GREAT LAKES FISHERY COMMISSION

1993 Project Completion Report[1]

Issues and Approaches in Applied Valuation

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October 1993

[1]Project completion reports of Commission-sponsored research are made available to the Commission's Cooperators in the interest of rapid dissemination of information that may be useful in Great Lakes fishery management, research, or administration. The reader should be aware that project completion reports have not been through a peer review process and that sponsorship of the project by the Commission does not necessarily imply that the findings or conclusions are endorsed by the Commission.

ISSUES AND APPROACHES IN APPLIED VALUATION

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January, 1993

The author would like to thank the Great Lakes Fishery Commission for funding this research and the Board of Technical Experts of the Commission for providing support and direction.

The author would also like to thank the following individuals who have helped through discussion or by reading earlier versions and suggesting improvements: L. Anderson, N. Bockstael, D. Cauvin, T. Cowan, R. Eshenroder, B. Knuth, G. Parsons, V.K. Smith, P. Sutherland and D. Topolniski. I am responsible for any errors that remain.

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TABLE OF CONTENTS

1. INTRODUCTION

The previous two papers in this series have established what is meant by economic values and how those values may enter into project evaluation and policy making. The purpose of this paper is to provide a link between theory and measurement. We will not examine all of the details of the statistical techniques that are used to measure economic values in different settings. Many of the techniques are quite complex from the point of view of both statistical theory and numerical analysis (when they are implemented). The major techniques have been contributed to and discussed within the economics literature. Survey articles, edited volumes, journal articles and working papers are available for those wishing a specialized understanding of the field. In contrast to a specialized understanding and, in keeping with the approach of the preceding papers, the goal of this paper is to provide an introduction and overview to the process of applied measurement of economic values for managers and policy makers. Theory and statistical approaches are examined to provide a basis for understanding the meaning and implications of the results of a given applied study. Specific details about the quality of a study can always be assessed by sending it out for blind expert review.

Before describing the order in which the major issues are introduced and addressed in this paper, we first provide some very general observations about applied valuation and

the values that can be measured. It is useful to keep these issues in mind while reading the remainder of this paper.

The first set of observations has to do with the process of applied modelling. As in all areas requiring statistical modelling, good applied analysis is very difficult. There are several reasons for this. First, the applied researcher must understand the underlying theory and must be prepared to adapt or expand it depending on the characteristics of the available data. Second, the researcher must obtain a clear understanding of the process by which the available data were generated. This includes both an understanding of the sampling process whereby the data were collected and the way in which the sample corresponds to the theoretical behaviour of economic agents. Third, the researcher must find a way of analyzing the data that is consistent with the principles of rigorous statistical analysis but which is also sensitive to the fact that no data set is ideal. There are usually errors and inconsistencies in data samples. These errors arise in measurement and recording. As well, the process by which the data are gathered often imposes a structure in the sample that may confound the discovery and measurement of the true underlying economic structure. The issue here is one of randomness of the sample. In particular, is the available sample of data random with respect to the economic structure that is to be estimated? Typically, the sample is not (completely) random and the estimation strategy must compensate for this feature. Fourth, and related to the third point, it is usually the case that as the applied analysis progresses, further problems with a given data set become

apparent. Most valuation studies are now based on data generated from samples of individual economic agents. Often the researcher analyzing the data is not the person who designed and implemented the sampling process. As a result, sample information may be ambiguous (because of the design of the questionnaire) and, if critical questions were not asked, incomplete in the sense that the researcher may not be able to use the data to sharpen or otherwise distinguish between some competing hypotheses about economic behaviour.

The second set of background observations deals in part with what might be thought of as the philosophy underlying applied economic analysis in general and valuation in particular. Recall from the previous two papers that the goal of economic theory is to develop a set of assumptions and a formal process of reasoning to represent individual economic decision making and which further can be used to predict behaviour. The theory can never be complete enough to describe exactly the decision making of an individual chosen at random in a society. Rather, it is meant to describe and predict the behaviour of a representative individual. As a direct consequence, we should not expect the same precision from applied statistical analysis in economics that may arise in double blind controlled experiments in the physical and biological sciences. What we must often settle for are indications (for or against) the existence of structure in the data that is broadly consistent with economic theory. The nature of available data is such that we cannot and should not always attempt to draw wide-ranging conclusions about estimated

economic values. Often, the most that can be reliably concluded is that the value of a particular resource or characteristic of a resource is relatively small or large. Even these conclusions must be tempered by practical experience and by an awareness of any 'special' or 'unexpected' features of the estimated model that may have contributed to the results.

As a final background point we repeat the purpose of the applied analysis. We wish to obtain measurements of the economic values associated with recreational sites and with characteristics of those sites. In the other two papers in the series we have examined measures of the value associated with the consumption of specific flows of services from recreational sites. Two of these values (equivalent and compensating surplus) are directly linked by a demand curve to the use or consumption of the flow of services from the site and its characteristics. Within the literature these values are referred to as 'use' values. As such, they are distinguished from 'nonuse' values. Nonuse values can be thought of as the value associated with the certain knowledge that a resource exists or that it will continue to exist (existence value) or be maintained (option, bequest value). While there can be no doubt that nonuse values may exist and be of significant size, it is also important to realize that they represent a second level of abstraction. As with characteristics of recreational sites, they are not traded in well-defined markets. As well, though, they are not observable and it is not clear that they correspond to a good or service that is comparable across individuals. It seems perfectly reasonable to ask

individuals how much they would pay for the return (at a certain level) of a currently extinct species. It is equally reasonable to expect that use and nonuse values may be inextricably linked or confounded for resources that currently exist.

