United States
Environmental Protection
Agency

Office of
Policy Analysis
Washington DC 20460

EPA-230-05-83-001
March 1983

EPA

A Comparison of Alternative Approaches for Estimating Recreation and Related Benefits of Water Quality Improvement

"The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under Contract No. 68-01-5838. It has been subject to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use."

March 1983

A Comparison of Alternative Approaches for Estimating Recreation and Related Benefits of Water Quality Improvements

Prepared for

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EPA Contract No. 68-01-5838

PREFACE

This research project was initiated and supported under work agreement 68-01-5838 by the Benefits Staff in the Office of Policy Analysis at the U.S. Environmental Protection Agency (EPA).

Throughout this research effort, the authors of this report were fortunate enough to take advantage of research activities already in progress. One author had partially completed an analysis of the problems of defining and measuring option value, for example, and another had partially completed research to design a generalized travel cost site demand model. In addition, the authors also benefited from free access to any array of related working papers—many of which have subsequently been published—that improved the final research design beyond that possible otherwise. Finally, access to an independently developed estimator for ranked data improved the authors' ability to make certain types of comparisons for the contingent ranking component of the survey. Although none of these complementary activities was contemplated when the project was initially proposed, each has played a substantial role in the final results. We would not expect these same circumstances to be easily replicated in future projects of comparable scale and duration.

This final report has been substantially improved through the constructive comments of many reviewers. In particular we would like to thank Ann Fisher, the EPA project officer, for her careful commentary and continuous support. In addition, as part of the EPA's review, six other individuals furnished detailed comments:

Richard Bishop, University of Wisconsin
Rick Freeman, Bowdoin College
Bill Lott, University of Connecticut
Robert Mitchell and Richard Carson, Resources for the Future (RFF)
Bill Schulze, University of Wyoming.

In addition, useful comments were also received from the following individuals:

Tayler Bingham, Research Triangle Institute (RTI)
Peter Caulkins, U.S. EPA
Warren Fisher, U.S. Fish and Wildlife Service
David Gallagher, University of New South Wales
Debbie Gibbs, Bureau of Reclamation
Jerry Hausman, Massachusetts Institute of Technology
Reed Johnson, U.S. Naval Academy and U.S. EPA
John Loomis, U.S. Forest Service
Glenn Morris, RTI
Doug Rae, Charles River Associates
Liz Wilman, RFF.

The authors also have benefited from the comments of participants at presentations given at RFF; Vanderbilt University; the University of Missouri–Rolla; Dillon, Colorado (Visual Values Workshop); Research Triangle Park (Triangle Econometrics Seminar); and Washington, D.C. (EPA). We are most grateful for all these efforts. Finally, we are most appreciative of the efforts of our editor, Hall Ashmore, and of Jan Shirley, Supervisor of RTI's Word Processing Center.

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CHAPTER 1

INTRODUCTION, OBJECTIVES, AND SUMMARY

1.1 INTRODUCTION

This Research Triangle Institute (RTI) report to the U.S. Environmental Protection Agency (EPA) compares alternative approaches for estimating the recreation and related benefits of water quality improvements. The results provide information on the performance of various ways to estimate the benefits of environmental quality improvements, so EPA can use such methods in preparing the regulatory impact analyses required by Executive Order 12291 and in evaluating other regulatory proposals. This report is also relevant to the proposed revision of the Federal water quality standards regulations, which recommends that States consider incremental benefits and costs in setting their water quality standards. Site-specific water quality standards are likely to play an important role in future water policy issues because they bring together the crucial elements of appropriate stream uses and advanced treatment requirements for municipalities and industries. Benefit-cost assessments can yield valuable information for these decisions.

Evaluations of benefits and costs depend on a determination of the links between regulatory policy, technical effects, and behavioral responses. Figure 1-1 illustrates one set of linkages--in this case for the proposed water quality standards regulations. This report addresses the last component of Figure 1-1, which involves estimating monetized benefits for regulatory policy. One of the difficulties in such a task arises from the absence of organized markets for many of the services derived from water resources.

The benefits of water resource regulations are usually measured with one of three types of approaches: (1) market-based approaches, which use indirect linkages between the environmental goods and some commodities exchanged in markets; (2) contingent valuation approaches, which establish an institutional framework for a hypothetical market; and (3) public referenda. This report considers the first two approaches; the last is omitted since it is beyond EPA's mandate.

Some opponents argue that benefit-cost analysis is invalid because it cannot measure all of the benefits of environmental regulations. Nevertheless, this report describes the measurement of several benefits from water quality improvements, including some regarded as unmeasurable in earlier environmental benefits research efforts. Specifically, as highlighted in Figure 1-2, this study considers both the recreation benefits that accrue to users of a recreation site and the intrinsic benefits* that accrue to both users and nonusers.

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*This classification modifies the one in Mitchell and Carson [1981].

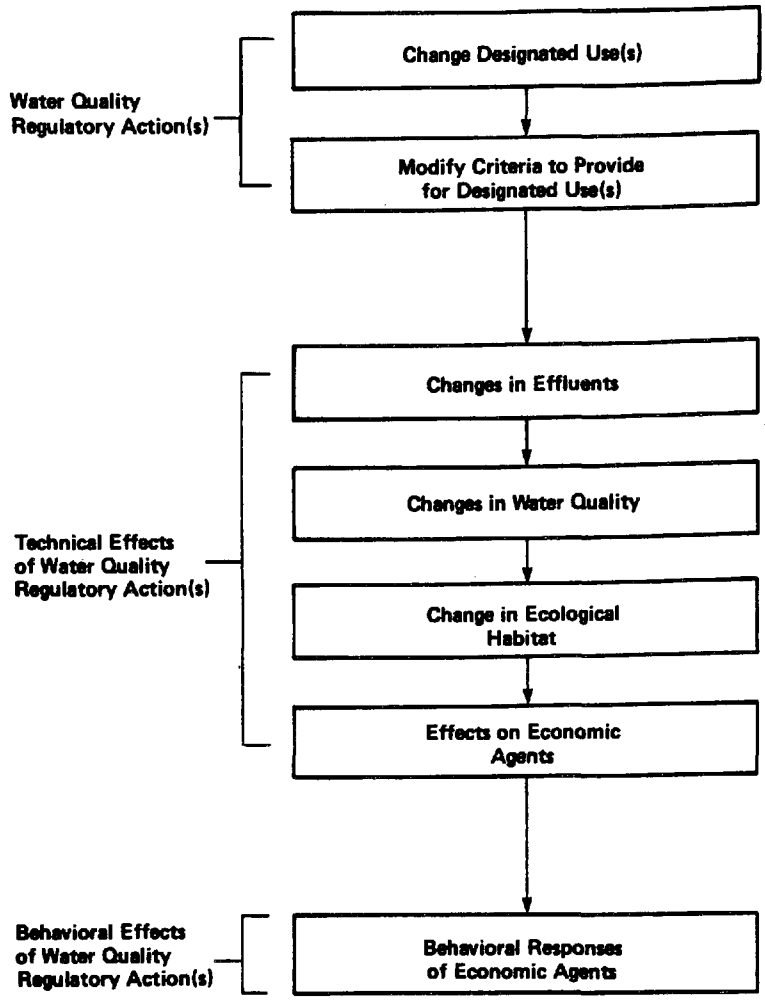

Figure 1-1. Effects and responses to water quality regulatory actions.

User benefits arise from recreation uses of the river and are measured by users' willingness to pay for the water quality levels necessary to permit these recreation uses. That is, the valuation depends on the use of the river. In this case, clean water in a river is worth something because recreationists are going to fish, boat, swim in, or picnic along the river.

Intrinsic benefits consist of two value types: option value and existence value. Relevant to both current users and potential future users, option value is the amount an individual would be willing to pay for improved water quality (over his expected user values) to have the right to use the river in the future when there is uncertainty either in the river's availability at a particular quality level or in his use of it (with the river meeting specified water quality conditions). For example, if an individual might use the river, but is not sure he will, he may pay some amount each year for the right (or option) to use it (with the river meeting specified water quality conditions). Under some conditions, this payment, the option price, will exceed his expected consumer surplus--the value he would derive from anticipated use. This excess--the amount that the option price exceeds the expected consumer surplus--is defined as the option value.

Potential Water Quality Benefits	Current User Benefits	Direct Use	In Stream	Recreational* – fishing, swimming, boating, rafting, etc. Commercial – fishing, navigation
			Withdrawal	Municipal – drinking water, waste disposal Agricultural – irrigation Industrial/Commercial – cooling, process treatment, waste disposal, steam generation
		Indirect Use	Near Stream	Recreational* – hiking, picnicking, birdwatching, photography, etc. Relaxation* – viewing Aesthetic* – enhancement of adjoining site amenities
	Intrinsic Benefits	Potential Use	Option*	Near-term potential use Long-term potential use
		No Use	Existence*	Stewardship – maintaining a good environment for everyone to enjoy (including future family use—bequest) Vicarious consumption – enjoyment from the knowledge that others are using the resource.

* Considered in this project.

Figure 1-2. A spectrum of water quality benefits.

Existence value, on the other hand, is an individual's willingness to pay for the knowledge that a resource exists. That is, an individual--either a user or a nonuser--might be willing to pay something to maintain a high level of water quality at a recreation site in a particular area, even though he will not use it, so that his children may have future use of the site or simply to know that the ecosystem at the site will be maintained.

This study's comparison of alternative benefits measurement approaches estimates user values by the travel cost approach (indirect method), by four different ways of eliciting option price in a contingent valuation experimental design (direct method), and by a contingent ranking of water quality outcomes and option price amounts. The central comparison evaluates whether there are differences between approaches because "true" values for each of these types of benefits are unknowns. In addition, since the other methods are not suitable for measuring them, option and existence values are compared only in terms of alternative ways for posing the hypothetical questions.

A distinguishing feature of this project is its use of a case study of the Pennsylvania portion of the Monongahela River as the point of reference for

both the comparison of approaches and the estimation of option and existence values. The Monongahela is representative of a number of rivers in the country, has multiple uses, and has recently been the focus of effluent guidelines for the iron and steel industry. The survey design for the Monongahela, calling for a household survey, is a middle ground between the macro approach for estimating benefits of water pollution controls (see Mitchell and Carson [1981]) and the user orientation of many micro contingent valuation efforts (see Schulze, d'Arge, and Brookshire [1981]). The design uses a representative sample of households for the region and, similar to Mitchell-Carson, includes both user and intrinsic benefits. It also is a specific application, considering individuals' willingness to pay for a specific river basin's water quality.

1.2 OBJECTIVES

The potential implications of this study for water policy dictated clearly defined objectives and a project design to achieve them. The overall objective of this project was to conduct a study comparing alternative approaches for estimating the recreation and related benefits of different water quality levels. In particular, the study sought to measure user, option, and existence values for the Pennsylvania segment of the Monongahela River and to estimate the recreation and related benefits that would be derived from providing different use classifications (fishable, swimmable, boatable) for this river segment.

In addition to meeting its own specific objectives, an environmental benefits research project ideally would fit the needs of those involved in the evaluation of public policy questions and the needs of the research community in general. Since the most important direct use of natural environments is for water-based recreation (see Freeman [1979a]), this project's general research area considers one of the primary components of environmental benefits research. In addition to its water quality orientation, the project is also relevant to two areas Freeman identified for future research:

> I think that a major research effort should be made to select an appropriate area and water bodies for a study, to develop a properly specified model, and to gather the necessary data. Until such an effort is made, the practicality of the Clawson-Knetsch [1966] [travel cost] technique for estimating recreation benefits will remain an open question. [p. 256]

> There should be carefully conducted experiments with the survey techniques for estimating willingness to pay for reduction in pollution. These experiments should be coordinated with studies based on other analytical techniques in an effort to provide a cross-check or validation of benefit estimates obtained by different approaches. [p. 265]

1.3 SUMMARY OF RESULTS

This section summarizes the major findings of the research. The findings are presented for individual approaches and for the comparison between approaches.

1.3.1 Overview

The results of this project strongly support the feasibility of measuring the recreation and related benefits of water quality improvements. Moreover, the benefits measurement approaches--several contingent valuation formats and the travel cost method--show consistent results for comparable changes in water quality. Indeed, the range of variation is generally less than that expected in models used to translate the effects of effluents in a water body into the corresponding water quality parameters. In addition, the results also clearly show that the intrinsic benefits of water quality improvements--especially option values--can be measured and that they are a sizable portion--greater than half--of the total recreation and related benefits total.

1.3.2 Contingent Valuation Approach

Based on the results of the Monongahela River case study, the general prognosis is good for the continued use of the contingent valuation approach to estimate the benefits of water quality improvements. Statistical analysis using regression methods to evaluate the determinants of the variation in the option price bids gave little indication that individual interviewers influenced the results. The consistently plausible signs and magnitudes of key economic variables suggest that the respondents perceived the survey structure as realistic and did not experience problems with the hypothetical nature of some of the questions. These findings were realized despite the fact that the sample included households whose socioeconomic profile was comparable to demographic groups that were found to be more difficult respondents in past contingent valuation surveys. On average, the respondents were older, less educated, and poorer than those in the most successful contingent valuation studies.

