggested. Elster (1989), for example, argues that observed behavior is a product of both social norms and self interests. Other explanations include altruism (as in the model above), the theory of social exchange in which individuals are motivated by the expectation of "social approval," and the sociobiological approach (see Holländer, 1990).[2] However, little is known about how individuals actually interpret CV questions, and consequently CV responses may often be misinterpreted. As suggested by Kahneman and Knetsch (1990), many CV responses may "reflect the willingness-to-pay for the moral satisfaction of contributing to public goods, not the economic value of these goods." Some respondents may indicate the value to them of contributing to a "good cause," and others might be willing to pay their "fair share" for the public good in question.

[2]Holmes (1990) detected altruistic behavior in the referendum vote on California's proposition 65 (the Safe Drinking Water and Toxic Enforcement Act of 1989). Although altruism had a relatively small impact, Holmes found that "regard for others safety apparently had about the same impact as regard for one's own safety in voting regarding environmental regulations."

Procedure, Information and Embedding Effects

Another issue concerns how existence value estimates are influenced by the contingent valuation procedure itself. The preference reversal phenomena reported in numerous studies suggests that individual preferences and values are often constructed while individuals are in the process of making decisions. Consequently, preferences are influenced by the procedures involved in making choices, and different methods of eliciting preferences will often give rise to systematically different ordering (Tversky and Thaler, 1990).[3]

The information conveyed to CV respondents is an important determinant of the monetary values placed on environmental commodities (Samples, Dixon and Gaven, 1986; and Bergstrom, Stoll and Randall, 1990). Embedding effects have also been demonstrated in which willingness-to-pay depends on the ordering of goods in the CV and on whether the environmental commodity is evaluated on its own or as part of a more inclusive category (see Kahneman and Knetsch, 1990 and Majid, Sinden and Randall, 1983).

Evidence of preference reversals, information and embedding effects raises obvious questions about the type of information that should be provided to CV respondents. Should the resource be considered in isolation? How should questions be framed? Since these questions do not have "right" or "wrong" answers, each possibility may comprise a different "product" or package yielding a different monetary value.[4] As noted by Randall (CBS, 1986), WTP estimates are likely to be based

---

[3]Tversky and Thaler (1990) describe three different views about the nature of individual values and preferences. First, "values exist--like body temperature--and people perceive and report them as best they can, possibly with bias...Second, people know their values and preferences directly--as they know the multiplication table...Third, values or preferences are commonly constructed in the process of elicitation" (p. 201). Tversky and Thaler suggest that the third view is most compatible with recent evidence.

[4]This problem might be viewed as analogous to that posed by the interrelationship between economic efficiency and equity whereby economic values cannot be defined independent of the distribution of income.

on the value of the commodity being offered, the process by which it is provided, and the payment method, so that the valuation of the good itself probably cannot be separated from the issues associated with its provision.

Wildlife existence values are likely to be quite volatile. Randall and Stoll (1983) for example, note that the snail darter had no value prior to its discovery. This suggests that small changes in information or knowledge may produce large shifts in value. Brown and Goldstein (1984) remind us that since the direction of evolution is unknown, we cannot know in advance which species to save and which to sacrifice.

Taken together these problems suggest strong reservations about the validity of monetary existence value estimates. Yet, there is little empirical evidence about the nature of individual decision making with respect to monetary commitment, the type and quality of decision making process employed or the ability of CV respondents to assign meaningful economic values to wildlife existence. These issues are examined in the case studies which follow.

THE CASE STUDIES

A CVM survey about the value of bald eagles and wild turkeys in New England was mailed to 1,500 randomly selected households in the spring of 1989.[5] The survey included introductory information, general questions about outdoor activities and the importance of wildlife, valuation questions, and several follow-up questions to examine individual decision making processes and the

---

[5]Although never abundant, the New England bald eagle population was devastated by insecticide use in the 1950's and 1960's. Restoration efforts began with the placement of eggs from Minnesota into eagle nests in Maine and the New England population, which now exceeds 100 nesting pairs, is expected to eventually expand to the capacity of the available habitat.

Land use changes eliminated wild turkeys from New England in the late 1800's. Restoration involved trap and transfer from remnants of the former population which persisted in Pennsylvania, and the population has increased to the extent that hunting is now permitted throughout New England.

consistency of results obtained from the valuation question. The total design method suggested by Dillman (1978) was followed throughout.

Most respondents reported very limited contact with bald eagles and wild turkeys. Only 25 percent had ever seen these animals in New England, yet 53% of respondents considered the existence of bald eagles in New England to be very important. Existence was somewhat important to 36%, and not important to only 11%. Wild turkeys were considered very important by 41% and somewhat important by 40%.

When asked why bald eagles are important, only 12% of the respondents indicated a personal use value, while 80 percent indicated some type of existence value; either giving others a chance to view eagles (16%), to insure that eagles are available for future generations (23%), or an intrinsic value, "because eagles have a right to exist" (41%).[6]

A logit model was used to investigate the relationship between socio-economic factors and the probability that respondents considered bald eagles and wild turkeys to be very important. Independent variables for this analysis included dummy variables for region of residence, S=1 if southern New England, 0 otherwise; whether or not the respondent is (or was) a hunter, H=1 if hunter, 0 otherwise; membership in environmental organizations, ORG=1 if member, 0 otherwise; and, type of residential neighborhood, U=1 if urban, 0 otherwise. Variables for respondents age, education and income were also included, and two functional forms were estimated; linear and quadratic with respect to education and income.

Logit estimations are presented in Table 1. Although the logit models had low explanatory power, they were statistically significant, and most independent variables had the expected sign. Hunters and respondents belonging to environmental organizations were more likely to view bald eagles and wild turkeys as very important, while urban residents were less likely to assign high

---

[6]A comparable question was not asked about wild turkeys.

importance to wild turkeys. A quadratic relationship appears to exist between importance and income; both the lower and upper income classes were less likely to view these species as very important.

For economic valuation, the sample was partitioned into three groups, each of which received an identical questionnaire except for the valuation question. The first group received a valuation question about bald eagles. The second group was asked about bald eagles and wild turkeys combined, and the third group was asked about wild turkeys. The economic valuation question confronted each individual with a specified amount of money, N (randomly selected within fixed intervals over a range of $5 to $150), which she/he could contribute to ensure wildlife existence. Respondents were then given an opportunity to bid an amount less (or greater) than the stated value, N. For example, the bald eagle valuation question was specified as follows:

> Wildlife management efforts sponsored in part by state, federal and local governments have helped to return some wildlife species from the brink of extinction. The bald eagle and the wild turkey, for example, have both been brought back to New England. Suppose that budget cuts eliminate these programs and that a private trust fund for the management of the bald eagle is set up to preserve and protect the bald eagle population in New England. Please assume that the bald eagle will not continue to exist in New England unless this fund is created. Would you contribute N $ per year over the next five years to this fund?

This formulation may create incentives for "free riding." An individual could, for example, refuse to pay, hoping that everyone else might contribute. Incentives for free riding in contingent valuation are often minimized by using payment vehicles, such as taxes, which exact payment from everyone. Taxation was not used in this case study for several reasons. Given the prevailing political climate, tax vehicles might have created strong incentives for protest and nonresponse. Voluntary payments, on the other hand, closely correspond to commonly experienced methods of contributing to wildlife preservation. Moreover, little evidence of free riding behavior has been found in previous studies (see CBS, 1986), and a donation vehicle is quite realistic in light of the budgetary problems facing many New England communities.

Results obtained from the donation vehicle must, however, be carefully interpreted. Some respondents may view this valuation question more as a way to express a desire for wildlife preservation than as a measure of how much they would actually pay. Other responses may reflect the satisfaction of contributing to a "good cause" rather than the value of the resource itself. Respondents were therefore asked a series of follow-up questions about why they were or were not willing to contribute.

Average bids, maximum bids, and standard deviations for each species are presented in Table 2. The average respondent was willing to pay $21.25 annually for bald eagles, $11.67 for wild turkeys, and $9.00 for bald eagles and wild turkeys combined. These value estimates fall well within the range of those reported elsewhere and seem "reasonable" when compared to previous research results. Boyle and Bishop (1987), for example, found average willingness-to-pay bids between $10.62 and $75.31 for bald eagle preservation. However, further analysis revealed several problems with the survey results reported here.

Protest Bids and Nonresponse

The survey response rate was low (37%) and many respondents refused to place a dollar value on wildlife.[7] Although over 80 percent of survey respondents said that bald eagles and wild turkeys are either very or somewhat important to them, a majority of respondents, 62 percent, would not pay any money for restoration. When asked why, 40 percent of those refusing to pay protested the method of payment used in this CVM; they stated that these species should be preserved but that the money should come from taxes or license fees. Twenty-five percent protested for ethical reasons; they said that wildlife values should not be measured in dollar terms. Only 6 percent of those not

[7]Loomis (1987) reports CVM response rates as low as 25% and 40-60% is about average for academic surveys of the general population.

willing to pay said that these species were worth nothing to them.[8] This implies that the average values in Table 2 are underestimated. When protest responses were removed from the data set the average respondent was willing to pay about $31 per year for bald eagles, $18.85 for wild turkeys and $13.12 for bald eagles and wild turkeys combined.

Irrational and Lexicographic Behavior

Many of those who <u>were</u> willing to pay expressed attitudes abut wildlife which, when viewed from an economic perspective, appeared "irrational." For example, forty-four percent of all respondents agreed with the statement that "preservation of wildlife should not be determined by how much money can be spent," and 67% of all respondents agreed with the statement that, "As much wildlife as possible should be preserved no matter what the cost." These respondents may have failed to give meaningful responses to the willingness-to-pay question, and when the bids by respondents who strongly agreed with these statements were also removed from the data, the average respondent would pay $25.35 for bald eagles, $18.90 for wild turkeys, and $10.66 for bald eagles and wild turkeys combined.

Additional evidence about the decision making behavior of respondents was gathered by asking them to agree or disagree with each of the following statements about tradeoffs:

(1) As long as I have enough money to live on, wildlife preservation is more important to me than having more money.

(2) Wildlife preservation and money are both important to me; but decisions have to be made and more money could make up for the loss I would feel if there were less wildlife.

(3) No matter how much money I have, having more money will always be more important to me than wildlife preservation.

---

[8]Protest bids are quite common in CV. For example, Desvousges, Smith and McGivney (1983) identified nearly half of the zero bids in their study of water quality as protest bids.

Forty-four percent of those who were willing to pay for bald eagles or wild turkeys agreed with (1) and 56% disagreed with (2). This suggests that most decisions about monetary commitment were not made according to the principles of neoclassical economic theory.

Regression analysis was also used to examine the decision-making behavior of survey respondents. A Tobit model was estimated in which the dependent variable was the actual dollar amount respondents would pay.[9] Independent variables included dummy variables for region of residence, membership in environmental organizations, type of residential neighborhood and whether or not the respondent hunts or has hunted. Variables for respondent's age, education and income were also included. The data from the three subsamples were pooled and dummy variables were used to represent survey type (D1=1 if bald eagle, D3=1 if bald eagles and wild turkeys combined). The results presented in Table 3 show a statistically significant relationship between payment and the variables representing education and income. Respondents with more education were willing to pay a greater amount. Although payment decreased with income (from 0 to $40,000 per year), it appeared to increase with income above this amount.[10]

However, this model does not adequately describe how individuals responded to the CV question; it explained very little of the variation in willingness-to-pay. As suggested by Hanemann (1984), CVM responses are expected to contain systematic and non systematic (random) components. Either the random component associated with individual responses was very large or this model of individual behavior is inappropriate.

---

[9]The Tobit model was used because the range of the independent variable is limited. OLS results are viturally identical.

[10]Two functional forms (linear and quadratic) were estimated with two sets of data (protest responses included and excluded). The results remained relatively stable when protest responses were omitted (see Table 3).

A variety of alternative behavioral models were examined. Independent variables in these models included, in addition to those listed in Table 3, dummy variables representing importance of wildlife as stated by the respondent, whether or not the respondent had made an actual donation for wildlife preservation, value of the initial starting bid N, and dummy variables for the respondent's attitude about the preservation of wildlife. None of these models explained much more of the variation in individual behavior; squared correlation values ranged from .12 to .20.

Embedding Effects

The average value of bald eagles and wild turkeys from the combined questionnaire was much less than when they were measured separately and then added together. Similar results have been reported elsewhere. Majid, Sinden and Randall (1983), for example, found that the benefits of a proposed public park were much larger when the park was considered in isolation than when the same park was considered as an increment to an existing park system.

Hypothetical versus Actual Behavior

Evidence obtained from follow-up questions showed that 32% of the respondents had actually made donations for wildlife preservation during the previous year; the average being approximately 70 dollars. On this basis the willingness-to-pay results---38% of respondents willing to pay an average of about $20 per year for bald eagles, about $12 per year for wild turkeys, and $9 per year for bald eagles and wild turkeys combined---seems "reasonable".

SUMMARY AND CONCLUSIONS

The results suggest a substantial economic benefit associated with bald eagles and wild turkeys in New England, most of which is attributed to some form of existence value. Consequently, existence values cannot be ignored in economic analysis. Yet, evidence from the follow-up questions raises several concerns about the meaning and validity of CVM existence value estimates.

The value estimates were very sensitive to whether or not species were evaluated separately or together. Moreover, the survey response rate was low (37%) and many respondents protested this CVM. They believed that wildlife should not be valued in dollar terms or that the money should come from somewhere else (taxes and license fees). Furthermore, a majority of those who would pay exhibited behavior which appears inconsistent with the neoclassical economic theory of tradeoffs between money and wildlife.

My principle concern is that we know very little about how people interpret CVM questions and even less is known about their decision making strategy. Consequently, we cannot be very certain about the meaning of the CVM results. One explanation for the results reported here is that questions about wildlife existence created ambivalence among respondents resulting in nonresponse, protest, and lexicographic behavior. Some respondents may have also been caught in the prisoner's dilemma created by the donation payment vehicle used in this CVM. This implies that existence values were underestimated.

Another possibility is that individual decisions about monetary commitment might be based primarily on social, cultural, or moral (as opposed to economic) considerations. According to Sagoff (1988), many people believe that natural resources should be allocated on normative, political, and cultural grounds, rather than an efficiency principle. Moreover, proponents of environmental ethics often argue that wildlife have a right to exist independent of human attitudes toward their existence. Consequently, we might expect that CVM respondents would often fail to make meaningful tradeoffs between money and wildlife.

Questions about the extent to which these results measure the economic value of existence remain unanswered. The monetary existence values reported here might measure the value of wildlife existence, they might reflect the amount of money which could be raised through private donations, or they might simply indicate the value of contributing to a "good cause."

These difficulties raise several obvious concerns about using benefit-cost analysis in decisions involving wildlife. Because very little is known about the process used by individuals in making choices about public goods involving altruism, ethical commitments, moral considerations, and ambivalence, we must investigate how individuals interpret CVM questions. Existence value studies should include follow-up questions to examine the quality and nature of respondents' decision making processes; questions about motivation should be used to cross-check the valuation results; and, nonmonetary preference scales for existence should be used in conjunction with the economic valuation question. As suggest by Smith (1985), "we must learn to communicate with the individuals we wish to interview. This will often mean asking them what they think we are asking for!"

REFERENCES

Bergstrom, J., J.R. Stoll and Al. Randall. 1990. "The Impact of Information on Environmental Quality Valuation Decisions." American Journal of Agricultural Economics. Vol. 72 (3): pp. 614-621.

Boyle, Kevin J. and Richard C. Bishop. 1987. "Valuing Wildlife in Benefit-Cost Analysis: A Case Study Involving Endangered Species," Water Resources Research, 23, 5, pp. 943-950.

Brown, Gardner and J.H. Goldstein. 1984. "A Model For Valuing Endangered Species," Journal of Environmental Economics and Management, Vol. 11, No. 4, pp. 303-309.

Cummings, R.G., D.S. Brookshire and W.D. Schulze. 1986. Valuing Environmental Goods: An Assessment of the Contingent Valuation Method. Rowman and Allanhead. New Jersey.

Desvousges, W.H., V.K. Smith and M. McGivney. 1983. "A Comparison of Alternative Approaches for Estimating Recreation and Related Benefits of Water Quality Improvement." EPA-230-05-83-001, Washington, D.C.

Dillman, Donald E. 1978. Mail and Telephone Survey: The Total Design Method, John Wiley and Sons, New York.

Edwards, Steven F. 1986. "Ethical Preferences and the Assessment of Existence Values: Does the Neoclassical Model Fit?", Northeastern Journal of Agricultural and Resource Economics, 15, 2, pp. 145-150.

Elster, Jon. 1989. "Social Norms and Economic Theory." Journal of Economic Perspectives. Vol. 3, No. 4, pp. 99-117.

Hanemann, W.M. 1984. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses," American Journal of Agriculture Economics, Vol. 66, pp. 332-341.

Harper, C.R. 1989. "Rational Roots of Irrational Behavior: Discussion," Northeastern Journal of Agricultural and Resource Economics, Vol. 18, No. 2, pp. 96-97.

Harris, C.C., B.L. Driver and W.J. McLaughlin. 1989. "Improving the Contingent Valuation Method: A Psychological Perspective," Journal of Environmental Economics and Management, 17, pp. 213-229.

Holländer, H. 1990. "A Social Exchange Voluntary Cooperation." American Economic Review, Vol. 80 (5); pp. 1157-1167.

Holmes, T. 1990. "Self-Interest, Altruism, and Health Risk Reduction." Land Economics. Vol. 66, No. 2, pp. 140-149.

Kahneman, D. and J. Knetsch. 1990. "Valuing Public Goods: The Purchase of Moral Satisfaction." Mimeo, University of California, Berkeley.

Kellert, S.R. 1981. "Assessing Wildlife and Environmental Values in Cost-Benefit Analysis." Mimeo, Yale School of Forestry and Environmental Studies.

Kneese, A.V. and W. D. Schulze. 1985. "Ethics and Environmental Economics" in Handbook of Natural Resources and Energy Economics, Vol. 1, J.L. Sweeney, ed., Elsevier Science.

Kunreather, H. and D. Easterling. 1990. "Are Risk-Benefit Tradeoffs Possible in Siting Hazardous Facilities." American Economic Review, Vol. 80, (2); pp. 252-256.

Loomis, John B. 1987. "Contingent Values and Aggregate Benefits," Land Economics, Vol. 63, pp. 396-402.

Loomis, John B. 1988. "Broadening the Concept and Measurement of Existence Values," Northeast Journal of Agricultural and Resource Economics, Vol. 17, No. 1, pp. 23-29.

Majid, I., J.A. Sinden and A. Randall. 1983. "Benefit Evaluation of Increments to Existing Systems of Public Facilities." Land Economics, Vol. 59 (59); pp. 377-392.

Margolis, H. 1982. Selfishness, Altruism, and Rationality. Cambridge University Press. Cambridge.

Opaluch, J.J. and K. Segerson. 1989. "Rational Roots of Irrational Behavior: New Theories of Economic Decision-Making," Northeastern Journal of Agricultural and Resource Economics, Vol. 18, No. 2, pp. 81-95.

Randall, A. and J.R. Stoll. 1983. "Existence Value in a Total Value Framework," in Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. R.D. Rowe and L.G. Chestnut, eds., Westview Press, Boulder, Colorado.

Sagoff, Mark. 1988. "Some Problems with Environmental Economics," Environmental Ethics, Vol. 10, pp. 54-74.

Samples, K.C., J. Dixon and M. Gowen. 1986. "Information Disclosure and Endangered Species Valuation." Land Economics, Vol 62 (3); pp. 306-312.

Smith, V.K. 1985. "Some Issues in Discrete Response Contingent Valuation Studies." Northeastern Journal of Agricultural and Resource Economics, April; pp. 1-4.

Tversky, A. and R.H. Thaler. 1990. "Preference Reversals." Journal of Economic Perspectives. Vol. 4, No. 2, pp. 201-211.

Table 1. Logit Model Estimation: Importance of Bald Eagles and Wild Turkeys

Variable	Bald Eagles Linear	Bald Eagles Quadratic	Wild Turkeys Linear	Wild Turkeys Quadratic
Constant	.62(1.05)	-3.23(1.70)*	.28(.46)	-2.24(1.17)
S	-.27(1.05)	-.21(.79)	.10(.39)	.14(.51)
U	.12(.45)	.10(.37)	-.51(1.84)*	-.52(1.89)*
H	.40(1.68)*	.41(1.70)*	.57(2.32)**	.57(2.32)**
ORG	.71(2.72)**	.76(2.84)**	1.25(4.75)**	1.29(4.81)**
Age	-.01(1.65)*	-.008(1.21)	-.006(.92)	-.005(.65)
Education	-.13(.88)	1.33(1.30)	-.28(1.87)*	.84(.80)
$Education^2$		-.19(1.43)		-.15(1.08)
Income	-.17(1.75)*	.85(2.04)**	-.09(.95)	.36(.83)
$Income^2$		-.17(2.54)**		-.07(1.10)
Maddala R^2	.05	.07	.09	.10
X^2	18.92	27.86	37.19	39.71
% Correct Predictions	.61	.64	.64	.64
N	381	381	381	381

*Asymptotic "t" statistic in parentheses
*Significant at .10 level (two tailed)
**Significant .05 level (two tailed)

Table 2. Statistics for Amount Bid

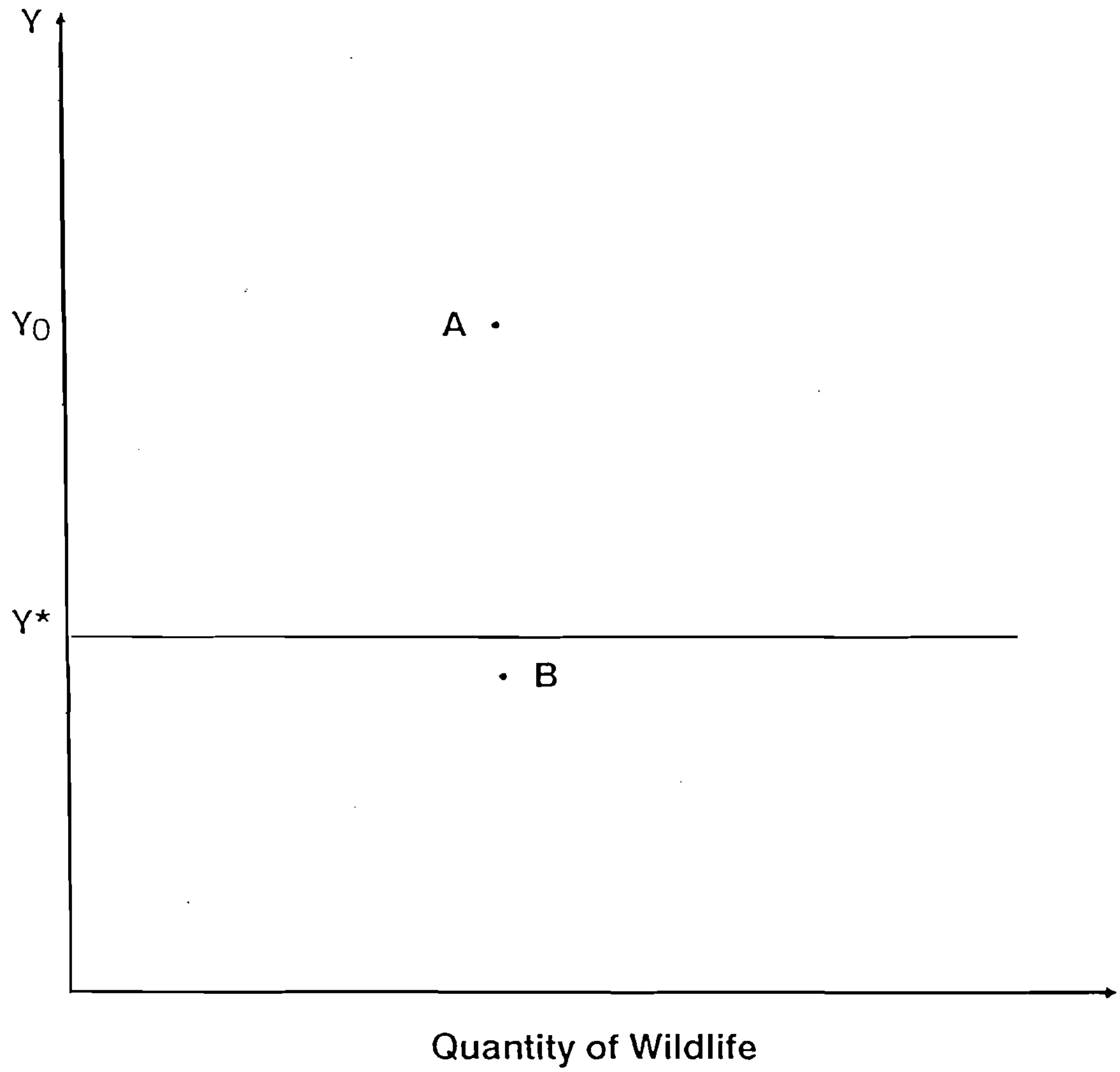
Species	Mean Amount Bid ($ Per Year)	Standard Deviation	Maximum
Bald Eagles	$21.25	38.36	200
Wild Turkeys	$11.67	27.84	150
Bald Eagles and Wild Turkeys Combine	$ 9.00	16.23	75

Table 3. Tobit Model: Payment Amount

Variable	All Data[a] Linear	All Data[a] Quadratic	Data With Protests Deleted[a] Linear	Data With Protests Deleted[a] Quadratic
Constant	-2.16(3.64)**	-1.39(1.87)*	-1.70(2.17)**	-.87(.93)
D1	.63(2.83)**	.65(2.92)**	.49(1.75)*	.54(1.94)*
D3	.14(.65)	.11(.49)	-.14(.51)	-.13(.45)
S	.21(1.00)	.15(.72)	.08(.32)	.02(.07)
U	.005(.002)	.05(.22)	.01(.05)	.04(.16)
H	.37(1.87)*	.36(1.83)*	.36(1.39)	.33(1.29)
Org	.34(1.77)*	.32(1.64)	.35(1.42)	.29(1.14)
Age	-.005(.76)	-.004(.67)	-.001(.16)	-.002(.22)
Education	.38(3.13)**	.38(3.14)**	.37(2.39)**	.39(2.51)**
Income	-.13(1.74)*	-.69(2.05)**	-.008(.08)	-.68(1.65)*
Income^2		.09(1.70)*		.11(1.66)*
Squared Correlation	.11	.14	.16	.19
N	191	191	106	106

[a]Normalized coefficients. Asymptotic "t" statistic in parantheses
* Significant at .10 level (two tailed)
**Significant at .05 level (two tailed)

Figure 1. Lexicographic Preference Map



National Accounting of Timber and Forest Environmental Resources in Sweden

Lars Hultkrantz*

* Department of Economics, University of Umeå, S–901 87 Umeå, Sweden. This paper was written during my visit in the Spring semester 1991 at the Department of Forestry and Resource Management, UC Berkeley.

Paper to be presented at the Western Regional Science/W–133 Joint Meeting, Monterey Feb 28, 1991.

1.Introduction

In integrating assessments of the degradation (or improvement) of the natural environment into national accounting systems, evaluations of changes in the volume and quality of forest resources are vital. Forests provide a variety of more or less essential services to mankind, but these utilities are only to some extent transacted in markets and hence included in the macroeconomic aggregates that are registered by national accounting systems. However, lack of reliable data seems to be an important obstacle to even modest extensions of the current accounting practices. Even in Western Europe, few countries can provide precise, annually up–dated estimates of for example the national inventories of growing stocks. Within a project on national resources account led by the Environmental Directorate of OECD, efforts are currently made to establish accounting systems that can provide a picture of annual timber material–balances in the forest industries of the OECD countries. Although this may represent an important step in the improvement of the national accounts, the mere fact that the focus in such work has to be laid on assessment of the flows of timber indicates that national accounting of non–marketed environmental services from forests still lies far ahead.

This paper outlines an extension of the national account of income from forest resources in Sweden 1987, incorporating changes in timber inventories, production of non–marketed timber and nontimber goods, and depletion or improvement in vital environmental stocks such as soil nutrients, biodiversity and carbon sinks. Sweden already has good data sources for timber accounting. The country, strongly dependent on it's vast timber resources, pioneered in nationwide forest assessment by implementing the National Forest Survey in the 1920's, which has been successively carried out and improved since then. Although timber still is important to the Swedish economy, it is widely recognized that non–timber goods and environmental services from forests also make substantial contributions to national welfare. However, this is so far not reflected in the national account. In these accounts, sawtimber and pulpwood are the only significant forest products.

2. "Green GNP" vs. sustainable income

The reasons for refining the national accounts with respect to their treatment of environmental resources are not entirely obvious. The recent upsurge in the uneasiness that apparently is felt with current practices for consideration of natural resources in the national accounts reflects in parts just a change of emphasis in the wellknown critique of national income as a measure of welfare. Environmental services are merely a subset among the non–marketed utilities, e.g. leisure, that are excluded from the national income accounts. In facing the limits to and costs of measurement and valuation, one may be inclined to conclude that the pursue for a comprehensive measure of welfare is vain. As pointed out by Eisner (1988, p. 1617), in a survey of several studies attempting to modify the national accounts in various directions, the national income accounts should not attempt to measure "welfare itself", just final products "that are the penultimate ingredients of human well–being".

This distinction may make possible reconciliation with the fact that national income does not incorporate a number of essential flows of utilities that emerge from forests, such as recreation services or production of oxygen. Although important to measure and evaluate in cost–benefit analysis studies whenever they are at stake, we may not have very much to learn from a revised national income figure that includes assessments of some of these utilities but still omits others equally important.

Moreover, adding a number of willingness–to–pay estimates of various non–priced environmental services to the registered national income does not give a correct measure of the national income that would be if these services really were priced. Such prices would change allocations within the non–environmental sector, within the environmental sector and between the two sectors. Apparently, the national income of a such economy would be another than the modified national income figure.[1]

However, besides the argument that estimates of the benefits from various flows of services from environment should be included to compose a "green GNP", there is also another argument for revision of national accounts, focusing the sustainability of income. The disastrous environmental experiences in Soviet Union and Eastern Europe, and the huge future environmental challenges posed by the rapid increase in world population and by the demand for descent standards of living in the third world countries, all point to the needs of taking into account depreciation of environmental assets when evaluating

[1]However, a large part of the non–environmental sector (i.e. the public sector) is non–priced likewise.

strategies for the promotion of economic growth. Although it may be a permissible short–cut to concentrate attention at GNP instead of at NNP as long as reproducible capital is the only stock that is taken into consideration, as long as those stocks can be assumed to be replaced in a rather constant manner, this may be inacceptable when the generation of gross income is combined with a continous depletion of natural resources.