In the remainder of this paper we will examine the two major techniques that are currently used to measure values for nonmarket resources. These techniques are referred to as the travel cost and contingent value methods or models, TCM and CVM respectively. TCM uses data on the observed or measured economic decisions of individuals to deduce the values associated with goods and services that they consume. Because these goods and services are not purchased in markets, the behavioral data is only indirect. Alternatively, CVM can be thought of as the hypothetical and sometimes experimental construction of these missing markets. Surveys and questionnaires are used in various ways to simulate the market decisions of individuals. For example, an individual may be asked to state the value he or she puts on consumption of a resource. The data are then analyzed as if they came from real markets. In the literature, this is referred to as the direct approach.

Both TCM and CVM share a formal validity in the sense that they both address valuation notions rooted in economic theory. Almost all attempts to value resources employ one or both of these techniques. In what follows we will examine each technique in turn. We will begin with the goals and major operating characteristics of each

approach. Summaries of the success (both real and potential) are presented for each of the techniques. These summaries include both the positive and negative aspects of each approach. The negative aspects are further broken down into potentially resolvable problems and potentially unresolvable problems. The paper concludes with an attempt to isolate the pivotal issues involved in using TCM and CVM to value resources.

As a final point in this introduction, I feel it important to point out that this paper is very strongly influenced by the work of V. Kerry Smith. It is difficult to think of a valuation issue that he has not directly researched or otherwise thought and written about in a careful and insightful way. Of course, he cannot be held responsible for what follows. At the same time it is important to emphasize the extent of his contribution to the field.

2. *TRAVEL COST MODELS (TCM)*

Introduction

The travel cost literature[1] began as an attempt to place an economic value on entire recreational sites. Early insight into the problem was provided by Hotelling (1947). He observed that while individuals do not interact in a market for recreational sites, they indirectly reveal their preferences by travelling to recreational sites. In effect, one can

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[1]An excellent survey of the literature at a more technical level can be found in V.K. Smith (1989).

value a site by determining the economic value of trips, visits or travel that bring individuals to a site. Early applied research was directed at estimating travel demand functions and then using economic theory and the estimated demands to estimate the value of sites.

Early TCM

Early value estimates were pieced together from a minimum amount of information. Any given recreational site often kept records of visits perhaps in terms of license plates or more exactly in terms of the origin of the visitors. This provided information on distance travelled and frequency of trips. Price and income information was also obtained. Costs of round trip travel were calculated at various levels of sophistication ranging from crow-flies measuring of distance and average fuel consumption to map-measured distances. Income, when included, was taken as the average income in the geographic zones of origin of the visitors. Variation in price and income (needed to statistically identify the demand for trips) came from grouping individuals into a set of origin zones at varying distances from the site.

It was generally the case that, other things being equal, fewer trips per capita were taken by individuals living in more distant zones of origin. Since a trip from a more distant site also cost more, a negative relationship was estimated between price and number of trips. This became the demand curve for trips and, indirectly, for the site. An

estimate of the value of the site for a representative individual from a zone could be obtained by rationing trips to zero. The total value of the site is obtained by adding the value of trips of all visitors to the site.

Modern travel cost models began to develop as more complete survey information became available. It was no longer necessary to model average travel rates by zone of origin. Individuals make decisions and it follows that this behaviour and not the behaviour of averages of data is what should be modelled. The better data also offered the opportunity to estimate separate demands for the characteristics, such as isolation and fish species, of a site.

Modern TCM

Modern survey data typically includes information by individual sampled on the number and duration of visits to various sites, estimates of thee costs of travel, other socioeconomic characteristics such as wages and income, location of residence, experience etc. as well as characteristics of the various sites including measures of congestion, pollution, huntable or fishable species, density etc. A variety of approaches have been developed to analyze these data and generate estimates of economic values.

Generalized TCM

One group of models has developed from extending TCM to the case of micro-level survey data and site characteristics. Those models, suggested by Vaughan and Russell (1982) and V.K. Smith et. al. (1983, 1985), involve estimating standard travel cost models for individual sites and then relating difference in the estimated travel/visit demand curves to differences in site characteristics. Variations in site characteristics are thereby linked to changes in estimated economic values. For example, this technique could be used to estimate the value of increased fish density at a given site.

Hedonic TCM

Hedonic travel cost models attempt to estimate the specific implied demand curves for the characteristics of given sites. The approach, as outlined in several papers by G. Brown, involves two steps. In the first stage the travel cost information is used to obtain estimates of the (marginal) costs faced by an individual attempting to obtain one more unit of a specific site characteristic. For example, how far do you have to travel to obtain a fish density that is larger by 1 unit? The actual statistical procedure involves a decomposition of costs known as a hedonic decomposition. In the second stage these estimated costs or prices of the site characteristics are used to estimate individual demands for characteristics. The economic value of a given characteristic can be measured from this estimated demand curve.

A variation on the first step of this process has been suggested by V.K. Smith et. al. (1991). The new approach involves estimating first stage costs using a linear programming estimate of the 'envelope' relationship between costs and characteristics.

Random Utility Models (RUM)

Random utility models differ from the travel cost model described to this point. RUM is not based on the explicit derivation and estimation of traditional curves. Rather, in random utility models the argument is made that individuals reveal their preferences by their choice of sites. Individuals choose a given site (or set of sites) because it (or the collection) is optional. Explicit linear forms for utility are postulated and estimated using multinominal discrete choice statistical methods. Hanemann has written extensively on this topic and has shown how the estimated models can be used to generate estimates of economic values.

Frontier TCM

Leith and Smith (1982) have recently suggested a new approach to valuing site characteristics. They point out that travel cost payments represent a consistent underestimate of the maximum that an individual would be willing to pay for the set of characteristics that define the site. They then point out how this information can be used to estimate the most that an individual would pay and that this is just the economic value that is sought. Estimates of values of individual characteristics follow in a straightforward

manner. This approach directly provides an estimate of the value frontier as opposed to the travel cost frontier of V.K. Smith et. al. (1991).