The contingent valuation estimates of the option price for water quality improvements, which include user and option values, are consistently plausible across the various analytical approaches, with estimates for the combined water quality levels ranging from roughly $50 to $120 per year per household sampled in the Monongahela River basin. Nonetheless, the empirical results do indicate that the methods used to elicit the willingness-to-pay amount have a statistically significant effect on the estimates of willingness to pay. For example, both the direct question with a payment card and the bidding game with a $125 starting point produced higher willingness-to-pay estimates than either the direct question without an aid or the bidding game with a $25 starting point. Thus, there is some evidence of starting point bias in the bidding game, but the statistical analyses are not conclusive. The results comparing the two bidding game methods as a set (i.e., those with $25 and $125 starting points) with the nonbidding games (direct question and payment card combined) indicated no differences between these two sets of approaches.

The findings provide clear support for a positive, statistically significant, and sizable option value for water quality improvements along the Monongahela River. The estimated option values for loss of the use of the area in its current condition (i.e., boatable) range from approximately $15 to $60 per year per household, and the option values for improving water quality to a swimmable level range from approximately $20 to $45 per year per household. Thus, option value is a substantial fraction of the user's option price, and the value of this change in water quality generally exceeds user values.

The survey also provided estimates of existence values. Unfortunately, respondents did not necessarily understand the distinction sought. Many bid the same amounts as they had earlier on the option price for a comparable change in water quality. It is not clear whether these responses were deliberate or a reflection of misunderstanding of the questions. Thus, while the findings suggest that these values are positive and statistically significant, prudence requires they be interpreted cautiously.

Of course, it should also be acknowledged that the available estimates of intrinsic values are quite limited. Most can be criticized for problems in the research design, including possible flaws in the survey. The design of the Monongahela River study relies on the use of a schematic classification of the sources of an individual's valuation of the river (i.e., a card showing different types of values) in eliciting a division of user and other benefits. Because this is the first application of this device, it was not possible to evaluate its effectiveness.

In addition to the more widely used bidding game and direct question formats for contingent valuation experiments, the Monongahela River basin survey also applied the contingent ranking format. This format requires only that individuals rank combinations of water quality levels and option prices and uses a statistical procedure (ranked order logit)* to estimate willingness to pay. While other contingent valuation formats require that individuals directly provide willingness to pay, contingent ranking asks them to rank hypothetical outcomes. In effect, it asks a simpler task of the respondent--only to rank outcomes--but requires more sophisticated and less direct techniques to estimate the value of the outcomes.

Since use of the contingent ranking format to estimate the benefits of environmental quality improvements is quite new, the behavioral model underlying its estimation procedures is also early in its development. Although this project provides a description of these underpinnings, its evaluation of the theoretical properties and practical issues is incomplete. Overall, the findings of this study suggest that, even though the behavioral models used to derive benefits estimates with the contingent ranking format were somewhat arbitrary, the results from the ranking format closely parallel other contingent valuation estimates.

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*In more technical terms, the procedure uses a specification for the indirect utility function together with a maximum likelihood estimator.

The mean estimates derived from the contingent ranking format--roughly $60 annually per household for improving water quality in the Monongahela to fishable and approxiamtely $50 more annually for improving it to swimmable--appear larger than those derived with other contingent valuation formats. However, these differences are not statistically significant. In addition, the benefit estimates from all contingent valuation formats are comparable across individuals, with the primary differences between contingent ranking and other methods stemming from the questioning format used in the other methods.

1.3.3 Travel Cost Approach

This study also developed and used a generalized travel cost model to predict the recreation benefits of water quality improvements at recreation sites.

The travel cost model assumes that site features or attributes affect both an individual's ability to participate in recreation activities at any particular site and the quality of his recreation experiences at the site. In considering the demand for a recreation site as a derived demand, the common sense rationale of the model suggests that a recreation site's features or attributes will influence the demand for its services. Since the level of water quality is a site attribute, a basis is established for relating water changes to shifts in demand for a recreation site's services.

The generalized model was estimated from data on 43 water-based recreation sites in the Federal Estate Survey component of the 1977 National Outdoor Recreation Survey. This survey provided information on recreation use patterns at each site during a single season. Based on sample sizes for each site that ranged from approximately 30 to several hundred respondents, the survey described individuals' recreation behavior, socioeconomic characteristics, travel time necessary to reach the site, residential location, and a variety of other factors.

Several advantages of this travel cost model include:

- Deriving individual estimates for the time associated with traveling to the site as well as the roundtrip distance for each trip.
- Using the opportunity cost of time to evaluate travel time and estimating opportunity cost for each individual based on his characteristics, including age, education, race, sex, and occupation.
- Considering for each site the potential effects of individuals' differences in onsite time per visit.

The generalized model was used to estimate the benefits for users of the Monongahela River, as identified in the survey of the basin. The travel cost model predicted a value of $83 per year per user household if a decrease in

water quality is avoided and a value of $15 per year for each user household if water quality is improved to a swimmable level.

Several features of the generalized travel cost model are of particular importance: it provides a framework for estimating the value of water quality improvements for a substantial range of sites, and its site-specific orientation is especially relevant for water quality standards applications. Finally, it includes the effect of key site features--like access and facilities--and can use data frequently available in the public domain.

1.3.4 Approach Comparison

One of the primary objectives of this research has been to compare available approaches for measuring the benefits of water quality improvement. Such a comparison--reflecting the assumptions inherent in each approach--will show the plausibility of the required assumptions as descriptions of real-world behavior and constraints. However, since the "true" value of water quality improvement benefits is unknown, a comparison cannot be interpreted as a validation of any one approach. On the other hand, an evaluation of the comparability of estimates across approaches that considers the reasons for their consistencies and differences provides a basis for an improved use of benefit methodologies. Consistency also would give increased flexibility in matching a method to available data for each particular application.

Based on the research for the Monongahela River basin case study, the comparison between the travel cost and contingent valuation approaches is the most interesting. Estimates of benefits from water quality improvement are compared for the 69 users identified in the survey of households in the basin area. Previous comparisons of approaches relied on the use of mean estimates from each method. When these means are compared, it is assumed that all individuals can be treated as drawing from populations with the same mean benefits. Differences in individuals or error in the pairing of means can lead to a confounding of the benefit comparisons. In contrast, this study compared each household's user value, derived from the contingent valuation survey, with the corresponding estimate for that household from the travel cost model. Thus, this study gives a more controlled comparison than was possible in earlier studies.

Table 1-1 shows the mean benefit estimates of user values for the travel cost and contingent valuation approaches. On theoretical grounds, the contingent valuation estimates of compensating surplus should be less than the travel cost estimates based on ordinary consumer surplus, but the differences should be slight due to the small income effects found in the research. However, this is not the case for three out of four contingent valuation estimates for <u>improvements</u> in water quality. Only the estimates derived with the $25 bidding game format are less than the travel cost estimates, although the travel cost estimates are within the range of contingent valuation estimates. For the loss of the area, the means comparison conforms to theoretical expectations, with the travel cost estimates larger than the contingent valuation estimates. Most of the differences between approaches exceed the size expected from theory. At best, simple comparisons of mean estimates--augmented by <u>a priori</u> information--are rough judgments of plausibility. On the basis of this compar-

Table 1-1. A Comparison of Mean Benefit Estimates (1981 Dollars)[a]

Approach	Water quality change[b]		
	Loss of area	Boatable to fishable	Boatable to swimmable
Contingent valuation			
Direct question	19.71 (17)	21.18 (17)	31.18 (17)
Payment card	19.71 (17)	30.88 (17)	51.18 (17)
Iterative bidding ($25)	6.59 (19)	4.21 (19)	10.53 (19)
Iterative bidding ($125)	36.25 (16)	20.31 (16)	48.75 (16)
Generalized travel cost	82.65 (94)	7.01 (94)	14.71 (94)

[a]The travel cost estimates were converted from 1977 to 1981 dollars using the consumer price index for December 1981, the last month of the survey.

[b]The numbers in parentheses after the means are the number of observations on which each of these estimates was based. The number for the travel cost estimates exceeds the sum of the sample size for the contingent valuation results because some users visited more than one Monongahela River site.

ison, however, the Monongahela River basin estimates are plausible, but not precise.

A more discriminating comparison of the travel cost and contingent valuation approaches, one that judges how the two approaches compare across individuals, is also possible with the Monongahela River basin benefit estimates. In this comparison, presented in Table 1-2, the contingent valuation measure of user value was regressed on the travel cost estimate (see Chapter 8 for details). The a priori expectations of comparability in methods can be structured as two statistical tests. These models also take account of the effect of question formats used in the contingent valuation survey.

The results from the regression tests generally reinforce the earlier conclusions based on comparing the means estimated from each method. Several additional conclusions are possible from these comparisons:

- The contingent valuation estimates of water quality improvements overstate willingness to pay--in contrast to the theoretical expectations--but the results do not permit a judgment of statistically significant differences between the two sets of estimates. Some caution is required, however, because the properties of the statistical tests are approximate.

- The travel cost model overstates--by an amount greater than theory would predict--willingness to pay for the loss of the area, and the estimates are not comparable to the contingent valuation estimates.

Table 1-2. Regression Comparisons of Contingent Valuation and Travel Cost Benefit Estimates[a]

Independent variables	Water quality change		
	Loss of area	Boatable to game fishing	Boatable to swimming
Intercept	21.86 (1.37)	33.99 (1.90)	59.57 (2.02)
Travel cost-benefit estimate	0.33 (1.17) (-4.36)[b]	-3.67 (-1.20) (-1.71)[b]	-2.71 (-1.14) (-1.79)[b]
Qualitative variables			
Payment card	-32.64 (-2.55)	51.76 (2.64)	77.01 (2.36)
Direct question	-14.60 (-1.27)	12.96 (0.75)	21.00 (0.73)
Iterative bid ($25)	-31.82 (-2.55)	-11.24 (-0.60)	-21.82 (-0.69)
R^2	0.10	0.12	0.11
F	2.42 (0.05)[c]	3.00 (0.02)[c]	2.62 (0.04)[c]

[a]The numbers below the estimated coefficients are t-ratios for the null hypothesis of no association.

[b]These statistics are the t-ratios for the hypothesis equivalent to unity for the slope coefficient for Ordinary Consumer Surplus (OCS) after adjustment is made for the fact that Compensating Surplus (CS) is measured in 1981 dollars and OCS in 1977 dollars.

[c]The number in parentheses below the reported F-statistic is the level of significance for rejection of the null hypothesis of no association between the dependent and independent variables.

- The comparative performance of the contingent valuation approach in relationship to the travel cost method is sensitive to differences in question format--with the clearest distinctions found between the payment card and the bidding game with the $125 starting point.

- The explanatory power of the models used in the comparison are not high, but the null hypothesis of no association between methods is clearly rejected at high levels of significance (based on the F-tests reported at the bottom of the table).

1.3.5 Considerations for Future Research

The findings of this project also suggest that there are a number of areas for future benefits research, including both general and specific issues--especially those concerned with particular benefits measurement approaches.

General Issues

Option and existence values remain the most difficult general issues to address adequately. The research design for this project relied on the individual to divide the hypothetical option price payment into its user and option value components and then to add existence values to these option price bids as an incremental premium. Other studies (Brookshire, Cummings, et al. [1982] and Randall, Hoehn, and Tolley [1981]) have elicited preservation values--including both option and existence values--as additions to user values. Mitchell and Carson [1981] found user values by subtracting non-user's option price payments from user option price payments. Regardless of the procedures, however, all these studies have found option and existence values to be substantial--greater than half of the total benefits of environmental improvements. The choice among elicitation procedures remains an open question.

One question that arises from the results of this and other recent studies of intrinsic benefits is, "Why worry about measuring option value when it is possible to elicit option price bids that include it?" Empirical estimates are of interest because of the controversy over the sign and magnitude of option value that has arisen in the theoretical literature. In addition, many practical applications of benefit methods do not measure intrinsic benefits, suggesting a need for empirical estimates to gauge the extent of the omitted portion of benefits from particular environmental policies. The early theoretical work seemed to imply (without explicitly stating this conclusion) that option values would be small in comparison to user values. Recent theoretical work by Freeman [1982] makes a case for positive option values and confirms this presumption by suggesting that option values should be small under almost all conditions. Only by attempting to distinguish between option and other intrinsic values will it be possible to bring some empirical evidence to bear on this question.

Proportional relationships between user and intrinsic values from earlier studies have often been used in attempts to infer the size of the omitted benefits when the intrinsic values are not directly estimated. The limited resources available for many public policy evaluations is the primary reason for the widespread use of the proportional approach. Since it is unlikely that these constraints on evaluations will ease in the future, more empirical research on the use and size of these proportions might be productive. For instance, determining how (and if) the proportions differ for certain classes of assets--ranging from unique natural environments to waterbodies with numerous substitutes--would provide useful guidance for applying these proportions. Moreover, attempting to distinguish between option and existence values for different classes of environmental assets may indicate the feasibility--and need--for such distinctions (see Fisher and Raucher [1982] for a review).

The research in this project has skirted another important issue--benefits aggregation. The travel cost model used in this project predicts recreation site benefits for "the representative" user. By assuming that all sites are possible substitutes (because one site's attributes can be "repackaged" to be equivalent to any other site), it implicitly maintains a simplistic view of the relationship between recreation sites within a region. Individuals always select the site providing the desired mix of attributes at the lowest implicit price. Clearly, not all sites adhere to these relationships. For example, a historical monument at the site may make it unique. What is needed is a more general characterization that would accommodate sites not conforming to the aggregation rule used to relate effective site services to site attributes. Such a framework would explain the relationship between an individual's patterns of site usage for facilities permitting very different types of recreation activities (e.g., water-based recreation versus skiing). Nevertheless, consistent regional and national benefit estimates will require a careful description of the interrelationships between the individual's demands for different types of recreation sites.