3.Approach

In the accounting exercise that is to be reported here, the focal point is on environmental stocks, as opposed to environmental flows. The capital theoretic framework for this approach is the one presented by Hartwick (1990) and Mäler (1990). The net national income concept derived therein is equal to "Hick's income" (Scott 1990), first proposed by Erik Lindahl (1933). The bottomline is that NNP, to be a consistent measure of welfare[2], should include the value of the change in resource stocks. Changes in value of stocks due to variation in asset prices should not be included. Increments or decrements in stocks should be valued by marginal net prices (price less marginal cost); however see below for application to a heterogenous forest resource.

Environmental assets and the services they provide should if possible be evaluated from the demand side (see Desaigues & Point 1990). Evaluation from the supply side, for example by using the so called permenent inventory method in assessing the value of the depletion of a stock, by using the cost of maintenance and/or replacements required to keep the level of the stock constant, may give huge overestimates of the true value. However, evaluations from the supply side are often more accessible. The public sector of the economy is for this reason normally valued from the supply side in the national accounts. To use cost measures, one should at least have some evidence of the utility of these costs. Such evidence utilized here will be environmental targets and evidence that specific critical load levels are exceeded. This requirement narrows the set of environmental resources that will be considered to, on the one hand, flow services (in specific, timber and nontimber products) where reasonable demand–side valuations are available; and, on the other, to environmental resources where there is concern that

[2]As first shown by Weizman (1974), the linear approximation to the current value Hamiltonian of a Ramsey problem, along the optimal trajectory, is NNP.

critical stock levels will be or already have been passed (as for e.g. soil acidification, greenhouse gases, biodiversity, etc), so that further detoriation will inflict "major" environmental damages.

We will thus not attempt to augment the national account with all services provided by forests ~~these provide~~. In particular, we will not try to incorporate use values related to recreation activities, pleasant sights, etc. There are indeed some very usable studies that estimate recreation values in Sweden of for instance hunting and the preservation of virgin forest areas (see section 5). However, Swedes live in small tears in a green carpet. Forests cover 60 % of the land area. The Swedish "land ethic rules", "Allemansrätten", gives everybody, within some limits, access to private forest lands. Assessing the total use–value benefits of forests therefore amounts to the intriguing task of estimating the value of living in Sweden in comparison to living in a similiar country without forests. So far, empirical research does not allow such broad inferences. Also, the introduction of recreational values is clearly inconsistent with the way leisure and work are accounted in the current national account, so this would call for a more profound revision than we are heading for in this study (see Mäler 1990 for formal derivation of a national income concept, consistent with cost–benefit rules for efficient resource management, when leisure and environmental stocks and flows affect utility).

Although we concentrate on stocks, we will extend the "flow account" in one direction. The current national account includes the production of non–timber goods and timber for other purposes than forest industry manufacturing (meat from game, berries, mushrooms, fuelwood, etc) only to the extent that these goods are (openly) transacted on markets. However, these goods are to a considerable extent produced for own household consumption or sold on informal markets (i.e., as non–accounted transactions) where value–added–taxes and income taxes can be evaded. The value of the production of these goods will be estimated and included in the revised national income account.

4. Timber and environmental resources in Swedish forests

We will proceed by estimating the income from a number of resources or "abilities" of the Swedish forests, each representing a specific type of service. This means that a resource, e.g. the growing stock of timber, that provides several kinds of services will be conceptually divided into several natural stocks. The stocks that will be considered, the benefits or disutilities that they yield, and the associated maintainance activities are shown in Table 1.

For timber, we will consider the value of the annual yield, maintainance costs and the change in the stock. For berries, mushrooms, and meat from hunting, we will consider yield only. As regards biological diversity, carbon–pools, depletion of base cations, and reindeer forage, only stock changes will be considered. Recreation, hydrological flows and nitrogen leaking will be briefly discussed but not included, for different reasons.

The reasons for this selectivity differ among the items. For berries and mushrooms, there are (as yet) no available data that can be used for assessing variation in stocks. For game there may indeed be annual estimates, albeit crude, of population size, at least for elk (the European moose, not to be confused with American elk). However, since, due to the relatively low "capital–output ratio", a change in the population size often comes up as a change in hunting yields in the next years, we have not considered it to be important to take these stock changes into account. For reindeer fodder, the flow service of lichen stocks are already included, implicitly, in the national account of reindeer husbandry. In case of biological diversity, soil alkalinity, and carbon sinks, attention can, for reasons that will be given below, be focused at stock effects.

5. Valuing the components of the income from forest resources

A. Timber production

The market value (at roadside) of timber in the national account is composed of the values of sawtimber, pulpwood, fuelwood, christmas trees and other roundwood. The corresponding figures for 1987 are shown in Table 2. Except for fuelwood, these values will not be modified.

The fuelwood component includes only (openly) market–transacted wood, e.g. fuelwood consumption by large–scale heating stations. However, small–scale household consumption in 1985 amounted to 6.0 mill. m^3f. Total consumption was estimated to 8.5

mill. m^3f.[3] Due to storage–space requirements, smoke emissons, etc, wood–heated family houses are most common in rural regions, where people often hold a forest estate of their own, or at least some of their neighbours do. Also, (open) market transactions give rise to income and value–added taxation. For these reasons, the lions share of the fuelwood production evades tax authorities as well as national accounting bodies. Here, however, we will include the value of the total fuelwood cut.

Some inferior wood utilized for heating purposes can not be used for pulping, but a significant portion can indeed be sold as pulpwood. An illustration of the relevant features of the Swedish fuelwood market is given in Figure 1. Since the fuelwood market is small in comparison to the market for pulpwood, there is in addition to the supply curve for inferior wood a perfectly elastic supply of pulpwood. The consumption of fuelwood will therefore consist of OF units of inferior wood and FC units of pulpwood; the price of fuelwood thus equals the price of pulpwood, p_{pw}.

Using pulpwood prices, the nearly double modified market value of fuelwood shown in Table 2 was calculated.[4]

In the national account, the contribution of forestry to GNP is calculated by adding timber income, subtracting the cost of inputs to forestry from other sectors, and finally adding maintainance and reinvestment costs (i.e. silviculture), as shown in Table 2. In the modified account, however, the contribution to NNP is calculated. We therefore subtract silvicultural costs but add the value of the increase in the volume of the growing stock.

For 1987, the increment in the growing stock is estimated to 26 mill. m^3sk.[5]

---

[3]These estimates are based on a number of surveys made by Skogsstyrelsen (1986). They include only "primary" fuelwood; excluding waste–products from sawmills, house–demolishons, etc.

[4]Pulpwood prices are determined for harvesting seasons (August to July) and vary (in narrow ranges) between regions and species. The arithmetic mean of the prices in the five price–regions for pine–wood and birch–wood the harvesting seasons 1986/87 and 1987/88 was 200 SEK/m^3f (inside bark). This price was multiplied with 7.5 mill. m^3f, taking into account that 1.0 mill m^3f of the 1985 fuelwood consumption was bark.

[5]Hans Toet, Dept of Forest Survey, Umeå, personal communication. The Swedish national forest survey is based on measurement of sample areas, so there is a stochastic error. To

Fellings amounted to 67 mill. m^3sk, so the portion of the annual growth that was added to the stock was significant. Moreover, this size of the annual increment is rather typical for the period after 1976. In point of fact, all years but one or two that have been covered by the national forest survey, beginning in the 1920's, have exhibited a net incrase in the forest inventory (see Statistical Yearbook of Forestry 1990, p. 113).

To value this stock increase one can, paradoxically, not use the timber income reported by the national account, since that includes both the net conversion value ("timber rents") and the labour income earned in forestry. A separate data source has therefore been used for the net conversion value.[6] Growth in the forest resource does not augment the national labour force, so clearly the valuation should be based on "timber rents" only.

As previously mentioned[7], marginal rents (price per unit of a resource less the marginal cost of extraction/harvesting) should be used in assessing the value of a change in a natural resource stock. Forest resources, however, are heterogenous. An increase in timber inventories may, for instance, make possible an increase in future production of both pulpwood (low net conversion value) and veneer logs (high net conversion value). Moreover, high transport costs make the location of the stand to an important characteristic (remember that the value of timber here is assessed at roadside; i.e. prices are f.o.b. prices, harvesting costs do not include road transport). Let Δx be the increase in total inventory x; the sums of increments Δx_i and the inventories x_i, respectively, where i denotes "quality". The total value of stock increments is

---

increase precision in comparisons between adjacent years, some sample areas are recurrently measured each year.

[6]Statistical Yearbook of Forestry 1990, p. 244. Actually, net income as reported by the two data sources are not consistent. The net conversion value (average of the harvesting seasons 1986/87 and 1987/88) is 9.25 bill. SEK, and the value added from fellings according to the national account is 14.81 bill. SEK (17.95 – 3.14, see Table 2). The difference should be labour costs in forestry. However, in relation to the total nuber of working–hours in forest work 1987 (see Statistical Yearbook of Forestry 1990, p. 224), this implies a wage cost per hour in forestry of 135 SEK, considerably above the actual wage cost (incl. social fees) of approximateley 85 SEK/hour. A probable explanation of this inconsistency is that the estimated cost of inputs from other sector in the national account may be too low; it is based on a twenty year old survey, reflecting a far less mechanized technology than the one currently employed in forestry. A new survey to update this estimate is being prepared.

[7]Hartwick (1990) emphazises this points, criticizing a number of studies (among them Repetto 198x) that have used average extraction costs.

$$V = \sum_i (q_i - mc_i)\Delta x_i ,$$

where q_i and mc_i are price and marginal extraction cost of quality i. Now, if all inventories are increased proportionally, i.e. $\Delta x_i/x_i = \Delta x/x = k$, k is a constant, then we have

$$V = [\frac{\sum_i x_i}{\sum_i x_i} - \frac{\sum_i mc_i x_i}{\sum_i x_i}]\Delta x_i = (q - ac)\Delta x ,$$

where q is average price and ac is average marginal cost, as defined above.

Thus, if the number of "qualities" are large, and the total stock increment is evenly distributed among them, it may be a reasonable approach to use the average net conversion value. Since differences in location and product assortments really do account for a large part of the differences in net conversion surplus between stands[8], and since the 26 mill. m^3sk increase in the growing stock is dispersed among regions, species, dimensions, and other stand characteristics, this approach will be implemented.

Using the average of the unit net conversion values 1986/87 and 1987/88[9], the stock increase in 1987 can be assessed to a total value of 3.80 bill. SEK. Leaving other changes of the national account aside, this component alone is sufficient to yield a timber income contribution to NNP exceeding the contribution to GNP!

B. Berries

The Swedish forestlands provide rich sources of different kinds of berries. Two of them, lingonberries (similiar in taste to crankberries) and blueberries are more or less consumed daily by many Swedes. Because of "Allemansrätten", however, there are no

---

[8]The access cost distribution in northern Sweden is estimated in Hultkrantz (1987).

[9]143 SEK/m^3sk and 151 SEK/m^3sk, respectively (Yearbook of Forest Statistics 1990, p. 244).

exclusive property rights assigned to this berries before they are picked. Thus, most berries are not transacted in markets, but are picked by each household individually. The national account records therefore a limited portion of the annual harvest. The market value of berries from forestlands 1987 in the national account is 100 mill. SEK.

The modified account value will be based on a survey that estimated the harvest of berries in 1977 (Hultman 1983, p. 284–297). The valuation is made with the 1987 export prices (unit value f.o.b.) for unfrozen berries (Statistical Yearbook of Trade, Swedish Official Statistics). The results appear in Table 3.

The estimated market value of berries is nearly six times the value reported in the national account. Of course, berry–picking on the one hand requires working effort, on the other hand may involve recreational values. However, in accordance with the accounting practices for labour income and leisure in the national account we will not consider any of these components. To account for other inputs than labour used, the estimated figure is rounded off downwards to 500 mill. SEK.

C. Mushrooms

The total harvest of mushrooms in Swedish forests 1977 was, according to the same survey study, 22 mill. kg. Findings from another survey (Kardell 1988) in a local community in northern Sweden suggest that the mushroom–picker puts a small number of easy recognizable and delicious fungi species in his/her basket; in this particular region chanterelles and morels accounted for 5/6 of total crop. Current prices paid by cannery firms are 25 SEK/kg for morels and 30 SEK/kg for chanterells. Since a part of the crop consists of less valuable species, the lower of these prices is used to value the annual harvest. The market value thus amounts to 550 mill. SEK.

D. Game

The total value of meat from hunting on Swedish forestlands 1987 is easy to obtain, since this is already estimated in Mattsson (1990a, 1990b), based on a survey study. The total meat value is estimated to 467 mill. SEK, thereof 350 mill. SEK for elk (European moose).

Actually, this value may seem surprisingly low. The meat bags were valued by the hunters own valuation of the meat. Hunters that got only a small bag attached a rather high price, close to retail prices, to it, whereas hunters that received one or several hundreds kg meat expressed low assessments of the value of the meat, even far below the producer's price for beef. Elkmeat, which often is esteemed as superior to beef, was in average valued to 27 SEK/kg, slightly above the producer's price for beef 1987 of 23–24 SEK/kg. Apparently, the lack of a well functioning market for elkmeat, probably due to the same tax evasion reasons as in the case of fuelwood, makes it difficult to determine an unambigous price level.

E. Recreation

The general problems involved in the inclusion of recreation values in the national account have already been mentioned. One might also add that there are a number of intriguing problems in defining recreational utilities. For instance, in the study by Mattson (1990a, 1990b) it is found that 25% of elkhunters in the northern part of Sweden would like to get lower hunting quotas on their lands, in order to get more time for other things, for instance hunting small game. Thus, to some extent elkhunting is seen upon as "work" rather than recreation. In another study, Drake (1987) estimates recreational values and other from the absence of trees on previous farmlands in Sweden. This illustrates that, at an aggregate level, the relationship between the size of forest resources and the recreational values that they provide may be very complex.

However, it is clear that the recreation use values of forest in Sweden are very important. This has been shown in a number of CVM–studies of the willingness to pay for various forest–related resources. The study by Mattsson (1990a, 1990b) just mentioned, estimates the recreation value of game hunting in Sweden in 1987 to nearly 1 bill. SEK; i.e. more than the assessed value of the meat. Kriström (1990) estimates WTP of Swedish households for (once and for all) protection of eleven highly esteemed forest areas around Sweden, featuring specific recreational values. The average WTP per household is found to be 1072 SEK. Aggregating over all households and using a 5 % rate of discount, this corresponds to an to an annuity of 230 mill. SEK/year. Another CVM–study of WTP for a forest area with high recreational features is Bojö (1985).

Although these areas are wellknown and much frequented, the by far most important source of "forest recreation" in Sweden are the "normal" forests, i.e. the forests in the vicinity. So far, the value of that has not been estimated. However, some work has recently started with the purpose to fill this hole. Therefore, at the present stage it seems too early to attempt to make an overall assessment of the recreational values of Swedish forests.

F. Biodiversity

The issue of protecting the diversity of species and biotops is probably the most urgent conflict today between forestry and conservationists in Sweden (as in many other countries). Because of the periodical ice covers, the Swedish nature contains relatively few species, so the fact that a significant number of species are endangered is widely accepted to be a severe problem. The causes of the threats to biodiversity varies, but the practices of the modern forestry, and, in specific, the extension of them to nearly all forestlands, are main contributors to the problems.

A CVM–study of WTP for protection of 300 endangered species in the flora and fauna of the Swedens forests has been made by Johansson (1987). Aggregated over the Swedish population, his results imply a total WTP of 360 mill. SEK per year for measures that can be expected to save 100 % of these species. The corresponding WTP for measures that are expected to protect 50 % of the species is 150 mill. SEK per year.

It has been argued that it is inappropriate to base (irreversible) decisions that affect biological diversity or the sustainablity of ecological systems on WTP–measures such as these (see e.g. Daly (1984)). Daly makes a distinction between "scale" and "allocation"; advocating that prices should be used for optimal allocation of resources, given some ultimate bounds, set as physical entities rather than as price/cost levels, that define the limits of the economic system. Similiar thoughts are expressed by advocates of "Leopold's ethics", due to one the leading intellectuals in the history of natural resources, Aldo Leopold, who explicitly rejected public lands policy based on economics alone (Leopold 193x, 1989).

Without a purpose of resolving philosophical or ethical issues, we have made an attempt to estimate an alternative valuation of the annual detoriation of biological diversity in forestry, starting from an explicit consideration of a limit to "allowable" outcrowding of species from the forest ecosystem.

Such a critical level is difficult to define in terms of "output", e.g. in terms of the survival or population size of specific species. Hardly any population of animals or herbs can be protected from all kind of natural or human–invoked shocks that may affect it's survival (perhaps not even mankind). The conditions for a high possibility of long–term survival may be quite another than the requirements that are needed to temporarily protect some population within a specific area (e.g., if long–term survival requires the possibility to accomodate to changing conditions by migration). Also, the number of species that have to be addressed in such definitions of "survival targets" is high.

For these reasons, a more convenient approach is to determine the level of input, i.e. the total area of protected land, that must be set aside in order to get a "reasonable" protection of the biological diversity. Assuming that the choice of and design of protected areas can be "optimized" subject only to a constraint on the total size of all areas set aside for conservation (which of course is an overly simplistic representation of reel conditions), biological diversity can be expected to be a monotonicly increasing function of the total area protected. It has been proposed by among other the representatives of WWF in Sweden that a minimum level, enough to save some important species but not all, in protection of endangered species in Swedish forests, is protection on 10 % of the forest land. This claim is supported by Swedish ecological expertise[10].

If this premise can be accepted, one would like to compare such a (minimum) target with the actual level of protection. The design of the Swedish environmental regulations on forestlands complicates that evaluation. With the exception of the forests in the "remote" mountain areas along the Norwegian border, there are few and small nature reserves on forestlands giving "complete" shelter to animals and herbs. Reserves

[10]Professor Lars Ericson, Department of Ecological Botanics, Umeå University, personal communication.

in the non–mountaneous regions cover only 0.22 % of the forest land. However, environmental regulations in the Forest Law are another source of protection, putting restraints on forest management. Admittedly, these restrictions are less reliable devices for protection than reserves. Since forest owners are not payed any compensation for complying to these rules, they are mandatory[11] only up to a specific total cost. Also, the prescriptions given by the Forest Law have other objectives than just protection of wildlife habitats, and these are to some degree in conflict with conservation. However, there is no doubt that the Forest Law provides some degree of protection that should be counted.

Based on forest data in the national forest survey, Wilhelmsson (1989) estimates the size of the total forest land area where clear–cut harvesting of timber is restricted. Table 4 gives an account of the outcome of his study, and of the areas protected as reserves. In this table, only 25% of area where restrictions apply because of adjacency, closer than 100 m, to dwellings has been included. The reduction to this (ambiguous) fraction is intended to reflect the low "efficiency" of protection in such areas where there are many other disturbances to wildlife from human activities.

Summation of the components in Table 4, gives that approximately 5 % of the forest land is protected. Hence, protection falls short of the "minimum target" with 5 % of the total land area.

It can be safely assumed that this difference consists of land that yield "normal" levels of revenue when harvested. Timberlands in the economic margin, i.e. mainly forestlands in the mountain areas, have already a considerably higher protection rate than other forest land. Thus, the annual protection cost must be raised by 5 % of the annual timber income in order to reach the target level. Alternatively this can be stated in the following way: To generate timber income, the stocks of biological variation are used and depleted. Acceptance of the 10 % target implies acceptance of maintainance to prevent more than a certain degree of detoriation of the stock. Maintainance activitity is in this case equal to deterrment of fellings, so the corresponding cost is the timber income that would have been foregone if forestry had complied to the 10 % protection limit.

---

[11]In fact, they are not mandatory at all, although there are some indirect but very rarely used possibilities for coercive inducement. See Eckerberg (1990), Hultkrantz (1991).

As before, we must distinguish between "timber rents" and labour income. The annual cost 1987 of the depletion of biological diversity is thus 0.05·12.15 bill. SEK = 600 mill. SEK. Apparently, the 10% target is not supported by the willingness to pay estimate (360 mill. SEK). However, we are not dealing with very precise estimates; we may have overlapping confidence intervals. Moreover, since we don't have the final arguments to settle the price vs. quantity dispute, we will use the range given by both estimates in modifying the national account.

G. Hydrological effects

Water is a very important input to the production of forests. Forests affect hydrological flows by their impact on rain, snow melting, runoffs, etc. These effects will, however, not be considered in the present context.

Forest growth "absorps" some of the rainfall water that otherwise would have streamed into rivers. This will affect the value added from hydrological power generation, and thus national income. Draination, clear–cut areas, and other forest management activites may have an influence on the speed of snow melting in spring. Since spring floods often cause considerable damages downstream, there may be some "hidden" costs of forestry from such effects. However, the nature of the causal relationships that may be involved are unclear. Hydrological flows also lead to erosion of forest soils, although Swedish forests are less vulnerable than forests in many other countries.

Drainage of forest wetlands threatens biodiversity in the "rain forests in Sweden"; so called because of the rich biological life in these biotops. Water runoff from forest soils may contain nitrogen, metals, etc. Both these two aspects on hydrological flows are contained within other environmental aspects (biodiversity and stocks of soil cations) that we are considering separately.

H. Carbon fixing

By photosynthesis, carbondioxide is assimilated from the atmosphere and transformed into biomass. The trees, other vegetation, and the soil of forestlands are very important carbon sinks; storing carbon in a way that is not harmful to the global climate. Sweden imposes since 1990 significant effluent charges on carbondioxide emissions. There are however no corresponding subsidies to absorption of carbon from the air. In this section, we will provide an estimate of the net increase of carbonpools in Swedish forests through 1987. We will also suggest a valuation of this environmental effect.

The stemwood extracted in loggings contains only slightly above 20 % of the carbon inventory of the forest. Approximately 40 % of the carbon inventory in a "typical" Swedish forest is in the trees, above and under the ground; an equal amount is in the mineral soil; and the rest is in other vegetation etc. The total stock of fixed carbon is usually reduced in the beginning of the life cycle of an evenaged stand; more carbon is released through decomposition processes than the amount of carbon assimilated by the new trees. Subsequently, the carbon inventory will rise. After the start of exploitation of a virgin forest, the growth of the volume of carbon in trees is offset by permanent reductions in the carbon inventory in soils and vegetation. After some rotatations, however, the carbon content in the soil is down at a rather stable level (Ågren 1990). The change in the total carbon inventory of a forest that has been managed under a sufficiently long period will then mainly be the change in the carbon inventory of the growing stock of trees. The main component of the variation in the carbon inventory in Swedish forests (of which 95 % or more are in successive rotations after the harvesting of the original nature forest) is therefore the carbon content of the increase in the growing stock of trees.

A rough estimate gives that the net increase in the carbon inventory in Swedish forests in 1987 was 7.3 mill. metric tons[12]. This means that the build up of carbon in the

---

[12]The volume of the growing stock increased by 26 mill. m^3sk. To get the volume of the total biomass we multiply this with 1.4 (30 % below stump height, 10 % above). Multiplication with 0.4 yields the oven–dry weight in metric tons. 49% of this is carbon.

The conversion factors are based on personal communication with Arne Albrektsson and Jan–Erik Hällgren at the Faculty of Forestry, Umeå. Similiar calculations were made by Gustafsson (1989). It seems that she overestimates the volume of the biomass and the oven–dry weight per volume unit. One should observe that the distribution of the biomass and the distribution of the growth in the biomass are not equal. The increase in the volume of the growing stock in Sweden emerges mostly from enhanced volume per hectare, not from growth on additional lands. Thus, the additional biomass is to a higher extent laid in forests corresponded to a reduction of approximately 40 % of the Swedish emission of carbon to the atmosphere from the industry, heating and traffic sectors.

¶ (Note, arguing, omitted)

The effluent fee on carbondioxide is 0.25 SEK per kg. carbondioxide, i.e. 0.92 SEK per kg. carbon. One can reasonably argue that this is a politically determined shadowprice of emissions, and thus on absorbtion too, that can be used for evaluating the net increase of the forest carbon sink. ¶ It then follows that the carbon stock increment 1987 is worth 6.7 bill. SEK. However, although the (high) level of the fee certainly reflects a major concern in the Swedish parliament over the greenhouse effect, it is not applied uniformly. Large industrial users of energy ~~will be~~ are unaffected since there is a maximum limit to the sum of carbondioxide fees and other energy levies payed by an individual user. Also, as recently mentioned, there are no corresponding subsidies to absorption into carbon sinks. Therefore, one may expect that the carbondioxide flows to and from the atmosphere are not balanced in a way that minimizes social costs of the overall net emission volume. The marginal cost of abatement in some parts of the carbondioxide system may be lower than the imposed charge. Leaving industrial users of energy aside, where the problem is one of differential international taxation, and thus of cost effiency of abatement in a broader, international, context, and assuming that other users of energy make an effecient allocation of resources given the carbondioxide fee, the scope for such cheaper abatement would be on the absorption side. There are three major sinks that can be used rather easily; landfillings, peat production (i.e. by filling ditches that drain former wetlands to reshape anaerobic environments), and forests. Indeed, the cost of landfillings and measures to increase peat production are probably rather low. However, both options will generate emissions of methane, also a greenhouse gas, so it is not clear that they are preferable. Thus, this leaves us with the forest sink option.

The opportunity cost of storing fixed carbon by not cutting trees is the timber income foregone. Using this approach to valuing the increase in the forest carbon inventory then boils down to counting the value of the increment in the growing stock, i.e. 3.8 bill. SEK, twice; one for timber, one for carbon. The higher shadow–value implied by the level of the effluent fee indicates that this opportunity cost valuation indeed is permissible with respect to at least the alleged utility of such measures as apprehended by the political system.

---

the stem volume.

This assessment gives an account of absorption of carbon into forests only. Of course, carbon in harvested materials will not be immediately released to the atmosphere. An old study by The U.S. Department of the Treasury (1942, cited in Row & Helps 1990) suggests that the average "life" of wood materials used for house construction may be 50 – 60 year. Paper products have, according to the same source, an average life of one year. However, the period that carbon remains fixed maybe substantially extended if the paper is recycled, deposited in landfills, etc. Of the volume of timber harvested 1987 (67 mill. m^3sk), 22 % was converted into sawnwood; 34 % went into paper products; and the rest 44 %, was left in the forest or burned (e.g. in recycling of black liquor in sulphate production). Clearly, to get a full picture of the contributions of human activity to the content of carbondioxide in the air, assessments of such sinks are important (see Sedjo 1990).

I. Depletion of exchangeable base cations

Weathering and atmospheric deposition provide forest soils with different salts. From these, the roots of the trees gather nutrients. The roots "exchange" base cations, such as NH_4^+, Ca^{2+}, and Mg^{2+}, with prothons (H^+), and anions with OH^-. The absorption of base cations dominates, so the result is acidification of the soil (pH declines). Also, acid deposition on the ground from acid rains reduces pH and depletes the stock of exchangeable cations in the soil.

As soil acidification is enhanced, chemical and in the long run also physical, soil properties are influenced. The solubility of P decreases, and the potentially toxic metals such as Al, Mn, Zn and Cd increase, while the pool of essential nutrients decreases (Falkengren–Grerup & Eriksson 1990). As guidelines for political action with respect to these issues, a number of critical load targets have been proposed (see Nilsson & Grennfelt). One such target is derived on the basis that the pH–level when aluminium starts buffering should not be reached, since the aluminum felled out may be harmful to the trees and to other biological organisms, including humans, using water that is contaminated with high contents of aluminium. However, this critical level has already been reached on large areas in south Sweden.

In view of the possibilities of far–reaching detrimental biological effects and degradation of drinking water quality, it seems that the qualifications are fulfilled for employing the permanent inventory method. To hold the current stock of exchangeable cations in forest soils constant is apparently a rather modest ambition. In fact, a pilot project to fertilize forest soils in Sweden with lime and other base nutrients, which possibly will be followed by a large–scale programme covering large parts of forestlands in south Sweden, is currently undertaken.

The annual depletion of exchangeable cations in forest soils in Sweden corresponds to a compensating supply of one mill. metric tons of limestone ($CaCo_3$) (see Sverdrup & Warfvinge 1988 and Gustafsson 1989). Of course, some of these limestone should be substituted by other nutrients, such as potassium and magnesium, although these are more expensive than limestone. The cost of liming one hectar of forestland from air with 3 tons of limestone and magnesium is currently about 1,800 SEK[13]. Thus, in a rough estimate, the replacement cost of the annually depleted exchangeable base cations in forest soils totals 600 mill. SEK.

J. Nitrogen leaking

Forest growth in Sweden is normally constrained by the supply of nitrogen. The forests are therefore a sink for depositions of nitrogen emissions. As the supply of nitrogen is increased, however, other nutrients will eventually limit growth. The result may then be nitrogen leaking from the forest ecosystem in water runoff etc. Nitrogen leaking may also occur under other circumstances when there are severe disturbances in forest growth, e.g. due to damages by insects, drought, frost, etc.

A number of studies show that specific forest areas in south Sweden have reached the nitrogen saturation level, and that there are nitrogen leaking from growing forests during the vegetation period.

These events are, however, probably closely related to soil acidification. If the limits to growth in case of nitrogen saturation are set by the supply of nutrients, then

[13]Hans Ekvall, Dept of Forest Economics, Umeå, personal communication.

th main problem is that the base cations exhausted by to acid rain and loggings have not been replaced. Evidence from experiments with fertilization with other nutritiens than nitrogen do indicate that they give a considerable impact on the forest growth (i.e. on nitrogen absorption), Rosen 1988. Thus, the evidence of nitrogen leaking do support the inclusion in the previous section of the replacement cost of holding the stock of nutritiens constant. Adding a cost representing the disutility from nitrogen leaking from the forest ecosystem would therefore be double counting.