Advantages of TCM

There are three major advantages associated with TCM. First, the estimated economic relationships such as demand curves and preference functions tend to be consistent with the underlying theory. This does not mean that the estimated values are accurate or even always reasonable. Nonetheless the value estimates are derived from estimated models that economic theory suggests we should observe. Second, the standard survey data is becoming more widely available and often is not expensive to obtain. Finally, to a large extent, the demand and valuation analysis follows the traditional economic paradigm of model, implied structure and estimated structure. The framework for understanding and judging the results has become well developed.

Potentially Resolvable Problems with TCM

One of the biggest issues found by TCM researchers is the measurement of the costs of travel. While some types of costs such as fuel, bait and entry permits are relatively straightforward, there remains the problem of assessing the value of time of the individual used in travel and on-site activities. These costs arise because the travel and recreational activity came at the expense of another activity such as a sport or more work depending on the flexibility in the individual job. One approach in the literature has been

to approximate the "opportunity cost" of travel by the foregone earnings of the individual. Not surprisingly, there has been considerable debate on this issue and it remains unresolved. It is further complicated by the fact that survey data often does not contain enough information about an individual's foregone alternatives to quantify many of the proposed solutions. The problem is further complicated by the fact that there may be many purposes of a given trip and many sites may be visited.

Another important issue involves the measurement of site characteristics. Not all individuals seem to perceive a site in the same way. As well, there are often (visited or unvisited) substitute sites and it is often difficult to incorporate these substitution possibilities into the analysis.

Finally, there are issues related to best econometric practice in searching for the structure in the data. These issues range from the specification, measurement and transformation of variable and equations entering the empirical model to the choice of stochastic assumptions and attendant estimation algorithms. Different assumptions can affect the size of the estimated economic values.

Overall, all of these problems are important and any one is sufficient to severely bias the statistical results. At the same time, knowing that these problems are present (as they are in one way or another in all applied work in economics) allows for the adoption

of defensive statistical strategies. The researcher does what she or he can with the available data but is very careful to report any discovered sensitivity of the reported results to violation of the assumptions. Good applied economic analysis is very much like good detective work. You do not jump to accept the first confession that comes along. A good case is woven from the facts and relationship that are discovered and seem to reappear regularly. As with detective work, good applied analysis is mostly slow, careful and methodical with the odd flash of understanding. There is no room for dogmatism and a good reviewer will usually be able to spot the weak aspects of the analysis.

Potentially Unresolvable Problems with TCM

TCM relies upon indirect market data. As such, it is not able to provide measures of nonuse values for individuals who have not participated in or been observed in a market setting related to the resource that is to be valued. On the other hand, individuals who, for example, form part of a data sample may also have nonuse values. Assuming, as seems reasonable, that nonuse preferences for existence and preservation affect decisions to participate in an activity, TCM will include nonuse values in total measured value.

3. *CONTINGENT VALUATION MODELS (CVM)*

Introduction and Background

In order to focus attention on the issues it is useful to consider first a tangible and measurable good or activity that is not marketed in the traditional sense of having the observed quantity and price respond to forces of demand and supply. Such goods (or bads) include most environment-based goods and services as well as 'bads' such as pollution. Next, we ask whether it is possible to create an experimental setting in which individuals are given the opportunity to behave or, in the more typical survey and questionnaire setting, anticipate their behaviour in a market for the good or service. That is, can useful experimental or hypothetical markets be created and can the 'pseudo' data from these experimental markets be used much like 'real or observational' market data to model the decision-making behaviour of individuals and further estimate the economic value of the nonmarketed goods and services?

CVM provides several approaches to constructing markets and analyzing the resultant data. CVM is considered a direct approach to economic valuation. In many cases participants are directly asked to disclose what an economist would interpret as economic values.

Approaches to CVM

This section will not cover all of the developments of CVM. As in the case of TCM, the purpose is to suggest the essential characteristics of the approach. The literature in this field has grown quickly. A thoughtful evaluation paper has been provided recently

by V.K. Smith (1991). To this can be added many other important references such as: Mitchell and Carson (1989), Freeman (1979), Cummings et. al. (1986), Bohm (1972) and Bishop and Haberlein (1979), Randall et. al. (1974), Sellar et. al. (1985, 1986) and Durden and Shogren (1988).

A convenient way to characterize different approaches to CVM is to consider providing individuals in hypothetical markets with different amounts of power. Suppose first that the individual had the ability to set the price for a good. We could ask the individual what price would he set or what he or she would be prepared to pay for the good. Some care needs to be exercised in interpreting the declared price as the maximum or minimum that would be paid. This declared price by the buyer is one approach to CVM for nonmarketed goods.

A second setting arises when there is some sharing of power by buyers and sellers in a market. Bargaining and negotiation (both of which take time and are thus costly) arise in markets for relatively and absolutely expensive goods and services. A range of prices will arise depending upon information, bargaining strength and preferences. The second form of CVM adapts the bargaining or bidding approach when interviewing individuals about the economic value they place on goods and services that are not marketed. The interviewer attempts to negotiate or determine the highest price that an individual would be prepared to pay. Since the interviewer is not usually giving up

anything, the negotiation process can be thought of as sharpening the attention of the individual being interviewed.

The final market setting arises when the buyer has no market power. This is closer to the competitive market model presented in economics textbooks. The buyer is presented with 'take-it-or-leave-it' prices by a seller. In the market simulated by some CVM studies, the individual being interviewed is presented with one price and asked if he or she would pay that amount of the nonmarketed good being studied. Variation in the amounts that surveyed individuals are willing to pay and in the acceptance decision at a given price serves to identify the preferences of the individuals and economic values of the good or services.

As a final point it is important to note that CVM researchers try to define and adopt best practice survey techniques. As well, the survey data is analyzed with a statistical techniques that continue to be improved and developed. Some recent developments can be found in Cameron (1988) and Cameron and James (1987). An excellent discussion of the process of analyzing the data and drawing conclusions from a CVM survey can be found in Kriström (1990).