Another unresolved issue involves regional aggregation of local benefits estimated with the contingent valuation approach. Conventional practice in statistical surveys is to use statistical weights, which reflect the probability of selecting a particular sampling unit, to estimate aggregate benefits for the representative population (see Mitchell and Carson [1981]). However, this approach raises fundamental problems with the conventional practice in economic modeling that assumes common (and constant) parameters across individuals for correctly specified behavioral models. The definition of a representative sample is often based on a description of statistical models, leading to observed data that are at variance with conventional economic modeling. More research following the work of Porter [1973] is needed to consider the relevance of this issue for the extrapolation of contingent valuation estimates.

Another general research issue involves comparing alternative benefit estimation approaches. This project's comparison, which examines benefits predicted with the generalized travel cost model and contingent valuation willingness-to-pay estimates for the same individuals, permitted a fairly direct comparison of estimates with theoretical bounds. However, this study used estimates from only 69 users of the Monongahela River. A comparison having a larger number of users and based on a water-based recreation site with a greater diversity of users would provide a more revealing comparison. Indeed, following Bishop and Heberlein, attempts to compare simulated market results with the results of this project also may shed light on the relationships among the estimation approaches. Before these comparisons are made, however, more systematic attention should be given to the theoretical underpinnings of the approaches, following the work of Schulze et al. [1981], Smith and Krutilla [1982], and Bockstael and McConnell [1982].

Future research should also reconsider the economic principles underlying comparisons of economic welfare--particularly the measurement basis (ordinary consumer surplus and the more precise Hicksian-based measures). The comparisons made in this project have involved expenditures of such a small percentage of individuals' budgets that the differences between the measures is

insignificant. Since some, and perhaps many, environmental issues may involve large price and quantity changes with more significant income effects, the empirical application of various measures becomes significant. Bockstael and McConnell [1980] have raised some empirically based issues, but a more extensive effort such as Willig's [1976], comparing recent approaches proposed by Hausman [1981], McKenzie and Pearce [1982], and Takayama [1982], may yield guidance for applications with these large changes.

A final general issue on the research agenda that, unfortunately, was beyond the scope of this project--and too many other benefits analyses--is the distribution aspect of benefit policies. By neglecting distribution concerns, economists are unable to appreciate many policy objections expressed in the political arena. For example, attention to the distributional effects of alternative water pollution policies would be a valuable complement to the efficiency-oriented questions that constitute the primary focus of benefits analysis. Further rationale for such efforts stems from Executive Order 12291, which recognizes the importance of distribution effects by requiring them in regulatory impacts analyses.

The future research agenda for the individual benefits estimation approaches contains items ranging in subject from experimental design and sampling to the behavioral models that underlie several approaches. Some of the agenda items are already being studied in various quarters, while others will involve substantial funding--e.g., basic data collection--for any progress to be made.

Specific Research Issues

The travel cost model developed in the project raises as many research questions as it answers. The main answer is that the model can be used to estimate the benefits of water quality improvements in a way consistent with economic theory.* However, many problems were encountered on the way to answering this fundamental question. For example, in the survey data used to estimate the travel cost model, as in many surveys involving noneconomic data, the data were heaped at specific points, possibly presenting problems for ordinary least-squares regression analysis. Specifically, all visitors who made only one visit to a site were heaped at the zero point for the logarithmic transformation of the dependent variable, while the visitors who made the maximum were heaped at the other end point. The maximum is the value (8) assigned to the open interval for five or more visits. The remaining visitors were arrayed at specific intervals in between. The need, obviously, is for a statistical estimator that can handle this problem. In terms of the absolute magnitude of the estimated values, which is important for estimating benefits, the differences may be small, but this is a fundamental question requiring statistical analysis rather than judgment. Equally important, the fact that all respondents have used the site at least once implies that this study fails to consider the demands of individuals whose maximum willingness to pay falls below their travel cost. This truncation can, as suggested in the report, lead to biased estimates of

*This is one of the items on Freeman's [1979a] research agenda cited earlier.

site demands. It is important to evaluate the implications of amending the statistical models to directly account for these effects for the benefit estimates derived for water quality improvements.

Many of the items on the travel cost research agenda stem from limited data. This project used the 1977 Outdoor Recreation Survey's Federal Estate component, which surveyed visitors at various recreation sites on Federal lands. Although in many ways these data are far better than those in earlier survey efforts, they omit many items important for the travel cost model. For example, there were no questions on substitute sites that respondents had considered--or even visited at other times--before visiting a particular site. While the generalized model assumes that site attributes are capable of reflecting substitution potential, the model would be considerably improved if it had a better measure of substitutes.

The travel cost model also assumed that the sole purpose of an individual's trip was to visit a particular site. However, Haspel and Johnson [1982] point out the potential for overstating benefits when there are multiple purposes for a trip, suggesting the need for more research using itinerary information to assess the importance of multipurpose trips. Also needed for the travel cost model are more data on the types of time allocations the individual considered in making the trip. For example, was work time forgone or compulsory vacation time? Each may have a different opportunity cost. With answers to these questions, it will be possible to improve the calculation of an individual's time costs for recreation.

Including site attributes in the travel cost model created several data-related questions. Specifically, because water quality data from the standard storage system (STORET) were inadequate for many recreation sites, observations were missing on key parameters, and the monitoring station information was frequently unreliable. Clearly, more comprehensive data are needed, especially for water quality parameters relevant to recreation activities. Data on other site attributes such as access or size were available for the U.S. Army Corps of Engineers' sites through the Corps' Resource Management System. However, to apply the model to other recreation sites--e.g., sites managed by the U.S. Forest Service--would require similar information on important site attributes. Presently, such data are not readily available.

The future research agenda for the contingent valuation approach is aimed at a more systematic treatment of issues involving the design of the hypothetical market. The research questions are in the general area that economists have termed "framing the question" (see Brookshire, Cummings, et al. [1982])--an area generally called "context" in the psychological literature. The definition of the commodity to be valued, the question format used to elicit the value, the ordering of various valuation and nonvaluation questions, the means of payment in the market, and the information provided in the survey questionnaire are all important elements in this framing process. More attention to these issues is likely to substantially improve the understanding of the approach and provide results that are easier to interpret.

This project addressed several general contingent valuation issues by comparing several question formats--bidding games with two starting points, direct question, and the unachored payment card--both to each other and to results from the contingent ranking format. Different payment cards, such as the anchored card used by Mitchell and Carson [1981], were not compared. In addition, the contingent ranking format was always used in conjunction with another question format, which limits the independence of the conclusions. Both of these are good candidates for future research.

This survey was conducted in a specific river basin, making the orientation more micro in scope than Mitchell and Carson's [1981]. A more systematic comparison of their results for overall national water quality and the results of this study for the Monongahela River basin may be useful. Moreover, the general framing questions are especially relevant to the macro approach, where it is more difficult to define the hypothetical commodity. If policy decisions require basin-specific results, either specific surveys (or the ability to transfer results between basins) or the ability to infer estimates for specific river basins from the macro approach will be required.

Recently, Brookshire, Cummings, et al. [1982] introduced the ideas of environmental accounts and budget constraints as part of the framing issue. The accounts question aims at determining whether people give an overall environmental quality bid in a survey or a bid for the specific hypothetical commodity. The budget constraint requires that individuals provide rough budget shares for their monthly incomes and then reallocate these categories to provide the budget amount for the hypothetical commodity. The preliminary results in Brookshire, Cummings, et al. [1982] suggest this is a useful avenue for learning more about framing influences.

Finally, improving efficiency in defining hypothetical markets is a neglected area in the contingent valuation literature. One promising approach is the use of focus groups (from market research literature) to obtain impressions about terminology, visual aids, and other framing issues. Applying these marketing research ideas to contingent valuation may indicate their overall merits.

Research agendas must continually evolve, producing new avenues from deadends that once offered promise. The present agenda tries to map some of these new avenues. The passage of time and the fruits of future research will mark its ultimate usefulness.

1.4 GUIDE TO THE REPORT

This chapter has introduced the report by highlighting the project objectives and summarizing the findings of the research. Chapter 2 provides a brief review of some of the theoretical issues of comparing alternative benefit estimation approaches. After describing the Monongahela River basin, Chapter 3 summarizes the sampling and survey plans for the contingent valuation and contingent ranking approaches used in the case study. Chapter 4 builds on the contingent valuation foundation laid in Chapter 3 by presenting the research design for the contingent valuation survey, by profiling key groups of respondents, and by summarizing the empirical option price results, includ-

ing the effects of question format, starting point, and interviewer bias. Chapter 5 synthesizes the theoretical underpinnings of option value, giving particular attention to the role of supply uncertainty, and presents empirical results for both option and existence values. Chapter 6 reviews the theory underlying the contingent ranking approach, provides a critical summary of its previous applications, considers appropriate measures of benefits, and summarizes the empirical findings from its application to the Monongahela River basin. Chapter 7 presents the development of a generalized travel cost model and describes its application to predict the recreation benefits of water quality improvements in the Monongahela River. The development of the model treats the empirical significance of model specification, site time costs, simultaneity in visit/site time decisions, and statistical biases in its predicted values. Chapter 8 compares the alternative approaches for estimating recreation and related benefits, in light not only of previous comparison attempts but also of a priori expectations. In addition, Chapter 8 also describes paired comparisons of the contingent valuation and travel cost approaches and of the contingent valuation and contingent ranking approaches using multivariate regression techniques.

CHAPTER 2

A BRIEF REVIEW OF THE CONCEPTUAL BASIS FOR THE BENEFIT ESTIMATION APPROACHES

2.1 INTRODUCTION

An ideal comparison of benefit estimation approaches would begin with a detailed theoretical appraisal of each approach, showing how each is derived from a common conceptual framework. However, this kind of appraisal is beyond the scope of this project. Instead, this chapter highlights the assumptions, information, and types of benefits measured by each of three approaches and compares these features on general, rather than on common, theoretical grounds.

The definition of economic benefits based on theoretical welfare economics has closely followed the model of consumer behavior, which suggests that individuals can acquire utility only through consuming goods or services. This framework leads to definitions of economic benefits best suited for describing user benefits associated with improvements in environmental quality. However, since the work of Krutilla [1967], nonuser, or intrinsic, benefits have been increasingly recognized as playing an important role in the aggregate values for certain environmental resources.

Intrinsic benefits are generally viewed as arising from two sources. The first source suggests that an individual can realize utility without direct consumption of a good or service. Rather, other motives can be satisified with allocation patterns for certain resources, and these motives--"stewardship" and "vicarious consumption" in Freeman's [1981] terms--can lead to utility, therefore providing nonuser benefits. An alternate view can be derived by redefining the act of consumption to admit what might be considered indirect use of the services of an environmental amenity.

The second source of intrinsic benefits is derived by relaxing one of the assumptions underlying conventional consumer behavior models. The simplest treatment of the conditions for efficient resource allocation assumes that all goods and services--whether they provide positive increments to utility or decrease it--are available with certainty. Of course, this is not the case in the real world. Indeed, in some circumstances--e.g., the degree of reversibility in water quality conditions--uncertainty may well be the most important element of the public policy problem. In these cases, therefore, consumer behavior models must be amended to reflect how households react to uncertainty and whether they would be willing to pay for action that would reduce it.

A second relevant feature of the definitions of economic benefits presumably arises from the early focus on goods or services exchanged in private markets. These definitions developed measures of benefits for price changes. Since environmental policy has dealt mostly with quantity (or quality) changes in services provided outside of private markets, these measures must be adapted to meet policy needs.

The purpose of this chapter is to briefly review the theoretical concepts generally used in measuring economic benefits. Specifically, Section 2.2 deals with the theoretical basis of benefit measurement based on the concept of an individual's willingness to pay and describes alternative ways to measure changes in consumer welfare. Section 2.3 outlines the framework for comparing different benefit estimation approaches--an adaptation of the Smith-Krutilla [1982] framework for classifying the different approaches and summarizing their conceptual bases. Section 2.4 describes the welfare measurement bases underlying the two benefit estimation approaches compared in this study--travel cost and contingent valuation (including the contingent ranking format). Finally, Section 2.5 prvides a brief summary.

2.2 A BRIEF REVIEW OF THE CONVENTIONAL THEORY OF BENEFITS MEASUREMENT

The primary emphasis for this study of recreation and related benefits of water quality improvements focuses on the measurement of benefits that accrue to individual households. Fortunately, the theory of consumer behavior provides a framework for measuring these benefits. This section briefly reviews this framework to set the stage for the comparison of approaches that follows.

The first guidepost for the definition and measurement of economic benefits that the theory of consumer behavior provides is the individual demand function, shown in Figure 2-1. This function describes for any good, X, the maximum amount an individual would be willing to pay for each quantity of X. The downward slope of the curve indicates that individuals are willing to buy more of X at lower prices than they are at higher prices. The simple two-dimensional diagram in Figure 2-1 assumes all other factors that might influence demand--income, the prices of related goods, etc.--do not change. Thus, according to the demand function, if the market leads to a price of P_0, the individual will purchase Q_0 of X and make a total expenditure equal to P_0AQ_0O. Since the demand curve measures the individual's maximum willingness to pay for each level of consumption, the total willingness to pay for Q_0 can be derived--total expenditures <u>plus</u> the triangle P_0P_iA. This difference between the amount they are willing to pay and what individuals actually pay with a constant price per unit is defined as the consumer surplus--the conventional dollar measure of the satisfaction individuals derive from consuming a good or service, exclusive of what they pay for it.