This is, however, not the whole story. Even if other nutrients are supplied so that leaking is avoided, the fact remains that the nitrogen status is increased. The positive effect of this on the stocks of timber and carbon, will be reflected in the modified NNP account as set out here. However, there will also be effects on other vegetation, favouring nitrophilous species and disfavouring others. Presumably, lingonberries and other herbs that are favoured by the lack of competition under innutrious conditions will be replaced by grass etc. Such effects will be disregarded in the present context, but may very well be included in further refinements of a modified income account, possibly using new sources of data.

J. Reindeer forage

30% of the forestlands in Sweden, in the northern parts of the countries, are used as wintertime pastures for reindeer grazing. The lichens on the ground and on the trees are a very valuable source of forage for the reindeer, in particular during the late winter (spring) when the reindeer somtetimes have to rely completely on treegrowing lichens. These can be found only on elder trees, i.e. trees above 100 years in age, so forestry has a significant impact on the supply of these lichens, as well as on lichens growing on the ground.

In a large part of the grazing area, annual consumption of lichens currently exceed reproduction, thus reducing the lichen stocks. The Lapps have already started to fodder some cattle with hay to substitute the lichen. Also, projections indicate that as a result of forest management, the reproduction of lichen will be severely reduced during the coming decades, although it is later expected to recover.

The annual reproduction of lichen can be estimed from annual forest data in the national forest survey, using methods that are presented in Wilhelmsson (1989). This study also reports on estimates of the reproduction volumes in 1980 and 1990. We will base our calculations for 1987 on the average annual change during this period..

The annual consumption of lichen is accounted for as a part of the value added in reindeer husbandry. Changes in lichen stocks are, however, as yet not included in the national account. A direct inclusion of such variation is however inaccessible since there are no lichen inventory surveys. However, an indirect assessment can be made by utilizing the data on reproduction, based on the forest survey. To this end, we will assume that the value of lichen stocks in year t as the capitalized value of a steady–state production flow at the level that is supported by the status of forests in year t. If the value of annual reproduction is denoted by I_t and r is the discount factor, then V_t, the value of the current stock, or, more accurately, the current reproduction capacity, is determined as $V_t = I_t/r$. Thus, if the annual reproduction level is changed, the value of the change in the stock is $\Delta V = \Delta I_t/r$, where ΔV_t and ΔI_t denotes annual change in V_t and I_t, respectively.

Since lichen is in scarce supply, the opportunity cost of lichen is the cost of foddering the reindeers with hay. The daily cost of foddering one reindeer with hay is 8 SEK (Bostedt & Öström 1990). Using this shadowprice for one day of lichen consumption by a reindeer, and a 5 % rate of interest, the resulting valuation of the annual increase in the stock of ground lichen ~~during the lichen~~ is 5.2 mill. SEK; and the value of the annual decrease in the stock of tree lichen is 20.4 mill. SEK.[14] The net effect thus was a 15.2 mill. SEK annual reduction in stocks. Clearly, this is a close to negligible size in relation to the other components we are considering. However, the projected significant future reductions in reproduction of ground lichen suggest~~s~~ that detoriation of lichen stocks may become a substantial component, so it should certainly be included in the modified income account.

[14]The total number of lichen grazing days of the "average" year is 70 millions (assuming that every fifth year is a "bad" year, when reindeer cannot graze on other vegetation). The imputed value of annual consumption of lichen is thus 560 mill. SEK. The annual increase in reproduction of ground lichen during the 1980's was estimated to just 0.065% of the annual consumption of 62,600 metric tons oven–dry weight). The annual decrease in reproduction of tree lichens was estimated to 2.9% of the 2,650 metric tons oven–dry weight of consumption.

6. The modified account for net income from forest resources 1987

Table 6 summarizes our assessment of the net income from forest resources in 1987. The total net value added provided by forest resources and forestry labour 1987 was, according to our estimates 21.85 bill. SEK. This modified NNP figure can be compared to the contribution of forestry to "ordinary" GNP as recorded by the national account; 16.36 bill. SEK.

The exercise we have undertaken gives rise to a number of conclusions. First, merely considering timber production, we may infer that the national accounts clearly underestimates the value of the production of timber by not considering the increase in the volume of the growing stock. This claim is valid not only for the year we have investigated here, but for all but a few years since the 1920's. Moreover, for 1987, we infer that the value of the net production of timber even exceeded the recorded value of gross production, since the value of the stock increase more than doubled the reinvestment costs (silviculture costs).

A second conclusion is that non–marketed products indeed represent a significant portion of the value of forest products in Sweden. The estimated values of fuelwood, berries, mushrooms and meat from game totals 3 bill. SEK. This is of course considerably less than the value added of harvested sawtimber and pulpwood (13.75 bill. SEK), but is, perhaps contrary to common beliefs, certainly not negligible even in such a comparison.

Thirdly, we conclude that as far as this investigation, limited to a forest perspective, goes, we have not found any clear warning signs indicating that the current level of national income in Sweden, as, in crude terms, it is estimated by the GNP, is far from a sustainable level of income. Of course, we would require a complete "modified" NNP account of the whole national economy to evaluate the degree of "sustainability" of income (or, more correct, consumption)[15]. However, our partial study of forests provides economic assessment of a number of the environmental issues that a priori could have been expected to be important "challengers" to sustainability, involving accumulation of huge "hidden" costs that someday have to be born. Both acidification of forest soils and degradation of biodiversity are regarded as some of the most important

[15]See Solow (1986) for a proposal on the definition of sustainable income.

environmental problems in Sweden (although there also are others equally, or more, important). However, if our estimates of the annual detoriation in these stocks are to be trusted, they correspond to "manageable" replacement costs. Also, we have noticed that absorbtion of carbon into the "forest sink" in Sweden represents an important countervailing factor to activities that give rise to emissions of carbondioxide.

Fourthly, we believe that this study indicates that the task of integration nature resource stocks in the national account is possible to undertake. Although some of the value estimates we have derived are fairly rough, it is clearly possible to get some idea of the relative size of the income or cost components that are involved. In comparison to other seemingly overwhelming problems posed to national accounting, such as appraisal of the value of the public sector, inclusion of natural resources into the national accounts may be rather operational. As for sustainability, these are tentative suggestions only, since we need complementary assessment of other natural and environmental resources before the full picture can be grasped.

Considerable further refinement of the estimates given here is possible. In fact, the most erroneous element in the account presented here may be the assessment of the cost of inputs from other sectors to forestry. Among the components we have added in the modified account, it seems to be most urgent to improve the accuracy of the value of the two by far most valuable ones; the increments in the stocks of timber and carbon. More detailed calculations, considering differences among species, regions, etc, can be based on available data from the national forest survey.

References

Adger, N & Whitby, M, 1990, "Accounting for the Impact of Agriculture and Forestry on Environmental Quality". Paper presented at the European Economic Association conference in Lisboa, August 1990.

Bostedt, G & Öström, P, 1990, "Skogsbruk i fjällnära skog – en samhällsekonomisk kostnads–intäktsanalys". Umeå universitet, inst f nationalekonomi, C–uppsats.

Bradford, ?,1990, Comment to Eisner, Journal of Economic Literature 28:.

Daly, H E, 1984, "Alternative Strategies for Integrating Economy and Ecology", in A M Jansson (ed), Integration of Economy and Ecology: An Outlook for the Eighties. Askö–laboratoriet, Stockholm.

Eisner, R, 1988, Extended Accounts for National Income and Product. Journal of Economic Literature 26:1611–1684.

Eisner, R, 1990, Reply to Bradford and Scott. Journal of Economic Literature 28:.
Gustafsson, K, 1989, "Kolflöden i Sverige som påverkar atmosfärens koldioxidinnehåll". Institutet för vatten– och luftvårdsforskning, Göteborg, IVL–rapport 89/196.

Hartwick,J M, 1990, "Natural Resources, National Accounting and Economic Depreciation". Journal of Public Economics (1990, in press).

Hartwick, J M, 1990, "Degradation of Environmental Capital and National Accounting Procedures". Queen's University, Kingston, Canada, working paper.

Johansson, P–O, 1987, The Economic Theory and Measurement of Environmental Benefits. Cambridge University Press.

Johansson,P–O, 1989, Valuing Public Goods in a Risky World: An experiment. In H Folmer & E Ireland (eds), Evaluation and Policy Making in Environmental Economics. Elsevier, Amsterdam.

Kardell, L, 1988, Skog och natur i Nordmaling. En attitydstudie 1986. SLU, inst f skoglig landskapsvård, Uppsala, rapport 45.

Kardell, L, 1989, (Contorta, SST)

Kortesharju, J, 1984, "Observations on Cloudberry Crops in Finland". Multiple–use Forestry in the Scandinavian Countries. The Finnish Forest Research Institute, Helsingfors.

Kriström, B, 1990, Valuing Environmental Benefits Using the Contingent Valuation Method: An econometric analysis. Umeå Economic Studies 219.

Mäler, K–G, 1990, "National Accounts and Environmental Resources". Paper presented at the Congres of the European Association of Environment and Resource Economics, Venice, 17–20 April, 1990.

Nilsson, J & Grennfelt, P (eds), 1988, Critical Loads for Sulphur and Nitrogen. Report from a workshop held at Skokloster, Sweden, 19–24 March, 1988. Nordiska rådet, Miljörapport 1988:15.

OECD, Environmental Directorate, 1990, "National Resources Account. Report on the Pilot Study Concerning Forest Resources". Drafted 28th August 1990.

Row, C & Phelps, R B, 1990, "Tracing the Flow of Carbon Through US Forest Product Sector". Paper presented at the 19th World Congres of the International Union of Forestry Research Organisations, Montreal, August 5–11, 1990.

Rosen, K, 1988, "Effects of Biomass Accumulation and Forestry on Nitrogen in Forest Ecosystems". I Nilsson & Grennfelt, 1988, se ovan.

Rosen, K, 1990, "The Critical Load of Nitrogen to Swedish Forest Ecosystems". SLU, inst f marklära, Uppsala, arbetsrapport.

Scott, ?, 1990, Comment on Eisner, Journal of Economic Literature 28:

Skogsstyrelsen, 1986, "Avverkningsberäkningar 1985 – AVB85". Jönköping.

Solow, R M, 1986, On the Intergenerational Allocation of Natural Resources. Scandinavian Journal of Economics 88:141–149.

Tengblad, Å, 1990, "PM ang beräkningarna över skogsbrukets produktion enligt Nationalräkenskaperna". SCB, PM 1990–09–27.

Tengblad, Å, 1990, "PM med reviderad beräkning av skogskapitalets nationalförmögenhetsvärde." SCB, NR–PM 1990:62, 1990–10–02.

Wilhelmsson, E, 1989, Modell och verklighet vid regionala avverkningsberäkningar. SLU, inst f skogstaxering, Umeå, rapport 48.

Ågren,G, 1990, "Kolbalansberäkningar för bränsleuttag i skogsbruk". SLU, inst f ekologi och miljövård, Uppsala, rapport till Vattenfall 1990–03–14.

Table 1. Natural stocks, yields and maintainance activities that will be considered.

	Yield	Maintainance	Stock
A.	Timber	Silviculture	Forest inventory
B.	Harvest of berries		Berry–yielding herbs
C.	Mushroom		Mycelium
D.	Meat (bag)	Game protection	Game populations
E.	Recreation	Various activities	Various features
F.	Biodiversity	Fauna and flora protection	Conditions for the survival of species
G.	Effects on hydro–logical flows	Measures that affect runoff	Forest inventory, bare lands, ditches, etc.
H.	Fixing of carbon	Silviculture and hoarding (non–harvesting)	Carbon pools
I.	Buffering of acid rain, tree nutrition	Liming, fertili–zation	Content of exchangeable base cations in soil and vegetation
J.	Nitrogen leaking	Construction of nitrogen sinks	Nitrogen–fixing capacity
K.	Reindeer forage		Lichen stocks

Table 2. Timber income 1987. Billions SEK.

	National account (GNP)	Modified account (NNP)
Market value (roadside)		
Pulpwood	8.77	8.77
Sawlogs	8.12	8.12
Fuelwood	0.12	1.50
Christmas trees	0.05	0.05
Other timber	0.19	0.19
TOTAL	17.95	18.63
Inputs from other sectors	–3.14	–3.14
Maintainance & reinvestment		
Silviculture	1.55	–1.55
Stock increase	—	3.80
TOTAL INCOME	16.36	17.74

Table 3. Quantity and value of picked berries from Swedish forest. 1977 yield, 1987 average export (f.o.b.) prices.

	Volume, mill. l.	Value, mill. SEK
Cloudberries	4.5	123
Lingonberries	34.5	258
Blueberries	28.8	153
Raspberries	7.5	40
TOTAL	75.3	574

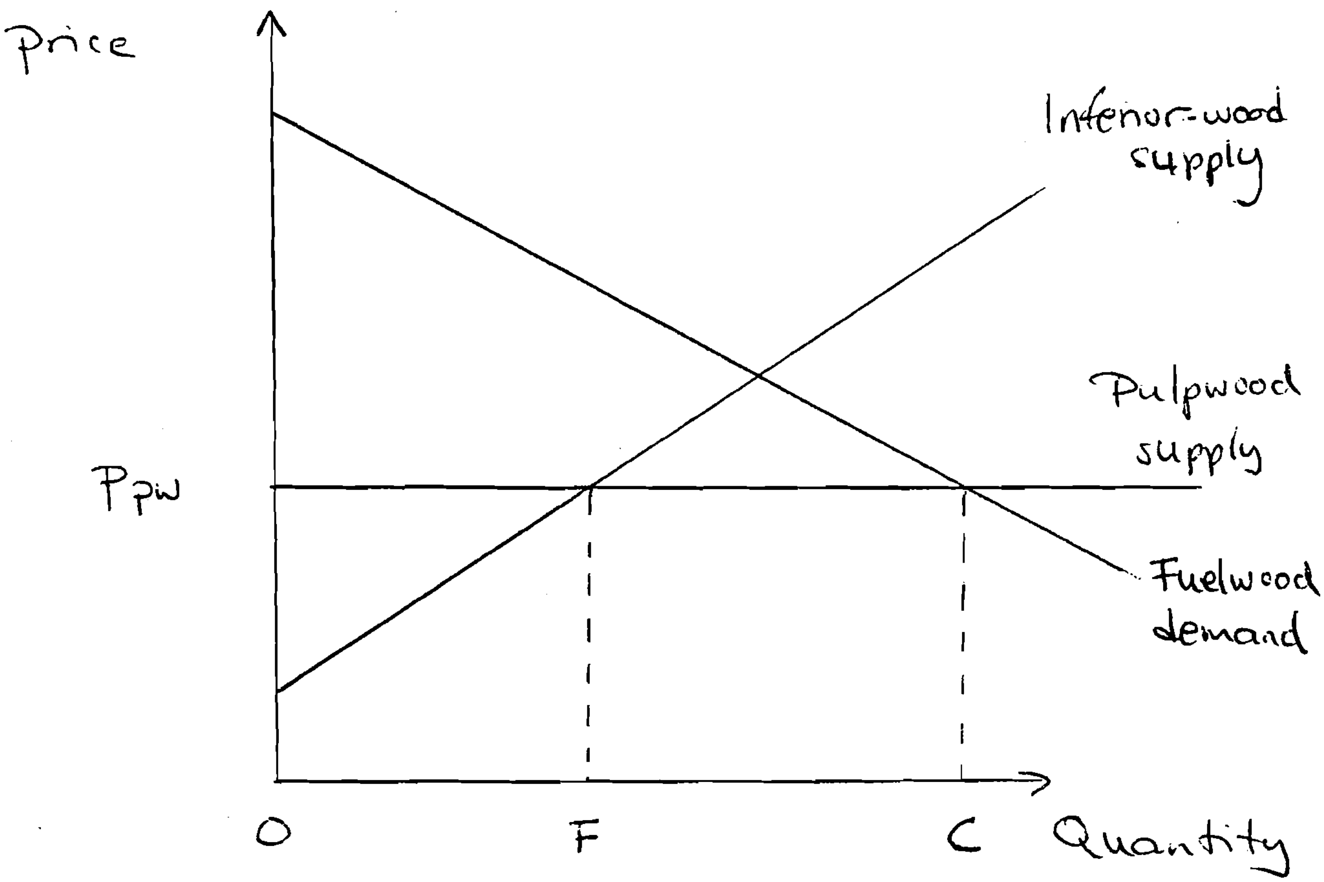
Table 4. Protected forest area in reserves and by the Forest Law, etc. Total area (1000 hectares) and portion of total forest land (percent).

	Hectares	Percent
Reserves (nature reservers, national parks & Domänreserves)		
lowlands	52	0.22
mountain region	460	1.92
Other "full" protection		
Protection due to soil or climate	262	
Other reserves	51	
Lake or sea within 100 m	13	
Technical obstacles	50	
Sensitive landscapes	173	
TOTAL	549	2.28
25% of area within 100 m from dwellings, etc.	153	0.64
TOTAL	1223	5.08

Table 6. Summary of the modified NNP account for income from forest resources in Sweden 1987. Billions SEK.

Timber products		
Market value (roadside)	18.63	
Inputs from other sectors	–3.14	
Increase in growing stock	3.80	
Silviculture	–1.55	
Subtotal 1	17.75	
Other products		
Berries	0.50	
Mushrooms	0.55	
Meat from game	0.47	
Subtotal 2	1.52	
Changes in environmental stocks		
Biodiversity	–0.60	(–0.36)
Carbon pools	3.80	(6.70)
Exchangeable cations in soil	–0.60	
Lichen stocks	–0.02	
Subtotal 3	2.58	(5.72)
TOTAL NET INCOME	21.85	

Figure 1. The Swedish market for fuelwood



Detecting Outliers and Influential Observations in Contingent Valuation Analysis

Cynthia Thomson
National Marine Fisheries Service
Southwest Fisheries Science Center
P.O. Box 271
La Jolla, California 92038

Presented at Western Regional Science Association/W-133 Conference in Monterey, California, February 27-28, 1991.

I. INTRODUCTION

The theoretical validity of contingent valuation responses can be tested by regressing willingness-to-pay (WTP) amounts on relevant explanatory variables and evaluating the size and sign of the estimated coefficients for consistency with theory (Mitchell and Carson 1989). Although observations which are obviously protest bids and refusals are routinely eliminated prior to regression analysis, the sample may still contain WTP responses that are not plausible given the respondent's income and/or demand for the good being valued. This paper refers to these pattern-disrupting observations as "outliers."

Of particular interest are outliers that are influential, that is, strongly affect inferences about the population that are drawn from the sample. Outliers are frequently but not always influential and not all influential observations are outliers. Detection of influential observations can be useful for evaluating the consistency of contingent valuation data with theoretical expectations, since it pinpoints coefficients that may be in doubt or at least sensitive to the presence or absence of particular data points.

Belsley, Kuh and Welsch (1980, p. 3) point out that "Unusual or influential data points, of course, are not necessarily bad data points; they may contain some of the most interesting sample information. They may also, however, be in error or result from circumstances different from those common to the remaining data. Only after such data points have been identified can their quality be assessed and appropriate action taken. Such an analysis must invariably produce regression results in which the investigator has increased confidence. Indeed, this will be the case even if it is determined that no corrective action is required, for then the investigator will at least know that the data showing the greatest influence are legitimate."

Treatment of outliers and influential observations in the contingent valuation literature, when discussed at all, is largely relegated to footnotes. An exception to this is provided by

Desvousges, Smith and Fisher (1987), who demonstrate the usefulness of identifying influential observations in contingent valuation analysis. This paper builds on their work by describing test procedures based on some commonly-used statistics available as routine output from statistical software packages such as SPSS and SAS and showing how the analysis of Desvousges et.al. fits in the context of these procedures.

Several points should be noted at the outset: First, outliers are always defined relative to an assumed model and correct identification of outliers presupposes a reasonable amount of confidence in that model. Secondly, subjective judgment plays an important role in deciding whether the sample contains observations that are sufficiently unusual to warrant outlier analysis, which test procedures to use when such analysis is undertaken and how to interpret the results. Not uncommonly, the analyst may choose to analyze the data in several different ways, in which case subjective judgment also becomes important in interpreting potentially conflicting results associated with different tests. Outlier analysis, however, is not intended to avoid subjectivity but to provide tools which allow us to reflect more carefully on our data and be subjective in a more explicit, consistent and less ad hoc manner.

II. THE MODEL

The procedures discussed in this paper pertain to a general linear model of the form:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{E}, \qquad [1]$$

where $\mathbf{y}$ is an nx1 vector of observations of the dependent variable, $\mathbf{X}$ is a matrix of n observations of p independent variables (including a column of ones), $\boldsymbol{\beta}$ is a px1 vector of unknown parameters and $\mathbf{E}$ is an nx1 vector of unknown errors which are assumed to be independent and have constant variance:

$$\text{var}(\mathbf{E}) = \sigma^2\mathbf{I}. \qquad [2]$$

The least-squares estimator of $\boldsymbol{\beta}$ is $\mathbf{b} = (\mathbf{X'X})^{-1}\mathbf{X'y}$ and the associated residual vector is:

$$\begin{aligned}\mathbf{e} &= \mathbf{y} - \hat{\mathbf{y}} \\ &= (\mathbf{I} - \mathbf{H})\mathbf{y}, \qquad [3]\end{aligned}$$

where $\mathbf{H} = \mathbf{X}(\mathbf{X'X})^{-1}\mathbf{X'}$. The variance-covariance matrix for $\mathbf{e}$ is:

$$\text{var}(\mathbf{e}) = s^2(\mathbf{I}-\mathbf{H}), \qquad [4]$$

where $s^2 = \mathbf{e'e}/(n-p)$ is the mean square error associated with the regression of $\mathbf{y}$ on $\mathbf{X}$. Although the true errors $\mathbf{E}$ are assumed to be uncorrelated and have constant variance, the same is not true of the estimated residuals $\mathbf{e}$.[1]

Outlier analysis focuses on identifying contaminants, i.e. observations that are sufficiently pattern-disrupting to be deemed inconsistent with the natural variability of the population, by application of a rejection rule to a case statistic. A similar procedure is used to identify influential observations. The next sections of this paper describe two types of case statistics. The first type are useful when the number of suspect observations is one (k=1), the second type when the number of suspect observations is greater than one (k>1).

III. TEST PROCEDURES WHEN k=1

A. Examples of Case Statistics for Outliers

The vector of predicted values $\hat{\mathbf{y}}$ associated with the model [1] can be expressed as:

$$\hat{\mathbf{y}} = \mathbf{Hy}, \qquad [5]$$

where $\mathbf{H} = \mathbf{X}(\mathbf{X'X})^{-1}\mathbf{X'}$ is commonly referred to as the hat matrix because it maps $\mathbf{y}$ into $\hat{\mathbf{y}}$. The ith element of [5] is:

$$\hat{y}_i = h_{ii}y_i + \sum_{j \neq i} h_{ij}y_j. \qquad [6]$$

According to [6], the h_{ij}'s (j=1,...,n) can be interpreted as weights that reflect the influence of the observed values (the y_j's) on each predicted value ($\hat{y}_i$). These weights are independent of the y_j's, since $\mathbf{H}$ depends only on $\mathbf{X}$. The influence is most directly reflected in the diagonal elements of $\mathbf{H}$ (the h_{ii}'s), which relate the y_i's to the corresponding $\hat{y}_i$'s.

The h_{ii}'s can be expressed as:

$$h_{ii} = \mathbf{x}_i'(\mathbf{X}'\mathbf{X})^{-1}\mathbf{x}_i = \frac{1}{n} + \tilde{\mathbf{x}}_i'(\tilde{\mathbf{X}}'\tilde{\mathbf{X}})^{-1}\tilde{\mathbf{x}}_i, \qquad [7]$$

where $\tilde{\mathbf{X}}$ is the matrix of explanatory variables centered about their respective mean values and $\mathbf{x}_i$ and $\tilde{\mathbf{x}}_i$ are row vectors representing the ith observation of $\mathbf{X}$ and $\tilde{\mathbf{X}}$ respectively. According to Cook and Weisberg (1982):

$$1/n \leq h_{ii} \leq 1/c, \qquad [8]$$

n being the sample size and c being the number of times that $\mathbf{x}_i$ is replicated in the sample.

Weisberg (1980) provides a useful graphical interpretation of the h_{ii}'s. In particular, $\mathbf{H}$ defines a series of p-dimensional ellipsoids that are centered at the mean of $\mathbf{X}$, with h_{ii} representing the distance of $\mathbf{x}_i$ from the mean. Hoaglin and Welsch (1978) refer to observations associated with large values of h_{ii} as "high leverage points." The h_{ii}'s are particularly useful for identifying outliers in situations where graphical depiction of the entire $\mathbf{X}$-space is not possible, that is, when the number of explanatory variables exceeds two or three.

While the h_{ii}'s are useful for measuring outliers in **X**-space, the regression residuals **e** measure the difference between **y** and $\hat{\mathbf{y}}$, with large residuals attributable to outliers in **y** and/or **X**. Because (recalling from [4]) the e_i's exhibit unequal variances across observations, a number of case statistics involving transformations of e_i have been devised which measure each residual relative to its inherent variability. One such statistic is the standardized residual r_i, which is computed as:

$$r_i = \frac{e_i}{s(1-h_{ii})^{1/2}} , \qquad [9]$$

where $s = [\mathbf{e}'\mathbf{e}/(n-p)]^{1/2}$. A similar statistic is the Studentized residual:[2]

$$t_i = \frac{e_i}{s_{-i}(1-h_{ii})^{1/2}} , \qquad [10]$$

which differs from r_i in that s is replaced by $s_{-i} = [\mathbf{e}_{-i}'\mathbf{e}_{-i}/(n-p-1)]^{1/2}$. Here $\mathbf{e}_{-i}$ is the residual vector associated with the regression of $\mathbf{y}_{-i}$ on $\mathbf{X}_{-i}$, $\{\mathbf{y}_{-i}\ \mathbf{X}_{-i}\}$ being the full data set minus the ith observation.

The r_i's and t_i's adjust for the unequal variances in the e_i's and thus can be used to identify outliers associated with a modest residual and a small variance. As shown in [9], the r_i's can be computed on the basis of the e_i's, h_{ii}'s and s obtained from a single regression involving the full data set. The t_i's are also easy to calculate (Cook and Weisberg 1982), since s_{-i}^2 can be expressed as:

$$s_{-i}^2 = \frac{n-p}{n-p-1} s^2 - \frac{e_i^2}{(n-p-1)(1-h_{ii})} . \qquad [11]$$

Because s_{-i} rather than s appears in the denominator of [10], the numerator and denominator are independent. Given this and assuming normality, t_i is distributed closely to a t-distribution with n-p-1 degrees of freedom. Cook and Weisberg (1982) show that t_i^2 is a monotonic transformation of r_i^2:

$$t_i^2 = \frac{r_i^2(n-p-1)}{(n-p-r_i^2)} \sim F_{(1,n-p-1)} \qquad [12]$$

Thus [12] can be used to transform r_i, which does not have a statistical test interpretation, to a form that is amenable for statistical testing.

The Studentized residual t_i has an interesting additional interpretation. Consider the model:

$$\mathbf{y} = \mathbf{d}_i\phi + \mathbf{X}\boldsymbol{\beta} + \mathbf{U}, \qquad [13]$$

where $\mathbf{d}_i$ is an nx1 vector of zeroes except for a one in the ith row. Model [13] is an example of a mean shift outlier model in which the suspected outlier has a different intercept that the rest of the sample. The t-statistic for testing the hypothesis that the ith observation has the same intercept as the rest of the sample (H_0: $\phi=0$) is identical to the test based on the Studentized residual t_i (Ellenberg 1976).

A large value for h_{ii} will usually not correspond to a large value for the corresponding residual (Studentized or otherwise). In fact, as h_{ii} approaches its maximum value of one (denoting an outlier in $\mathbf{X}$-space), var(e_i) approaches zero (see [4]) and e_i will be small regardless of the value of y_i. As Hoaglin and Welsch (1978, p. 20) point out, "These two aspects of the search for troublesome data points [h_{ii}'s and t_i's] are complementary; neither is sufficient by itself."

Barnett (1983) distinguishes between case statistics that are inclusive (based on the entire sample) and exclusive (based on the sample minus the potential outlier). Because $\mathbf{e}$ is based on regression results for the entire sample, residuals (Studentized or otherwise) are inclusive statistics and therefore affected by the very outliers that they are intended to identify. Ellenberg (1976), however, points out that $\mathbf{e}$ and $\mathbf{e}_{-i}$ are functionally related:

$$\mathbf{e}_{-i}'\mathbf{e}_{-i} = \mathbf{e}'\mathbf{e} - (e_i^2/h_{ii}). \quad [14]$$

Thus the distinction between inclusive and exclusive measures is more apparent than real, leading Barnett (1983, p. 140) to conclude that "...it is largely irrelevant which is used provided the value is referred to the correct null distribution."

B. Examples of Case Statistics for Influential Observations

Procedures for identifying influential observations are frequently based on sample influence functions, which measure the change in a statistic (such as a parameter estimate) associated with deletion of one or more observations from the sample. Belsley et.al. (1980) suggest a sample influence function for $\boldsymbol{\beta}$ which they call $\mathbf{DFBETA}_i$. The jth element of this vector, which describes the change in the jth coefficient associated with deletion of the ith observation, is:

$$\text{DFBETA}_i^{\,j} = b^j - b_{-i}^{\,j}, \quad [15]$$

where b^j and $b_{-i}^{\,j}$ are the jth elements of $\mathbf{b}$ and $\mathbf{b}_{-i}$, $\mathbf{b}$ and $\mathbf{b}_{-i}$ being the least squares parameter estimates associated with $\{\mathbf{y}\ \mathbf{X}\}$ and $\{\mathbf{y}_{-i}\ \mathbf{X}_{-i}\}$. When scaled by a measure of standard error, [15] looks like:

$$\text{DFBETAS}_i^{\,j} = \frac{b^j - b_{-i}^{\,j}}{s_{-i}\ [(\mathbf{X}'\mathbf{X})^{jj}]}, \quad [16]$$

where s_{-i} is the square root of the mean square error associated with regression of $\mathbf{y}_{-i}$ on $\mathbf{X}_{-i}$ and $(\mathbf{X}'\mathbf{X})^{jj}$ is the jth diagonal element of $(\mathbf{X'X})^{-1}$. A large absolute value for $DFBETA_i^j$ or $DFBETAS_i^j$ indicates that observation i is influential in estimating the jth coefficient.