Advantages of CVM

If the CVM technique is valid then it holds many potential advantages over the TCM approach. For example, the potential exists to focus questions on issues of quantity and quality and the associated economic value of nonmarketed goods. CVM can establish or estimate both user and nonuser values for nonmarketed goods. As long as the costs of sampling are not prohibitive there is much to be gained from being able to focus on issues by means of direct questions.

Potentially Resolvable Problems with CVM

CVM, because of its dependence on surveys and interviews, is potentially influenced by the biases that can arise in these types of data generating processes. The adoption and development of best practice techniques lessens these biases. As with TCM, no data set or statistical analysis will ever be fully ideal.

There are several types of bias that may arise. For example, a strategies bias exists if the respondent feels there is something to gain by choosing to answer other than truthfully. Even a truth-teller may be confused or misled by either a question or the process by which it is asked. The answer given may depend upon the type of survey . . . telephone, mail or, perhaps, direct contact. As a final example, answers may depend upon the market power attributed to those being interviewed and the interviewees interpretation of any hypothesized market structure.

Potentially Unresolvable Problems with CVM

There is one major issue here: Can we be assured that CVM is valid? Will it lead directly to reliable estimates of economic values? It is important to realize that this is not a question about bias in implementation of the survey. Rather, it concerns whether the economic decisions reported by surveyed individuals (in the absence of any biases) should be accepted as accurate estimates of what these individuals would in fact do if they were in a real market environment.

Some of the best insights into this problem can be found in comments prepared by one of our Nobel Laureates, K. Arrow (1986).

Professor Arrow is quick to cut to the heart of the issue. He asks what is the systematic methodology that allows the researcher to translate verbal responses to questions into assured actions? Alternatively, how do you translate CVM survey "words" into equivalent "deeds"? There is considerable scope for concern here because the necessary methodology seems to be absent in most other fields. For example, even though the theory (physics) of weather is well understood, this theory, according to Professor Arrow, is only mildly helpful in forecasting weather. Another example concerns new product launches. Only 50% of new products actually brought to market are successful. This is despite the best survey practices purchased by businesses and the collective experience of those associated with introducing the products.

It would appear that much can go wrong and much can be different in verbal answers as opposed to deeds. Even if we agree that CVM provides an accurate measure of how people **feel** at a point in time, it still must be demonstrated that, on average, they will do what they say. It is not at all clear that such a demonstration is possible. Suppose, for the moment that the survey provides the individual with all the objective information necessary to describe a nonmarketed good, service or resource and that the interviewee then answers a hypothetical valuation question. It would appear that all subsequent information received by the individual (say, on the availability of substitutes) and all subsequent events (such as expenditures on other goods and services) will tend to reduce the amount that an individual would actually spend. As an example of part of what can go wrong, suppose that a surveyed individual states that preserving a fish species is worth $100 to him or her. Suppose that the individual then agrees to and actually does make a contribution to **another** charity. There may be no money left for the fish species. It does not seem reasonable to continue to argue that the fish species is worth $100 to the individual. Regardless of the intent of the individual, the reality is that nothing may be spent in support of the resource. How can the CVM researcher take this into account in preparing an estimate of the economic value of a resource?

In summary, it would appear that the case has not yet been convincingly made that we have a good idea of the possible error bounds or confidence intervals around CVM estimates of economic values. As both Arrow and V.K. Smith note, it is further not clear

what can be concluded from the sometimes consistency of estimates between TCM and CVM approaches. Both approaches could be wrong. Professor Arrow notes that something may be learned from conducting CVM studies for marketed goods where independent direct estimates of values can be calculated and compared. V.K. Smith (1991) refers, however, to research by Pratt et. al. (1979) where it was found that even in competitive markets for 'marketed' goods, one observes ratios of maximum to minimum price paid ranging from 1.11 to 6.67. Economic data inherits considerable 'noise' from the activities of individuals in markets. As noted in the introduction to this paper, we must be very careful in framing our goals from applied research.

4. CONCLUSIONS

The foregoing sections lead to the conclusion that, notwithstanding the care that goes into the economic theory, the design of experiments and the theory and practice of statistical analysis, the confidence intervals around estimates of economic values are likely to be large. Professor Arrow suggests that we should not dismiss outright the notion of errors on the order of 3:1 or 5:1. Professor Arrow further suggests that this may not be unusual for most sciences. Economic reality, it would appear, only shows itself through a mist.

Two final issues should be raised in concluding this paper. First, as noted by V.K. Smith (1991), the valuation exercise does not conclude with a statistical analysis of the

determinants of economic value in a **sample** of individuals. The sample was taken as representative of a **population** of individuals. If we wish to determine the total economic value of a nonmarketed good or resource we must develop a methodology of translating our sample results to the population. This is a nontrivial problem that is certainly more complex than simply "grossing-up" the sample results. If we don't know the size and extent of the population then we do not know how, exactly, the sample relates to the population. As well, this is only one side of the market . . . the demand side. There is also a supply side. The total value of a good or resource also depends upon the extent to which substitute goods exist or could be created.

Finally, it is worth raising the issue of how or even if value estimates at a point in time can be used to forecast a future stream of values from the resource. Products and even industries regularly turn over or fail and goods and services come into and drop out of favour in irregular cycles. Even economic variables with a seeming 'regular' history prove very difficult to track let alone forecast. The problem of forecasting future economic values therefore remains a major challenge.

BIBLIOGRAPHY

Adamowicz W.L., Fletcher J.L. & Graham-Tomasi T. (1989), "Functional Form and the Statistical Properties of Welfare Measures", American Journal of Agricultural Economics, 7, (May 1989); pp. 414-421.

Adams R.D., Crocker T.D. & Thanavibulchai N. (1982), "An Economic Assessment of Air Pollution Damages to Selected Annual Crops in Southern California", Journal of Environmental Economics and Management, Vol. 9; pp. 42-58.

Anderson L.G. (1986), The Economics of Fisheries Management, The John Hopkins University Press, Baltimore and London.