As a dollar measure of individual welfare, however, consumer surplus is not ideal. The most direct way of understanding its limitations is to consider

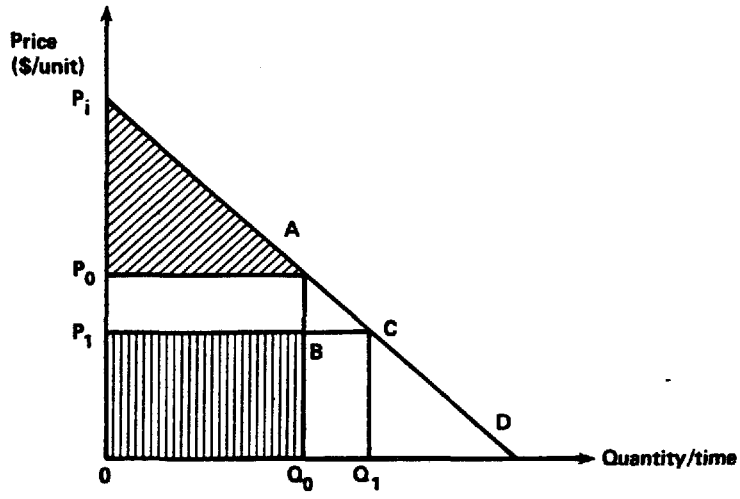


Figure 2-1. The demand function and the consumer surplus welfare measure.

the measurements underlying a conventional demand function. An individual's demand function describes the maximum an individual with a given nominal income would be willing to pay for each level of consumption of a particular good. Specifically, if the price paid changes, it will affect not only what the individual can purchase of this good, but also the purchases of all other commodities through its effect on the remaining disposable income. Thus, movement along a conventional demand function affects the level of satisfaction an individual will be able to achieve with a given income. For example, suppose the price of hypothetical good X declines to P_1. The individual can purchase the same quantity of X at its new price as indicated in Figure 2-1 by the area OP_1BQ_0 and have income remaining, as given by P_1P_0AB, to purchase more X or more of other goods and services. The movement to a consumption level of OQ_1 describes the increased selection of X under the new price. This change leads to a higher utility level because more goods and services can be consumed with the same income. For consumer surplus to provide an "ideal" dollar measure of individual well-being, however, the conversion between dollars and individual utility levels must be constant for every point on the demand curve. According to this example, then, each point on a conventional demand function in principle corresponds to a different level of utility. Thus, no single conversion factor links consumer surplus and utility.

In his seminal work on consumer demand theory, Hicks [1943] noted that an ideal measure would require that utility be held constant at all points along the demand curve. As a practical matter, however, the difference between the area under such an ideal, Hicksian-based demand curve and that under a conventional demand curve depends on the size of the income effects accompanying the price changes associated with movements along the ordinary demand curve. As suggested earlier, price reductions lead to more disposable income. To judge the association between the two measures of welfare change, all aspects of the choice process that affect the size of the change in disposable income must be considered. For example, if the price change for X is small and the share of the budget spent on the good X is also small, the

change in disposable income is likely to be small. Thus, little difference will exist between the ordinary measure of consumer surplus and the measure derived from Hicks' idealized demand curve. However, the same outcome arises either if income has little effect on the demand for X or if an individual's preferences are such that the demand responsiveness to income is equal for all goods (i.e., unitary income elasticities of demand).

Of course, each of the conditions described above is a special case. When ordinary demand functions are used to measure the benefits of an action in practical applications, the factors influencing the demand function's relationship to an ideal dollar measure of welfare change must be identified. Fortunately, Willig [1976] and Randall and Stoll [1980] have derived such guidelines for cases involving price and quantity changes, respectively. To understand these guidelines, the possible theoretical measures of individual welfare change must first be defined in more precise terms.

Hicks' [1943] theoretical analysis of measures of welfare change provides the basis for developing a set of rigorous measures and, with them, the error bounds for ordinary consumer surplus. The four Hicksian welfare measures for a price decrease are summarized below:

- Compensating variation (CV) is the amount of compensation that must be taken from an individual to leave him at the same level of satisfaction as before the change.

- Equivalent variation (EV) is the amount of compensation that must be given to an individual, in the absence of the change, to enable him to realize the same level of satisfaction he would have with the price change.

- Compensating surplus (CS) is the amount of compensation that must be taken from an individual, leaving him just as well off as before the change if he were constrained to buy at the new price the quantity of the commodity he would buy in the absence of compensation.

- Equivalent surplus (ES) is the amount of compensation that must be given to an individual, in the absence of the change, to make him as well off as he would be with the change if he were constrained to buy at the old price the quantity of the commodity he would actually buy with the new price in the absence of compensation.

As a simplified comparison, Figure 2-2 highlights the essential differences between the Hicksian variation measures and the ordinary consumer surplus measures when the price of a good decreases. The two Hicksian demand curves holding utility constant (at levels U_0 and U_1 with $U_1 > U_0$) are shown as $H(U_0)$ and $H(U_1)$, the prechange and postchange levels of utility, respectively. The ordinary demand curve--also known as the Marshallian demand curve--is shown as D, where income, and not utility, is held constant. The

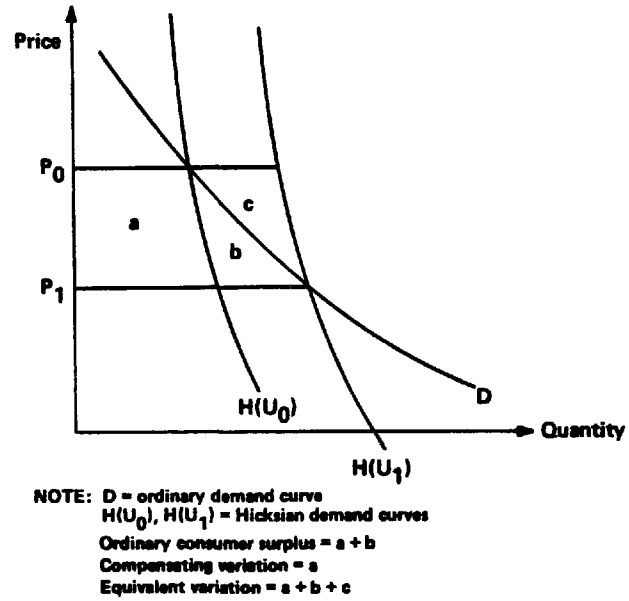
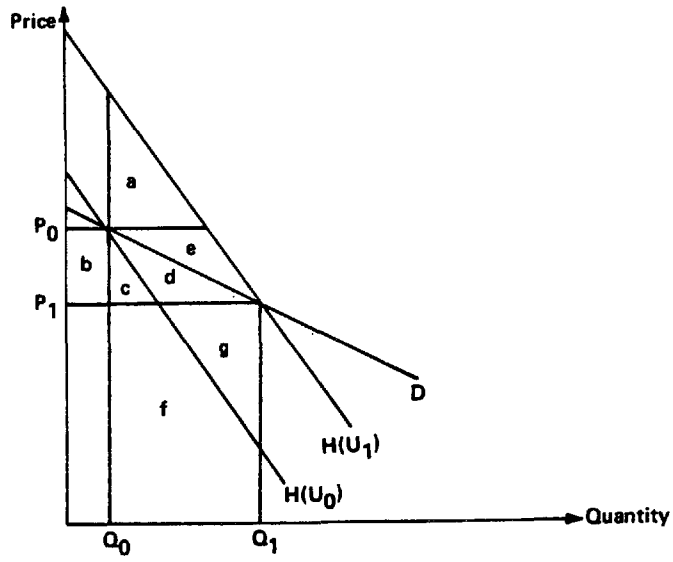


Figure 2-2. A comparison of alternative welfare measures.

compensating variation measure, labeled as area a, uses the original level of utility as its reference point and indicates the amount of compensation that must be taken from an individual to leave him at the original level of utility when the price changes from P_0 to P_1. The equivalent variation measure is represented by area a+b+c. It measures the change in income equivalent to the change in prices and thereby permits an individual to realize the new level of utility with old price P_0. The change in ordinary consumer surplus is the area under the ordinary demand curve, D, between P_0 and P_1. In Figure 2-2 it is shown as areas a+b.

The concepts of compensating surplus and equivalent surplus were originally defined as measures of the welfare change resulting from a price change, given that the quantity of the good whose price has changed is not allowed to adjust. However, it is also possible to interpret these concepts as measures of the welfare change associated with a quantity change (see Randall and Stoll [1980]). Just, Hueth, and Schmitz [1982] have recently offered a diagrammatic illustration of compensating and equivalent surplus in a format similar to that used above to describe compensating and equivalent variation. However, in the present example, the price is assumed constant at some arbitrarily low value (effectively zero for Figure 2-3), and D is interpreted as an ordinary demand curve (i.e., as if the quantities consumed could be realized only at the corresponding prices and not the constant price). In Figure 2-3 a change in the quantity of the good available from Q_0 to Q_1 leads to a compensating surplus of c+f and an equivalent surplus of a+e+c+d+f+g. The ordinary consumer surplus is c+d+f+g, which is d+g more than the compensating surplus measure and a+e less than the equivalent surplus.



Source: Just, Hueth, and Schmitz [1982].

Note: Ordinary consumer surplus = c + d + f + g
Compensating surplus = c + f
Equivalent surplus = a + e + d + c + f + g

Figure 2-3. Surplus measures for a change in quantity.

Table 2-1 relates the welfare measures under different conditions of willingness to pay/accept, showing quite clearly that no one unique measure exists. Rather, the appropriate measure is determined by the particular situation. Table 2-1 reinforces this point by presenting the types of welfare measure in relation to different situations. For a price decrease, for example, the following relationship holds between the alternative welfare measures:

$$ES > EV > CV > CS \ .$$

For a quantity increase, the equivalent surplus measure will be greater than the compensating surplus measure. The primary reason for the differences between welfare measures is that the equivalent surplus and equivalent variation are not bounded by an individual's income constraint, while the compensating variation and compensating surplus measures are. It should also be noted that the measures are symmetrical and that, for a price increase or quantity decrease, the relationship between the measures is exactly the reverse.

It is important to recognize that the compensating and equivalent measures of welfare changes differ because they imply a different assignment of property rights to the individual and therefore are based on different corresponding frames of reference. For example, with a price decrease, the compensating variation measure takes the initial price set as an individual's frame of reference and asks, in effect, "What is the maximum amount he would be willing to pay to have access to the lower prices?" By contrast, equivalent variation takes the new, lower price set as an individual's frame of reference and

Table 2-1. Alternative Welfare Measures and Types of Consumer Surplus Measures for Contingent Valuation Studies

	Price decrease	Price increase	Quantity increase	Quantity decrease
WTP	CV; CS	EV; ES	CS	ES
WTA	EV; ES	CV; CS	ES	CS

NOTE:

CS is the amount of compensation that must be taken from an individual, leaving him just as well off as before the change if he were constrained to buy at the new price the quantity of the commodity he would buy in the absence of compensation.

CV is the amount of compensation that must be taken from an individual to leave him at the same level of satisfaction as before the change.

ES is the amount of compensation that must be given to an individual, in the absence of the change, to make him as well off as he would be with the change if he were constrained to buy at the old price the quantity of the commodity he would buy in the absence of compensation.

EV is the amount of compensation that must be given to an individual, in the absence of the change, to enable him to realize the same level of satisfaction he would have with the price change.

WTA is the amount of money that would have to be paid to an individual to forego the change and leave him as well off as if the change occurred.

WTP is the amount of money an individual will pay to obtain the change and still be as well off as before.

describes the minimum amount an individual would be willing to accept to relinquish his right to the lower price. These measures bound the range of dollar values for the welfare changes because they describe the results obtained from the perspectives of the initial utility level and the final utility level. Consequently, Willig [1976] uses this feature to establish conditions under which conventional consumer surplus would approximate "ideal" measures for the welfare change associated with a price change. Moreover, Randall and Stoll [1980] follow essentially the same logic to gauge the relationship between ordinary consumer surplus measures for a quantity change and the corresponding compensating and equivalent surplus measures.

Equations (2.1) and (2.2) provide the basis for the Willig bounds for the difference between the ordinary consumer surplus measure and the equivalent

variation and compensating variation measures of a change in welfare due to a price change:*

$$\frac{CV - OCS}{|OCS|} \cong \frac{|OCS|\ N}{2\ M}\ , \tag{2.1}$$

$$\frac{OCS - EV}{|OCS|} \cong \frac{|OCS|\ N}{2\ M}\ , \tag{2.2}$$

where

OCS = ordinary consumer surplus measure of welfare change

N = income elasticity of demand = $\frac{\Delta Q}{Q} / \frac{\Delta Y}{Y}$

M = initial level of income.

These relationships can be evaluated at different values for the income elasticity of demand over the region for the price change and thereby provide bounds for the magnitude of the discrepancy between ordinary consumer surplus and the equivalent and compensating variation welfare measures. Equations (2.1) and (2.2) assume that the income elasticity of demand (N) is approximately constant over the region for the price change (see Willig [1976], pp. 592-593, for a discussion). If this assumption is relaxed, the bounds can be stated as inequalities for the percentage difference between ordinary consumer surplus and the corresponding measures of welfare, as in Equations (2.3) and (2.4):

$$\frac{|OCS|\ N_S}{2\ M} \leq \frac{CV - OCS}{|OCS|} \leq \frac{|OCS|\ N_L}{2\ M}\ , \tag{2.3}$$

$$\frac{|OCS|\ N_S}{2\ M} \leq \frac{OCS - EV}{|OCS|} \leq \frac{|OCS|\ N_L}{2\ M}\ , \tag{2.4}$$

where

N_S = the smallest value of the income elasticity of demand over the region for the price change

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*It is important to note that the direction of the price change affects the sign of ordinary consumer surplus, compensating variation, and equivalent variation and, thus, the interpretation of Equations (2.1) through (2.4). This formulation adopts Willig's convention that ordinary consumer surplus is positive for a price increase and negative for a price decrease so that it corresponds to the interpretation of compensating variation or equivalent variation. See Willig [1976], p. 589.