Using $\mathbf{DFBETA}_i$ or $\mathbf{DFBETAS}_i$ to identify influential observations involves evaluating the effect of n different observations on each of p parameter estimates. Because the influence of each observation may vary across the p parameters, it may be difficult to evaluate the overall influence of each observation in an unambiguous way.

Less ambiguous measures of influence can be derived from a class of norms (Cook and Weisberg 1980) which take the general form:

$$D_i(\mathbf{M},c) = (\mathbf{b}_{-i}-\mathbf{b})'\mathbf{M}(\mathbf{b}_{-i}-\mathbf{b})/c, \qquad [17]$$

where $(\mathbf{b}_{-i}-\mathbf{b})'\mathbf{M}(\mathbf{b}_{-i}-\mathbf{b})$ defines an ellipsoid oriented by a positive semi-definite matrix $\mathbf{M}$ and standardized by a positive scale factor c. Norms such as [17] map sample influence functions into the real line and thus are useful for summarizing the influence of each observation in a single number.

A commonly used version of [17] is Cook's distance (Cook 1979), which takes the form:

$$COOKSD_i = \frac{(\mathbf{b} - \mathbf{b}_{-1})'(\mathbf{X'X})(\mathbf{b} - \mathbf{b}_{-i})}{ps^2}$$

$$= \left[\frac{h_{ii}}{1-h_{ii}}\right] \frac{r_i^2}{p} . \qquad [18]$$

The statistic [18] summarizes the influence of observation i on the entire parameter vector by examining the difference in the fitted value of y_i associated with $\mathbf{b}$ and $\mathbf{b}_{-i}$. Another norm in common use is based on Belsley et.al.'s (1980) $DFFITS_i$:

$$\text{DFFITS}_i = \frac{\mathbf{x}_i[\mathbf{b} - \mathbf{b}_{-i}]}{s_{-i}(1-h_{ii})^{1/2}} . \qquad [19]$$

Squaring DFFITS_i and dividing by p yields the norm:

$$\frac{1}{p}\,\text{DFFITS}_i^2 = \frac{(\mathbf{b} - \mathbf{b}_{-i})(\mathbf{X}'\mathbf{X})(\mathbf{b} - \mathbf{b}_{-i})}{ps_{-i}^2}$$

$$= \left[\frac{h_{ii}}{1-h_{ii}}\right] \frac{t_i^2}{p}. \qquad [20]$$

COOKSD_i [18] and the normed version of DFFITS_i [20] consist of similar components: a scaled residual (either r_i or t_i) and h_{ii}. Both are computationally convenient in that they can be calculated from the results of a single regression involving the full data set. A large value for either of these norms indicates that observation i is influential in estimating the parameter estimates as a whole and the predicted value of y_i.

The two norms [18] and [20] differ in one important respect (Weisberg 1983). Because the n values of COOKSD_i are scaled by the same metric, they are directly comparable; thus COOKSD_i can be used to determine, for instance, whether observation i is more or less influential than observation j. Graphically COOKSD_i defines a series of p-dimensional ellipsoids centered at **b**. If $\text{COOKSD}_i = \text{COOKSD}_j$, observations i and j lie on the same ellipsoid and are equally influential. If $\text{COOKSD}_i > \text{COOKSD}_j$, observation i lies farther from **b** than observation j and is more influential than j.

By contrast, each of the n values of DFFITS_i is scaled by a different metric (s_{-i}). Thus while it is possible to use DFFITS_i to evaluate the influence of observation i, it cannot be used to determine whether i is more or less influential than j because DFFITS_i and DFFITS_j are not directly comparable. In general, norms for which **M** or c vary among observations are not directly comparable.

IV. REJECTION RULES

Rejection rules of various types are available for evaluating whether a suspect observation is sufficiently different from the rest of the sample to be judged a contaminant or influential observation.

A. Typology

1. Absolute and Size-Adjusted Cutoffs

A rejection rule may take the form of an absolute cutoff level, with observations associated with case statistic values greater than the cutoff treated as contaminants. For case statistics that vary with the size of the model p or the sample n, absolute cutoffs make it more difficult to detect contaminants and influential observations as p or n increase. In such situations size-adjusted rather than absolute cutoffs may be better. An absolute cutoff exposes a decreasing proportion of the sample as extreme observations as the sample size increases, while a size-adjusted cutoff exposes approximately the same proportion regardless of sample size.

For case statistics that have a statistical test interpretation, the significance level for the test can serve as an appropriate cutoff. Thus for instance, an analyst who suspects observation i of being a contaminant could test this hypothesis with the Studentized residual t_i by applying the rejection rule $t_i > t_\alpha$. In situations where the identity of the suspect observation is not known prior to inspection of the data, the rejection rule is usually applied to the observation associated with the most extreme value of the case statistic. This is equivalent to performing n significance tests, one for each of the n observations. In this case, critical values are usually determined on the basis of the first-order Bonferroni inequality, which states (Weisberg 1980 p. 116) that "for n tests each of size α, the probability of falsely labeling at least one point as an outlier is no greater than $n\alpha$."

Because of the correlation among residuals (see [4]), the Bonferroni inequality provides an upper bound to the critical value and can generally be interpreted as a conservative rejection rule. However Barnett and Lewis (1984, p. 287) point out that for $t* = \max(t_i)$, "...if the maximum absolute correlation between the residuals is not too large, then the approximate critical value given by the first-order Bonferroni upper bound will be the exact critical value." Using the Bonferroni inequality, for nominal significance level α the observation associated with t* would be deemed a contaminant if $t* > t_{\alpha/n}$.

An additional complication pointed out by Collett and Lewis (1976) is that the conventional interpretation of the significance level of a test may not hold, since only those samples that are suspected of containing extreme observations are subject to testing. Defining $t_{(n)}$ as the case statistic associated with $z_{(n)}$, the most extreme observation in the sample, $p_j(t_{(n)})$ as the subjective probability that analyst j will consider $t_{(n)}$ sufficiently surprising to warrant testing, and $f(t_{(n)})$ as the probability of observing a case statistic value of $t_{(n)}$ for $z_{(n)}$,, the probability that analyst j will subject $z_{(n)}$ to testing is:

$$\int_{-\infty}^{\infty} p_j(t_{(n)})\, f(t_{(n)})\, dt. \qquad [21]$$

Thus the probability that analyst j will judge $z_{(n)}$ a contaminant is:

$$\int_{t_\alpha}^{\infty} p_j(t_{(n)})\, f(t_{(n)})\, dt = \pi_j(\alpha). \qquad [22]$$

Unless the analyst routinely applies the test to all samples (i.e., $p_j(t_{(n)})=1$), $\pi_j(\alpha)$ will be less than α.

2. Relative Cutoffs

Relative cutoffs define a contaminant on the basis of its case statistic value relative to other values in the sample. Thus, for instance, a large gap between the most extreme value of a case statistic and its closest neighbor(s) would suggest that the observation associated with this extreme value is a contaminant.

Belsley et.al. (1980) suggest another type of relative cutoff based on Tukey's 5-number summary of a data set, which includes the median, the two extremes and the two hinges (a hinge being the value halfway between the median and one of the extremes). The interquartile range IR, which is the difference between the two hinges, is an outlier-resistant estimate of spread (Mosteller and Tukey, 1977). Belsley et.al. recommend that an observation be considered a contaminant if the value of its associated case statistic exceeds (7/2)*IR.

The use of a relative cutoff implicitly assumes that case statistic values are comparable across observations. Strictly speaking, relative cutoffs can be applied to r_i, h_{ii}, and $COOKSD_i$ but not to t_i, $\mathbf{DFBETAS}_i$ and $DFFITS_i$.

B. Rule-of-Thumb Recommendations from the Literature

Table 1 describes some specific recommendations from the literature regarding rejection rules. Belsley et.al. (1980) give a "t-like" interpretation to t_i, $\mathbf{DFBETAS}_i$ and $DFFITS_i$ and recommend an absolute cutoff value of two (corresponding approximately to a critical value of $t_{0.975}$ for a two-tailed test) for each of these statistics. Belsley et.al. also suggest a size-adjusted cutoff of $2/\sqrt{n}$ for $DFBETAS_i^j$ and $2(p/n)^{1/2}$ for $DFFITS_i$. Cook and Weisberg (1980) recommend the rejection rule $t^* > t_{h_{ii}\alpha/p}$ in lieu of $t^* > t_{\alpha/n}$ in order to increase power for cases with large h_{ii}. For h_{ii} Hoaglin and Welsch recommend a cutoff of 2p/n corresponding to two times the mean value of the h_{ii}'s.[3] Huber (1983) recommends a cutoff of 0.2-0.5 for h_{ii} and Cook (1977) recommends a cutoff of 1.0 for $COOKSD_i$.

V. TEST PROCEDURES WHEN k>1

Procedures for identifying multiple contaminants or influential observations in a sample fall into two general categories: consecutive and block.

Consecutive procedures involve repeated application of a k=1 case statistic to a progressively smaller sample. After the case statistic is computed for the entire sample, a rejection rule is applied to the observation associated with the most extreme value for the statistic. If the rule indicates that the observation is a contaminant, the observation is deleted from the sample, a new version of the case statistic is computed for the remaining n-1 observations and the rejection rule applied to the most extreme value in the n-1 sample. The sample is reduced, the case statistic recomputed and the rejection rule applied repeatedly until the rule indicates that all contaminants have been removed from the sample. In applying a consecutive procedure, one can either specify k (the number of suspected outliers) in advance or allow k to be determined by the procedure.

In situations where contaminants are clustered near each other, use of a consecutive procedure may cause an extreme observation to be masked by adjacent observations. If this happens, the rejection rule is likely to indicate that all the contaminants have been identified when in fact they have not. Masking can be responsible for a significant reduction in power when consecutive procedures are used to detect multiple outliers.

Block procedures involve simultaneously testing a subset of the sample for the presence of contaminants. The procedure begins with computation of a block statistic for a subset of k potential outliers. If the rejection rule indicates that the k-subset is significantly different from the rest of the sample, the entire k-subset is deemed to be contaminant and the procedure terminates. If the rule indicates that the k-subset is not significantly different from the rest of the sample, a new version of the block statistic is computed for each combination of k-1 observations in the k-subset and the rejection rule is applied to the k-1 subset associated with the largest value of the block statistic. The procedure is repeated on successively smaller subsets until the rule indicates that a subset of contaminants has been identified.

Block procedures reduce the possibility of masking, provided that the k-subset used to initiate the procedure is sufficiently large. If k is chosen too large, however, block procedures may cause observations that are not extreme to be "carried" by observations that are. This phenomenon is known as swamping. The choice of the initial k-subset is important for avoiding both masking and swamping.

The initial k-subset can be chosen in a number of ways. One is to compute the block statistic for each combination of k observations that can be made from the n data points and initiate the block procedure with the k-subset associated with the maximum value of the block statistic. This approach requires prior specification of k and can be computationally burdensome, particularly when the number of potential k-combinations is large.

A more informal procedure involves computing the values of a designated k=1 case statistic for the n observations and identifying potential members of the k-subset on the basis of case statistic values that appear to the analyst to be large and/or widely separated from the rest of the sample. Unlike the consecutive procedure described earlier (which identifies a single contaminant on the basis of a case statistic computed for the entire sample, a second contaminant on the basis of the same case statistic computed for the entire sample minus the previously identified contaminant, etc.), this non-iterative approach involves simultaneous identification of multiple potential outliers on the basis of a single set of case statistic values computed for the entire sample.

When identifying multiple outliers via a consecutive procedure or identifying an initial k-subset for a block procedure via the non-iterative approach described above, analysts generally rely on several different k=1 case statistics. Each case statistic may yield somewhat different results regarding the identity of outliers and careful interpretation of the data is required in evaluating such results. A complicating factor for case statistics based on residuals is pointed out by Cook (1979, p. 172), who states that "The residual correlations can combine two seemingly unlikely candidates as the most likely outlier pair" and warns that "If more than two outliers or influential observations are suspected, an examination of the residual correlations, while helpful, may not be sufficient." Cook (1979), Belsley et.al. (1980) and Reiss (1990) provide good examples of how to reconcile conflicting results from different case statistics.

A. Examples of Block Statistics for Outliers

Denoting the n-k "ordinary" observations in a sample by $\{\mathbf{y}_0\ \mathbf{X}_0\}$ and the k potential outliers by $\{\mathbf{y}_1\ \mathbf{X}_1\}$, model [1] can be expressed as:

$$\begin{pmatrix}\mathbf{y}_0\\ \mathbf{y}_1\end{pmatrix} = \begin{pmatrix}\mathbf{X}_0\\ \mathbf{X}_1\end{pmatrix} \boldsymbol{\beta} + \begin{pmatrix}\mathbf{E}_0\\ \mathbf{E}_1\end{pmatrix} \qquad [23]$$

Using [23], the multiple-outlier version of the standardized residual [9] can be expressed (Cook and Weisberg 1982) as:

$$r_1^2 = \frac{\mathbf{e}_1'(\mathbf{I}-\mathbf{H}_1)^{-1}\mathbf{e}_1}{s^2}, \qquad [24]$$

where $\mathbf{e}_1$ is the residual vector associated with regression of $\mathbf{y}_1$ on $\mathbf{X}_1$ and $\mathbf{H}_1 = \mathbf{X}_1(\mathbf{X}_1'\mathbf{X}_1)^{-1}\mathbf{X}_1'$. The multiple-outlier version of the Studentized residual [10] can be similarly expressed as:

$$t_1^2 = \frac{(\mathbf{e}_1'[\mathbf{I}-\mathbf{H}_1]^{-1}\mathbf{e}_1)(n-p-k)}{(n-p)s^2-(\mathbf{e}_1'[\mathbf{I}-\mathbf{H}_1]^{-1}\mathbf{e}_1)k} \sim F_{(k,n-p-k)}. \qquad [25]$$

Just as t_i is a monotonic transformation of r_i (see [12]), t_1^2 can be obtained from r_1^2 as follows:

$$t_1^2 = \frac{r_1^2(n-p-k)}{k(n-p-r_1^2)} \sim F_{(k,n-p-k)} \; . \qquad [26]$$

Cook and Weisberg (1982, p. 30) point out that "critical values for the multiple outlier test can be based on the Bonferroni inequality but these critical values are likely to be very conservative."

A multiple-outlier version of the mean shift outlier model described in [13] is:

$$\mathbf{Y} = \mathbf{D}\boldsymbol{\phi} + \mathbf{X}\boldsymbol{\beta} + \mathbf{U}, \qquad [27]$$

where $\mathbf{D}$ is an nxk matrix with kth column $\mathbf{d}_{ik}$ consisting of zeroes except for a one in the ith row and $\boldsymbol{\phi}$ is a kx1 vector of unknown parameters. A Chow test of the hypothesis H_o: $\boldsymbol{\phi}=\mathbf{0}$ (Gentleman and Wilk 1975) is:

$$\frac{(\mathbf{e}'\mathbf{e} - \mathbf{u}'\mathbf{u})/k}{\mathbf{u}'\mathbf{u}/(n-p-k)} \sim F_{(k,n-p-k)}, \qquad [28]$$

where $\mathbf{e}'\mathbf{e}$ and $\mathbf{u}'\mathbf{u}$ are the residual sums of squares associated with the original model [1] and the mean shift outlier model [27]. The equivalency noted earlier between the Studentized residual t_i and the t-statistic for testing H_o: $\phi=0$ in the mean shift outlier model [13] applies to multiple outliers as well. Thus the familiar Chow test [28] and the Studentized residual [25] are equivalent test statistics for multiple outliers.

Now consider the model:

$$\begin{pmatrix} \mathbf{Y}_0 \\ \mathbf{Y}_1 \end{pmatrix} = \begin{pmatrix} \mathbf{X}_0 & \mathbf{0} \\ \mathbf{0} & \mathbf{X}_1 \end{pmatrix} \begin{pmatrix} \boldsymbol{\beta}_0 \\ \boldsymbol{\beta}_1 \end{pmatrix} + \begin{pmatrix} \mathbf{V}_0 \\ \mathbf{V}_1 \end{pmatrix}$$

where again $\{\mathbf{y}_0\ \mathbf{X}_0\}$ consists of the n-k "ordinary" observations and $\{\mathbf{y}_1\ \mathbf{X}_1\}$ is the k-subset of potential outliers. Regressing **y** on D and **X** and regressing $\mathbf{y}_0$ on $\mathbf{y}_0$ yield equivalent values for the residual sum of squares (Gentleman and Wilk 1975). Thus the Chow test described in [28] is equivalent to:

$$\frac{(\mathbf{e}'\mathbf{e} - \mathbf{v}_0'\mathbf{v}_0)/k}{\mathbf{v}_0'\mathbf{v}_0/(n-p-k)} \sim F_{(k,n-p-k)}, \qquad [30]$$

where $\mathbf{v}_0'\mathbf{v}_0$ is the sum of squared residuals associated with the regression of $\mathbf{y}_0$ on $\mathbf{X}_0$.

B. Examples of Block Statistics for Influential Observations

The influence of a k-subset of observations on the parameter estimates can be evaluated by testing the hypothesis that the parameter estimates associated with the n-k "ordinary" observations $\{\mathbf{y}_0\ \mathbf{X}_0\}$ and the k potential outliers $\{\mathbf{y}_1\ \mathbf{X}_1\}$ are the same (H_o: $\boldsymbol{\beta}_0 = \boldsymbol{\beta}_1$). The appropriate Chow test in this case is:

$$\frac{(\mathbf{e}'\mathbf{e} - \mathbf{v}_0'\mathbf{v}_0 - \mathbf{v}_1'\mathbf{v}_1)/p}{(\mathbf{v}_0'\mathbf{v}_0 + \mathbf{v}_1'\mathbf{v}_1)/(n-2p)} \sim F_{(p,n-2p)}, \qquad [31]$$

where $\mathbf{v}_0'\mathbf{v}_0$ and $\mathbf{v}_1'\mathbf{v}_1$ are the residual sums of squares associated with the regression of $\mathbf{y}_0$ on $\mathbf{X}_0$ and $\mathbf{y}_1$ on $\mathbf{X}_1$. If $k \le p$, there are insufficient degrees of freedom to calculate $\mathbf{v}_1$, in which case $\mathbf{v}_1$ becomes zero under the unrestricted hypothesis (Fisher 1970). Under these circumstances the intercept test [30] and the regression coefficients influence test [31] become indistinguishable, making it impossible to judge whether $\{\mathbf{y}_1\ \mathbf{X}_1\}$ influences the regression coefficients or contaminates the results in some other way (Reiss 1990).

Norms that are used to measure the influence of a single observation, such as $COOKSD_i$ ([18]) and $DFFITS_i$ ([19]), can be generalized to multiple observations. The k>1 version of $COOKSD_i$ is:

$$COOKSD_1 = \frac{(\mathbf{b} - \mathbf{b}_0)'(\mathbf{X}'\mathbf{X})(\mathbf{b} - \mathbf{b}_0)}{ps^2}, \qquad [32]$$

where $\mathbf{b}_0$ is the least squares parameter vector associated with regression of $\mathbf{y}_0$ on $\mathbf{X}_0$. A similar normed version of $DFFITS_i$ is:

$$\frac{1}{p} DFFITS_1^2 = \frac{(\mathbf{b} - \mathbf{b}_0)(\mathbf{X}'\mathbf{X})(\mathbf{b} - \mathbf{b}_0)}{ps_0^2}, \qquad [33]$$

where s_0^2 is the mean square error associated with regression of $\mathbf{y}_0$ on $\mathbf{X}_0$. Both these norms summarize the influence of $\{\mathbf{y}_1\ \mathbf{X}_1\}$ on the entire parameter vector on the basis of the differences in n fitted values associated with $\mathbf{b}$ and $\mathbf{b}_0$.

VI. DESVOUSGES, SMITH AND FISHER (1987)

Desvousges, Smith and Fisher (1987) described a model relating option price bids for water quality improvements on the Monongahela River to use of the Monongahela, income and other demographic variables. Their search for influential observations focused on the coefficient for the income variable on the basis that "This is the only economic variable that can be unambiguously specified a priori as important to the option price responses."

Defining b and b_{-i} as income coefficient estimates based respectively on the full data set and the full data set minus the ith observation, the measure of influence they used was $\theta_i = (b-b_{-i})/b$. Desvousges <u>et.al.</u> refer to θ_i as the "DFBETA elasticity" since it is equivalent to Belsley <u>et.al.</u>'s (1980) $DFBETA_i$ (see [15]) scaled by b. They identified influential observations as data points for which $|\theta_i| \geq 30\%$ because "Most of the index values for the remaining observations were much less than the ±30% value used to classify a response as an outlier with only a few responses around ±20%." Desvousges et.al. used a relative cutoff criterion (described above) based on the gap between the suspect data points above the cutoff and the rest of the sample. Their approach for identifying influential observations was similar to the non-iterative technique described above for identifying a k-subset with which to initiate a block procedure.

The influential respondents identified by Desvousges et.al. were found to be older, predominantly female, less educated and less affluent than the average respondent. These results were consistent with the authors' expectations regarding the socioeconomic profile of individuals whose responses to the survey questions were likely to be less reliable than average. The case statistic results combined with the ancillary socioeconomic information provided Desvousges et.al. with a rationale for deleting these influential observations from their sample.

VI. SUMMARY AND RECOMMENDATIONS

CVM practitioners, who can appreciate the difficulties of obtaining accurate responses to survey questions, are generally quite sensitive to the possibility of contaminants in their data and the potential effect of contaminants on the inferences that are drawn about the population. As demonstrated by Desvousges et.al. (1987), outlier/influence analysis is a useful tool for addressing these concerns.

Identification of outliers and influential observations generally involves application of a rejection rule to a case statistic. Procedures for evaluating a single suspect observation are complicated by issues pertaining to correlation among residuals and the meaning of the "significance level" of a test.

Additional complications arise when the number of suspect observations exceeds one. Consecutive procedures may lead to misleading results because of swamping. Block procedures require specification of an initial k-subset of suspect observations, a determination which may be difficult to make but is important for avoiding both masking and swamping. Both consecutive and block procedures tend to be computationally burdensome. Despite these difficulties and the subjectivity inherent in these test procedures, they provide useful tools with which to reflect on our data and be subjective in a more explicit, consistent and less ad hoc manner.

For outliers that can be traced to measurement or coding error, the obvious solution is correction (if possible) or deletion (if correction is not possible). For outliers of questionable origin, however, treatment is more problematic. Barnett and Lewis (1984, p. 31) point out that "we may indeed decide to reject (or replace) the discordant outliers and proceed to analyse the residual (modified) data on the original model, but there are other prospects of possibly greater importance. We may choose to modify the model to incorporate the outliers in a non-discordant fashion, or we may concentrate attention on the discordant outliers as a welcome identification of unsuspected factors of practical importance."

Regardless of how the analyst chooses to handle outliers, their presence and treatment should be routinely reported as part of the data analysis. According to Kruskal (1960, p. 157), "...apparent outliers should always be reported, even when one feels that their causes are known or when one rejects them for whatever good rule or reason. The immediate pressures of practical statistical analysis are almost uniformly in the direction of suppressing announcements of observations that do not fit the pattern; we must maintain a strong seawall against these pressures."

Like outliers, influential observations arising from measurement or coding errors should be deleted or (if possible) corrected. Cook and Weisberg (1982, p. 104) suggest that "Collecting more data or reporting the results of separate analyses with and without the cases in question are two additional possibilities that are often appropriate. Finally, in situations where predictions are important it may be possible to circumvent partially the effects of influential cases by isolating stable regions, or regions where the influence is minimal and unimportant."

This paper selectively focuses on several commonly used case statistics. It does not exhaust the repertoire of case statistics that are available for linear models and does not address at all test procedures for nonlinear models or procedures for accommodating outliers (robust regression techniques). Though itself limited in scope, the paper is intended to suggest possibilities and encourage more routine use and reporting of outlier/influence analysis among CVM practitioners.

Table 1. Rule-of-Thumb Cutoff Levels Recommended in the Literature for Selected Case Statistics

Case Statistic	Recommended Cutoff	Reference
t_i	2	Belsley, Kuh and Welsch (1980)
$\max(t_i)$	$t_{\alpha/n}$	Barnett and Lewis (1984)
	$t_{hii\alpha/p}$	Cook and Weisberg (1980)
h_{ii}	0.2–0.5	Huber (1983)
	2p/n	Hoaglin and Welsch (1978)
$COOKSD_i$	1	Cook (1977)
$DFFITS_i$	2	Belsley, Kuh and Welsch (1980)
	$2(p/n)^{1/2}$	Belsley, Kuh and Welsch (1980)
$DFBETAS_i^j$	2	Belsley, Kuh and Welsch (1980)
	$2/\sqrt{n}$	Belsley, Kuh and Welsch (1980)

REFERENCES

Barnett, Vic. 1983. Principles and Methods for Handling Outliers in Data Sets. In Wright, Tommy (ed.) Statistical Methods and the Improvement of Data Quality. Academic Press, Inc.

Barnett, Vic and Toby Lewis. 1984. Outliers in Statistical Data. New York: John Wiley & Sons. 463 pp.

Beckman, R.J. and R.D. Cook. 1983. Outlier..........s. Technometrics. 25:119-163.

Belsley, David A., Edwin Kuh and Roy E. Welsch. 1980. Regression Diagnostics. New York: John Wiley & Sons. 292 pp.

Collett, D. and T. Lewis. 1976. The subjective nature of outlier rejection procedures. Applied Statistics. 25:228-237.

Cook, R.D. 1977. Detection of influential observation in linear regression. Technometrics. 19:15-18.

Cook, R.D. 1979. Influential observations in linear regression. Journal of the American Statistical Association. 74:169-174.

Cook, R.D. and S. Weisberg. 1980. Characterizations of an empirical influence function for detecting influential cases in regression. Technometrics. 22:495-508.

Cook, R.D. and S. Weisberg. 1982. Residuals and Influence in Regression. New York: Chapman and Hall. 230 pp.

Desvousges, W.H., V.K. Smith and A. Fisher. 1987. Option price estimates for water quality improvements: a contingent valuation study for the Monongahela River. Journal of Environmental Economics and Management. 14:248-267.

Ellenberg, J.H. 1976. Testing for a single outlier from a general linear regression. Biometrics. 32:637-645.

Fisher, F.M. 1970. Tests of equality between sets of coefficients in two linear regressions: an expository note. Econometrica. 38:361-366.

Gentleman, J.F. and M.B. Wilk. 1975. Detecting outliers. II. Supplementing the direct analysis of residuals. Biometrics. 31:387-410.

Hoaglin, D.C. and R.E. Welsch. 1978. The hat matrix in regression and ANOVA. The American Statistician. 32:17-22.

Huber, P.J. 1983. Minimax aspects of bounded-influence regression. Journal of the American Statistical Association. 78:66-80.

Kruskal, W.H. 1960. Discussion of the papers of messrs. Anscombe and Daniel. Technometrics. 2:157-158.

Mitchell, R.C. and R.T. Carson. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington, D.C.: Resources for the Future. 463 pp.

Mosteller, F. and J.W. Tukey. 1977. Data Analysis and Regression. Reading, Massachusetts: Addison-Wesley Publishing Company, Inc. 588 pp.

Reiss, P.C. 1990. Detecting multiple outliers with an application to R&D productivity. Journal of Econometrics. 43:293-315.

Weisberg, S. 1980. Applied Linear Regression. New York: John Wiley & Sons. 283 pp.

Weisberg, S. 1983. Some principles for regression diagnostics and influence analysis. Technometrics. 25:240-244.

NOTES

1. Each true error vector described in this paper will be denoted by an upper case letter and the associated vector of estimated residuals by the corresponding lower case letter.

2. The terminology for r_i and t_i varies somewhat in the literature. For instance, Cook and Weisberg (1982) refer to r_i as the internally Studentized residual and t_i as the externally Studentized residual.

3. Since the hat matrix H is symmetric and idempotent, $\Sigma h_{ii} = p$, so that the mean value of the n diagonal elements is p/n.

PROPOSED REVISIONS TO FOREST SERVICE LAND MANAGEMENT PLANNING REGULATIONS:

Some Implications for Economic Analysis and Use of Nonmarket Values

Linda L. Langner and Christopher S. Hansen

The authors' affiliations are respectively Resources Program and Assessment Staff, Washington, D.C. and Pacific Northwest Region Fish and Wildlife Staff/Mt. Baker-Snoqualmie National Forest, Mountlake Terrace, Washington, USDA Forest Service. Presented at the Annual Meeting of Regional Research Project W-133 (Benefits and Costs in Natural Resources Planning), Monterey, CA., February 26-28.

PROPOSED REVISIONS TO FOREST SERVICE LAND MANAGEMENT PLANNING REGULATIONS:

Some Implications for Economic Analsysis and Uses of Nonmarket Values

Linda L. Langner and Christopher S. Hansen

USDA Forest Service

The public lands managed by the Forest Service are subject to a variety of competing resource demands. To aid resource allocation decisions, the Forest Service is required by the National Forest Management Act of 1976 (NFMA) to prepare integrated land and resource management plans for the National Forests and to use economic analysis to aid in developing those plans.

The planning regulations guiding land management planning are currently being considered for revision. The Forest Service issued an Advance Notice of Proposed Rulemaking on February 15, 1991 (Federal Register, 1991, pp. 6508-6538). The advance notice describes the proposed changes to the existing regulations. A 90-day public comment period follows the issuance of the advance notice, after which a Proposed Rulemaking will be published in the Federal Register for another round of public comment. A Final Rulemaking will then be published with the new planning regulations.

This paper covers five topics: 1) the legislative requirements for Forest Service land managment planning, 2) the economic analyses required in the current planning regulations, 3) the results of the Land Management Planning Critique (conducted in 1989-1990) pertaining to economic analysis, 4) the proposed changes to the planning regulations for economic analysis, and 5) the implications for economic analysis and the use of nonmarket values.

Legislative Requirements for Land Management Planning in the Forest Service

The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) provided the first specific direction to the Forest Service for land management planning. The RPA requires the Forest Service to develop a long-range plan for all Forest Service programs on a 5-year cycle, the most current version being the 1990 RPA Program. The RPA also makes reference to planning at a local level, but no specific language was included.

The National Forest Management Act of 1976 amended the RPA and expanded directions on local land management planning. The NFMA requires land and resource management plans for units of the National Forest System. The first regulations to implement NFMA were issued in 1979, and then replaced in 1982 with the current regulations. Most planning units are National Forests, but the Forest Service has the authority to designate other planning units. Planning activities must also comply with various other laws, such as the National Environmental Policy Act of 1969 (NEPA) and the Endangered Species Act of 1973 (ESA).