Arrow K. (1986), Comments in Cummings et. al. (eds.), Valuing Environmental Goods, (Totawa, N.J.: Rowman and Allanheld).

Becker G. (1965), "A Theory of the Allocation of Time", The Economic Journal, 75 (299) pp. 493-517.

Bishop R.C. (1982), "Option Value: An Exposition and Extension", Land Economics, Vol. 58, No. 1; pp. 1-15.

Bishop R.C. & Heberlein T.A. (1979), "Measuring Values of Extra-Market Goods. Are Indirect Methods Biased?", American Journal of Agricultural Economics, 61; pp. 926-930.

Bishop R., Heberlein T. & Kealey M.J. (1983), "Contingent Valuation of Environmental Assets: Comparisons with a Simulated Market", Natural Resources Journal, Vol. 23, (July); pp. 619-633.

Bishop R., Heberlein T., Welsh M. & Baumgartner R. (1984), "Does Contingent Valuation Work? Results of the Sandhill Experiments", Department of Economics, University of Wisconsin, -mimeo-.

Bishop R. & Heberlein T. (1986), "Does Contingent Valuation Work?", in Cummings et. al. (eds.), Valuing Environmental Goods, (Totawa, N.J.: Rowman and Allanheld).

Boadway R.W. & Bruce N. (1984), Welfare Economics, Basil Blackwell, Oxford.

Bockstael N.E. & King C.L. (1988), "Valuing Environmental Quality: Weak Complementarity with Sets of Goods", American Journal of Agricultural Economics, 70 (August); pp. 654-662.

Bockstael N.E., Hanemann W.M. & Strand Jr. I.E. (1987b), Measuring the benefits of water quality improvements using recreation demand models, Vol. III Report to U.S. Environmental Protection Agency, Department of Agricultural and Resource Economics, University of Maryland.

Bockstael N.E. & Strand I.E. (1987), "The Effect of Common Sources of Regression Error on Benefit Estimates", Land Economics, (63); pp. 11-20.

Bockstael N.E., Strand Jr. I.E. & Hanemann W.M. (1987d), "Time and the Recreational Demand Model", American Journal of Agricultural Economics, 69 (May); pp. 293-302.

Bockstael N.E. & McConnell K.E. (1983), "Welfare Measurement in the Household Production Framework", The American Economics Review, 73;(4); pp. 806-814.

Bockstael N.E. & McConnell K.E. (1981), "Theory and Estimation of the Household Production Function for Wildlife Recreation", Journal of Environmental Economics and Management, (8); pp. 199-214.

Bohm P. (1984), "Revealing Demand for an Actual Public Good", Journal of Public Economics, 24, pp. 135-151.

Bohm P. (1972), "Estimating the Demand for Public Goods: An Experiment", European Economic Review, 3; pp. 111-130.

Bohm P. (1971), "An Approach to the Problems of Estimating Demand for Public Goods", Swedish Journal of Economics, (73), No. 1; pp. 94-105.

Bowes M.D. & Loomis J.B. (1980), "A Note on the Use of Travel Cost Models with Unequal Zonal Populations", Land Economics, (56); pp. 465-470.

Boyle K.J. & Bishop R.C. (1988), "Welfare Measurements Using Contingent Valuation: A Comparison of Techniques", American Journal of Agricultural Economics, 1, (1988); pp. 21-28.

Boyle K., Bishop R. & Walsh M. (1985), "Starting Point Bias in Contingent Valuation Bidding Games", Land Economics, Vol. 61; pp. 188-194.

Brookshire D.S., Thayer M.A. Schulze W.D. & d'Arge R.C. (1982), "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches", American Economic Review, 72; pp. 165-172.

Brookshire D., Randall A. & Stoll R. (1980), "Valuing Increments in and Decrements in Natural Resource Service Flows", American Journal of Agricultural Economics, Vol. 62, 3; pp. 478-488.

Brown Jr. G., and Mendelsohn R. (1984), "The Hedonic Travel Cost Method", Review of Economics and Statistics, 66, (August); pp. 427-433.

Brown G.M. & Pollakowski H.O. (1977), "Economic Valuation of Shorline", Review of Economics and Statistics, (5); pp. 272-278.

Brown J. & Rosen M. (1982), "On the Estimation of Structural Hedonic Price Models", Econometrica, Vol. 50; pp. 765-768.

Brown W.G., Sorkus C., Chou-Yong B. & Richards S. (1983), "Using Individual Observations to Estimate Recreational Demand Functions", American Journal of Agricultural Economics, 65 (February); pp. 154-157.

Burt O.R., & Brewer D. (1971), "Estimation of Net Social Benefits from Outdoor Recreation", Econometrica, 39 (September); pp. 813-828.

Caulkins P.P., Bishop R.C. & Bouwes N. (1985), "Omitted Cross-Price Variable Biases in the Linear Travel Cost Model: Correcting Common Misperceptions", Land Economics, 61 (May); pp. 182-187.

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 & Management, 15; pp. 355-379.

Cameron T.A. & James M.D. (1987), "Efficient Estimation Methods for Closed-End Contingent Valuation Surveys", Review of Economics and Statistics, 69; pp. 269-276.

Cesario F.J. (1987), "Value of Time in Recreation Benefit Studies", Land Economics, Vol. 52; pp. 32-41.

Cesario F.J. (1976), "Value of Time in Recreation Benefit Studies", Land Economics, (52); pp. 32-41.

Cesario F.J. & Knetsch J.L. (1970), "Time Bias in Recreation Benefit Estimation Models", Water Resources Research, (6); pp. 700-714.

Chipman J.S. & Moore J.C. (1980), "Compensating Variation, Consumer's Surplus, and Welfare", American Economic Review, 70, pp. 933-949.

Ciccheti C.J., Fisher A.C. & Smith V.K. (1976), "An Economic Evaluation of a Generalized Consumer Surplus Measure: The Mineral King Controversy", Econometrica, 44 (November); pp. 1259-1276.