N_L = the largest value of the income elasticity of demand over the region for the price change.

The Willig approximation is reasonable if the value of $\frac{|OCS|\ N}{2\ M} \leq 0.05$. If this value is greater than 0.05, Willig has provided a table of error bounds based on the relationships used to derive these approximate bounds.*

2.3 A FRAMEWORK FOR COMPARING ALTERNATIVE BENEFIT MEASUREMENT APPROACHES

Comparing alternative approaches for estimating the recreation and related benefits of water quality improvements at first seems formidable because of the wide range of consumer behavior outcomes described by each. However, despite this diversity, all approaches adhere to a consistent general model of consumer behavior: individuals allocate their monetary and time resources to maximize their utility subject to budget and time constraints. As noted at the outset, a complete comparison of the methods could derive each method from this common conceptual basis. However, this section simply provides a taxonomic framework that eases the comparison of approaches by drawing clear distinctions between the assumptions underlying each.

Figure 2-4 presents the Smith-Krutilla [1982] framework for classifying the alternative approaches for measuring the recreation and related benefits of water quality improvements. This framework considers linkages between changes in water quality and observable actions of economic agents that affect the information available for measuring water quality benefits. In particular, Smith and Krutilla suggest that all approaches for measuring the benefits of a change in an environmental resource can be classified as involving either physical or behavioral assumptions.

The category associated with physical assumptions in this framework maintains that the association between the environmental service of interest (i.e., water quality) and the observable activities (or changes in goods or services) is a <u>purely physical</u> relationship. The responses are determined by either engineering or technological relationships. Thus, the evaluation of water quality changes in such a framework must begin by identifying the activities affected by water quality. Analysis must then focus on measuring the technical relationships, sometimes referred to as damage functions, assumed to exist between water quality and each activity. Because water quality improvements can be associated with the support of gamefish, swimming, and the use of water for human consumption, the physical approach seeks to specify the technical linkages between water quality levels and permitted amounts of recreation fishing, swimming, and water consumption. Another example of the

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*Two excellent discussions of the practical implications of the Willig bounds for benefit measurement are available in Freeman [1979a], pp. 47-50, and in Just, Hueth, and Schmitz [1982], pp. 97-103.

	Types of Linkage Between Water Quality Change and Observed Effects		Types of Assumptions Required	Measurement Approaches
No Role for Behavioral Responses of Economic Agents	Physical Linkages		Responses are determined by engineering or "technological" relationships	Damage Function
Behavioral Responses of Economic Agents Are Essential	Behavioral Linkages	Indirect Links	Restrictions on the nature of individual preferences OR observed technical associations in the delivery of goods or services	Hedonic Property Value Travel Cost*
		Direct Links	Institutional	Contingent Valuation* (including Contingent Ranking*)

*Approaches compared in this study.

Figure 2-4. Smith-Krutilla framework for classifying the measurement bases and approaches of economic benefits resulting from improved water quality.

physical approach to evaluating the effects (and, ultimately, the benefits) of a water quality change can be found in the dose-response models used to evaluate the health risks associated with certain forms of water pollution (see Page, Harris, and Bruser [1981] for a review of these models). Although these models ignore economic behavior and postulate that the relationships involved can be treated independently of the motivations of economic agents, they may well provide reasonable approximations of the actual effects on water quality for certain classes of impacts. However, these models are unlikely to be adequate when economic agents can adjust their behavior in response to the water quality changes and, as a result, are not considered in this study.

The behavioral category of valuation methodologies in the Smith-Krutilla framework relies on the observed responses of economic agents and on a model describing their motivations to estimate the values (or economic benefits) associated with a change in a nonmarketed good or service. Within this class, direct or indirect links identify three classes of assumptions that can be used to develop measures of individual willingness to pay. The first type of assumption used within the indirect behavioral framework requires restrictions on the nature of the individual's utility function and is usually associated with Mäler's [1974] weak complementarity. This type of assumption maintains that an individual's utility function is such that there is a specific association between the nonmarketed good (or service) and some marketed commodity such

that the marginal utility of an increment to the consumption of the nonmarketed good is zero when the individual is not consuming some positive amount of the associated, marketed commodity. This assumption maintains that a type of "jointness" exists in the formation of the individual's utility, which, in turn, constrains the feasible responses to price changes for the marketed good (or changes in the availability of the nonmarketed good). Thus, the selection of the two goods is joint, and market transactions for one good can be used to determine demand for the other. Of course, this approach depends upon the plausibility of the restriction on an individual's utility function. Researchers have used this restriction to justify both hedonic property value and travel cost studies.

Smith and Krutilla [1982] argue that the weak complementarity behavioral restriction is not necessary for these approaches and that the observed technical associations between marketed and nonmarketed goods are responsible for the ability to use these methods to measure benefits of changes in a nonmarketed good. In the case of the technical assumptions, the availability of the nonmarketed service is tied to some marketed good by the nature of its natural delivery system, making the linkage an observable phenomenon rather than a feature of an individual's preferences. For example, water-based outdoor recreation is undertaken using the services of recreation sites on rivers or lakes. Each recreationist is interested in the water qualities only at the sites considered for his recreation use. By selecting a site for these activities, an individual is also selecting a water quality, because the two are "technically linked" or jointly supplied. Thus, where there is a range of choice (i.e., several different combinations of recreation sites and water quality), how an individual values the nonmarketed good or service can be seen through his observable actions, including such decisions as the selection of a residential location or visits to specific recreation facilities (see Rosen [1974] and Freeman [1979c]). This study specifically considers the travel cost method, which uses this technical association as its basis for measuring water quality benefits.

The last case of behavioral approaches to benefit estimation involves direct linkages between water quality and an individual's actions. The assumptions made to ensure these linkages are labeled institutional, a designation somewhat more difficult to understand than previous descriptions because it encompasses the contingent valuation and contingent ranking methods for measuring an individual's valuation of environmental amenities. Specifically, the institutional assumptions arise because the analyst assumes that individual responses to hypothetical decisions (or transactions) are completely comparable to individual responses revealed in actual transactions. The term institutional is used for this class because the organized markets in which goods and services are exchanged are institutions that provide the information on individuals' marginal valuations of the commodity involved. With the survey approach, the interviewer poses the survey questions to construct an equivalent institutional mechanism in the form of a hypothetical market. Both the contingent valuation and the contingent ranking methods will be considered under this approach.

2.4 THE NATURE OF THE BENEFITS MEASURED IN THE ALTERNATIVE APPROACHES

This section highlights the nature of the benefits measured in the travel cost and contingent valuation approaches.

2.4.1 Travel Cost Approach

The travel cost approach measures the change in ordinary consumer surplus for a water quality improvement, represented for an individual incurring travel costs per trip of OP_1 by area ABCD in Figure 2-5. To empirically develop the ordinary consumer surplus estimate, the travel cost approach assumes both that travel to a recreation site reveals a respondent's reservation price for that site's services and that water quality is jointly supplied along with the other site attributes. If other variables are held constant, and if sites are placed on a common measurement scale,* area ABCD can be measured by observing individuals' site selections across sites with varying levels of water quality, thus revealing the effect of water quality on site demand. Therefore, while both Freeman [1979b] and Feenberg and Mills [1980] maintain that conventional travel cost models cannot measure benefits associated with water quality change,† the generalized travel cost model developed for this

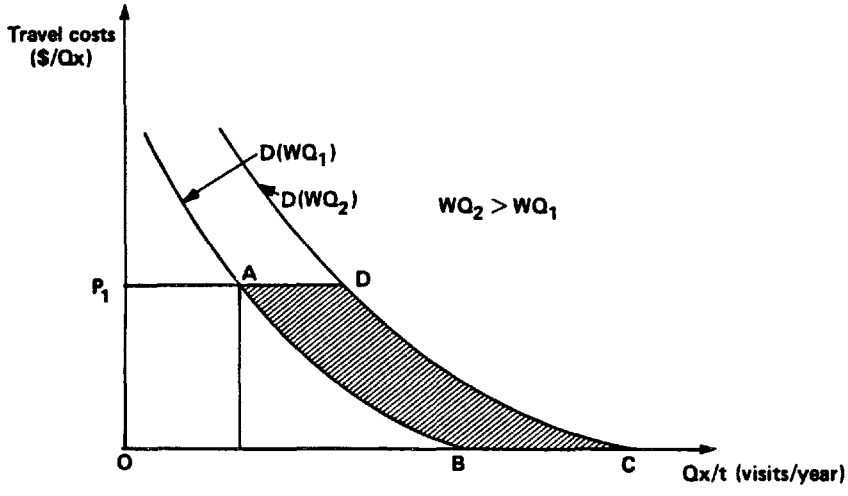

Figure 2-5. Travel cost demand function with water quality improvement.

*The rationale for this measurement approach is presented in more detail in Section 7.3.

†Their models do not gauge the demand change that accompanies a water quality change.

study (see Chapter 7) uses the responses of individuals at different locations to both travel cost and water quality levels to infer benefits of water quality changes. The information provided by these responses allows the change from $D(WQ_1)$ to $D(WQ_2)$ in Figure 2-5 to be distinguished (where WQ_1 and WQ_2 represent different levels of water quality, with $WQ_2 > WQ_1$).

2.4.2 Contingent Valuation Approach

The contingent valuation approach directly measures an individual's willingness to pay for water quality in an institutional arrangement that approximates the market for water quality. Unlike the travel cost approach, contingent valuation does not require observations of individuals' decisions on use of recreation sites with given "implicit" service prices, but it does assume an individual's response in the hypothetical market is the same as it would be in a real market. That is, respondents are assumed not to behave strategically, not to give unrealistic responses, and not to be influenced by the survey questionnaire or the interviewer who administers the survey questionnaire. Furthermore, the contingent valuation approach imposes an institution that leads to a hypothetical change in an individual's budget constraint by requiring that the individual "pay" for the specified water quality improvement. Thus, the new budget constraint for the utility maximization process includes both the prices and quantities of market goods and the hypothetical price and defined quantity of water quality.

The institutional design underlying contingent valuation surveys requires that ownership of the property rights for water quality at the recreation site be determined in the specification of the question, thus affecting the appropriate measure of consumer welfare. Specifically, consumer ownership of property rights would indicate a willingness-to-accept measure as the appropriate valuation concept, and industry ownership would dictate a willingness-to-pay measure. Although currently boatable throughout, the Monongahela River--the site used for this study (see Chapter 3)--supports swimming and fishing only upriver from Pittsburgh, and property rights are in a state of flux with considerable confusion over ownership (see Feenburg and Mills [1980]). Thus, a reasonable allocation for this study's survey of Pittsburgh residents is that consumers own the rights to boatable water (which suggests an equivalent surplus measure), while no one yet owns the rights to fishable, swimmable water along the entire river (which indicates a compensating surplus measure).

While using a willingness-to-accept measure for maintaining a boatable water quality level and a willingness-to-pay measure for the value of moving to fishable and swimmable levels is consistent with current Monongahela property rights, willingness-to-accept measures have proven difficult in hypothetical market experiments, thus creating serious problems in the development of a workable survey methodology. For example, respondents have either refused to answer, given infinite bids, or refused to accept any compensation for reductions in environmental quality [Schulze, d'Arge, and Brookshire [1981] and Bishop and Heberlein, 1979]. To cope with this problem, this study employs a willingness-to-pay (equivalent surplus) measure for the decrease from boatable water quality and a compensating surplus measure for improvements from the same level.

2.4.3 Contingent Ranking Approach

Like the other contingent valuation formats, contingent ranking relies on individuals' responses in a hypothetical market situation. However, instead of requiring an individual to respond with the maximum willingness to pay for a water quality improvement, contingent ranking requires that individuals rank outcomes--consisting of a hypothetical payment and a corresponding level of water quality--from most preferred to least preferred. The implicit argument underlying contingent ranking is that an individual is better able to respond to the hypothetical market when both outcomes are specified. In the utility maximization framework underlying the contingent ranking approach, an individual ranks the alternatives based on their implications for his ability to maximize utility with a given income, the prices of other goods, and the proposed combination of payment and water quality. Analytically, this choice can be described by comparisons of the indirect utility functions arising from each of these sets of decisions. An appropriate compensating surplus measure can then be derived from estimates of the indirect utility function.

2.5 Summary

Partly because they are all based on the common standard of constrained utility maximization, the travel cost, contingent valuation, and contingent ranking approaches can each develop measurements of changes in consumer welfare. The travel cost approach measures the change in ordinary consumer surplus, the contingent valuation approach measures equivalent and compensating surpluses, and the contingent ranking format yields a compensating surplus welfare measure.* The relationship between each of these methods' measures of the welfare changes associated with water quality changes is considered in the comparison analysis reported in Chapter 8.

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*It should be noted that, for the contingent valuation approaches, questions have been formulated to include both user and nonuser values. Strictly speaking, both approaches measure the option price, but the contingent valuation approach permits the user value component to be identified.