Current Land Management Planning Regulations

Detailed requirements for economic analysis are part of the guidelines for land management planning, and include the regular use of nonmarket values. The regulations are found in 36 CFR Part 219. They were developed to implement the NFMA and currently guide land management planning procedures. They are commonly referred to as the "219 regs," the "NFMA regs," or the "LMP regs."

The current 219 regulations are concerned primarily with Forest-level planning. However, there is minor direction on national and regional planning. At the national level, the regulations specify that the RPA Program "shall consider the costs of supply and relative values of both market and nonmarket outputs" (36 CFR 219.4 (ii)). At the Regional level, a Regional Guide is to be developed to establish Regional standards and guidelines and provide linkage between the RPA Program and individual National Forest objectives (36 CFR 219.4(a)(2)).

The overall intent of the regulations is to develop plans that provide information to decision-makers to improve decisions on land and resource allocations and scheduling of timber harvest or other resource uses. They establish extensive analytical and procedural requirements for development, revision, and amendment of Forest plans. Under the purposes and principles, it is stated that "the resulting plans shall provide for multiple use and sustained yield of goods and services from the National Forest System in a way that maximizes net public benefits[1] in an environmentally sound manner" (36 CFR 219.1(a)).

In the Forest planning process detailed in the existing regulations, a step called the "analysis of the management situation" is required (36 CFR 219.12(e)). This step must be completed prior to the formulation and evaluation of actual Forest management alternatives to be included in the Environmental Impact Statement (EIS). The analysis of the management situation requires, among other things, the formulation and evaluation of a series of "maximizing" and "minimizing" resource allocation scenarios, referred to in the regulations as "benchmark analyses." These benchmarks also include at least two "monetary benchmarks." In one, present net value[2] (PNV) for resources with established market prices is maximized, with only very basic constraints applied in the optimization modeling. In the second, PNV is maximized using both market prices for commodity outputs, and estimated values for nonmarket outputs.

The benchmarks must encompass a broad range of resource allocation choices. At one end of the spectrum is the situation where the Forest Service merely maintains the integrity of the unit (a maximum stewardship concept); at the other end are scenarios that maximize physical and biologial production of

----

[1]Net public benefits are defined as "an expression used to signify the overall long-term value to the nation of all outputs and positive effects (benefits) less all associated inputs and negative effects (costs) whether they can be quantitatively valued or not...." (36 CFR 219.3)

[2]Present net value is defined as "the difference between the discounted value (benefits) of all outputs to which monetary values or established market prices are assigned and the total discounted costs of managing the planning area." (36 CFR 219.3)

goods and servics. Also included are the monetary benchmarks maximizing PNV, described above. Costs of activities and benefits of outputs are used to the extent possible. Benefits used include both market prices and estimated values for nonmarket goods and services. A present net value is to be calculated for each benchmark that includes resources with established market prices or assigned values.

The purpose of the benchmarks is to establish the "decision space" for Forest management alternatives, i.e. the production possibility frontier for Forest goods and services. The monetary benchmarks also establish a point against which to compare the PNV of other alternatives. The purpose of the benchmark analysis is to facilitate evaluation of opportunity costs, resource tradeoffs, present net value, and benefits and costs.

After completion of the analysis of the management situation, a broad range of alternatives for management of the Forest are formulated within the decision space defined by the benchmarks. Since a Forest plan requires a programmatic Environmental Impact Statement (EIS), the evaluation of alternatives has to follow procedures set out in NEPA and its regulations. In addition to the NEPA requirements, the existing 219 regulations specify the following analyses for each alternative as a minumum (36 CFR 219.12(g)):

1) expected outputs of market and nonmarket goods and services;
2) relationship of expected outputs to RPA Program objectives;
3) expected financial costs;
4) expected financial value of resource outputs;
5) total receipts to the Federal Government;
6) direct economic benefits to users;

7) local income;

8) local employment; and

9) changes in present net value (monetary opportunity costs).

The specific language describing these requirements refers to the incorporation of nonmarket goods and services. Estimated values for nonmarket goods are acceptable. Where no dollar estimates are available, other quantitative or qualitative measures may be used (36 CFR 219.12(g)(3)(ii)).

The Land Management Planning Critique

The Forest Service has been engaged in NFMA planning activities for over a decade. In 1989 a critique of the process began. A variety of surveys and workshops were undertaken to get opinions from Forest Service employees and external groups. The results of the critique were published in 1990 in a set of 11 documents (USDA Forest Service, 1990a). There was a consensus that the Forest planning process has been a valuable learning experience, and there are both strengths and weaknesses in the existing system. The critique results provided much of the impetus for the proposed revisions discussed in the next section.

The critique covers all aspects of Forest planning. The role of economic analysis was addressed in two of the critique documents. The first (Hoekstra, et al., 1990) addresses analytical tools and information authored by a study team of 10 Forest Service personnel. The authors acknowledge that the requirements of NFMA and its implementing regulations "put into place the most rigorous analytical and information requirements that exist for planning by a

Government natural resource agency" (p. v). The results reported in this document are based on questionnaires answered by Forest Service personnel, the results of two FORPLAN symposia held in 1986, a review of the literature on national forest planning, and the experience of study team members in forest planning.

Seven issues were discussed concerning economic analysis:

1) planning direction;
2) FORPLAN;
3) demand and benefit values (prices);
4) supply and cost;
5) regional economic and distributional analysis;
6) planning and budgeting linkages; and,
7) suitable timberlands.

Issues 1 and 3 are most directly relevant to the use of nonmarket values. The concerns that surfaced under planning directives related to the uncertainty surrounding the role of economic analysis in Forest planning. Policies for economic analysis were perceived as confusing, lacking focus, and sometimes conflicting. It was also the general consensus that without the specific requirements imposed by the regulations, analysts would have done less economic analysis in the planning process.

The concerns that surfaced about demand and benefit values focused on nonmarket values. During the critique, economists and analysts asserted that nonmarket values played virtually no role in allocation decisions. There was little faith expressed in the methods used to estimate nonmarket methods, and therefore little faith in the values themselves. A more specific concern was the lack of price-quantity relationship information for resource demands (not limited strictly to nonmarket outputs). Generally, one value was used regardless of output levels, and no marginal information was available for sensitivity analysis.

Concern was also expressed about using regional average values from the RPA Program (USDA Forest Service, 1990b) for benefits, while costs are estimated at the Forest level. Furthermore, the 1990 RPA Program provides three values for each resource output (fees, market price, and willingess to pay). Considerable confusion occurs in deciding the appropriate value to use in planning applications.

Economic efficiency analysis in Forest planning was discussed in Teeguarden (1990), a commissioned paper to discuss what needs fixing in Forest planning. The author is less pessimistic about nonmarket values. He emphasizes that the 219 regulations were designed to emphasize trade-offs between market and nonmarket goods. The nonmarket values used in the planning process drew attention to those goods, allowing them to compete more effectively with market outputs, even if the actual values and PNVs calculated are not considered important. Although acknowledging the shortcomings of nonmarket values, it is not an area the author considers to be in need of fixing in the second round of planning. The current regulations are broadly worded, and allow for the use of nonmonetary measures. Of more value would be procedures to estimate the "marginal opportunity cost of successively higher levels of unpriced outputs in the context of each planning alternative under consideration" (p. 44).

The overall concerns about economic analysis led to a recommendation (Hoekstra, et al., 1990) that an Office of Economic Policy Coordination be created in the office of the Deputy Chief of National Forest System. This office would "establish and clarify the procedural mechanisms for identifying, explaining, and resolving economic issues for review by Chief and Staff." Further, the Office should "establish consistent policies regarding use of market and nonmarket benefit values, various accounting stances, and demand estimation procedures in Forest planning." The Office would also be the main liaison between the National Forest System and Research economists.

Proposed Revisions to the 219 Regulations

The proposed revisions (Federal Register, 1991) are presented in two subparts. Subpart A consists of the existing regulations, and relates to the 8 National Forests not yet having an approved Forest plan. These 8 Forests would use the existing regulations to complete their Forest plans. Subpart B is new and contains land and resource management planning requirements that pertain to National Forests with approved plans. Only Subpart B is discussed here.

A major motivating force behind proposed changes to the 219 regulations is the belief that revisions to approved Forest Plans should be incremental in nature, and not require development and analysis of wide-ranging alternatives. It is basically a "fine-tuning" approach to amendment (minor change) and revision (major change) of plans. The broad alternative approach was useful in determining the intial management path for a National Forest, but also required time consuming, data-intensive analysis of alternatives that were not generally within the feasible solution set. By narrowing the focus of the analysis to needed changes in the existing land and resource allocations and managment direction, the planning process should be simpler, more understandable, and shorter.

The proposed regulations in Subpart B address:

1) how Forest plans are implemented, amended, and revised;

2) how Forest plans relate to project decisionmaking;

3) how Forest plans relate to compliance with NEPA and implementing regulations; and

4) how Forest plans fit within the agency's overall resource planning and decisionmaking framework.

The proposed section on purposes and principles states: "The National Forest System is to be managed for the multiple-use and sustained-yield of goods, services, and environmental and amenity values in an ecologically sound manner in order to meet the needs and desires of the American people " (Federal Register, 1990, p. 6529). This statement is similar in content to the definition of net public value, but more generally encompasses consideration of economic, equity, and distribution impacts.

Under the proposed regulations, the role of Forest plans is to serve as broad, programmatic documents which provide the framework for management of National Forests, but which generally do not provide final authorization for irretrievable resource commitments. The intent of the Forest plan in this revision of the 219 regs is to provide guidance for the Forest, while project level analysis will make decisions on actual investments and resource commitments.

The streamlining of the regulations has resulted in a reduction in the specific procedural directions for economic and other types of analysis. The basic requirements for Forest plans remain the same. They must establish multiple use goals and objectives, establish standards and guidelines, delineate management areas and associated management prescriptions, identify lands not suited for timber production, and establish monitoring and evaluation requirements.

The proposed regulations drop all requirements for doing the analysis of the management situation step and associated benchmark analyses when revising Forest Plans. Definition of the Forest's "decision space" with resource and monetary benchmarks is no longer required.

Unlike the current regulations, no analytical procedures are specified regarding formulation of alternatives and evaluation of their associated benefits and costs. Instead, the Regional Forester is given the authority to determine the level and type of analysis required to provide sufficient information for environmental, social and economic analysis. The guidelines for analysis are:

1) analysis is to be commensurate with data available;
2) analysis must adequately disclose trade-offs; and,
3) analysis is limited to "generally accepted methods."

Forest Service directives should provide the guidance on what methods are classified "generally acceptable." However, it is unclear at this time in what forum or format this will be done, or whether it will be done at the Regional or national level. The introductory text to the proposed revisions states that revisions to planning direction in the Forest Service Manual regarding "generally acceptable methods" will be available for public review and comments before the regulations are finalized (Federal Register, 1990, p. 6522-6523).

The current regulations provide a list of required analyses. The proposed revisions require certain information in the programmatic EIS that accompanies plan revisions. Alternatives will still be examined, but within a narrower framework than previously. Analysis of each alternative must include:

1) indicators of investment performance, including PNV;
2) average annual federal expenditures and revenues, including cash receipts;
3) income and employment projections;
4) anticipated receipt shares to state and local governments; and,
5) quanitative or qualitative estimates of outputs or effects not assigned market values.

The required analyses are quite similar to the existing regulations, but nonmarket values are not dealt with explicitly, and the requirements have less detail.

Implications of the Proposed Changes

Two basic goals of public land management should be to protect the sustainability of the resource base and to improve social welfare. Economic analysis is one of the tools capable of providing information on how resource allocation choices affect social welfare. The question to ask is whether the proposed revisions affecting economic analysis serve to provide the best possible economic analysis to promote these goals.

Total versus incremental change

The proposal to treat future revisions as incremental changes to approved Forest plans should substantially reduce the burden for data collection and complex analytical procedures. If one accepts that an approved plan reflects a contract with the public on the best future management path, then it seems redundant to return to ground zero and examine the entire world again. The exception would be if dramatic changes occurred in the ecological, economic, or social conditions affecting the National Forest (Hurricane Hugo would be an example). In such an event, the Regional Forester would be able to require a more extensive analysis.

Scope of economic analysis requirements

The Regional Forester is to decide on the scope of analysis needed for Forest planning. This is a significant change from the existing regulations, which detail the range of alternatives to consider and require PNV analysis. On the positive side, this change would provide flexibility in analytical procedures, since the level of analysis required is often a function of the degree of competition for Forest resource outputs. For example, Forests with high timber harvest levels tend to have the most resource conflicts, which require more detailed analyses. On the negative side, the way would be open for inconsistency between Regions in analytical requirements for similar situations. The differences in level of analysis should be a function of Forest individuality, not necessarily Regional individuality. It may be more useful to develop a schedule of requirements that is consistent nationally, but varies by Forest resource situation. Lack of consistency also hinders comparions among Forest plans, for both internal review and public review.

Types of economic analysis required

The second aspect relating to changes in economic analysis requirements is the type of analysis required. The requirements for social impact analysis (jobs, income, federal receipts, etc.) are similar to the existing regulations. The substantial difference is in the level of required efficency and welfare analysis. Nonmarket values are not treated explicitly, although neither are they ruled out. Again, much will depend on how the Forest Service Manual and Handbook would be revised.

The Forest Service provides policy direction and guidelines through the Forest Service Manual (FSM) and Forest Service Handbook (FSH). The parts of the FSM most relevant to economic analysis in the planning process are FSM 1920 (Land and Resource Management Planning), FSM 1970 (Economic and Social Analysis), FSM 1971 (Evaluating Economic Efficiency), and FSM 1972 (Economic Impact Analysis). The Economic and Social Analysis Handbook (FSH 1909.17) provides details on estimation techniques and examples. The preamble to the proposed revisions states that adoption of these revisions would require significant revisions to the FSM and FSH to provide specific direction that would no longer appear in the regulations. What these revisions would actually include is not known at this point, nor is the division between Regional Forester direction and FSM/FSH direction and guidelines.

Forest Service directives currently define what are "generally accepted methods." As of now, contingent valuation and travel cost methods are approved methods, and the use of nonmarket values is relatively routine. Significant revisions in the Directives System would provide an opportunity to reconsider use of these methods. In light of the critique comments, this area could be vulnerable to change. Even if nonmarket techniques remain acceptable, they may not be required. The possible result would be to ignore available information on nonmarket values and therefore not provide the best information available.

Project-level analysis

It is unknown right now how the proposed revisions to the 219 regulations, which directly relate to Forest planning, will affect project planning as well. Direction for using economics in project-level planning and analysis is contained in the Forest Service Manual (FSM 1970-72) and elaborated on somewhat in Forest Service Handbook 1909.17. Until the revisions in the Manual and Handbook are completed, we will not know if there will be a reduced emphasis on economic efficiency analysis at the Forest planning level. If there is a reduced emphasis, the change may also translate into a similar reduction in emphasis at the project level. Also, what direction might be retained or dropped in terms of using nonmarket values at the project analysis level is unknown. We already have difficulty in getting consistent economic analysis done at the project level. A reduction of emphasis on economics carried through to the Manual and Handbook could make it even more difficult to get economic analysis incorporated into project-level decision-making. However, dropping nonmarket values and more complete economic efficiency analysis does not necessarily imply dropping cost effectiveness and financial analysis.

Summary and Conclusions

The Forest Service has learned a number of lessons from over a decade of Forest planning. The current effort to revise the land management regulations is a response to lessons learned and a changing planning environment. We only focused on a narrow segment of the planning regulations, namely the sections dealing with economic analysis.

The effect of the proposed revisions on economic analysis requirements compared to the current regulations can be quickly summarized. The focus of analysis would be much narrower, being restricted to incremental changes from the approved Forest plan. The requirements for benchmark analysis and a broad decision space would be dropped. The tools and approaches could vary between Forests and between Regions because the analytical requirements would be at the discretion of the Regional Forester. "Generally accepted methods" of analysis would be undefined, which would require revisions to the Forest Service Manual and Handbook for definition. Requirements for resource supply and demand assessment and market area analyses would be dropped. The emphasis would shift to more "descriptive economics," especially evident in the display requirements for the EIS. Nonmarket values would still be included, but more implicitly than explicitly.

The actual effects of the proposed revisions for economic analysis would depend primarily on revisions to the Forest Service Manual. Given the sentiments about nonmarket values expressed in the Land Management Planning Critique, the direction on use of nonmarket values could change or be dropped.

The implications of the proposed revisions and the comments from the Land Management Planning Critique also have implications for the role of economists in the Forest Service and in the research community. Forest Service economists involved in Forest planning have an obligation to use the best economic information available and to do the best economic analysis possible. This group does not generally conduct nonmarket valuation studies to estimate values. Instead, they depend on input from the research community for both techniques and values.

The research communitity (including Forest Service Research) has been instrumental in providing methodology and nonmarket values for planning purposes. This group should play a role in providing advice on policy direction, and in responding to the research needs for improving nonmarket values. Particular attention needs to be directed at the types of questions surfaced in the Land Management Planning Critique. Forest planning provides an excellent forum for testing the application of these values. If the Forest Service relaxes its requirements for economic analysis in the nonmarket valuation area, the consequences will be felt in a much broader arena.

REFERENCES

36 CFR 219. 1982. National Forest System Land and Resource Management Planning. Federal Register 47(190): pp. 43026-43052.

Federal Register. 1991. 36 CFR Part 219 National Forest System Land and Resource Management Planning; Advance Notice of Proposed Rulemaking. Volume 56 (32): 6508-6538, February 15, 1991.

Hoekstra, T.W. et al. 1990. Analytical Tools and Information. USDA Forest Service FS-455. Washington, D.C. (Volume 4 of the Land Management Critique)

Teeguarden, D.E. 1990. National Forest Planning Under RPA/NMFA: What Needs Fixing? USDA Forest Service FS-462. Washington, D.C. (Volume 11 of the Land Management Planning Critique)

USDA Forest Service. 1990a. The Land Managment Planning Critique. FS-452-462. Washington, D.C. (Set of 11 volumes)

USDA Forest Service. 1990b. The Forest Service Program for Forest and Rangeland Resources: A Long-Term Strategic Plan. USDA, Washington, D.C., May 1990.

A MODEL OF THE WELFARE EFFECTS OF CHANGES IN QUALITY: NEW MEXICO FISHING

by

Frank A. Ward and John Fiore

Abstract

A model is described that estimates a total benefits function defined over environmental characteristics. The model is specified to be consistent with a flexible form utility index. The system of ordinary demands derived from the utility index is estimated from observed data at 130 sites, 9 zones-of-origin, and 8 fishing seasons. The model is designed to be used to assess the incremental welfare effects of a variety of policies that would change the quality or price of fishing opportunities in New Mexico.

Authors' affiliations are both Department of Agricultural Economics, New Mexico State University, Las Cruces, NM, 88003. This paper was presented at the meetings of the Western Regional Research Project "Benefits and Costs on Natural Resource Planning," (W-133) held in Monterey, California, February 1991. The New Mexico Department of Game and Fish and New Mexico Water Resources Research Institute provided outside research support.

A MODEL OF THE WELFARE EFFECTS OF CHANGES IN QUALITY: NEW MEXICO FISHING

1. INTRODUCTION

Many western rivers have been engineered into systems that impound water and manage flow rates for irrigation, hydropower, flood control, and recreational uses. Reservoirs and connecting waters in these river systems provide sportfish habitats that support valuable recreational fisheries. A management policy imposed on one part of the system has effects that extend both upstream and downstream to other parts of the system. These interactions may change as the distribution and amount of water is altered over wet and dry cycles.

Because of complex but unknown interactions among water, biology, and economic benefits, fishery managers typically have had little choice other than to manage individual fishing sites as if they were hydrologically and economically independent. However, growing demands for optimizing the use of scarce water supplies in the arid west including recreational uses, have encouraged the development of models integrated across disciplines that can be operated to anticipated the total effects on a river basin system of various fishery management policies.

This paper presents the mathematical documentation of the economics component of a set of models that is currently being completed in New Mexico. The group of models is referred to collectively as RIOFISH, described in more detail in Cole, et. al (1990a) and Cole, et. al (1990b).

The economics model in RIOFISH is important because the New Mexico Department of Game and Fish (NMGF) and other recreational and environmental interests in New Mexico need an economic evaluation of various fisheries and water policies in addition to biological and hydrological assessments. The economic model assesses the change in statewide benefits to anglers derived from NMGF management policies as transmitted through the ecosystem, as compared to management costs and other opportunities foregone.

Angler benefits are measured in the mathematical documentation described below by anglers willingness-to-pay for price changes and unpriced quality improvements. The benefit measure is based on the theoretically correct expenditure function estimated from an observable, utility-theoretical demand system. The demand system is estimated from interactions among travel distances, visitor-days, and unpriced site qualities defined in part by the aquatic ecosystem, both of which are affected by management decisions.

2. DEMAND

A system of demands predicts average trips per kth zone angler (1) to the ith site and (2) to the aggregate of the ith site's substitute sites. The vector of trips to these two site types is specified to be:

(1a) $$\mathbf{X}_{ik} = \{\boldsymbol{\beta}_{XX}^{-1}\, \mathbf{P}_{ik}(\mathbf{P}_{ik}'\boldsymbol{\beta}_{XX}^{-1}\mathbf{P}_{ik})^{-1}[\mathbf{P}_{ik}'\boldsymbol{\beta}_{XX}^{-1}(\boldsymbol{\alpha}_{ik}) + M_k]\} - \boldsymbol{\beta}_{XX}^{-1}(\boldsymbol{\alpha}_{ik})$$

where

(1b) $$\boldsymbol{\alpha}_{ik} = \boldsymbol{\alpha}_X + \boldsymbol{\beta}_{XQ}'\mathbf{Q}_i + \boldsymbol{\beta}_{XZ}'\mathbf{Z}_k$$

$$\mathbf{X}_{ik} = \begin{bmatrix} X_{1ik} \\ X_{2ik} \end{bmatrix}$$

X_{1ik}: predicted trips to the ith site from the kth zone

X_{2ik}: predicted trips to the sum of all substitutes for the ith site from the kth zone.

(1c) $$\boldsymbol{\alpha}_X = \begin{bmatrix} 3.124 \\ [71.60]^{1} \\ \\ 0.890 \\ [*] \end{bmatrix},$$

3.124 [71.60][1]: marginal utility of trip quantities consumed at the ith site

0.890 [*]: marginal utilities of quantities consumed at substitute for ith site

(1d) $$\boldsymbol{\beta}_{XX}^{-1} = \begin{bmatrix} -0.05 & 0.10 \\ [-185.13] & [\ \ ] \\ & \\ 0.10 & -11.66 \\ [*] & [-53.74] \end{bmatrix},$$

[1] Student t-statistics are in brackets, * indicates not defined.

where β_{XX}^{-1} is the matrix consisting of the inverse of four elements in β_{XX} matrix in utility function equal to $\frac{\partial\left(\frac{\partial U}{\partial X_i}\right)}{\partial X_j}$ described in the utility function (4).

$$
(1e) \quad \beta_{XQ} = \begin{bmatrix}
\beta_1 \ (\ 0.0001) \ [6.17] & 0 \\
\beta_1 \ (\ 0.2419) \ [55.42] & 0 \\
\beta_1 \ (-0.0165) \ [-6.45] & 0 \\
\beta_1 \ (-0.0081) \ [-2.48] & 0 \\
\beta_1 \ (\ 0.0162) \ [7.81] & 0 \\
\beta_1 \ (-0.0971) \ [-3.67] & 0 \\
\beta_1 \ (-0.0022) \ [-1.00] & 0 \\
\beta_1 \ (\ 0.0238) \ [1.02] & 0 \\
\beta_1 \ (\ 0.0013) \ [3.07] & 0 \\
\beta_1 \ (\ 0.0019) \ [0.78] & 0 \\
\beta_1 \ (\ 0.0401) \ [4.93] & 0 \\
\beta_1 \ (\ 0.0319) \ [2.12] & 0 \\
\beta_1 \ (\ 0.0422) \ [1.48] & 0 \\
\beta_1 \ (\ 0.0005) \ [2.12] & 0 \\
\beta_1 \ (-0.0130) \ [-0.35] & 0 \\
0 & \beta_2 \ (\ 1.9939) \ [\ 11.05] \\
0 & \beta_2 \ (\ 0.2292) \ [\ 20.28] \\
0 & \beta_2 \ (-0.2628) \ [\ 1.97] \\
0 & \beta_2 \ (\ 4.6390) \ [\ 8.27] \\
0 & \beta_2 \ (\ 0.7134) \ [\ 11.86] \\
0 & \beta_2 \ (\ 0.0406) \ [\ 12.89]
\end{bmatrix}
$$

where β_1 = 22.04; β_2 = 0.11, and $\frac{\partial \left(\frac{\partial U}{\partial X_i}\right)}{\partial Q_i}$ elements in the utility function described in (4).

$$\text{(1f)} \quad \beta_{XZ} = \begin{bmatrix} \beta_1\,(0.0127) & \beta_2\,(0) \\ [5.34] & [*] \\ \beta_1\,(-0.0077) & \beta_2\,(-0.0038) \\ [-8.61] & [-1.19] \\ \beta_1\,(-0.2204) & \beta_2\,(1.3157) \\ [-7.51] & [10.59] \end{bmatrix}$$

where $\beta_{XZ} = \frac{\partial \left(\frac{\partial U}{\partial X_i}\right)}{\partial Z_j}$ elements in the utility function described in (4).

(1g) $\mathbf{P}_{ik}$ = $\begin{bmatrix} P_{1ik} \\ P_{2ik} \end{bmatrix}$

P_{1ik}: (round trip miles x travel cost/mile + entry fee); where travel cost/mile includes an opportunity cost of time valued at 1/2 the hourly wage.

P_{2ik}: $\sum_{i' \neq i} P_{1ik} X_{1ik} / \Sigma X_{1ik}$, price of the composite substitute for ith site, equal to the weighted average of prices to all substitutes for $i' \neq i$. Observed trips are the weights, i.e. a proxy for their importance to the angler.

(1h) M_k = recreational expenditure by the typical kth zone-of-origin angler, to the ith site and its substitutes defined by the recreational budget constraint $\mathbf{P}_{ik}' \mathbf{X}_{ik}$.

(1i) $\mathbf{Q}_i$ = $\begin{bmatrix} (Q_{11ij})^{.9} \\ Q_{12ij} \\ Q_{13ij} \\ Q_{14ij} \\ (Q_{15ij})^{.9} \end{bmatrix}$

Q_{11} = average water surface acres, ith site, jth season

Q_{12} = close proximity and ideal weather conditions, weighted by (surface acres)^3 at ith site, jth season

Q_{13} = precip at ith site, jth season

Q_{14} = extent of macrophytes, ith site, jth season

Q_{15} = number of concrete boat ramps weighted by quality factor, ith site, jth season

Q_{16ij}	Q_{16} = no power boats allowed, ith site, jth season
Q_{17ij}	Q_{17} = muddiness of water, ith site, jth season
Q_{18ij}	Q_{18} = drinking water available, ith site, jth season
$(Q_{19ij})^{.9}$	Q_{19} = number of developed campsites within 10 miles of ith site, jth season
$(Q_{110ij})^{.9}$	Q_{110} = number of modern toilets at ith site, jth season
Q_{111ij}	Q_{111} = site is a tailwater below a dam (0-1 dummy), ith site, jth season
$(Q_{112ij})^{.3}$	Q_{112} = average length of fish caught, ith site, jth season
$(Q_{113ij})^{.9}$	Q_{113} = average number of fish caught per hour, ith site, jth season
Q_{114ij}	Q_{114} = percent shoreline accessible to general public, ith site, jth season
Q_{115ij}	Q_{115} = catch and release fishery (0-1 dummy), ith site, jth season
$(Q_{21ij})^{.1}$	Q_{21} = average water surface acres at substitute for ith site (for all $i' \neq i$), jth season, weighted by trips to each substitute for $i' \neq i$. This weights substitute surface acres by the importance of each substitute for the given ith site.
Q_{22ij}	Q_{22} = close proximity and ideal weather conditions, weighted by surface acres, at substitute for ith site, jth season, weighted by trips.
$(Q_{24ij})^{.1}$	Q_{24} = macrophytes at substitute for ith site, jth season weighted by trips.
$(Q_{28ij})^{.1}$	Q_{28} = drinking water at substitute for ith site, jth season weighted by trips.
Q_{211ij}	Q_{211} = substitutes for ith site, jth season, with tailwater fishery, weighted by trips.
Q_{214ij}	Q_{214} = percent of shoreline accessible to general public at substitute for ith site, jth season, weighted by trips

Note that each quality variable Q_{21} through Q_{214} is a composite index of that dimension of quality at all substitutes for the ith site. Sites are placed into two groupings "own site" and "substitute site." The substitute site's quality for surface acres of water, is the trip weighted sum of surface acres at all 131 substitutes for the site in question.

Zones-of-origin characteristics are specified as:

$$(1j) \quad Z_{jk} = \begin{bmatrix} Z_{1jk} \\ Z_{2jk} \\ Z_{3jk} \end{bmatrix}$$

Z_1, average temperature F° for jth season, kth zone-of-origin

Z_2, urbanness jth season, kth zone-of-origin

Z_3, northern part of state (0-1 dummy), jth season, kth zone-of-origin

Equations (1a) consist of a set of two equations that predict the demand for two "site types" the "own" site and the aggregate of "all other" substitute sites. Thus, sites are differentiated solely by their characteristics, and no site is a unique other than what is completely accounted for by its characteristics. The system of nonlinear equations was estimated by a seemingly unrelated regressions. There are 9360 observations for each site type, for each of four seasons over two years, nine zones-of-origins, and 130 sites.

Total predicted angler days visited to each ith site are calculated by multiplying trips per angler by site and zone, X_{1ik} in (1), times average observed days per trip at the ith site, times kth zone angler population times a calibration coefficient of 1/2, then summing over zones. It is defined as

$$(2) \quad D_i = \sum_k X_{1ik} \; d_i \; APOP_k,$$

where d_i, observed average days per trip at the ith site and $APOP_k$ kth zone angler population, and

(2a) $(TPOP_k)(f_k) = APOP_k$

where $TPOP_k$ total kth zone population and f_k, fraction of population that are anglers. In the percent implementation of the model APOP is exogenously determined for each year, based on ongoing statewide angler telephone survey data. For future versions of the model we hope to better understand how angler populations change in response to changes in management policy. As currently designed, the model may underestimate the increase in trips, resulting from a change in stocking regulations that enhances fishing and conversely, underestimate the decrease in trips resulting from a deterioration in fishing conditions.