Clawson M. (1959), Methods of Measuring the Demand for and Value of Outdoor Recreation. Reprint No. 10, Resources for the Future (February).

Clawson M. & Knetch J.L. (1966), Economics of Outdoor Recreation, Resources for the Future Inc., Washington, D.C.

Cornes R. & Albon R. (1981), "Evaluation of Welfare Change in Quantity-Constrained Regimes", Economic Record, 57, pp. 186-190.

Cropper M.L. (1981), "Measuring the Benefits from Reduced Morbidity", American Economics Review Papers and Proceedings, Vol. 71, No. 2; pp. 235-340.

Cuddington J.T., Johnson F.R. & Knetsch J.L. (1981), "Valuing Amenity Resources in the Presence of Substitutes", Land Economics (57); pp. 527-535.

Cummings R.G., Brookshire D.S. & Shultze W.D. (1986), Valuing Public Goods: The Contingent Valuation Method, Rowman and Allanheld Publishers, Totowa, N.J.

Cummings R.G., Brookshire D.S. & Shultze W.D. (1986), (Eds. and authors), Valuing Public Goods: A State of the Art Assessment of the Contingent Valuation Method, (Totawa, N.J.: Rowman and Allanheld).

Desvousges W.H., Smith V.K., & McGivney M.P. (1983), A Comparison of Alternative Approaches for Estimating Recreation and Related Benefits of Water Quality Improvements, US Environmental Protection Agency, Washington, D.C.

Diamond P.A. & McFadden D. (1974), "Some Uses of the Expenditure Functions in Public Finance", Journal of Public Economics, 3; pp. 3-22.

Dickie M., Fisher A. & Gerking S. (1987), "Market Transitions and Hypothetical Demand Data", Journal of the American Statistical Association, 82, p. 69-75.

Durden D. & Shogren J.F. (1988), "Valuing Non-Market Recreation Goods: An Evaluative Survey of the Literature On the Travel Cost and Contingent Valuation Methods", Review of Regional Studies, 18 (3), Fall 1988; pp. 1-15.

Duffield J. (1984), "Travel Cost and Contingent Valuation: A Comparative Analysis", in V.K. Smith and A.D. White (eds.), Advances in Applied Microeconomics, Vol. 3, Greenwich, Ct, JAI Press.

Dwyer J.F. & Bowes M.D. (1978), "Concepts of Value for Marine Recreational Fishing", American Journal of Agricultural Economics, (60); pp. 1008-1012.

Farrell M.J. (1957), "The Measurement of Productive Efficiency", Journal of the Royal Statistical Society, (Series A); pp. 120:253-281.

Freeman A.M. (1982), Air and Water Pollution Control: A Benefit-Cost Assessment, Wiley, New York; 1982.

Freeman A.M. (1979b), "Hedonic Prices, Property Values and Measuring Environmental Benefits", Scandinavian Journal of Economics, Vol. 81; pp. 154-173.

Freeman, A.M. (1979b), "The Benefits of Environmental Improvement, Theory and Practice, John Hopkins University Press, Baltimore.

Freeman A.M. (1974), "On Estimating Air Pollution Control Benefits from Land Value Studies", Journal of Environmental Economics and Management, Vol. 1, No. 1; pp. 74-83.

Gregory R. (1986), "Interpreting Measure of Economic Loss: Evidence from Contingent Valuation and Experimental Studies", Journal of Environmental Economics & Management, 13, pp. 325-337.

Halvorsen R. & Pollakowski H. (1981), "Choice of Functional Forms for Hedonic Price Equations", Journal of Urban Economics, Vol. 10; pp. 37-49.

Hammack J. & Brown G. (1974), Waterfowl and Wetlands: Toward Bioeconomic Analysis, John Hopkins University Press, Baltimore.

Hanemann W.M. (1989), "Welfare Evaluations in Contingent Valuation Experiments with Discrete Response Data: Reply", American Journal of Agricultural Economics, 71 (November); pp. 1057-1061.

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

Hanemann W.M. (1984b), "Discrete/Continuous Models of Consumer Demand", Econometrica, 52 (May); pp. 541-561.

Hanemann W.M. (1980), "Measuring the Worth of Natural Resource Facilities: Comment", Land Economics, 56 (November); pp. 482-486.

Haspel A.E. & Johnson F.R. (1982), "Multiple Destination Trip Bias in Recreation Benefit Estimation", Land Economics, 58 (August); pp. 364-372.

Hausman J.A. (1981), "Exact Consumer Surplus and Deadweight Loss", American Economic Review, 71 (September); pp. 662-676.

Heckman J. (1979), "Sample Selection as a Specification Error", Econometrica, (January) pp. 47:153-162.

Heckman James J. (1976), "The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables, and a Sample Estimator for Such Models", Annals of Economics and Social Measurement, (5); pp. 475-492.

Hicks J.R. (1956), A Revision of Demand Theory, Oxford England: Clarendon Press.

Hicks J.R. (1943), "The Four Consumer's Surpluses", Review of Economic Studies, 11; pp. 31-41.

Hicks J.R. (1945/6), "The Generalized Theory of Consumer's Surplus", Review of Economic Studies, 13, pp. 68-73.

Hoehn J.P. & Randall A. (1987), "A Satisfactory Benefit Cost Indicator from Contingent Valuation", Journal of Environmental Economics & Management, 14, pp. 226-247.

Hotelling H. (1947), "Letter to National Park Service", An Economic Study of the Monetary Evaluation of Recreation in the National Parks, U.S. Department of the Interior, National Park Service and Recreational Planning Division, 1949.

Johanson P.-O. (1987), The Economics Theory And Measurement of Environmental Benefits, Cambridge University Press, Cambridge.

Johanson P.-O., Kriström B. & Mäler K.G. (1989), "A Note on Welfare Evaluations with Discrete Response Data", American Journal of Agricultural Economics, 71, pp. 1054-1056.