CHAPTER 3

SURVEY DESIGN

3.1 INTRODUCTION

Estimating the recreation and related benefits of water quality improvement with the contingent valuation approach requires an integrated survey design. This chapter describes the survey design for the case study of the Monongahela River. Specifically, Section 3.2 describes the general background of the Monongahela River basin area, Section 3.3 highlights the sampling plan for the project, and Section 3.4, a discussion of the survey plan, concludes the chapter with detailed information on the survey field procedure.

3.2 GENERAL DESCRIPTION OF THE MONONGAHELA RIVER BASIN

This section describes the Monongahela River basin, providing a general description of river geography, river uses, river-related recreation activities, and a socioeconomic profile.

3.2.1 Geography

Formed by the confluence of the West Fork and Tygart Rivers near Fairmont, West Virginia, the Monongahela River drains an area of 7,386 square miles in southwest Pennsylvania, northern West Virginia, and northwest Maryland. (See Figure 3-1 for a map of the area.) It flows northerly 128 miles to Pittsburgh, where it forms the Ohio River headwaters with the Allegheny River, and has two major tributaries, the Youghiogheny and Cheat Rivers. All 128 miles of the Monongahela are navigable year round by motorized commercial traffic.

Characterized by steep banks and rugged terrain, the Monongahela River basin lies in five Pennsylvania Counties (Allegheny, Greene, Fayette, Westmoreland, and Washington) and two West Virginia counties (Monongalia and Marion) in the Appalachian Plateau and the Allegheny Mountains. The Monongahela basin currently supports four major reservoirs:

- Deep Creek Reservoir--A privately owned Maryland facility operated on a Youghiogheny River tributary to generate 51 megawatts of electric power.

- Lake Lynn Reservoir--A privately owned West Virginia facility operated on the Cheat River to produce 19 megawatts of electric power.

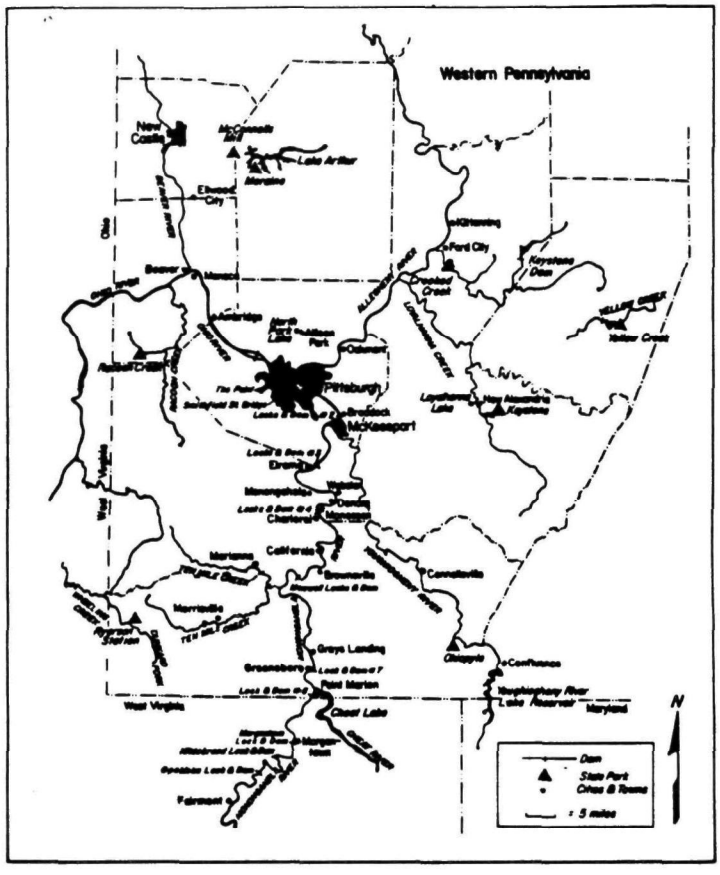

Figure 3-1. Map of Monongahela River and other area recreation sites.

- Tygart River Reservoir--A facility operated by the U.S. Army Corps of Engineers to provide flood control, recreation, and low flow augmentation. This reservoir provides most of the Monongahela's augmented flow, a minimum of 340 cfs in the upper river.

- Youghiogheny River Reservoir--A facility operated by the U.S. Army Corps of Engineers to provide a minimum flow of 200 cfs for the Monongahela River.

Comprising nearly 30 percent of the river basin's seven-county area, the following urban areas and boroughs (listed below with 1970 census population) line the Monongahela's banks:

Pittsburgh	520,117	Donora	8,825
McKeesport	37,977	Charleroi	6,723
Clairton	15,051	Brownsville	4,856
Duquesne	11,410	Braddock	8,795
Monessen	17,216	Glassport	7,450
Monongahela	7,113	Munhall	16,574
Morgantown	29,431	Port Vue	5,862
Fairmont	26,093	West Miffin	28,070

3.2.2 Uses

As part of the Mississippi River Waterway System, the Monongahela has a 9-foot-deep navigation channel from Pittsburgh to Fairmont to support both commercial and recreation river traffic. This navigation channel ranges in width from a minimum of 250 feet to nearly full river width at the river's mouth and is currently maintained by a series of nine lock and dam structures. The heaviest barge traffic occurs at Structures 2 and 3. Use of the locks and dams for generating hydroelectric power is currently under consideration and would provide an estimated total capacity of 96.2 megawatts. To support river traffic, the Monongahela's banks have a boat dock concentration approaching one dock per mile. However, these docks--which numbered 147 in 1979--are mostly single-purpose, single-user facilities.

Industrial activity along the Monongahela is dominated by the primary metals industry, which accounts for over 31 percent of the area's total manufacturing employment, including 29 percent of all Pennsylvania's steel industry employment. Also important with respect to industrial activity along the Monongahela are significant amounts of natural resources, including oil and gas, limestone, sandstone, sand and gravel, and coal. Area coal reserves are estimated at approximately 23 billion tons, and the Monongahela River region alone accounted for 24 percent of total 1977 coal production in Pennsylvania and West Virginia. Underground mining in the area produced 78 percent of this total, with strip mining operations accounting for the remainder.

3.2.3 Recreation

Because it essentially is a series of large pools--ranging from 400 to 1,741 surface acres--created by its nine lock and dam structures, the Monongahela offers substantial opportunities for recreation. In fact, although the lower 20 river miles, subjected to heavy industrial and urban development, offer limited recreation opportunities, the remaining 108 miles have seen dramatic increases in recreation usage over the last 10 years, partially because of improved water quality. As a result of this increased recreation usage, numerous public and private facilities have been developed along the Monongahela, ranging from single-lane boat launching ramps to boat club docks, commercial marinas, and community parks.

The primary recreation activities along the river are power boating and fishing. Because power boating is more popular, many recreation facilities have been constructed primarily to serve it. Partially as a result, the Monongahela River comprises a substantial portion of the water acreage available in the region for unlimited horsepower boating.

Although it is second to power boating in popularity, fishing occurs over a greater number of water acres in the area when small lakes and streams are considered. In fact, fishing accounts for approximately 12 percent of all current uses of the Monongahela. Fishing in the river is encouraged by special programs in both Pennsylvania and West Virginia to stock warmwater fish, and fish sampling has revealed the presence of up to 47 separate species,

plus 3 hybrids. Of special interest, the U.S. Environmental Protection Agency (EPA) and the Pennsylvania Fish Commission, which have monitored fish population trends in the Monongahela since 1967, have reported a dramatic increase over an 11-year period in species' diversity and biomass, particularly in the upper reach.

In addition to power boating and fishing, the Monongahela also offers other recreation opportunities at several major facilities, including two constructed by the U.S. Army Corps of Engineers at the Maxwell and Opekiska pools; the Tenmile Creek Recreational Area (adjacent to the Maxwell Pool), which showed increased visitor days from 1972 to 1975; and the Prikett Bay Recreational Area (at Opekiska Pool), which has also experienced increased visitation from 1972 to 1975. Recreation activities offered by these sites include picnicking, camping, boating, and swimming. Despite its length and general popularity for recreation, the Monongahela nowhere offers either campgrounds or State parks for potential recreationalists, who are forced to the substitute sites offered by the Youghiogheny River Reservoir and the Allegheny River. Both of these substitutes offer better water quality than the Monongahela and, perhaps, more scenic settings for recreation.

3.2.4 Socioeconomic Profile

In 1977, population for the seven-county area of the Monongahela River basin totaled 2,417,885, which results in an average population density of 518 persons per square mile. Although density is greatest along the river, there is a recent trend to move into other areas. However, population changes in the basin vary according to State: several Pennsylvania counties have experienced a noticeable population decrease in the period from 1960 to 1977, but Monongalia County in West Virginia experienced a dramatic population increase during the same period. In general, the basin has a greater percentage of urban population than either the Pennsylvania or West Virginia State averages.

Per capita income within the basin is lower than either the Pennsylvania or West Virginia State averages, and the basin in fact contains a higher percentage of persons living below the poverty level than does either State generally. Not surprisingly, then, much of the basin's housing stock is generally considered substandard, and, in 1970, 70 percent of it was more than 25 years old.

The average education level, which has steadily increased since 1950, is higher in the basin than it is in either Pennsylvania or West Virginia or in the United States generally. However, the difference between the basin and the nation has almost disappeared, eroded by a steadily rising U.S. education level. Another steadily eroding difference between the basin and the nation as a whole is in the percentage of the workforce made up of craftsmen and laborers. Specifically, due primarily to the area's heavy concentration of primary metals and extraction industry, the basin still has a higher concentration of blue collar workers than does the nation generally, but this difference has greatly diminished during the last 20 years.

3.3 SAMPLING PLAN

The following subsections describe the sampling plan implemented to accomplish the objectives of this study. A single-stage, area household sampling design was used to contact approximately 384 sample households in a four-county area of southwest Pennsylvania. Appendix A contains additional details of the survey design, sample selection, and weight calculation.

3.3.1 Target Population

Five counties comprised the sample area for this study (outlined in Figure 3-2): Allegeny, Fayette, Greene, Washington, and Westmoreland. These counties were selected because they contain the reach of the Monongahela River within Pennsylvania. The random nature of the sample resulted in no sample segments being chosen in Greene County. The target population consisted of all households in this five-county area. Group quarters were not included, and only adult (persons 18 years and older) household members were eligible for interview. One adult was selected for the interview from each household.

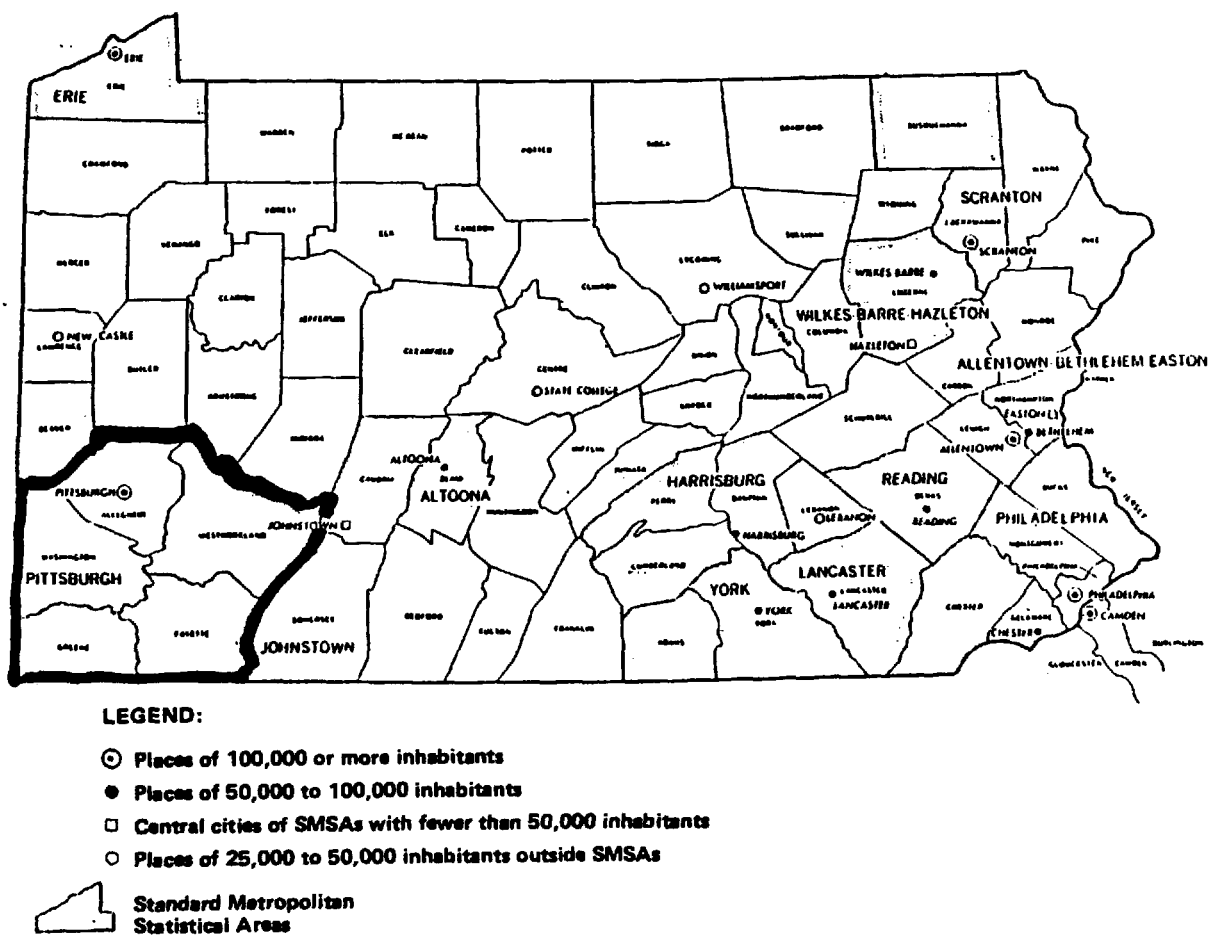

Figure 3-2. Geographic location of survey area.