A calibration factor is applied to total predicted angler days from (2) so that it corresponds to observed angler days by site, consistent with New Mexico Game and Fish Card Survey Data. Corrected angler days predicted at the ith site are:

(3) $D^*_i = D_i + \Delta D_i$

where ΔD_i is the residual difference between predicted angler days and days measured by the Card Survey. The residual ΔD_i is partitioned out among each kth zone-of-origin proportional to each zone's D_i.

3. BENEFITS

A central purpose of this model is to allow fisheries managers to assess the angler benefits of making policy changes that would change the vector of site qualities in (1b) from baseline values, $\mathbf{Q}^o$ to new-policy values, $\mathbf{Q}$. Another purpose is to see how the value of those quality changes are conditioned by travel cost when they vary from baseline values $\mathbf{P}^o$ to new values $\mathbf{P}$ or by angler characteristics that vary from $\mathbf{Z}^o$ to $\mathbf{Z}$. This section describes how we compute the benefits associated with changing baseline ($\mathbf{P}^o$, $\mathbf{Q}^o$, $\mathbf{Z}^o$) to new-policy ($\mathbf{P}$, $\mathbf{Q}$, $\mathbf{Z}$).

Angler benefits predict per capita benefits for any time period compared to a baseline year of 1981. Statewide benefits are found by summing over zones. Benefits are only meaningfully defined "with a policy" as opposed to "without the policy." The with and without policy must be defined over the same time and space. Thus to correctly evaluate the relative payoff to anglers of any two fish management policies, PO_1 and PO_2 over the same time and space, the benefits of PO_1, relative to 1981 must be compared to PO_2 also relative to 1981. The year 1981 was selected as a convenient frame of reference and has no special economic significance.

Benefits can be evaluated by either changing the price (**P**), or quality (**Q**) vectors in (1). If neither a price nor a quality is changed by a policy, benefits are by definition zero. No new variables are required to predict benefits once 1981 and new-policy trips are predicted.

Benefits are measured as a compensating variation (CV). The CV is defined as the difference between actual recreational expenditure, M_{ik} in (1h) and the minimum expenditure needed to sustain original utility under new-policy prices and qualities.

For any kth zone and ith site, the recreational fishing expenditure needed to achieve 1981 level utility is computed by inverting the indirect utility function. The indirect utility function achieved by the typical angler under 1981 prices and qualities for the ith site and kth zone is defined by the following second order Taylor approximation to any utility index in prices and unpriced qualities:

$$(4) \qquad \mathbf{U}^{\circ}_{ik} = \boldsymbol{\alpha}^{\circ\prime}_{ik}\, \mathbf{X}^{\circ}(\ )_{ik} + .5\mathbf{X}^{\circ}(\ )_{ik}\boldsymbol{\beta}_{XX}\, \mathbf{X}^{\circ}(\ )_{ik}$$

where $\boldsymbol{\alpha}^{\circ\prime}_{ik}$ is (1b) defined at pre-policy levels of $\mathbf{Q}^{\circ}_i$[2] and $\mathbf{Z}^{\circ}_k$ and where $\mathbf{X}^{\circ}(\ )_{ik}$ (1a) under pre-

[2] Since all substitute site qualities are a weighted sum of own-site qualities, care is taken to avoid double counting benefits from a single quality change. This is accomplished by resetting all substitute site quality demands in $\mathbf{Q}_i^{\circ} = \mathbf{Q}_i$, thus resetting the pre-policy indirect utility function.

policy conditions, $(\mathbf{P}^o, \mathbf{Q}^o, \mathbf{Z}^o)$, i.e. is the system of equilibrium demands for the ith site and its substitute from the kth zone.

The demand system (1) is derived from and consistent with the utility function (4) and the recreational expenditure constraint.

$$(4a) \qquad M_{ik} \quad = \quad \mathbf{P}_{ik}' \mathbf{X}_{ik}.$$

The indirect utility function at 1981 reference levels can be inverted to solve for M_{ik} as function of new policy values of $\mathbf{P}_{ik}$, $\mathbf{Q}_i$, $\mathbf{Z}_k$ and the level of (indirect) utility achieved in 1981, U^o_{ik}. U^o_{ik} is a function of 1981 values of $\mathbf{P}^o_{ik}$, $\mathbf{Q}^o_i$, and $\mathbf{Z}^o_k$.

The expenditure function needed to sustain baseline 1981 utility is solved by inverting the indirect utility function (4). It is :

$$(5) \qquad E_{ik} \, (U^o_{ik}(.); \mathbf{P}_{ik}, \mathbf{Q}_i, \mathbf{Z}_k) \quad = \quad - \frac{b_{ik} + [b^2_{ik} - 4a_{ik}c_{ik}]^{.5}}{2a_{ik}}$$

where

$$(5a) \qquad a_{ik} \quad = \quad .5 \, \mathbf{T}_{2ik}' \, \boldsymbol{\beta}_{XX} \, \mathbf{T}_{2ik}$$

$$(5b) \qquad b_{ik} \quad = \quad .5 \, (\mathbf{T}_{1ik}' \, \boldsymbol{\beta}_{XX} \, \mathbf{T}_{2ik} + \mathbf{T}_{2ik}' \, \boldsymbol{\beta}_{XX} \, \mathbf{T}_{1ik}) + \boldsymbol{\alpha}_{ik}' \, \mathbf{T}_{2ik}$$

$$(5c) \qquad c_{ik} \quad = \quad .5 \, \mathbf{T}_{1ik}' \, \boldsymbol{\beta}_{XX} \, \mathbf{T}_1 + \boldsymbol{\alpha}_{ik}' \, \mathbf{T}_{1ik} - U^o_{ik}$$

where $\boldsymbol{\alpha}_{ik}'$ is the value of (1b) at new policy levels of $\mathbf{Q}_i$ and $\mathbf{Z}_k$, and U^o_{ik} is the pre-policy indirect utility function defined in (4), as a function of $\mathbf{Q}^o_i$, $\mathbf{Z}^o_k$ and $\mathbf{P}^o_{ik}$; and

$$(5d) \qquad \mathbf{T}_{1ik} \quad = \quad \boldsymbol{\beta}_{XX}^{-1} \, \mathbf{P}_{ik} \, (\mathbf{P}_{ik}' \, \boldsymbol{\beta}_{XX}^{-1} \, \mathbf{P}_{ik})^{-1} \, [\mathbf{P}_{ik}' \boldsymbol{\beta}_{XX}^{-1} \, \boldsymbol{\alpha}_{ik}] - \boldsymbol{\beta}_{XX}^{-1} \, \boldsymbol{\alpha}_{ik}$$

$$(5e) \quad T_{2ik} = \beta_{XX}^{-1} P_{ik} (P_{ik}' \beta_{XX}^{-1} P_{ik})^{-1}$$

Per capita benefits from the kth zone associated with any policy change in $\mathbf{P}_{ik}$ or $\mathbf{Q}_i$ relative to 1981 at the ith site or its substitute aggregate can be calculated as:

$$(6) \quad BCAP_{ik} = M_{ik} - E_{ik}(\bullet).$$

where M_{ik} is actual kth zone recreational expenditure at the ith site and its substitutes, $E_{ik}(\bullet)$ is defined in (5). Benefits per capita can be computed for a policy that changes **P**'s and **Q**'s from 1981 levels at any ith site in question and/or the ith site's substitutes.

Total kth zone benefits from the policy change is found by summing over sites as:

$$(7) \quad Bene_k = \sum_i (BCAP_{ik}) (APOP_k)$$

where $APOP_k$ is the estimated population of anglers in the kth zone defined in (2 - 2a). Total statewide benefits from a change in policy from $(\mathbf{P}^o_{ik}, \mathbf{Q}^o_i, \mathbf{Z}^o_k)$ to $(\mathbf{P}_{ik}, \mathbf{Q}_i, \mathbf{Z}_k)$ are found by summing (7) over zones:

$$(8) \quad Bene = \sum_k Bene_k$$

4. CALIBRATION OF DEMAND AND BENEFITS

4.1. Negative Demands

One complication arises when a kth zone's per capita trips to the ith site in question predicted by (1) are negative.[3] In such a case, the benefits of a quality increase or at any ith

[3] Negative predicted trips only occurs at the site in question (site 1). With 131 substitutes included in the composite site (site 2), predicted trips to $X_{2ik} >> 0$.

site predicted by (6) turn out to be negative, i.e., a nonsense result. To stop this from happening the following principle is applied:

If visits fall from positive to negative as a result of reducing a site's quality from 1981 levels, then we lessen the quality reduction so that visits only go zero. Then compute benefit losses based on that lessened quality reduction. Similarly if a quality improvement increases a site's predicted visits from negative to positive, then reset 1981 baseline quality so that predicted visits start at zero before increasing.

To accomplish this, two check flags are set.

Flag #1: For the status quo policy of no change: Flag all zone site combinations (i,k) for which predicted per capita trips from (1), $X_{1ik} < 0$.

Flag #2: For the new (modified) policy: Again flag all zone site combinations (i,k) for which $X_{1ik} < 0$

Three possibilities can occur:

4.1.1 Both Flags Occur

If any zone-site combination (i,k) has both flags, then reset new Q_i back to the original baseline Q°_{i}. This resetting results in the new policy leaving visits and benefits unaffected compared to baseline. The theory behind this adjustment is that anglers gain or lose no benefits for quality changes at a site for which quality is inferior with and without the policy.

4.1.2 Only Flag #1 Occurs

For any (i,k) that has Flag #1 (new Q is better overall, as it increases X_{1ik} from negative to positive), reduce the increase in quality by resetting the baseline quality Q° so that predicted visits ≈ 0. This means resetting Q° up "toward" the new-policy Q until a Q^{mod} is found for which

$X_{1ik} \approx 0$.

First, find a λ_{ik} between 0 and 1, by which we can multiply $X^{o}_{1ik} - X^{m}_{1ik} = \Delta X_{1ik}$ so that $\lambda_{ik}\Delta X_{1ik}$ when subtracted from new visits leaves "modified original" visits at the ith site in question at approximately zero. Thus, if original predicted trips per capita from (1) were -1.0 and new policy visits are 3.0, then $\lambda = 3.0 / (3.0 + 1.0) = 3/4$. In general the formula is

$$(9) \qquad \lambda_{ik} = \frac{X^{m}_{1ik}}{|X^{o}_{1ik}| + X^{m}_{1ik}}$$

Second, use the above λ_{ik} to shrink the $\Delta \mathbf{Q}_i$ from its actual change to a modified change $= \lambda_{ik} \Delta \mathbf{Q}_i$. This shrinkage factor is applied to each jth dimension of the vector $\mathbf{Q}_i$ changed by the policy. This requires finding the "length" of each element ΔQ_{ij} for each jth dimension of the quality vector. After all the ΔQ_{ij}'s are computed, reset the original baseline quality from its actual level Q^{o}_{ij} to the modified

$$(10) \qquad Q^{r}_{ij} = Q_{ij} - \lambda_{ik}\Delta Q_{ij}$$

where "r" is a "reset" superscript. Do this over each dimension (j) of quality that the policy changed. For each dimension of the quality vector that did not change, i.e., for which $\Delta Q_{ij} = 0$, then that dimension is left alone. Some dimensions of quality may increase (e.g. more fish) while others may go down (e.g. less water). In any case, shrink the size of all quality changes (positive or negative) by using the above λ_{ik} formula.

The theory behind this follows: Anglers never actually visit any site at negative levels. But they may perceive a site's quality as being so poor that they wouldn't consider visiting it until quality improved considerably. So they are not willing to pay anything for (derive benefits from) further quality improvements until quality is at a sufficiently high threshold level. Thus we only compute benefits from quality improvements once quality crosses the threshold of bringing visitors to the site.

4.1.3 Only Flag #2 Occurs

For any zone site combination (i,k) that has only Flag #2, new policy quality is worse overall. Where this occurs X_{1ik} is reduced from positive to negative, and we lessen the quality reduction. This means "pulling" new $\mathbf{Q}$ back toward the original baseline $\mathbf{Q}^o$ until finding a $\mathbf{Q}^{mod}$ for which $X_{1ik} \approx 0$.

The math follows:

First, look for a λ_{ik} between 0 and 1. The intent is to multiply the λ_{ik} by ΔX_{1ik} with the purpose of reducing ΔX_{1ik} to a lesser amount $\lambda \Delta X_{1ik}$. This lesser change leaves new visits at approximately zero. Thus if original visits were 2.2 and new policy visits are - 1.1, then $\lambda = 2.2/(2.2 + 1.1) = 2/3$. The general formula is

$$(11) \qquad \lambda_{ik} = \frac{X^o_{1ik}}{X^o_{1ik} + |X^m_{1ik}|}$$

Second, use the above λ_{ik} to shrink the $\Delta \mathbf{Q}_i$ from its actual change

$$(12) \qquad \Delta \mathbf{Q}_i = \mathbf{Q}_i - \mathbf{Q}^o_i$$

to a reduced change $= \lambda_{ik}\Delta \mathbf{Q}_i$. This shrinkage factor is applied to all dimensions of the quality vector $\mathbf{Q}_i$ which changed due to the policy. This method requires finding the "length" of each element $\Delta\, Q^o_{ij}$ for each jth dimension of the quality vector. After all the $\Delta\, Q_{ij}$'s are computed, reset the modified quality from $\mathbf{Q}_i$ to $\mathbf{Q}^{mod}_i = \mathbf{Q}^o_i + \lambda_{ik}\Delta \mathbf{Q}_i$ over all dimensions (j) of quality that the policy changed. For any dimensions of Q_{ij} that did not change, i.e. for which $\Delta Q_{ij} = 0$, then that dimension is left alone. For example, if only volume and fish catch are changed by the policy, rest only those two dimensions of Q_i. Note that some dimensions of quality may go up (e.g. more fish), which others may go down (e.g. less water), the net effect still showing visits falling to negative. If this occurs, the rule above is still followed, i.e. shrink the size of all quality changes (positive or negative) toward zero. This method for resetting quality results in predicted visits going to approximately zero under reset modified quality.

Third, after going through these steps to reset quality, visits from a zone to each site and benefits accruing to a zone from all sites can be computed. For the new policy level of quality, use the reset value of the quality vector:

$$(13) \qquad Q^{mod}{}_i = Q^o{}_i + \lambda_{ik} \Delta Q_i$$

Benefits from the quality change are then recomputed using $Q^{mod}{}_i$ in place of Q_i in equations (1) - (8).

This procedure assures that quality changes will only be valued when quality is in the relevant range of consumption of related quantities. The relevant range of consumption is that range for which the vector of site qualities are weakly-complementary to quantities. This means that quality changes at a site only have value to the angler when that site's demand exceeds zero.

4.2 Positive Demand When Critical Site Quality Variables are Zero

When the quality of a fishing site is so poor that nobody fishes there, visitation will fall to zero. Especially for (1) site access, (2) acreage of water, (3) average fish size and (4) fish catch per hour, one can be fairly certain that visitation will fall to zero if any of these variables go to zero.

Unfortunately, the functional form for the demand system (1) does not guarantee that angler trips will be exactly zero when any of these variables equal zero. To accomplish this one additional flag is set, one without and one with the policy.

Flag #3: For both the status quo and modified policy. Flag all zone-site combinations (i,k) for which $\mathbf{X}_{ik} > 0$ when any of the critical site quality variables equal zero. This flag is typed for both the ith site in question X_{1ik} and its substitute X_{2ik}.

For any (i,k) that trips Flag #3 (positive predicted trips when common sense says they should be zero), we insert an augmented demand function that applies when quality lies in the range between the threshold level and zero.

The first step in computing the augmented demand function is to find a shrink factor $\boldsymbol{\delta}_{im} = [\delta_{1im}, \delta_{2im}]'$ between 0 and 1, for each ith site and its composite substitute and mth dimension of site quality that could by itself completely close down visitation. Each dimension of quality that lies below the known threshold level, Q^r_{im}, combines to interactively reduce the predicted demand from (1) by producing the following augmented demand:

$$(14) \quad \mathbf{X}^*_{ik} = \mathbf{X}_{ik}(\cdot) \quad \times \quad \prod_m \boldsymbol{\delta}_{im}$$

where $\mathbf{X}_{ik}(\cdot)$ is demand predicted by (1); and × indicates that each element in $\mathbf{X}_{ik}(\cdot)$ is multiplied by corresponding elements in the vector $\boldsymbol{\delta}_{im}$. The first element of $\boldsymbol{\delta}_{im}$

$$(15) \quad \delta_{1im} = \frac{Q_{im}}{Q^r_{im}}$$

where Q_{im} is the actual value of the mth critical quality variable at the ith site, and Q^r_{im} is its fixed threshold values. A similar computation is done for both δ_{1im} and δ_{2im}, so "own site" and substitute site visits will always equal zero when quantity is sufficiently poor at either type of site.

The effect of (14) - (15) is to reduce each ith site's demand and its substitute to zero for each kth zone whenever any mth quality attribute among the set of critical quality variables at the site (substitute) is zero. If several quality attributes in the m index are less than their threshold levels but greater than zero, then demand is shrunk in proportion to the product of the ratios of actual to threshold qualities.

5. CONCLUSIONS

Probably the most important feature of this economics model in particular and RIOFISH in general is the ability it offers to managers to replace past management indices with improved economic performance measures of potential decisions. For example, agencies typically use a numerical catch rate as an index of fishery performance and often aim to maintain a target catch rate (e.g., 0.5 fish per hour). This is done despite the fact that angler benefits per fish caught typically vary greatly depending on the distance traveled, fish size, species distributions, availability and cost of substitute fishing opportunities, and other factors. By contrast, for each management decision tested, RIOFISH provides an estimate of additional benefits accruing to the angler, that can be contrasted with the management and other cost incurred.

We see several advantages of our two-site generic demand/benefits model. First the same demand model is applied to all sites (132 in the present model). Each site is one observation on a unique bundle of price and quality characteristics. Next, as is the case with the real world, the model accounts for a unique incremental benefit from a policy change for every site, site characteristic, and time period. That is, the benefits from a policy change at any site depend on conditions at both that site and all substitutes. Additionally, despite the high level of aggregation, the model is essentially consistent with utility theory and an angler budget constraint, thus accounting for complex substitutions across a changing opportunity set. Furthermore, our empirical recovery of the expenditure function permits us to estimate the theoretically correct Hicksian compensating variation welfare measure, thus bypassing completely the Marshallian surplus welfare approximations.

Additionally, the flexible form utility index parameters test for substitutions between qualities and quantities, with relatively little possibly wrong structure forced on the utility function. Furthermore, the model is completely general, and as such is expandable to any arbitrary number of sites and geographical frame of reference. Finally, qualities and prices at all relevant sites can be incorporated into the model.

The model is not without its limitations. First, all sites are assumed inherently equal, differing only by their bundle of site characteristics. Second, a more serious theoretical objection imposed by the nature of the aggregation is that the same substitution structure between quantities of trips at any it site and its composite substitute site is imposed on the angler's preference ordering. Third, because the modeled utility function is a Taylor series approximation to the true underlying preferences, the accuracy of the compensating variation welfare measure is reduced as hypothetical policies move the angler farther away from baseline observed data. Finally, the nonlinearizable inflexible demand system and assumption of separability of recreational expenditure from that of other goods present problems for which solutions are not currently well-understood.

In summary, we see the comparative advantage of the model described in this paper as lying where the resource managing agency manages several geographically separated sites in which sites and unpriced site attributes are strong substitutes or complements in the preference ordering of resource users.

REFERENCES

Cole, R. A., Timothy Ward, Frank Ward, Robert Deitner, Susan Bolton, Katherine Green-Hammond, "RIOFISH, a Fishery Management Planning Model for New Mexico Reservoirs," New Mexico Water Resources Research Institute Report No. 253, December 1990.

Cole, R. A., F. A. Ward, T. J. Ward, and R. M. Wilson, "Development of an Interdisciplinary Planning Model for Water and Fishery Management," Water Resources Bulletin, August 1990, Vol. 26, No. 4, pp. 597-609.

The SAGE Method in Endangered Species Management: Constructing Proxy Utility Functions to Measure Relative Values

Renatte K. Hageman, Department of Economics, San Diego State University
V. Maureen Witkowski, National Marine Sanctuaries and Reserves, NOAA, U.S. Dept. of Commerce, Washington, D.C.

1. INTRODUCTION

Nation-wide interest in species preservation sparked passage of the Endangered Species Conservation Act in 1969; in the same year, the National Environmental Policy Act established mandates for preparing environmental impact statements for federal programs that entail significant impacts on the human environment. Though clearly the intent of these mandates is to increase national responsibility for the public's concerns and perceived impacts associated with environmental degradation, and the loss of habitat and species diversity which can result, measurement of socio-economic impacts has "often been perceived to be a procedural burden rather than an opportunity to improve decision making."

In a recent comprehensive survey and comparison of assessment methodologies which have been applied throughout the 70's and 80's, Hyman and Stiftel (1988) make the following observation:

> The principal reason for this disappointing experience is the failure to integrate facts and values in a framework that can assist in making tradeoffs among multiple objectives. A considerable amount of information is available on determining the physical, chemical and biological effects of human actions. Yet, most major public policy issues are transcientific; they cannot be resolved simply by weighing objective evidence without considering *subjective values* (emphasis added).

The analysis which follows provides a description of a socio-economic impact analysis of an endangered species protection program proposed for the Seal Beach National Wildlife Refuge in Orange County, California. Requested by the U.S. Fish and Wildlife Service and the U.S. Department of the Navy, the study was a court-ordered response to a lawsuit by an animal rights group on behalf of the fox population charging that public resources were not being managed appropriately under the current management program.

The difficult issue for this analysis was the problematic necessity of completely eliminating a non-native, non-endangered predator (the red fox) from the Refuge in order to assure the continued viability of two endangered species of birds. Because the wildlife organization was suing for protection of the red fox, the impact analysis required some comparison of the relative values that society holds for methods of protecting the various species in this wetlands ecosystem. In this vein, the section which follows presents a discussion of valuation techniques and examples of other wildlife management problems.

The multi-objectives inherent in the Seal Beach Wildlife Refuge management problem led us to employ a relatively new technique for measurement of societal relative values -- the SAGE Method (Hyman and Stiftel 1988). This study is the first field test of the methodology. The survey instrument is discussed in Section 3. Study setting and sample populations are outlined in Section 4. Section 5 provides results and analysis using the SAGE Method; concluding remarks on SAGE are offered in the final section.

2. PREVIOUS METHODS AND WILDLIFE MANAGEMENT PROGRAMS

Traditionally, many environmental assessment analyses of non-commercial socio-economic impacts have relied upon expert opinion. As a result, program managers and planners can be taken by surprise when unexpected public impacts come to light. For example, in 1984 the U.S. Marine Mammals Commission issued permits for the live capture of 100 killer whales off the coast of Alaska. The non-endangered species is abundant and successful in its habitat, and the captured animals were to be taken to popular aquaria exhibits throughout the country. However, the resulting public outcry in Alaska protesting the capture program resulted in a petitioning by the State government of Alaska for a moratorium on the taking of killer whales. Caught off-guard, officials yielded to the strong and persistent protest, and the moratorium remains in effect.

The seemingly straightforward methods of predator removal by trapping, hunting, and poisoning raises environmental and ethical issues, namely, nest destruction by non-target predators, immigration of exploited predator population, avoidance behaviors of predators, losses of non-target species, ethics of predator destruction and non-consumptive values of predators.

There is growing protectionist opposition to culling animals for any reason. One such case is the black tailed deer on Angel Island in San Francisco (White,1981) No natural predator of the deer exists in the park and hunting is not allowed. Periodic peaks of deer overpopulation in the park would ultimately result in starving deer, vegetation destruction and soil erosion. November 1966 was a time of deer overpopulation on the island. Park officials gave public notice and then shot 50 animals in an effort to control the number of deer on the island. Public protest prevented any further shooting of deer that year and the animals were allowed to die "naturally" through starvation and disease. Again in 1975 a die-off of the deer due to starvation occurred. That year the Department of Parks and Recreation permitted the San Francisco Society for the Prevention of Cruelty to Animals (SPCA) to operate a supplemental feeding program for the starving deer. It is unclear whether or not this was a successful program. However, the deer population on the island did not explode again until 1980.

At that time a wildlife management expert proposed the introduction of a predator, coyotes, to control the deer population. During the course of public hearings it became very evident that this idea had strong opposition. The plan was supported by a few environmentalists but was firmly opposed by the animal protection organizations. It is interesting to note that public response at the hearings indicated that the majority of the public would prefer other solutions such as birth control or moving excess animals but would not object to a shooting program if no other practical alternative could be found.

However, before the California Department of Fish and Game (DFG) could take into account the public response at the hearings in formulating any management programs for the island, the SPCA filed a lawsuit in an effort to force the state to capture and relocate all the deer on the island. The SPCA offered to pay all costs incurred in the capture and relocation project. The DFG agreed to allow the relocation of the deer if two conditions were met. First, all the deer to be moved must have their health screened and blood samples taken to prove that the animals were free of any disease. This was to prevent the transmission of disease from the deer to livestock or other wild animals. Second, an acceptable transfer site had to identified. The site had to be within the State of California and have the same subspecies of deer which was being relocated. If any landowner within one mile of the release site objected or if a qualified wildlife biologist determined the site to be near or at its deer carrying capacity, the site was not considered suitable. The relocation project also included a one-year follow-up study to be funded by the SPCA to track the relocated animals.

A follow-up study which examined the survival rate of the relocated deer from Angel Island concluded that "the low survival rate of the deer during the first year following the release make it difficult to justify relocation on the grounds that it is indeed humane, as claimed by protectionists. Furthermore, removing large ungulates is expensive. Direct cost of moving the Angel Island deer was $87,568 or $431/animal at the time of relocation, or $2,876/deer surviving for one year after release (assuming the survival rate of the radio-collared sample is representative of the relocated population.)" (O'Bryan 1985)

Whenever humans have introduced a new species into a habitat, altered the predator-prey relationship, or significantly reduced habitats there have always been some environmental repercussions. These repercussions have intensified in recent years with the accelerated loss of native habitat, especially in California. As of 1987, fifteen native vertebrates, more than 18 native invertebrates (that are known) and 25 - 30 native plant species are extinct in California. The three major causes of extinction of these species are: (1) habitat destruction or degradation, (2) direct persecution and (3) introduction of non-native species (Miner, 1989). Due to rapid habitat loss of salt marshes in southern California, the natural predator-prey balance has been upset and all predators pose a threat to endangered species. Introduction of yet another predator, such as a non-native one, could be enough to put the prey species over the edge of extinction. How the public perceives this predicament of predator and feral animal invasion and habitat loss will, to some extent, shape the choice of resource management enhancement policies.

A variety of techniques have been developed to address the need for assessment of socio-economic impacts when human activities alter wildlife habitats and animal populations are affected. If commercial losses are involved, such as fish kills due to an oil spill in a commercial fishery, then direct dollar losses can be measured as an estimate of economic impacts. However, when non-commercial impacts occur, such as the loss of public recreation value in a sportfishery, indirect estimation methods must be employed. The most widely used technique for measurement of socio-economic impacts when recreation values are affected is known as hedonic analysis. Used to indirectly estimate the "social value" of wildlife resources such as sportfisheries and game animals (see, for example, Miller and Hay 1984), this method applies statistical techniques to data on the public's travel expenditures to recreation resources (see Loomis et al 1984).

Travel cost studies become problematic if little or no travel is involved in using a wildlife resource. However, assessment methodologies which rely on market prices to estimate socio-economic values are especially inapplicable if the wildlife resource is not actually used by the public; i.e., in many cases of wildlife loss, the public may value an animal species without actually deriving recreation value from its existence. In fact, some people may attach socio-economic value to a species simply because of a desire for species diversity (see Fisher and Hanemann 1984) or integrity in the food chain, rather than a desire to observe the species in the wild (see Brookshire et al 1982).

The method which has been used to address the need for socio-economic impact assessment when use values are not relevant measures is known as contingent valuation (see Cummings et al 1986). This technique relies on personal interviews with the affected human population wherein respondents' answers are used to estimate their valuation of specific environmental services (see Davis 1963), such as a wildlife protection program. The first attempt to apply this technique in an analysis of endangered species preservation looked at the social value of a Texas reserve when whooping cranes were present (Stoll and Johnson 1984). Other studies have identified social values associated with species preservation, but the difficulty of specifying a value for just one animal species in light of the many others which are found in any ecosystem (see Hageman 1985) has led researchers to look at the combined impacts of a particular program rather than one isolated effect on one particular species.

The need to integrate the technical views of experts in an environmental program with the public's perceptions of impacts led to the development of the SAGE Method (Hyman and Stiftel 1988). It relies on a variety of experiences in environmental assessment in water resources (U.S. Water Resources Council), land-use planning, and habitat evaluation (U.S. Fish and Wildlife Service). Its formulation is constructed to incorporate expert knowledge on factual information about possible effects on society of alternative programs under consideration into a survey format which can then be evaluated by public interviewees. Its advantage lies in its ability to allow the public to specify perceived impacts associated with multi-objective programs.

It is clear that public perceptions and input are making more and more of an impact on wildlife management. Public response has swung from managing the wildlife resource for the full potential of human use to fully protecting all species equally. The public's responses and decisions sometimes come as a surprise to the policy makers who do not fully understand the components which influence public perception and reactions. Even when managers and the public share the same attitudes, the public response may not always be what was expected. Resource managers need to better understand public perceptions, to employ methods which explore their biases, and educate the citizens utilizing the resource in question.

Educating the public about environmental issues has historically been the responsibility of the natural resource agencies. Traditionally, natural resource agencies have given higher priority to wildlife and fisheries management and law enforcement programs than to their education departments. It has been questioned whether this order of priorities, today, provides the agency with the ability to address the expectations of a growing urban, non-hunting public (Adams, et al., 1988).