Johanson P.-O, Kriström B. & Mäler K.G. (1989), "Welfare Evaluations in Contingent Valuation Experiments with Discrete Response Data: Comment", American Journal of Agricultural Economics, 71 (November); pp. 1054-1056.

Just R.E., Hueth D.L. & Schmitz A. (1982), Applied Welfare Economics and Public Policy. Prentice-Hall, Englewood Cliffs, New Jersey.

Kealy M.J. & Bishop R.C. (1986), "Theoretical and Empirical Specification Issues in Travel Cost Demand Studies", American Journal of Agricultural Economics, 69 (August); pp. 660-667.

Kling C.L. (1988), "The Reliability of Estimates of Environmental Benefits from Recreation Demand Models", American Journal of Agricultural Economics, 70; pp. 892-901.

Kling C.L. (1988), "Comparing Welfare Estimates of Environmental Quality Changes from Recreation Demand Models", Journal of Environmental Economic Management 15; pp. 331-340.

Knetsch J.L. (1964), "Economics of Including Recreation as a Purpose of Eastern Water Projects", Journal of Farm Economics, 46(5); pp. 1148-1157.

Knetsch J.L. & Sinden J.A. (1984), "Willingness to Pay and Compensation Demanded: Experimental Evidence of an Unexpected Disparity in Measures of Value", Quarterly Journal of Economics, 99; pp. 507-521.

Kopp R.J. & Smith V.K. (1989), "Benefit Estimation Goes to Court: The Case of Natural Resource Damage Assessments", Journal of Policy Analysis and Management, 8 (Fall); pp. 593-612.

Kriström B. (1990) "Valuing Environmental Benefits Using the Contingent Valuation Method: An Econometric Analysis", Umeå Economic Studies, No. 219, University of Umeå, Umeå, Sweden.

Kriström B. (1990) "A Non-Parametric Approach to the Estimation of Welfare Measures in Discrete Response Valuation Studies", Land Economics, 66, pp. 135-139.

Krutilla J. & Fisher A. (1975), The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources, John Hopkins University Press, Baltimore.

LaFrance J.L. & Hanemann W.M. (1989), "The Dual Structure of Incomplete Demand Systems", American Journal of Agricultural Economics, 71 (May); pp. 262-274.

Lee L.-F., and Pitt M.M. (1986), "Microeconomic Demand Systems with Binding Non-Negativity Constraints: The Dual Approach", Econometrica, 54 (November); pp. 1237-1242.

Leith B. & Smith J.B. (1992), "A New Approach to Hedonic Modelling: Valuing the Saskathewan Recreational Fisheries", (mimeo).

Loomis J.B. (1990), "Comparative Reliability of the Dichotomous Choice and Open-Ended Contingent Valuation Techniques", Journal of Environmental Economics & Management, 17, pp. 78-85.

Maler K-G. (1974), Environmental Econometrics, John Hopkins University Press, Baltimore.

McConnell K.E. (1985), "The Economics of Outdoor Recreation", Handbook of natural resources and energy economics, ed. A.V. Kneese and J.L. Sweeney. Amsterdam: North Holland.

McConnell K.E. (1979), "Values of Marine Recreational Fishing: Measurement and Impact of Measurement", American Journal of Agricultural Economics, 61; pp. 921-925.

McConnell K.E. (1975), "Some Problems in Estimating the Demand for Outdoor Recreation", American Journal for Agricultural Economics, 57 (May); pp. 330-334.

McConnell K.E. & Strand I.E. (1981), "Measuring the Cost of Time in Recreation Demand Analysis: An Application to Sport Fishing", American Journal of Agricultural Economics, 63; pp. 153-156.

McFadden D. (1981), "Econometric Models of Probabilistic Choice", In Structural analysis of discrete data, ed. C.F. Manski and D. McFadden. Cambridge: MIT Press.

McFadden D. (1976), "Quantal Choice Analysis: A Survey", Annals of Economic and Social Measurement, 5, pp. 363-390.

McFadden D. (1974), "Conditional Logit Analysis of Qualitative Choice Behavior", in Zarambka, P. (ed.), Frontiers of Econometrics, Academic Press, New York.

McKenzie G.W. (1979), "Consumer's Surplus without Apology: Comment", American Economic Review, 69, No. 3; pp. 465-468.

McKenzie G.W. & Pearce I.F. (1982), "Welfare Measurement - A Synthesis", American Economic Review, 72, pp. 669-682.

Mendelsohn R. (1984), "An Application of the Hedonic Travel Cost Framework for Recreation Modeling to the Valuation of Deer, Advances in applied micro-economics, Vol. 4, ed. V.K. Smith and A.D. Write, Greenwich, CT:JAI Press.

Milon J.W. (1989), "Contingent Valuation Experiments for Strategic Behavior", Journal of Environmental Economics & Management, 17, pp. 293-308.

Mitchell R.C. & Carson R.T. (1989), Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington, D.C.

Mitchell R.C. & Carson R.T. (1985), "Option Value: Empirical Evidence from a Case Study of Recreation and Water Quality: Comment", Quarterly Journal of Economics, 100; pp. 291-294.

Morey E.R. (1981), "The Demand for Site Specific Recreational Activities: A Characteristic Approach", Journal of Environmental Economics and Management, 8; pp. 345-371.

OECD (1989), "Environmental Policy Benefits: Monetary Valuation", Organization for Economic Cooperation and Development, (OECD); Paris.

Pearce D.W. (1976), "The Limits of Cost-Benefit Analysis as a Guide to Environmental Policy", Kyklos, Vol. 29; pp. 97-112.

Polinsky, A.M. & Rubinfield D.L. (1977), "Property Values and the Benefits of Environmental Improvements: Theory and Measurement", Public Economics and

the Quality of Life, ed. Lowdon Wingo and Alan Evans, Baltimore: Johns Hopkins University Press.