3.3.2 Sample Selection and Survey Design

The design was a single-stage, stratified cluster sample. The sampling units (SUs) were noncompact clusters of approximately seven households each. The clusters were developed by partitioning all the block groups (BGs) and enumeration districts (EDs) within the five-county area into noncompact clusters. The clusters were nonoverlapping and, when aggregated, completely accounted for all of the households in the five-county area.

The sampling units were stratified into three disjoint groups: (1) Pittsburgh, (2) not in a place, and (3) a place other than Pittsburgh. Fifty-one clusters with an average of 7.78 sample housing units (SHUs) each were selected, yielding 397 SHUs. A roster of all adults was compiled for each SHU. One adult was randomly selected from each SHU for interview.

3.3.3 Sampling Weights

The probability structure used to select the SHUs and the adults within each SHU allows calculation of the selection probability for each individual interviewed. The sampling weights, reciprocals of the probability of selection, were then calculated. Because interviews were not obtained from all selected SHUs (80.59 percent response), the sampling weights were adjusted for the nonresponse.

3.4 SURVEY PLAN

This project required a detailed survey plan to enable the successful completion of a full range of survey tasks. The following subsections discuss the procedures and methods developed to carry out these tasks. The major field tasks were as follows:

- To design and perform a limited local pretest of the survey questionnaire.
- To retain field interviewers.
- To count and list households within the randomly selected area segments. (Two field supervisors and two interviewers performed this task.)
- To develop a field procedures manual and interviewer training materials.
- To conduct a field interviewer training session.
- To administer the benefits instrument at randomly selected households within the area segments. (One questionnaire was to be administered by an in-person interview at each sample household. The desired number of interviews to be conducted was 305.)

- To develop and implement onsite and offsite quality control procedures on the work performed by the field staff.

- To conduct an interviewer debriefing.

- To develop and implement data receipt, data editing, and keypunch procedures for all resultant data.

3.4.1 Questionnaire Design and Limited Local Pretest

The design of the benefits questionnaire involved the combined talents of RTI staff knowledgable in benefits analysis and questionnaire design, the EPA project officer, and selected consultants. Efforts to design the questionnaire centered on satisfying the two primary objectives:

- To collect the data required for analysis

- To collect the data in such a way that reliability and validity are enhanced.

In meeting these objectives, the number and types of questions included in the instrument and the format that those questions took were determined by several interrelated factors: Those factors included:

- The precise analytic goals of the survey.

- The adequacy of the project budget to support the data collection required.

- The facility of the interviewers in administering the instrument.

- The tolerance of potential respondents of the time and effort required to answer the questions.

- The ability of respondents to provide the data requested.

Table 3-1 outlines questionnaire development activity. After the data collection was completed and the interviewers debriefed, it was clear that the careful attention given to questionnaire design had reaped substantial rewards. The nuances of the questions and intricate skip patterns made necessary by anticipated responses necessitated a considerable investment of time early in the questionnaire development.

Another factor that had a considerable effect on the overall quality of the instrument was the variety of skills brought to bear on the wording of questions. The economic concepts, of course, resided with the economists. However, the wording of questions was critiqued by survey specialists for sensibility and administrative ease and further reviewed by staff experienced in questionnaire formatting and overall survey methodology. The net effect of these efforts was a questionnaire that was more comprehensible than the economists could have ever produced themselves and more sophisticated than the survey specialists alone would have designed.

Table 3-1. Questionnaire Development Activity

Activity	Date (1982)
Review existing survey work: Resources for the Future, Inc. (RFF) (Mitchell); Colorado State; Wyoming	August 5
Develop first draft for presentation at workshop	August 10
Revise draft for review by EPA project officer, consultant, and survey specialist	August 17
Incorporate revisions from review	August 20
Review by survey staff	August 22
Send revisions to EPA project officer for review by EPA survey liaison officer	August 24
Perform limited pretest in Raleigh area	August 26
Revise instrument based on pretest	August 28
Submit draft instrument to EPA for review	September 2
Revise instrument based on additional pretest	September 6
Submit Office of Management and Budget (OMB) package	October 9
Incorporate OMB suggestions	October 27
OMB approval	November 5

After the instrument was developed, it was administered on a limited pretest basis in the Research Triangle Park, North Carolina, area. Further limited pretesting of the instrument was completed in Pittsburgh after the Office of Management and Budget (OMB) package was submitted for EPA review.

The Research Triangle Park pretest was conducted on people from the Pittsburgh area to detect major faux pas in the instrument that Triangle-area residents could not perceive. As a result of this pretest, several recreation sites were added to the site list, the groups of activities were rearranged, and a better map was developed. Most of the benefits from the pretest came from finding flaws in the logic of the questionnaire. The pretest was especially helpful in determining what subsequent questions were appropriate for zero bidders and for bidders who gave a zero to only certain parts of the questionnaire.

A limited budget prevented extensive pretesting in the target area. In future surveys this activity should be budgeted. Because of the logical consistency desired across all items in the questionnaire, a pretest in the survey area would reveal potential logical inconsistencies only sample area residents could expose via their responses. Researching the river and the sample area was a viable substitute, but a pretest in Pittsburgh would have been a valuable complement.

3.4.2 Retaining Field Supervisors and Hiring Interviewers

The project used two field supervisors experienced in hiring and training interviewers and in managing survey fieldwork to supervise and carry out the count-and-list task and to recruit the field interviewers who performed the household interviewing task. Because much of the cost of a data collection effort is due to count-and-list activities and to interviewer recruiting, using offsite field supervisors made the project's field operations more economical. The survey task leader closely monitored the field supervisors in the count-and-list and recruiting activities, which were carried out during the week of October 19, 1981.

Project staff and the field supervisors worked together to select the interviewers from among experienced applicants who had previously performed well on similar surveys. Top prospects in the Pittsburgh area were screened by telephone to verify general qualifications, availability, and interest. During the count-and-list activity, the field supervisors interviewed some of the best qualified applicants in person. Personal and work references were checked before final selections were made. Relevant selection criteria included interest in the objectives of the study, availability of dependable transportation, perceived ability to relate well to the sample population of interest, input from personal and work references, and interviewing skills (e.g., ability to read questions clearly, to follow instructions, to use nondirectional probes, to record responses accurately and legibly, etc.).

The selected interviewers were nine professionals who had extensive experience in household surveys, focus groups, census work, and a variety of other interviewing activities. These interviewers performed admirably throughout the data collection process, overcoming inclement weather, a few irate refusals, and an approaching holiday season. This was done with a refreshing enthusiasm and reinforced the confidence of the project team members. The interviewers were aware of all the things that can possibly bias a respondent and were careful to follow the procedures outlined in the manual and covered in the training session. In summary, the importance of using experienced, professional interviewers cannot be overstated.

3.4.3 Counting and Listing of Sample Segments

Two field supervisors and two experienced interviewers conducted all counting and listing of sample segments. This task involved:

- Locating the segment
- Identifying segment boundaries

- Counting the housing units
- Listing all eligible housing units.

The count-and-list task was completed in 1 week and the materials returned for an in-house check and preparation of interviewer assignments. Appendix B shows samples of the results from the count-and-list activities. Details of how these materials were used by the interviewers are provided in the Field Interviewer's Manual, available from Research Triangle Institute.

3.4.4 Developing Field Manuals and Conducting Interviewer Training

Because the interviewers were supervised from the Research Triangle Park during the household interviewing phase, a high degree of administrative organization of field personnel was required for the project. Interviewers were carefully informed of reporting and communications channels, procedures, schedule requirements, documentation of nonresponse, reassignments, quality control techniques, and other operating procedures required to complete the project in a timely, cost-effective manner. The Field Interviewer's Manual provided the details of the organization of the field procedures and covered the following topics:

- Purposes and sponsorship of the project
- Role of the interviewer
- Data collection schedule
- Field sampling and locating procedures
- Contacting and obtaining cooperation from sample members
- Reporting results of attempts to secure interviews
- Documentation of nonresponse
- Validations, field edits, and other quality control procedures
- Disposition of completed cases
- Completion of administrative forms (e.g., field status reports, reassignment forms, and production and expense reports)
- Communications with central office staff.

In addition to the Field Interviewer's Manual, a series of administrative forms was developed including a household control form (see Appendix B), which served the following functions:

- Provide assignment information for the interviewer (i.e., sample household address).

- Provide the interviewer with an introductory statement explaining the survey.

- Provide appropriate household enumeration questions and queries to obtain demographic data on persons in the sample household.

- Provide the interviewer with instructions for selecting a household member to be interviewed.

- Require the interviewer to document all attempted and successful contacts with the sample member.

- Provide an appropriate set of result codes for describing interim and final results for each case.

- Require the interviewer to record certain information required for validation of completed interviews and noninterviews.

The training materials developed for the project included background on benefits analysis and administrative procedures. The Interviewer's Manual and a copy of the questionnaire were sent to the interviewers prior to their classroom training. A specified amount of time was authorized for advance study, and interviewers were expected to read the manual and specifications prior to the training session.

3.4.5 Training Session

The extensive experience of the interviewers enabled the project team to focus on the unique aspects of the project and to highlight the technical details of the interviewing procedures. The agenda, shown in Figure 3-3, shows the variety of topics covered in the 2-day session on November 11 and 12, 1981.

In addition to covering the project objectives, the training session provided an opportunity for personal interaction with the interviewers. The session focused on benefits, EPA water policy, the water pollution basics, and mock interviews with all versions of the questionnaire. The mock interviews included zero bidders, recalcitrant and reluctant bidders, use of the payment card, and procedural problems that might be encountered. The interviewers were reminded not to provide supplemental information but to reread an item as many times as necessary. Each interviewer received a healthy dose of information on benefits methodology and the important policy implications of the project. The participation by the project officer in the training also conveyed the feeling that the interviewers were important to the successful completion of the survey.

3.4.6 Conducting Household Interviews

Face-to-face interviews were conducted between November 13 and December 20, 1981. Conducting the interviews involved a series of interrelated operations, which included taking steps to obtain the desired number

Field Interviewer Training Session Agenda

Study for Estimating Recreation and Related Benefits of Water Quality

November 11, 1981		
9:00 a.m.	Introduction of RTI staff and field interviewers	Kirk Pate
9:10 a.m.	Review of training agenda	Kirk Pate
9:15 a.m.	*Project administrative procedures*	Kirk Pate
9:45 a.m.	Break/picture taking and IDs	
10:15 a.m.	Explanation of the Benefits Study	Bill Desvousges
11:00 a.m.	Overview of field interviewer responsibilities	Kirk Pate
11:15 a.m.	Locating sample housing units	Kirk Pate
12:00 a.m. - 1:00 p.m.	Lunch	
1:00 p.m.	Completing household control form and selecting sample individuals	Kirk Pate
1:30 p.m.	Questionnaire administration	Kirk Pate
2:30 p.m.	Demonstration interview	Kirk Pate/ Bill Desvousges
2:45 p.m.	Break	
3:00 p.m.	Mock interview—Version A	Group
5:00 p.m.	Adjourn	
November 12, 1981		
9:00 a.m.	Questions and answers/discussion of yesterday's session	Kirk Pate/ Bill Desvousges
9:30 a.m.	*Water pollution: Dimensions of a problem*	Bill Desvousges
10:00 a.m.	The Benefits Study	Dr. Ann Fisher
10:30 a.m.	Mock Interview—Version C	Group
12:00 a.m. - 1:00 p.m.	Lunch	
1:00 p.m.	Questions and answers Distribution of assignments	
2:00 p.m.	Adjourn	

Figure 3-3. Field interviewer training session agenda.

of interviews, instituting interviewer assignment and reporting procedures, making initial household contacts and obtaining cooperation, enumerating household members, and administering the instrument.

Initial assignments of cases to interviewers were made on the basis of each interviewer's location and characteristics. Generally, assignments were made on the basis of the interviewer's geographic proximity to the sample segments. That was, of course, a cost-effective practice and usually resulted in interviewers sharing some characteristics with the people to be interviewed.

Efforts were made to equalize interviewer workloads; however, individual assignments were made after careful consideration of factors related to the difficulty of the areas assigned to each. Based on an assumed equal distribution of cases per interviewer, the average number of cases initially assigned per interviewer for the 6-week data collection period was 40. Under Number of Cases Assigned, Figure 3-4 shows the final case load for each interviewer after adjustments in the field.