The past twenty years in the United States have seen an increased environmental concern among this growing urban population. Rallying behind special interest groups, portions of this population are vocalizing their concerns and perceptions frequently questioning traditional management approaches for natural resources. This public participation has brought about some dramatic and broadly sweeping changes in policies. However, sometimes the special interest groups are singular in cause and may lose sight of the overall impact on the environment. For example, researchers have noted humans' tendency to anthropomorphize animals and interfere with species' natural roles in the environment; Blumenthal (1989) provides a particularly vivid account of such an incident involving endangered sea turtles on the Galapogos Islands. Members of an American tour group spotted a newly hatched sea turtle emerging onto the beach before sunset and rescued it from an avian predator. Given a false signal of safety, a large number of hatchling turtles followed from the nest too early and headed towards the sea, only to be engulfed by the awaiting birds still feeding during the daylight hours. The group watched in horror as all the young turtles were eaten, realizing that their well-meaning intention to save one turtle led to the demise of an entire nest of an endangered species.

In a recent example in California, increased publicity about the decreasing numbers of Desert Tortoise has prompted some Desert Tortoise pet owners to return their pets to the desert. The pets near the coast carry a respiratory disease which has now been introduced into the wild population in the desert and is taking its toll on the already endangered native population.

Public awareness is not necessarily a negative component of environmental issues. Increased awareness and changed perceptions played an important role in the enactment of much of the environmental legislation in the early 70's, including such mandates as the National Environmental Protection Act , Clean Air and Clean Water Acts, the Marine Mammals Protection Act, and the Wild And Free-Roaming Horse and Burro Act. The last pertains specifically to public response to removal of animals from Federal lands.

Prior to 1971, wild horses and burros were removed from federal lands throughout the United States, as they were perceived as nuisances. It is believed that the horses and burros had once belonged to early Spanish explorers, settlers, miners or the U.S. Calvary. In essence the animals were viewed as a non-native species overrunning federal lands. Most of the animals were captured by the Bureau of Land Management and sold for commercial products, or simply destroyed. Public awareness of these practices prompted passage of federal legislation to protect these "living symbols of the West." Under the protection of the Wild Free-Roaming Horse and Burro Act the excess horses and burros on federal lands are now removed and set up for adoption through the nationwide Adopt-A Horse (or Burro) Program which was established in 1976. Old, lame or sick animals are destroyed humanely, and excess animals for which there is no adoption demand may also be humanely destroyed (Bureau of Land Management, 1984). Federal funding for the wild horse and burro program increased the first ten years of the program. In the early 80's, this funding trend reversed, as with most Federal programs at that time. This was an attempt to recoup a greater portion of the operating costs from the public benefiting from the program, in this case the adopters. Costs include preparation of removal plans and environmental impact assessments, plus the cost of animal collection and transport to a holding facility. Adoption costs, which are partly offset by the adoption fees, include medical treatment, brand inspection, feeding and handling, public affairs and transportation. Approximately 15% of the removal and adoption costs were recovered through adoption fees.

Currently, there is a moratorium on destroying excess healthy horses and burros for which there is no adoption demand. Additionally, increased adoption fees were partially responsible for a reduction in adoptions. These factors have resulted in the animals spending longer periods of time in holding facilities, resulting in high feed and handling costs. In general, this is an animal removal program which satisfies both the management needs of the natural resource planners and the emotional response of the public,as well as covering some of the operating costs of the project. The future of this program will be interesting to monitor if the adoption rate continues to decline. At that time alternatives will need to be investigated if the needs of all parties involved will continue to be balanced.

Understanding what motivates public perceptions and actions is becoming increasingly important in assessing public response and predicting the success of resource management programs. Failure of the policymakers and resource managers to foresee public reaction can result in expensive delays, bad press and lengthy court battles. To better incorporate public reaction into specific environmental decisions public beliefs, values and attitudes must first be measured (Vining and Schroeder, 1989). Once the views of the resource managers, special interest groups, and the general public have been identified, a successful management program must find a way to mesh these ideas together without losing sight of the resource.

One way to identify views, beliefs and perceptions of the population is to conduct direct surveys of a sample of the population. In the discussion which follows, there is an underlying focus on incorporating expert information into the survey as a means of educating the public while eliciting public opinion. The SAGE Method is employed to identify socio-economic impacts perceived by potentially affected individuals. Factual information on both the monetary cost to the region as well as environmental quality changes associated with program alternatives will be used to elicit public responses wherein social values are implicit. Both positive and negative impacts can be delineated as a means of determining how closely (or divergently) the public's view of socio-economic impacts compare with the perceptions of program managers and policymakers.

3. The SAGE Method: Survey Design

A. Expert Team Survey. In order to provide the public with expert evaluations of program alternatives, a survey of fourteen experts on the SBN Wildlife Refuge was conducted to ascertain the environmental quality goals of the Endangered Species Protection Program at the Seal Beach National Wildlife Refuge.The respondents were all biologists, wildlife mangers, or federal program managers working in the study area. A copy of the expert team survey is provided in Appendix A. The survey asks the experts to compare and rank ten program outcomes associated with the alternatives in terms of their importance in achieving environmental quality goals at the Refuge. This survey relies on pair-wise ranking, which can then be summed over the grid (chosen alternatives are assigned one point each time they are selected). Pair-wise comparisons are used throughout the SAGE methodology because this exercise better allows individuals to make their assessments, as opposed to the confusion which results when individuals are asked to express their evaluations by comparing a list of all possible choices at once. As in Hyman and Stiftel (1988), the pair-wise rankings are then used to calculate weights for each of the program alternatives in terms of their relative success at achieving these environmental quality goals.

After the experts' survey results on the program's environmental quality goals were completed, we applied the weights to each of five program alternatives which address some of these environmental quality goals. The five policies are:

(1) No action taken;
(2) Red foxes captured and humanely euthanized;
(3) Red foxes captured using only non-lethal means and held in captivity in zoos or other long term holding facilities ;
(4) Erect a specialized fence around the Refuge and periodically remove foxes which are found inside.
(5) Ecosystem restoration. Coyotes and natural vegetation are reintroduced to the Refuge. Coyotes would serve as a natural control of the fox population; this would be an effort to create a self-maintaining

ecosystem by restoring a mixed native habitat and a natural balance in the food chain.

However, it is important to note that the statistical analysis of the data (in Section 5 to follow) requires at least 5 alternatives since three objectives (goals) are being considered. This is a mathematical requirement for solving a linear model with three variables using the SAGE method to obtain value weights. However, only four policy alternatives are relevant for this EIS report. Therefore, a fifth "artificial" alternative, the construction of a fence around the Refuge, has been introduced. For the purposes of this report, it is important to emphasize that this alternative was introduced for statistical completeness rather than its true viability as a program choice. As a single control measure, construction of a fence around the entire refuge is not only prohibitively expensive, but it is an unworkable single solution because of the presence of waterways affected by tidal action and roads at the site. However, the use of barriers on a small scale can be effective if used in concert with other management methods.

For purposes of ordering the environmental quality goals achieved by these five programs, the results of the expert survey follow. Weights are shown on a scale of 0 - 1 in order of greatest attainment of environmental quality goals to least attainment:

Ecosystem Restoration =	.765
Capture and Euthanize =	.637
Capture and Cage =	.528
Fence =	.419
No Action =	.155

These values were used to show respondents to the public survey how each of the five programs compared in terms of achieving environmental quality goals. Programs with weighted values below the average of the five were rated "low", at the average were "medium", and above the average were rated "high.". These same values are also used as input (the ENVQ independent variable) to the regression analysis in Section 5 where public perceptions are analyzed with respect to achieving environmental quality goals.

<u>B. Public Survey Instrument.</u> The measurement instrument was constructed to determine socio-economic impacts perceived by southern Californians. The findings of Dillman (1978) on the efficient and unbiased application of survey techniques were followed closely during all phases of construction and administration of the survey instrument. A copy of the complete survey is provided in Appendix B. A short description of the Endangered Species Protection Program Study was provided to all respondents.

The Study description was limited to factual statements about species relationships in the coastal wetland environment. The location and size of the National Wildlife Refuge in Seal Beach were specified. Respondents were informed about the mandates of the National Endangered Species Act, and they were told that their opinions/perceptions of policy options which could be chosen to meet the Act's mandates would be made available to government planning agencies. Introductory text reads as follows:

> "Hello, I am a student researcher at San Diego State University. We are studying coastal wetland species management. We are looking at policies which try to protect endangered species at the 1000 acre National Wildlife Refuge in Seal Beach, Orange County. This information will be available to help local and federal agencies make future Wildlife Refuge plans.
>
> There are many plant and animal species in Southern California's coastal wetland habitats. Sometimes different species directly compete with each other for the use of these remaining wetlands.
>
> Recently, at the Seal Beach National Wildlife Refuge there have been excessive reductions in endangered birds' fledglings and eggs. There is strong evidence of predation by red foxes, a non-native, non-endangered species which was accidentally introduced by humans to the Orange County area. At one time, the fox population was controlled by the presence of another predator, the native coyote. But coyotes have been removed from the Refuge and the fox population has grown very rapidly.
>
> The National Endangered Species Act requires the Federal government to protect the endangered birds; by federal law this mandate must be met. Possible solutions include the removal of non-native red foxes, or re-introduction of native coyotes which act as a population control on red foxes and other small animals."

Next, three policy goals were described as follows:

> "We would like your opinion on possible management alternatives. When reviewing the alternatives, consider three goals of this type of federal program:
>
> (1) A National Goal of meeting legislative requirements to protect the endangered birds under the Endangered Species Act;
>
> (2) A Regional Goal of economic responsibility in spending public funds;
>
> (3) An Environmental Quality Goal based on society's preferences."

C. Eliciting Value Weights Using the SAGE Method. Those individuals surveyed on-site were then shown five cards. Each card represented one of five alternative policies. Copies of the five cards follow. Each is labeled with a letter randomly selected so as not to bias the respondent's ranking of alternatives, but to provide surveyors with a simple code for recording information about opinions provided by respondents for each alternative. The five policies are:

(1) No action taken (labeled P);
(2) Red foxes captured and humanely put to sleep (labeled M);
(3) Red foxes captured using only non-lethal means and held in captivity in zoos or other long term holding facilities (labeled G);
(4) Erect a specialized fence around the Refuge and periodically remove foxes which are found inside (labeled S);
(5) Ecosystem restoration. Coyotes and natural vegetation are reintroduced to the Refuge. Coyotes would serve as a natural control of the fox population; this would be an effort to create a self-maintaining ecosystem by restoring a mixed native habitat and a natural balance in the food chain. (labeled Y);

The SAGE method of eliciting socio-economic values utilizes a technique known as the Q-sort technique (Pitt and Zube 1979). The cards are used to facilitate easier pair-wise comparisons than would be possible for respondents asked to consider a lengthy list of alternatives on a questionnaire. The construction of information on the cards follows the SAGE method of environmental impact assessment . The text and format for the five cards are shown in the following pages:

Alternative P:
No action taken

National Legislative Goal: The mandates of the Endangered Species Act will not be met because the non-native red foxes will eradicate many endangered birds and their eggs.

Regional Economic Impact: There is no added program cost.

Environmental Quality Impact: Endangered birds and their eggs will have very little chance of survival. Non-native red foxes will be the dominant predator in the ecosystem, preying upon endangered and non-endangered birds and small animals. Native predators may not be able to compete. Residents of local neighborhoods will sometimes see wild red foxes.

National Legislative Goal	Regional Economic Impact	Environmental Quality Goals
not met	zero	low

Alternative M:
Red Foxes captured and humanely put to sleep.

National Legislative Goal: The Endangered Species Act will be met because the non-native red foxes will be removed and many endangered birds and their eggs will survive.

Regional Economic Impact: Program cost is $8,000.00 per year for 10 years. This is less than 1% of the Federal government's budget for Wildlife Refuges in Southern California.

Environmental Quality Goals: Endangered birds and their eggs will have a much better chance of survival. Non-native red foxes will no longer be the dominant predator in this ecosystem. Native predators (such as hawks, owls and skunks) will utilize the area. Residents of local neighborhoods may see fewer free-roaming red foxes.

National Legislative Goal	Regional Economic Impact	Environmental Quality Goals
high	low	high

Alternative G:

Red foxes captured using only non-lethal means and held in captivity in zoos or other long term holding facilities.

National Legislative Goal: We do not know if the Endangered Species Act will be met. Some non-native red foxes will be removed and some endangered birds and their eggs may survive.

Regional Economic Impact: Program cost is $36,000.00 per year for 10 years. This is 3% of the Federal government's budget for Wildlife Refuges in Southern California.

Environmental Quality Goals: Endangered birds and their eggs may have a somewhat better chance of survival. Some non-native red foxes will be removed from this ecosystem, but some red foxes will also escape capture. Residents of local neighborhoods may see fewer free-roaming red foxes.

National Legislative Goal	Regional Economic Impact	Environmental Quality Goals
medium	medium	medium

Alternative S:

Erect a specialized fox-proof fence around the Refuge and periodically remove foxes which are found inside.

National Legislative Goal: The Endangered Species Act may or may not be met because some non-native red foxes will find their way inside the fence to destroy many endangered birds and their eggs.

Regional Economic Goal: Program cost is $163,000.00 per year for 10 years. This is 13% of the Federal government's budget for Wildlife Refuges in Southern California.

Environmental Quality Goals: Endangered birds and their eggs will have a much lesser chance of survival than if all red foxes were removed. Some non-native red foxes may still enter this ecosystem. Native predators (such as hawks, owls and skunks) may or may not utilize the area. Residents of the local neighborhoods will have a greater chance of seeing free-roaming red foxes, and increased number of foxes kept outside the fence could create a potential hazard to public safety.

National Legislative Goal	Regional Economic Impact	Environmental Quality Goals
medium	high	medium

Alternative Y:

Ecosystem restoration. Coyotes and natural vegetation are reintroduced to the Refuge. Coyotes would serve as natural predators' of foxes and small animals, though they would also eat native plants. This would be an effort to create a self-maintaining ecosystem by restoring a mixed native habitat and a natural balance in the food chain.

National Legislative Goal: The Endangered Species Act will be met because the non-native red foxes will be controlled and many endangered birds and their eggs will survive.

Regional Economic Impact: Annual program cost is $25,000 per year for 10 years. This is 2% of the Federal government's budget for Wildlife Refuges in Southern California.

Environmental Quality Goals: Endangered birds and their eggs will have a much greater chance of survival. Non-native red foxes will no longer be the dominant predator in this ecosystem. Native predators (such as hawks, owls, skunks and coyotes) will utilize the area. Residents of local neighborhoods may see free-roaming coyotes and red foxes, but to a lesser extent.

National Legislative Goal	Regional Economic Impact	Environmental Quality Goals
high	medium	high

Each card summarizes the management strategies for one policy, and the annual cost for the specific policy is stated in current dollars and also as a percentage of the U.S. Fish and Wildlife Service's annual operating budget for National Wildlife Refuges in southern California. Each card also includes a description of the environmental consequences of the policy option in terms of protecting endangered birds in the study area as well as impacts on other species. Information on the relative effectiveness and consequences of the policy alternative shown on the card is also summarized along the card's lower margin for each of the three goals stated at the outset.

The summary information on the three program impacts -- the National Legislative Goal, the Regional Economic Impact, and the Environmental Quality Goal -- is based upon a comparison of the five alternatives. First, the program alternatives' likelihood of meeting the National Legislative Goal can be compared on a low-to-high ordinal scale depending upon how well each policy meets the mandates of the Environmental Protection Act. Thus, "No Action" is ranked lowest, since the Act 's mandates would not be met. On the other hand, the"Capture/Put to Sleep" policy is ranked high, with the other three alternatives ordered in between.

The third policy consequence, Environmental Quality effects, is based upon summary information gathered from members of the EIS team of experts. (The procedure is described above in Section A). Of the five policies, alternatives which have scaling factors below the average are rated on the cards as "low" in achieving environmental quality goals, and those alternatives above the average are rated as "high". The alternatives which have scaling factors at the average are shown to be "medium" on the ordinal scale of attaining environmental quality goals.

Regional Economic Impact is compared on the cards based on an absolute value scale, where the average of the program costs is ranked "medium", and those alternatives with costs below the average are rated "low"; above the average were ranked "high." Ten-year program costs for the capture/put to sleep alternative are estimated at $8,000/year by U.S. Fish and Wildlife Service officials, which is low compared to other alternatives. This assumes that 10-14 red foxes are captured within the Refuge annually. The Service cost estimate for fence construction and maintenance, annualized over ten years, is $162,800/year, which is orders of magnitude higher than any other alternative. In the medium cost range, Service experts project the cost of ecosystem restoration to be about $25,000 annually. The capture/cage alternative will cost the Service about $13,000/year for live capture; however, the holding, feeding, and veterinarian care for an average of 12 animals over a six-month quarantine period will cost $10/animal/day, plus $35/animal for transport cages and $100/animal for air transport -- which results in a total program cost of $36,220/year for the capture/cage alternative. (Re-release within the State would be prohibited by the State Department of Fish and Game on the grounds that introduction of a non-native species is ecologically unsound. Therefore, the transport costs assume animals would be transported by air from LAX to St. Louis; trucking firms will not assume responsibility for the care required in transporting the live animals on trips of this length. Note that most states will not agree to re-release, so costs would be even higher if the foxes survive and must be fed and cared for in cages for the duration of their lifespans.)

Respondents in the field study were given the five cards arranged in a different random order for each person. While looking at brief summaries of the alternative program costs, as well as national legislative and environmental quality results shown on each card, respondents were then given the following verbal instructions:

> "If the federal government is considering these five alternative plans to attempt to best meet all of these goals, please take a moment to look at how well these goals are met on the cards you have been given. Please put the five cards in order of your preference, with the most preferred on top, down to least preferred alternative on the bottom.
>
> Now please look at the scale shown and point to the number (from 0-100) you would assign to each of the five alternatives if the number represents ranking of that alternative compared to the others. This is like a "score" or "grade" you give to each alternative, assuming these five are the only choices. "

0	10	20	30	40	50	60	70	80	90	100

D. Socio-Economic Characteristics of Respondents. Lastly, all respondents were asked to answer the following questions:

1. Were you aware that the Seal Beach National Wildlife Refuge exists and is home to five (5) endangered bird species?
2. Where are you from? City, State
3. How many times per year do you visit a Wildlife Refuge?
4. Are you a member of any conservation organization?
5. Do you hunt or fish?
6. What is your age?
7. What is your highest grade of education completed?
8. From the categories listed, what is your yearly household income?

A.	LESS THAN $5,000	E.	$40,00-$54,999
B.	$5,000-$14,999	F.	$55,000-$69,999
C.	$15,000-$24,999	G.	$70,000-$99,999
D.	$25,000-$39,999	H.	$100,000 OR MORE

4. Data Collection

A. Site Selection and Sample Populations. Information on public perceptions of the Endangered Species Protection Program at the Seal Beach National Wildlife Refuge was collected from two groups:

(1) Seal Beach : 100 on-site interviews
- local respondents (51 individuals at a City shopping site)
- recreators (49 individuals at Bolsa Chica State Beach)

(2) Sweetwater Marsh National Wildlife Refuge : 100 on-site interviews

In the city of Seal Beach, one hundred on-site interviews were conducted to address the views of residents and recreators proximate to the Refuge. Further, to determine perceptions of individuals familiar with a wetlands ecosystem and endangered wetlands birds, we interviewed one hundred visitors at the Sweetwater Marsh National Wildlife Refuge in Chula Vista, California. This alternative site was chosen for its similarity to the study area since Seal Beach National Wildlife Refuge is not available for public access. The Sweetwater Refuge is 316 acres located ten miles south of downtown San Diego on the San Diego Bay and Sweetwater River. This site located approximately 90 miles due south of the Seal Beach National Wildlife Refuge.

The interviews were conducted from July 18-29, 1989. There are 188 completed surveys conducted on-site. On-site interviews began with the Q-sort ranking and scoring of the five alternative policies shown on cards. The results from the cards for the 188 on-site interviews will be presented separately later in the final section.

B. Socio-Economic Characteristics. Roughly one-third of the survey respondents reside in Orange County and San Diego County; almost one-fourth reside in Los Angeles County. The remainder reside in northern California or were visitors from outside the State. The socio-economic characteristics of the respondents sampled are reported in Tables 1 and 2. Each range for an average shown was derived by using the standard deviation and a t-statistic to compute the interval in which we can have 95% confidence that the average is in this range. Median values are also shown since the measure is less sensitive to extreme values.

A comparison of the respondents to average Californian households indicates that the survey study group is slightly younger, more educated, and perhaps of higher income than statewide averages. 1980 Census data report an average adult age in California of 43.5, average education of 12.2 years, and average household income of $32,602 (1984 dollars,California Dept. of Finance.) However, our study sample was drawn only from Southern Californian households. Of those surveyed, both average age and income were higher among respondents in the Seal Beach area, and education was above average for respondents at the Sweetwater Wildlife Refuge.

5. The SAGE Method: Statistical Analysis and Implicit Socio-Economic Values

A. Ranking and Scoring Program Alternatives. The results shown in Figures 1-6 reflect the rankings of 93 respondents at Sweetwater and 95 respondents in the city of Seal Beach. Those 99 responses were collected from shoppers in the city and from recreators at Bolsa Chica State Beach on the outskirts of the city.

Following the Q-sort technique, each respondent ordered the five program description cards according to his/her perception of the importance of the three program characteristics -- the national legislative goal, regional economic impact, and environmental quality goal. The program descriptions provided to respondents are summarized as follows:

(1) No Action taken .
(2) Red foxes captured and humanely euthanized.
(4) Red foxes captured using only non-lethal means and held in captivity in zoos or other long term holding facilities .
(5) Erect a specialized fence around the Refuge and periodically remove foxes which are found inside.
(5) Ecosystem restoration. Coyotes and natural vegetation are reintroduced to the Refuge. Coyotes would serve as a natural control of the fox population; this would be an effort to create a self-maintaining ecosystem by restoring a mixed native habitat and a natural balance in the food chain.

TABLE 1. SOCIO-ECONOMIC CHARACTERISTICS
SWEETWATER REFUGE (98 RESPONDENTS)

	AVERAGE*	MEDIAN
Aware of study site	16%	--
Annual visits to wildlife refuges	4.3-11.4 times/yr	3
Member of conservation group	38%	--
Hunt or fish	46%	--
Age	35.2-39.6 years	36
Years of education	14.6-15.6 years	16
Annual household income	$33,576-$50,604/year	$46,340

*Range values indicate 95% confidence level (t=1.96) that the population average falls in the interval shown.

TABLE 2. SOCIO-ECONOMIC CHARACTERISTICS
CITY OF SEAL BEACH (100 RESPONDENTS)

	AVERAGE*	MEDIAN
Aware of study site	47%	--
Annual visits to wildlife refuges	1.4-6.9 times/yr	0
Member of conservation group	20%	--
Hunt or fish	35%	--
Age	32.2-38.4 years	31.5
Years of education	13.7-14.5 years	14
Annual household income	$37,605-$63,663/year	$33,000

*Range values indicate 95% confidence level (t=1.96) that the population average falls in the interval shown.

Surveyors who conducted the on-site interviews reported that respondents were interested in and serious about ranking the alternatives on the cards. There were also very few individuals who refused to participate in the survey, so the results represent a strong sample of individuals who were at the sites.

Figure 1 summarizes the data for all respondents' first-ranked choice among the five program alternatives. Ecosystem restoration is a strong first choice, having been selected by one-half of all those persons interviewed. Individuals' second and third choices are aggregated in Figure 2. Note that the Capture/Cage option and Fence option are generally preferred to the Capture/Put to Sleep option. The No Action alternative is always a distant position chosen by a small minority of respondents.

Looking at Figures 3 and 5, a comparison can be made between visitors to the Sweetwater Wildlife Refuge and the shoppers/recreators in the city of Seal Beach. At both locations, the top ranked alternative is Ecosystem Restoration, though more individuals selected this option at Sweetwater. As shown in Figures 4 and 6, respondents at both sites were equally split between the Fence and Capture/Cage alternatives as a second choice.

After ordering the cards according to preference, respondents placed a score on each using a 0 - 100 scale. The average and median values for the scored alternatives are shown in Table 3. For the total sample of 188, Ecosystem Restoration received the highest average score, followed by the Capture/Cage alternative, then Fence, Capture/Put to Sleep, and No Action. The median value shows the breakeven point where 50% of the scores fall. A t-statistic was constructed using the standard deviations to test the hypothesis that the mean scores were statistically different from one another at the 95% confidence level; this hypothesis is accepted for the mean values reported across all alternatives over the total sample.

The results are virtually the same for the Sweetwater sample alone, except that statistical significance is not found for the t-test of difference of means between the Capture/Cage alternative and the Fence (i.e., statistically, these two alternatives' scores can not be shown to be different from one another). Again, the results for the Seal Beach sample alone are much the same; however, statistical significance does not hold for the difference of means between the Ecosystem Restoration score and the Capture/Cage alternative.

To facilitate a comparison of individuals' relative rankings, the assigned scores are standardized by subtracting the mean of the rank values and dividing by the standard deviation. The standardized scores are presented in Table 4. Values can fall on a -1 to +1 scale. Weighted values greater than one provide information on the relatively positive impact associated with a program alternative, and those weighted values which are less than one represent relatively negative impacts projected for the program alternative. This method is preferable to direct questioning about each alternative because these final results capture anticipated impacts of the <u>combination</u> of effects (meeting (or not) national legislative requirements, extent of regional fiscal impacts, and changes in environmental quality.)

For the total sample, the results in Table 4 show that the public experiences the greatest positive socio-economic impacts if the Ecosystem Restoration program is pursued. The No Action alternative would result in relatively high negative impacts, with the other program alternatives falling between. The standardized score for Fence alternative is near zero, meaning the positive impacts of this program alternative are being nearly offset by the negative impacts. These general conclusions are much the

FIGURE 1. PROGRAM RANKINGS

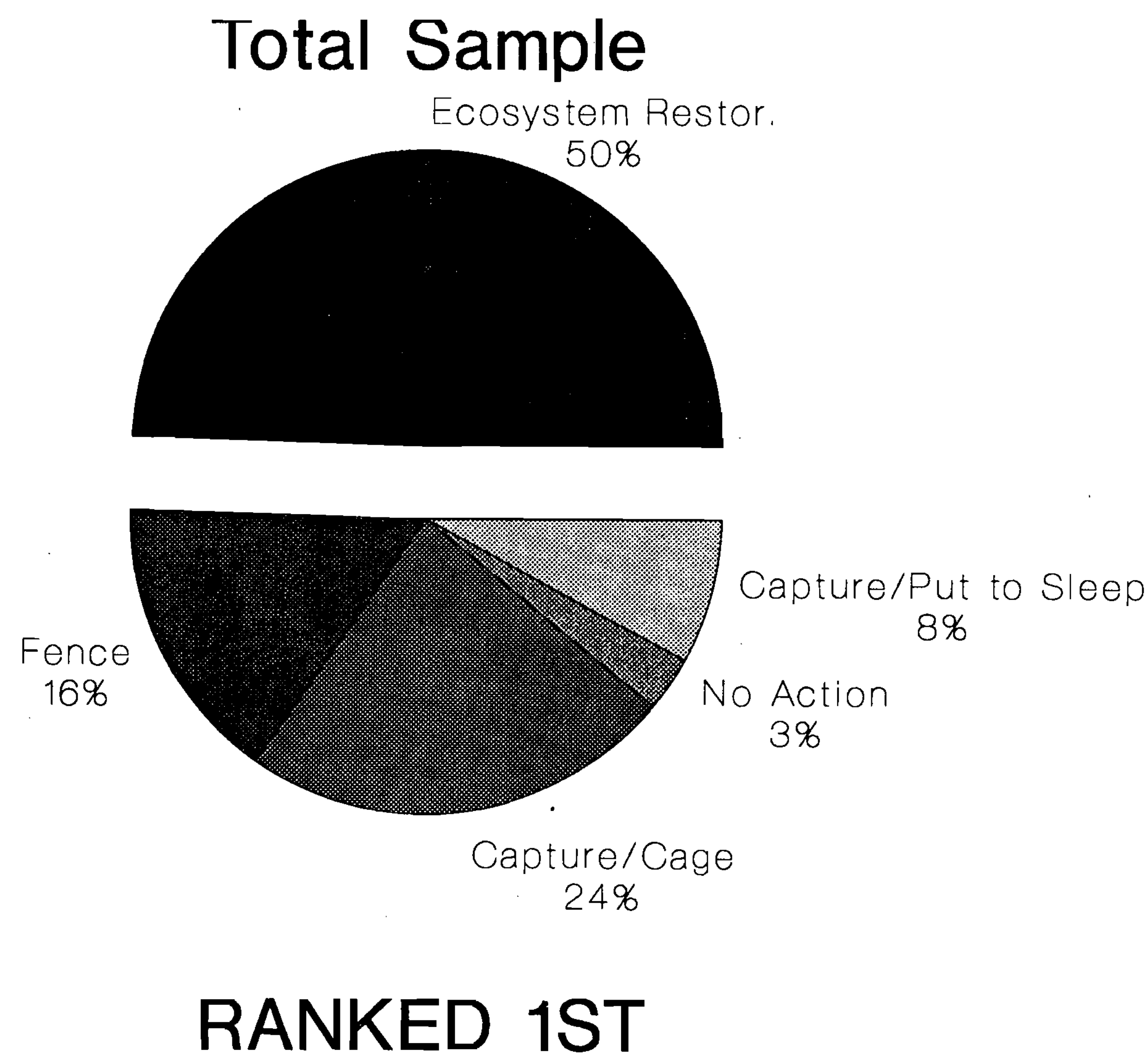
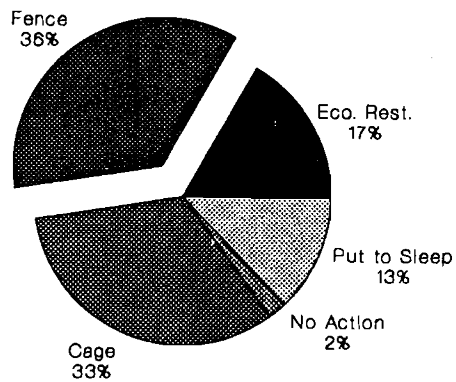
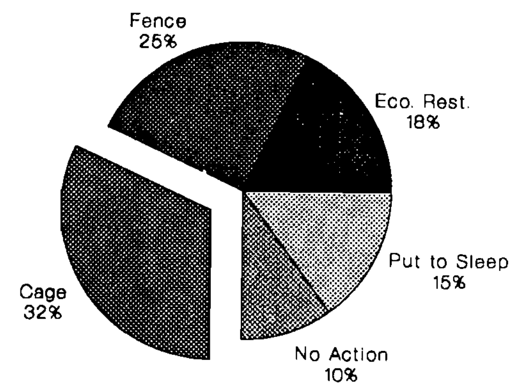