Pollack R.A. & Wachter M. (1975), "The Relevance of the Household Production Function and its Implication for the Allocation of Time", Journal of Political Economy, 83; pp. 255-277.

Pratt J.W., Wise D.A. & Zeckhauser R. (1979), "Price Differences in Almost Competitive Markets", The Quarterly Journal of Economics, 93 (May); pp. 189-212.

Randall A. (1984), "Theoretical Bases of Non-market Benefit Estimation", Valuation of Wildland Resource Benefits, G.L. Peterson and A. Randell, editors, Westview Press, Boulder, Colo.

Randall A. & Stoll J.R. (1980), "Consumer Surplus in Commodity Space", American Economic Review, 70, pp. 49-55.

Randall A., Ives C.B. & Eastman C. (1974), "Bidding Games for Evaluation of Aesthetic Environmental Improvements", Journal of Environmental Economics and Management, 1, No. 2; pp. 132-149.

Rosen S. (1974), "Hedonic Prices and Implicit Markets: Product (Differentiation in Pure Competition", Journal of Political Economy, 82 (January) pp. 34-55.

Rosenthal D.H. (1987), "The Necessity for Substitute Prices in Recreation Demand Analyses", American Journal of Agricultural Economics, 69; pp. 828-837.

Rowe R., D'Arge R.C. & Brookshire D.S. (1980), "An Experiment on the Economic Value of Visibility", Journal of Environmental Economics and Management, 7, pp. 1-19.

Samples K.C. & Bishop R.C. (1985), "Estimating the Value of Variations in Anglers' Success Rates: an Application of the Multiple-site Travel Cost Method", Marine Resource Economics, 2; pp. 55-74.

Samuelson P.A. (1947), Foundations of Economic Analysis, Cambridge, Mass.: Harvard Press.

Schultze, W.D. et. al. (1981), "Valuing Environmental Commodities: Some Recent Experiments", Land Economics, 57(2); pp. 151-172.

Sellar C., Stoll J.R. & Chavas J.-P. (1986), "Specification of the Logit Model: The Case of Valuation of Nonmarket Goods", Journal of Environmental Economics and Management, 13; pp. 382-390.

Sellar C., Stoll J.R. & Chavas J.-P. (1985), "Validation of Empirical Measures of Welfare Change: A Comparison of Non-Market Techniques", Land Economics, 61, pp. 156-175.

Shaw D. (1988), "On-Site Samples Regression: Problems of Non-Negative Integers, Truncation, and Endogenous Stratification", Journal of Econometrics, 37 (February); pp. 211-224.

Silberberg E. (1978), The Structure of Economics: A Mathematical Analysis, New York: McGraw-Hill Book Company.

Silberberg E. (1972), "Duality and the Many Consumer's Surpluses", American Economic Review, 62; pp. 942-952.

Smith, V.K. (1991), "Is Nonmarket Valuation of Environmental Resources Sustainable?", mimeo.

Smith V.K. (1990a), "Estimating Recreation Demand Using the Properties of the Implied Consumer Surplus", Land Economics, 66 (May); pp. 111-120.

Smith V.K. (1989), "Taking Stock of Progress with Travel Cost Recreation Demand Methods: Theory and Implementatiion", Marine Resource Economics, Vol. 6; pp. 279-310.

Smith V.K. & Kaoru Y. (1990a), "Signals or Noise: Explaining the Variation in Recreation Benefit Estimates", American Journal of Agricultural Economics, 72 (May); pp. 419-433.

Smith V.K., Palmquist R.B. & Jackus P. (1990); "Combining Farrell Frontier and Hedonic Travel Cost Models for Valuing Estuarine Quality", mimeo.

Smith V.K. & Kaoru Y. (1987), "The Hedonic Travel Cost Model: A View from the Trenches", Land Economics, 63 (May); pp. 179-192.

Smith V.K. & Desvousges W.H. (1986), Measuring Water Quality Benefits, Boston: Kluwer-Nijhoff.

Smith V.K., Desvousges W.H. & Fisher A. (1986), "A Comparison of Direct and Indirect Methods for Estimating Environmental Benefits", American Journal of Agricultural Economics, May; pp. 280-290.

Smith V.K. & Desvousges W.H. (1985), "The Generalized Travel Cost Model and Water Quality Benefits: A Reconsideration", Southern Economics Journal, 52 (October); pp. 371-381.

Smith V.K. & Desvousges W.H. (1983), "The Opportunity Cost of Travel Time in Recreation Demand Models", Land Economics, 59 (August); pp. 259-278.

Smith V.K., Desvousges W.H. & McGivney M.P. (1983), "Estimating Water Quality Benefits: An Econometric Analysis", Southern Economic Journal, October, pp. 422-437.

Thayer M. (1981), "Contingent Valuation Techniques for Assessing Environmental Impacts: Further Evidence", Journal of Environmental Economics and Management, Vol. 8; pp. 27-44.

Vaughan W.J. and Russell C.S. (1982), "Valuing a Fishing Day: An Application of a Systematic Varying Parameter Model", Land Economics, 58 (November); pp. 450-463.

Willig R.D. (1978), "Incremental Consumer's Surplus and Hedonic Price Adjustment", Journal of Economic Theory, 17, pp. 227-253.

Willig R.D. (1976), "Consumer Surplus Without Apology", American Economic Review, 66, pp. 589-597.

Wilman E.A. (1987), "A Simple Repackaging Model of Recreational Choices", American Journal of Agricultural Economics, 69 (August); pp. 603-612.

Wilman E.A. (1980), "The Value of Time in Recreation Benefit Studies", Journal of Environmental Economics and Measurement, 7 (September); pp. 272-286.

Zimer R.E., Musser W.N. & Hill R.C. (1980), "Recreation Demand Equations: Functional Form and Consumer Surplus", American Journal of Agricultural Economics, 62; pp. 136-141.