FIGURE 2. PROGRAM RANKINGS

Total Sample



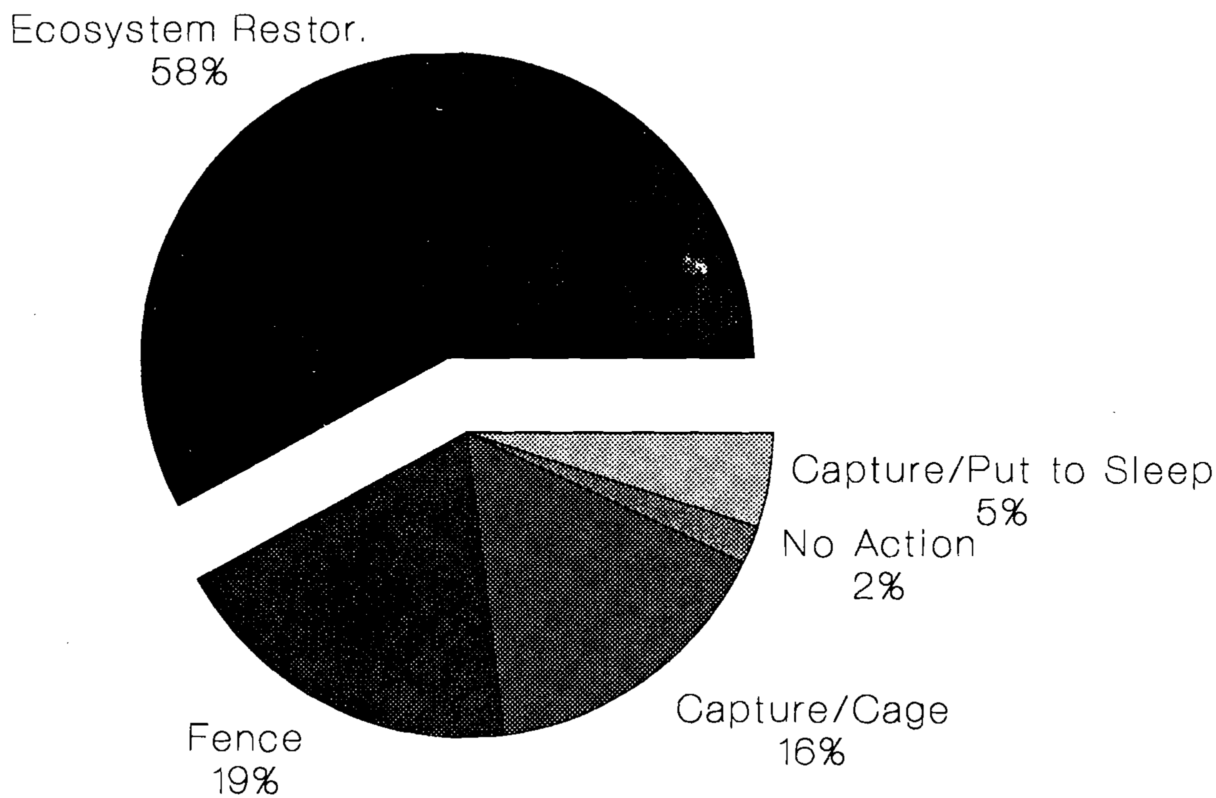
RANKED 2ND



RANKED 3RD

FIGURE 3. PROGRAM RANKINGS

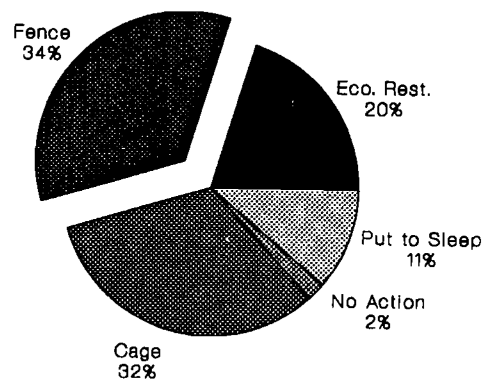
Sweetwater Sample



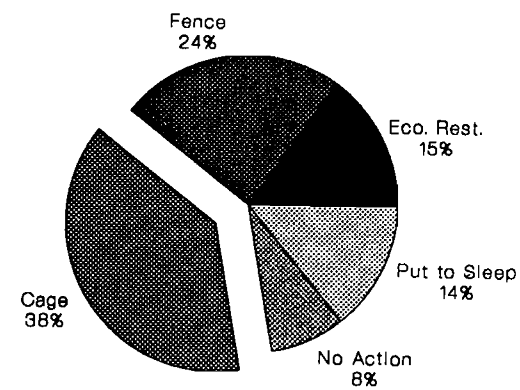
RANKED 1ST

FIGURE 4. PROGRAM RANKINGS

Sweetwater Sample



RANKED 2ND



RANKED 3RD

FIGURE 5. PROGRAM RANKINGS

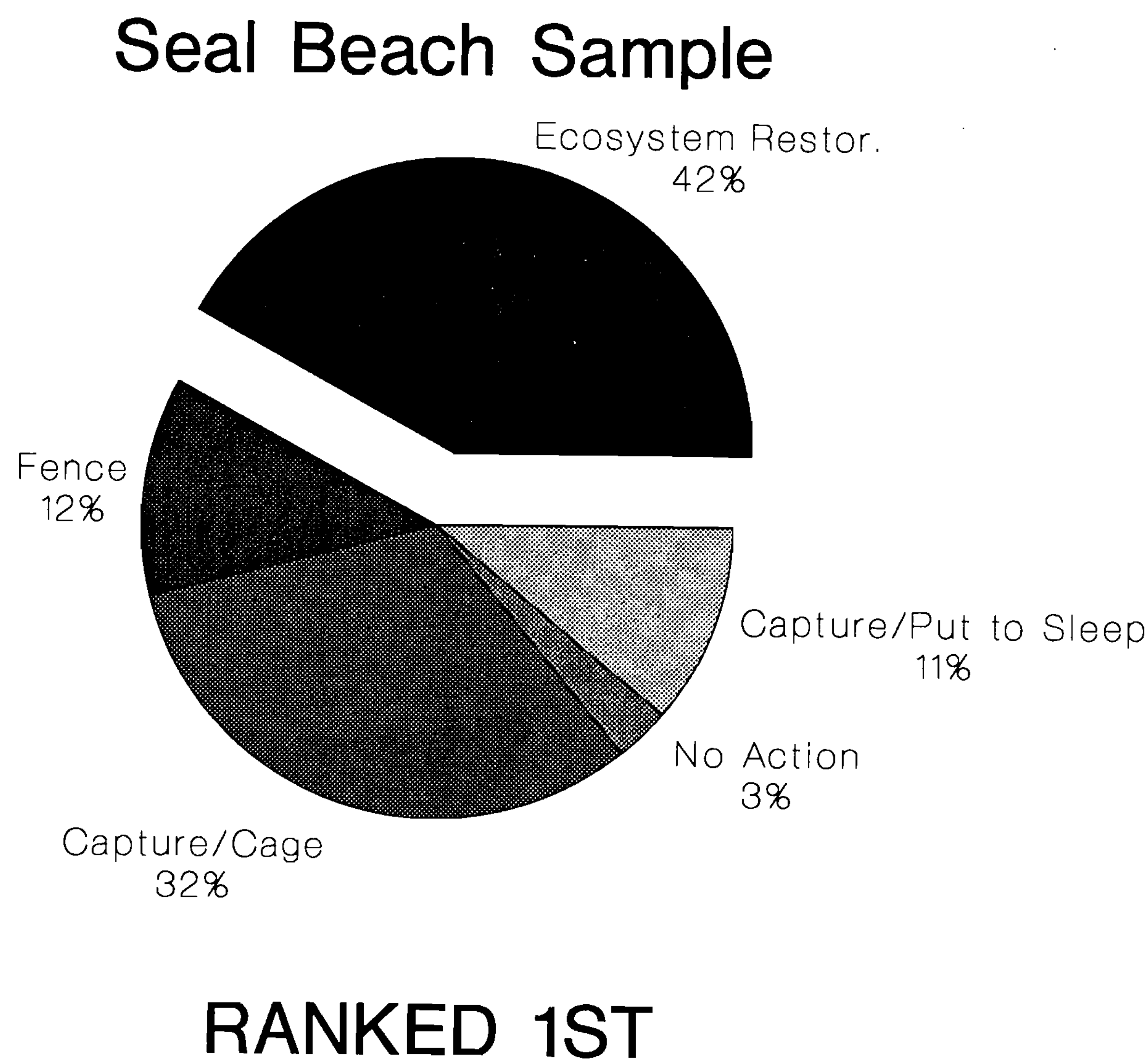


FIGURE 6. PROGRAM RANKINGS

SEAL BEACH

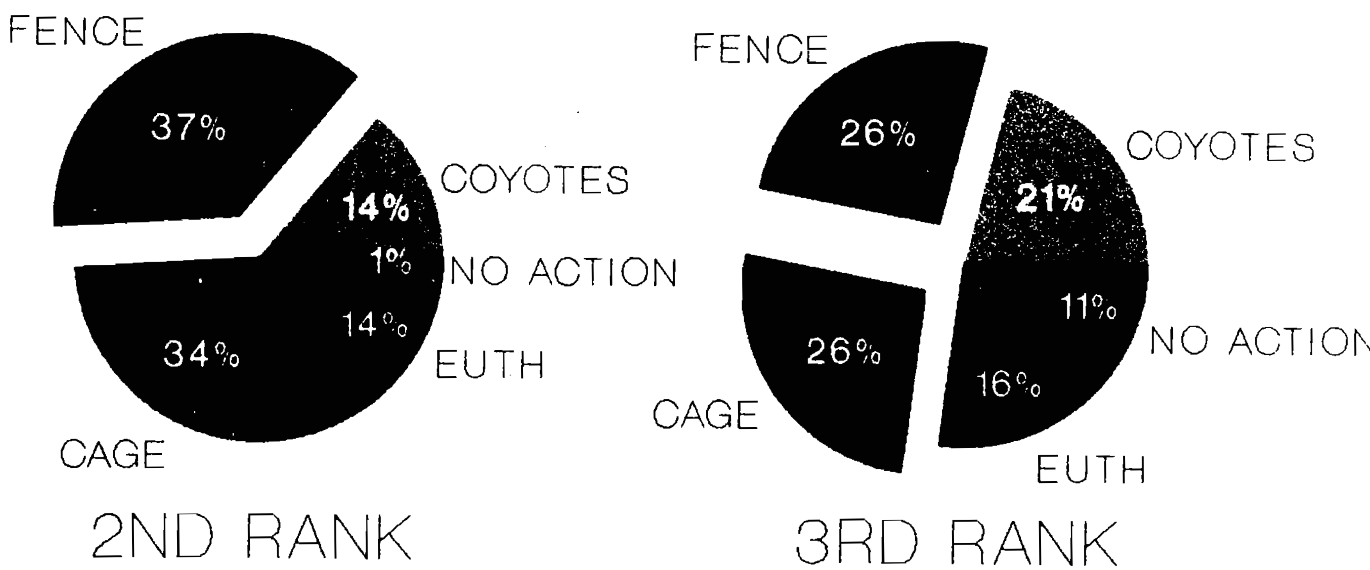


TABLE 3. AVERAGE SCORES [a] ON PROGRAM ALTERNATIVES

	TOTAL[b]		SWEETWATER[c]		CITY OF SEAL BEACH[d]	
	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN
ECOSYSTEM RESTORED	66 (30)	80	77 (23)	80	57[d] (33)	50
NO ACTION	19 (23)	10	18 (23)	10	19 (23)	10
CAPTURE AND CAGE	61 (27)	65	59[c] (23)	50	63[d] (30)	70
CAPTURE AND EUTHANIZED	31 (31)	20	28 (28)	20	33 (34)	20
FENCE	55 (28)	60	56[c] (27)	60	54 (29)	60

a/Standard deviations shown below in parentheses.

b/For the total sample of N=188, the difference between all mean scores is statistically significant at the 95% confidence level

c/For the Sweetwater sample of N=93, the difference between all mean scores is statistically significant at the 95% confidence level except the Trap and Cage alternative is not statistically different from the Fence alternative.

d/For the City of Seal Beach sample of N=95, the difference between all mean scores is statistically significant at the 95% confidence level, except the Ecosystem restoration alternative is not statistically different from the Trap and Cage alternative.

TABLE 4. MEAN STANDARDIZED SCORES

	TOTAL	SWEETWATER	CITY OF SEAL BEACH			EXPERTS
			Shoppers	Recreators	TOTAL	
Fence	.235	.243	.107	.452	.274	-.349
Capture/Cage	.401	.323	.449	.652	.543	.121
Ecosystem Rest.	.544	.831	.217	.461	.334	1.142
No Action	-.751	-.831	-.637	-.710	-.669	-1.487
Capture/Euth	-.424	-.537	-.214	-.380	-.291	.991

same when the Sweetwater Refuge visitors' responses are analyzed, except the intensity of the impacts at the two extremes is somewhat stronger than for the overall sample.

The results shown in Table 4 for the City of Seal Beach show the most favorable impacts for the Capture/Cage alternative, with the Ecosystem Restoration program having positive but less intense impacts on community members and recreational visitors. Strongly negative impacts are in evidence if the No Action alternative occurs. Interestingly, though the Capture/Put to Sleep alternative initiates negative impacts over all sample groups, these impacts are least intense among Seal Beach community members.

Table 4 also provides a comparison of the standardized scores derived from the initial survey of the expert team. Note that the experts' rankings of program goals resulted in an ordering of (1) Ecosystem Restoration, (2) Capture/Euthanize, (3) Capture/Cage, (4) Fence, and (5) No Action. In comparison, the public also ranked the Ecosystem Restoration first, but the Capture/Euthanize alternative was ranked fourth. The Capture/Cage option was chosen first by the smaller sample of community members and visitors in the City of Seal Beach.

The Ecosystem Restoration program is the preferred alternative. Respondents tend to favor as next-best options the Capture/Cage and Fence programs. As explained previously, the Fence alternative is an artificial alternative which was added only for statistical completeness, and the real costs of both of these choices are prohibitively high. After the first choice is made, the rank orderings of the general public deviate from the environmental quality goals assessed for program alternatives in the expert survey conducted at the outset of this study. Surveyors who asked interviewees for additional comments were repeatedly told that respondents' perceptions are that human intervention has encroached on natural areas too much already. Thus, many respondents stated that:

(1) protection of endangered birds must be a primary priority in the interest of maintaining balanced ecosystems in California, and

(2) the program alternatives which were selected are perceived to represent the least additional human interference (e.g., many individuals stated that their preference was to have fewer wild animals destroyed by humans.)

The reason for the disparity between the public's rankings and the experts' rankings of program alternatives becomes more apparent in light of this finding. Scientists and policy experts on the study team rated the Capture/Cage and the Fence alternatives as relatively low in terms of achieving environmental quality goals of endangered species protection and reduced disruption of the environment at the Refuge. Likewise, if citizens' strongest preference is for endangered species protection through preservation/enhancement of natural ecosystems, then fencing of open areas or confinement of wild animals to cages might not be the preferred alternatives if the experts' information about the level of human intervention involved in such alternatives were disseminated more widely among affected citizen groups.

B. Socio-Economic Value Weights. We hypothesized that the rankings and scores assigned by respondents to the cards depend upon the implicit socio-economic values which the respondents place on the five program alternatives' three policy outcomes: (1) the relative achievement of environmental quality goals at the wildlife refuge (ENVQ), (2) how well the policy meets the legal requirements of NEPA and the Endangered Species Conservation Act (LAW), and (3) the regional economic cost (COST) of each program. The SAGE method enables individuals involved in this study to reveal their implicit socio-economic values through their assignment of relative scores on each of the five program alternatives, since explicit information was provided on the three potential impacts (ENVQ, COST, and LAW.)

Table 5 provides the values used to estimate a proxy utility function for the stated scores on the five program alternatives. All variables were standardized by subtracting their sample mean and dividing by their standard deviation. The equation to be estimated is shown below:

$$ST(SCORE) = \beta_1 ST(ENVQ) + \beta_2 ST(LAW) + \beta_3 ST(COST)$$

The three dependent variables are those three program goals which were stated on each of the program cards used in the Q-Sort survey procedure. ENVQ is the environmental quality variable; its values for the program alternatives are the weighted values determined in the initial expert team survey. LAW is the extent to which the legal mandates of the Endangered Species Protection Act are met; a value of 0 indicates no legal requirements are met, a value of 1 indicates that the Act's mandates are met in full, and a value of .5 indicates that there is only some chance that the legal requirements can be met with the program described. The last variable, COST, consists of the regional fiscal cost of program implementation. No other economic impacts on the community are anticipated in this particular species management program.

Table 6 shows the means and standard deviations of the 940 responses to the Q-sort survey (5 scores on the program alternatives which were stated by a each of 188 respondents.) The correlation matrix is also shown; note the very low correlations between the Score and the socio-economic characteristics of age (AGE), years of education (EDUC), annual household income(INC), frequency of visits to wildlife refuges (VISIT), membership in a conservation group (CONS 0,1), and participation in hunting and fishing activities (HUNT 0,1). Efforts to include any of these variables in the regression analysis resulted in no findings of statistical significance on any of the coefficients on these socio-economic variables.

The regression results for the standardized variables are summarized in Table 7 for the total sample, and for the two separate survey sites: the visitors to the wildlife refuge at Sweetwater, and the respondents in the City of Seal Beach. The betascores on each of the three program outcomes were statistically significant at the 99% level in every case. In each sample, the environmental quality variable ENVQ has the most effect in determining respondents' program score. The program cost has the least effect.

As might be expected, the program's environmental quality rating is positively related to respondents' scores; however, there is the negative relationship between the score and the programs' achievement of legal requirements. Also, in their preliminary work on the SAGE model, Hyman and Stiftel hypothesize that the program cost should be negatively related to respondents' score values. However, the results of this first study show that the effect of program cost on respondents' scores is not only the least important determining factor but cost is also positively related to the score values.

These preliminary results lend themselves to further analysis. It may be that respondents are primarily concerned with ecosystem integrity and maintenance of natural habitats, and legal considerations are unimportant as are program costs. The latter may be true if perceptions that spending agency budgets are disembodied

TABLE 5. PROGRAM GOALS:
INDEPENDENDENT VARIABLE VALUES

	Achieve Environmental Quality Goals(ENVQ)	Meet Legal Mandates(LAW)	Regional Cost Constraints(COS
Fence	.419	.5	$163,000
Capture/Cage	.528	.5	$ 36,000
Ecosystem Restoration	.765	1.0	$ 25,000
No Action	.155	.0	$ 0
Capture/Euthanize	.637	1.0	$ 8,000

TABLE 6. SURVEY DATA

SMPL range: 1 - 940
Number of observations: 940

Series	Mean	S.D.	Maximum	Minimum
SCORE	45.788298	33.829946	100.00000	0.0000000
ENVQ	0.5008000	0.2076488	0.7650000	0.1550000
LAW	0.6000000	0.3743649	1.0000000	0.0000000
COST	46.400000	59.679385	163.00000	0.0000000
AGE	36.018085	13.077792	84.000000	18.000000
EDUC	14.569149	2.5003738	22.000000	0.0000000
INC	48519.787	51975.562	250000.00	2500.0000
VISIT	5.6861702	15.851831	100.00000	0.0000000
CONS	0.2765957	0.4475529	1.0000000	0.0000000
HUNT	0.3989362	0.4899403	1.0000000	0.0000000

	Covariance	Correlation
SCORE,SCORE	1143.2477	1.0000000
SCORE,ENVQ	1.6298192	0.2322581
SCORE,LAW	1.9727660	0.1559342
SCORE,COST	539.35915	0.2674328
SCORE,AGE	-11.481278	-0.0259787
SCORE,EDUC	1.8385751	0.0217589
SCORE,INC	59326.104	0.0337760
SCORE,VISIT	-16.244098	-0.0303233
SCORE,CONS	0.0181304	0.0011987
SCORE,HUNT	0.2599876	0.0157026
ENVQ,ENVQ	0.0430722	1.0000000
ENVQ,LAW	0.0746200	0.9609326
ENVQ,COST	-0.9319201	-0.0752813
ENVQ,AGE	1.017E-15	3.748E-16
ENVQ,EDUC	-1.045E-15	-2.014E-15
ENVQ,INC	-1.999E-12	-1.854E-16
ENVQ,VISIT	-2.620E-16	-7.967E-17
ENVQ,CONS	-1.761E-17	-1.897E-16
ENVQ,HUNT	-1.417E-17	-1.395E-16
LAW,LAW	0.1400000	1.0000000
LAW,COST	-1.3400000	-0.0600410
LAW,AGE	1.616E-15	3.304E-16
LAW,EDUC	-1.531E-16	-1.637E-16
LAW,INC	1.264E-12	6.501E-17
LAW,VISIT	1.150E-16	1.941E-17
LAW,CONS	-2.362E-19	-1.411E-18
LAW,HUNT	1.311E-17	7.155E-17
COST,COST	3557.8400	1.0000000
COST,AGE	1.143E-13	1.466E-16
COST,EDUC	-1.615E-14	-1.083E-16
COST,INC	8.335E-11	2.690E-17
COST,VISIT	7.211E-15	7.631E-18
COST,CONS	-1.002E-16	-3.754E-18
COST,HUNT	8.957E-16	3.067E-17
AGE,AGE	170.84669	1.0000000
AGE,EDUC	6.8801324	0.2106297
AGE,INC	55851.342	0.0822550
AGE,VISIT	-1.8815582	-0.0090859
AGE,CONS	1.1386148	0.1947423
AGE,HUNT	0.7278916	0.1137238
EDUC,EDUC	6.2452184	1.0000000
EDUC,INC	29605.653	0.2280514
EDUC,VISIT	3.8228712	0.0968060

TABLE 7: BETASCORES

TOTAL SAMPLE

Number of observations: 940

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
STENVQ	1.1439394	0.1056858	10.823967	0.000
STLAW	-0.9257682	0.1056111	-8.7658256	0.000
STCOST	0.2979941	0.0293121	10.166267	0.000

R-squared	0.201099	Mean of dependent var	-5.03E-05
Adjusted R-squared	0.199394	S.D. of dependent var	0.999998
S.E. of regression	0.894764	Sum of squared resid	750.1654
Durbin-Watson stat	2.106598	F-statistic	117.9308
Log likelihood	-1227.777		

SWEETWATER SAMPLE

Number of observations: 465

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
STENVQ	1.7311700	0.1309807	13.216987	0.000
STLAW	-1.3398628	0.1308881	-10.236705	0.000
STCOST	0.2975462	0.0363276	8.1906350	0.000

R-squared	0.394158	Mean of dependent var	-6.21E-05
Adjusted R-squared	0.391535	S.D. of dependent var	0.999872
S.E. of regression	0.779941	Sum of squared resid	281.0386
Durbin-Watson stat	2.248205	F-statistic	150.2874
Log likelihood	-542.7321		

CITY OF SEAL BEACH SAMPLE

Number of observations: 475

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
STENVQ	0.5999391	0.1570301	3.8205353	0.000
STLAW	-0.5423672	0.1569191	-3.4563487	0.001
STCOST	0.2989337	0.0435525	6.8637629	0.000

R-squared	0.110691	Mean of dependent var	9.11E-05
Adjusted R-squared	0.106923	S.D. of dependent var	1.000031
S.E. of regression	0.945057	Sum of squared resid	421.5586
Durbin-Watson stat	2.024123	F-statistic	29.37463
Log likelihood	-645.6488		

expenditures; i.e., if the respondent does not view agency funds as related to his/her own expenditure choices. However, these data will be analyzed further using a multi-logit model on the rank orderings (1 - 5) of the programs (as opposed to the scores on a 0 - 100 scale) in order to determine if the relative values and signs on ENVQ, LAW, and COST behave consistently.

6. CONCLUDING REMARKS

The respondent sample provides a data set drawn from Orange County, Los Angeles County, and San Diego County -- the three counties where citizens in southern California are most likely to perceive impacts associated with the Seal Beach Endangered Species Management and Protection Program. The application of the SAGE method in this study allows us to address the needs/concerns of the three groups which are relevant for making a comprehensive assessment of socio-economic impacts:

(1) scientists and policymakers responsible for management of the resource,
(2) special interest groups, whose needs may or may not reflect the views of the general public, and
(3) citizens in local and regional communities.

Impacts on the general populace were addressed from two perspectives. First, we attempted to identify special interests of environmentally concerned groups by interviewing individuals visiting a wildlife refuge located in a nearby wetlands area which is very similar to the study site. These respondents were primarily from southern California, although some were visitors from other areas in the state, the nation, and other countries. We also interviewed citizens and recreators who were residing or visiting the city of Seal Beach in order to capture local community impacts.

This initial application of the SAGE method was conducted in its entirety over a three month period. The outcome in the policy application has been a court finding that the Fish and Wildlife Service may proceed with protection of the endangered birds at the Seal Beach National Wildlife Refuge, and that the Ecosystem Restoration program has merit as an appropriate policy option. This preliminary study points out several weaknesses as well as benefits of using the methodology when environmental/resources management policy requires socio-economic impact assessment.

The SAGE method relies on an an ordinal scale on program goals. Since the value weights are derived assuming ratio data, this is an inherent weakness in the methodology. Also, further studies are required to test how well the method can capture respondents' ability to handle uncertainty associated with program alternatives; in this test case, there was almost no uncertainty about program outcomes, though some respondents' views on uncertainty may have been captured in responses to ranking the coyote reintroduction strategy. Third, because statistical analysis of the equations requires that the number of policy goals be two fewer than the number of programs being ranked, there is an unfortunate limitation on the amount of information which can be provided to respondents in the form of goals unless artificial programs are constructed as part of the exercise. Lastly, if the policy-maker deems it necessary to evaluate programs based upon dollar values for willingness-to-pay, the SAGE method as described herein does not provide relative values in dollar terms.

On the benefits side, the survey procedure itself incorporates expert opinion into the process and provides educational information to the affected public groups. Second, when there are many objectives involved (e.g., protecting important, but conflicting resourcesof value, such as competing wildlife species), SAGE allows respondents to reflect upon the relative level that different objectives (cost, quality of life, etc.) may be achieved. Third, the pair-wise ranking of alternatives is straight-forward, even fun, for respondents and can be accomplished without the time-consuming and difficult process typical of many other survey methods. Fourth, the non-economists and policy-makers involved in the EIS process found the method to be understandable and useful in a decision-making setting because of the presentation of the programs' relative rankings and scores. Fifth, in a practical sense, public policy decisions with short time frames and funding limitations can meet socio-economic impact analysis requirements with an efficient SAGE study. Lastly, because of the "embedding" problems often encountered in CVM studies which look at several valuations over more than one environmental good, SAGE can be useful in avoiding this problem since it does not require respondents to estimate a dollar value for willingness-to-pay.

BIBLIOGRAPHY

Adams, Clark E., RA. Stone, and John K. Thomas. 1988. Conservation Education Within Information and Education Divisions of State Natural Resource Agencies. Wildl. Soc. Bull. 16:329-333

Blumenthal, Michael, July 23, 1989. "All Too Human," The New York Times.

Brookshire, D. S., M. A. Thayer, W. D, Schulze and R. C. D'Arge, 1982 "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches," American Economic Review 72(1):165-177.

Bureau of Land Management, 1984. Administration of the Wild Free-Roaming Horse and Burro Act, 5th Report to Congress.

Cummings, R. G., D. S. Brookshire and W. D. Schulze, 1986 Valuing Environmental Goods: A State of the Arts Assessment of the Contingent Valuation Method. Totowa, New Jersey: Rowman and Allanheld.

Davis, R. K. 1963, "Recreation Planning As An Economic Problem," Natural Resources Journal, 3(2):238-249.

Dillman, D.A. 1978. Mail and Telephone Surveys: The Total Design Method. New York: Wiley.

Fisher, A.C. and M.C. Hanemann. 1984. "Endangered Species and the Economics of Irreversible Damage," American Economics Association Meetings, Dallas.

Hageman, R., 1985 "Valuing Marine Mammal Populations: Benefit Valuations in a Multi-species Ecosystem," National Marine Fisheries Service, Southwestern Fisheries Center, La Jolla, California Report No. LJ-85-22.

Hyman, Eric, David Moreau and Bruce Stiftel. 1984. "SAGE: A New Participant-Value Method for Environmental Assessment." Water Resources Bulletin. 20:915-922.

Hyman, Eric and Bruce Stiftel. 1988. Combining Facts and Values in Environmental Impact Assessment: Theories and Techniques. Boulder, Colorado: Westview Press.

Loomis, J.B., G. Peterson and C.F. Sorg. 1984. "Field Guide to Wildlife Analyses," Proceedings of the 49th North American Wildlife and Natural Resources Conference, Boston.

Miller, J.R. and M.J. Hay. 1984. "Estimating Substate Values of Fish and Wildlife." Proceedings of the 49th North American Wildlife and Natural Resource Conference, Boston.

Miner, Karen, 1989. California Department of Parks and Recreation, Resource Ecologist , Personal communication.

O'Bryan, M. K., and O. R. McCullough. 1985. "Survival of black-tailed deer following relocation in California." J. Wildl. Manage. 49:115-119.

Pitt, David and Ervin Zube. 1979. "The Q-Sort Method: Use in Landscape Assessment Research and Landscape Planning." In Proceedings of Our National Landscape: A Conference on Applied Techniques for Analysis and Management of the Visual Resource, edited by Gary Elsner and Richard Smardon. Berkeley, Calif.: U.S. Forest Service Pacific Southwest Forest and Range Experiment Station.

Stoll, J.R. and L.A. Johnson. 1984. "Nonmarket Values of the Whooping Crane." Proceedings of the 49th North American Wildlife and Natural Resources Conference. Boston

Vining, Joanne and H. W. Schroeder. 1989. "The Effects of Perceived Conflict, Resource Scarcity, and Information Bias on Emotions and Environmental Decisions." Environmental Management 13: 2: 199-206.

White, J. 1981. "Trouble on Angel Island." Outdoor Calif. 42:9-12.