RTI Project 2222-2

FIELD DATA COLLECTION WEEKLY STATUS REPORT

ESTIMATING BENEFITS OF WATER QUALITY

Week # 6 Dates Covered: 12 / 15 / 81 to 12 / 21 / 81 Date Report Prepared: 12 / 22 / 81

FI Name	Number of Cases Assigned	No Action Taken	Cases in Progress	Enumeration Final Status Code*						Interview Final Status Code**					
				02	04	05	06	07	08	20	22	23	24	25	26
	42	0	42	1	3		4			29		3	1		1
	39	0	39	3	1					28		2	4		1
	57	0	57		6		4	2	1	40		1	3		
	36	0	36	1	1		2			31			1		
	64	0	64		1		1		1	54	1	1	3	1	1
	48	0	48	1			6			34	1	4	2		
	41	0	41	1	3					33		1	3		
	6	0	6							5			1		
	44	0	44	1				1		36		1	5		
	20	0	20	1	2		1		1	13		1	1		
TOTAL	397	0	397	9	17		18	3	3	303	2	14	24	1	3

*Status Codes:

02 No Enumeration Eligible Home
04 Enumeration Refused
05 Language Barrier
06 Vacant SHU
07 Not an SHU
08 Other

**Status Codes:

20 Completed Interview
22 Interview Breakoff
23 Not at Home/No Contact
24 Refused
25 Language Barrier
26 Other

Distribution List:

B. Desvousges
K. Pate
D. Smith
SOC Dept. 2 Files (2222-2)

Figure 3-4. Summary of completed interviews.

Once interviewer assignments were identified, interviewers' names were associated with each household control form. Thus, manual control of assignments was established and maintained. This control of assignments was updated weekly on the basis of status reports and receipt of completed work.

Once assignments were issued at the conclusion of training, rigid reporting procedures were implemented. At a specified time each week, each interviewer telephoned the survey specialist and reported the status of each assigned case, using the current status code from his copy of the household control form. The staff member entered the codes on a field status form for the reporting period and discussed each active case showing no progress or indicating a problem.

3.4.7 Initial Contacts and Obtaining Cooperation

Obtaining cooperation depended upon the persuasiveness of interviewers, who, as a result of training and experience, were able to communicate to respondents their own convictions regarding the importance of the study. There was no major problem in obtaining respondent cooperation. Interviewers indicated that people who were uncooperative for this project were no different from other survey experiences in the Pittsburgh area.

3.4.8 Household Enumeration

Once the interviewer made contact with an eligible household member, he proceeded to enumerate all individuals residing in the household. This procedure ensured that each age-eligible individual was given a chance to be selected for interviewing. All reasonable field efforts were made to interview all sample individuals. The following situations were anticipated and were handled as indicated below:

- Field efforts were discontinued once it was determined that a sample member had moved outside the sample counties.
- Field efforts were discontinued upon learning that sample members were deceased or institutionalized.
- When non-English-speaking respondents were encountered, an attempt to identify a close relative to serve as interpreter was made in an effort to complete the interview. There was only one interview with a language barrier, so no special effort was made in this area.
- An initial call and at least three additional callbacks were made at different times of the day and different days of the week in an attempt to establish contact with sample individuals to complete the interview.
- Contacts with neighbors were made after the second call to obtain "best time to call" information.

The enumeration process was facilited by the design of the household control form (see Appendix B), which contained procedural instructions, questions, and recording mechanisms to assist the interviewer in identifying and listing household members and determining sample status. Procedures for assigning appropriate unique identifiers were also included.

3.4.9 Interviewing Procedures

Interviewers were instructed to attempt to conduct interviews immediately following the enumeration process when the sample member was identified and if he were available. If necessary, appointments were made to return at a time convenient for the sample member. All interviews were completed by means of a face-to-face interview. The average length of a completed interview was approximately 35 minutes.

Table 3-2 highlights the final tally from the field data collection. The final number of sample housing units was 397 due to the discovery by field interviewers of 13 housing units not listed during the listing phase of the

Table 3-2. Final Distribution of Sample Housing Units

Result category	Number	Percentage of SHUs
Out-of-Scope[a] SHUs.	21	
Vacant	18	4.53
Not an HU	3	.76
	21	5.29 (of 397 SHUs)
In-Scope[b] SHUs.	376	
No enumeration eligible at home	9	2.39
Enumeration refused	17	4.52
Other enumeration result	3	.80
Completed interviews	303	80.59
Interview breakoff	2	.53
Sample individual not at home	14	3.72
Sample individual refused	24	6.38
Language barrier	1	.27
Other interview result	3	.80
	376	100.00

[a]Out-of-scope refers to sample housing units not included in response rate calculation.

[b]In-scope refers to sample housing units included in response rate calculation.

project.* The interviewers completed 303 interviews during the data collection period of November 13 through December 20, 1981--two interviews short of the desired goal. The response rate (80.59 percent) was ever so slightly above the anticipated 80 percent rate, while the refusal rate equaled 10.90 percent.

*The count-and-list process is an imperfect one because interviewers are not required at that stage to actually knock on each door in an effort to identify housing units (HUs). Procedures for discovering HUs missed during the listing process are implemented during the household interviewing stage. The inclusion of each missed HU in the survey improves the statistical representativeness of the initial sampling frame.

Twenty-three sample households either did not complete the interview or refused to cooperate. These were 23 cases in which either no one was at home to provide the enumeration or the enumeration of the household members was obtained but the sample individual was never available to complete the interview. The crush of the Christmas holidays and a week of inclement weather conditions prevented resolution of these cases. Without either of these hindrances, it is not unreasonable to expect that an additional 15 to 20 interviews could have been obtained by the interviewers.

3.4.10 Interviewer Debriefing

The project staff and the project officer conducted a 1-day debriefing session in mid-December. This session provided an opportunity for the interviewers to evaluate survey procedures and the questionnaire relative to their other interviewing experiences. The overall conclusion of the debriefing session was that the questionnaire was generally easy to administer and that there were few major problems.

The comments that follow represent general impressions and evaluations of the interviewers. There is no way to validate them, but they certainly provided valuable insight for the project staff. The debriefing session was highly valuable for project staff, both in terms of current project and ideas for handling problems in future efforts.

Training Materials

- More background on water pollution and recreation would have been helpful.
- Background and policy setting provided "keys" for getting in doors. Interviewers simply found it easier to pique people's interest because they understood the project objectives better.
- More explanation of the payment vehicle--how people are currently paying for water pollution in higher prices and taxes--would have been helpful to the interviewers.

Interviewing Process--General Comments

- Count-and-list maps and materials worked well.
- Drinking water was a major concern of many people, especially the elderly. This was not addressed in our instrument because of the recreation focus.
- There were occasions in which a spouse intervened or critiqued the interview responses of the sample individuals. The interviewers felt, however, that the respondents gave responses that reflected the households' views.

- Refusals were generally three types: busy, timid, or nasty. This was no different from other household surveys, according to interviewers.

- Thirty minutes was the ideal length both in terms of administration and getting critical cooperation of respondents.

Evaluation of Specific Parts of Questionnaire

- Section A, with activities listing and sites, worked very well. Easy to administer and established interest of many respondents--especially recreators.

- Section B introduction is still wordy, especially B-1 introduction. "Season" ticket needed after advance in introduction.

- B-2. needed a skip pattern for nonrecreators.

- Few problems with B-3 or B-4.

- There was some confusion in B-5 as to how to interpret zero response to this question. Does it mean no change or a complete reduction? This will require careful attention in analysis. There was also some confusion over how the water quality might be bad sometimes and not at other times.

- Few problems with B-6.

- There was some concern in B-7 whether the amount given was the total amount already given, a new amount independent of other amounts, or an amount in addition to those given earlier.

Visual Aids

- Map and water quality ladder worked well.

- Visual aid showing how (but not how much) people are currently paying was needed to aid less perceptive respondents.

- Rank order card design was effective. People had little trouble connecting levels and dollar amounts, but cards should have been larger for easier use.

- Numbers on scale in water quality ladder were too small for elderly respondents.

- There could have been several more sites on the site listing.

- A better visual aid is needed for "use--might use," perhaps with color and/or larger print.

Questionnaires

- The direct question of willingness to pay without a payment card was the most difficult version to administer because people often seemed uncomfortable without some aid (consistent with Mitchell and Carson's [1981] finding). The payment card was the easiest to administer.

- The bidding games usually reached an amount quickly as respondents supplied amounts after seeing how the process worked. The $125 starting point for each level was high relative to many bids making this slightly embarrassing for the interviewers to administer. Reason for high amount was to test for bias due to starting points.

- Specific suggestions for revising the questionnaire are presented in Appendix D.

3.4.11 Data Receipt, Editing, and Keypunching

The last phase of the survey process required careful handling of the survey data, coding, editing, and keypunching. Appendix B provides the details of this process. In general, completed questionnaires were received from the interviewers on a flow basis during the data collection period. In-house editing was performed by the survey specialist for the purpose of detecting any irregularities. As necessary, irregularities were discussed with the appropriate interviewer.

The only major coding of responses that was required involved the occupation questions. The verbatim responses were coded into the occupation classes from the Bureau of the Census.* Household control form and questionnaire data were keypunched on cards and verified before analysis began.

*March 1971, publication from the Census of Population, U.S. Department of Commerce, Washington, D.C. 20233.

CHAPTER 4

CONTINGENT VALUATION DESIGN AND RESULTS: OPTION PRICE AND USER VALUES

4.1 INTRODUCTION

Application of the contingent valuation approach, also referred to as the direct survey approach in environmental economics, asks individuals their dollar valuation of a nonmarket "commodity"--i.e., some good or service not traded in an actual market.* In environmental applications, the analyst must create a hypothetical market by describing how individuals would pay for specific improvements in environmental quality. For this benefits study of the Monongahela River basin, the contingent valuation design used a household survey to ask individuals' valuation in terms they could understand--terms that translate the water quality improvements into additional activities, such as swimming and recreation fishing, that individuals could undertake along the Monongahela River.

Contingent valuation offers the analyst considerable flexibility in designing the "commodity" to be valued in the hypothetical market. At the same time, however, it requires that he take considerable care in designing the market so it is both credible and understandable to the respondent. Indeed, research suggests that contingent valuation results may be sensitive to the question formats used to elicit an individual's valuation, the mechanism used to obtain the hypothetical payments (payment vehicle--e.g., user fee or utility bill increase), and the interviewers used to conduct the survey. To give useful results, the survey design must successfully surmount these influences.

The contingent valuation design for estimating the recreation and related benefits of improved water quality in the Monongahela River used research methods in fields ranging from survey and sample design to resource economics. This chapter traces the origins of the design, describes the survey questionnaire, characterizes the survey respondents, and presents the results on option price and user value for the water quality improvements.

Section 4.2 reviews survey design issues, paying close attention to potential biases in contingent valuation research, and Section 4.3 describes major components of the survey questionnaire, including the design for determining

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*The interpretation of the valuation requested of respondents will depend upon the nature of the question. For example, whether a willingness-to-pay or willingness-to-sell measure is elicited will depend on the property rights and nature of the change proposed in the question.

differences in techniques to elicit option price responses, the selection of a payment vehicle, and the design of tests for achieving plausible results. Section 4.4 characterizes the survey respondents and the main groups of interest among them (users and nonusers of the river and people who refused to pay <u>any</u> amount for improved water quality), Section 4.5 describes the estimated values for option price and the statistical analyses of these estimates, and Section 4.6 provides the same information for user values. Section 4.7 summarizes the chapter's main findings.

4.2 A REVIEW OF DESIGN ISSUES IN CONTINGENT VALUATION SURVEYS

In constructing a hypothetical market, the contingent valuation approach defines the commodity to be valued, specifies how the exchange would occur, and describes the other structural elements of the market. Brookshire, Cummings, et al. [1982] have labeled this process as "framing the question," or as simply setting the context presented to respondents as part of the contingent valuation experiment. As with almost any type of experimental design, the context can influence the outcome. For example, within the range of different contingent valuation contexts, an individual might participate directly in a bidding procedure to elicit willingness to pay for the hypothetical commodity, might directly reveal this value (with or without the aid of some type of payment card), or simply might evaluate (rank) various outcomes of the hypothetical market, as in the case of the contingent ranking format.

Partially because of this range of contexts, the various attempts to classify the methods for implementing the contingent valuation approach--and their design features--have created considerable confusion. Therefore, to consider the context of the contingent valuation approach used for the Monongahela River basin, this section is organized according to the approach's potential biases. These biases are not neatly compartmentalized; rather, they are overlapping and in some cases interrelated. (Indeed, one analyst's strategic bias is another's hypothetical bias.) At the risk of blurring the boundaries between compartments, the section notes the most important of these interrelationships. The boundaries themselves may, in large part, be a question of judgment.

4.2.1 <u>Hypothetical Bias</u>

Hypothetical bias in contingent valuation surveys is the bias attributable to the use of a hypothetical, not an actual, market situation, and it arises when individuals cannot or will not consider the questions in a manner that corresponds to how they would treat the actual situation. Consequently, we can expect that they provide inaccurate answers to the contingent valuation questions about it. Mitchell and Carson [1981] argue that hypothetical bias may increase respondents' uncertainty and ambivalence about the hypothetical experiment or induce them to provide answers that they perceive are socially desirable. In general, hypothetical bias may result in respondents rejecting or refusing to participate in the contingent valuation experiment, but the net effect is to increase the statistical variance and to lessen the reliability of the estimated willingness-to-pay amounts.

The empirical evidence on hypothetical bias is somewhat mixed, with some studies hindered by it and others showing no evidence. To test for several biases, Bohm [1971] designed an experiment that compared alternative bidding and payment schemes for the valuation of public television. Several alternatives were provided to respondents, and, in some cases, the respondents were actually given money to spend on several alternatives to public television. Bohm compared results from the group that answered hypothetical willingness-to-pay questions with those from a group that actually had to pay for public television. The willingness-to-pay bids from respondents who had to pay for public television were less, and significantly different, than those from respondents who were simply asked how much they were willing to pay. These results imply that hypothetical and strategic behavior were present in the contingent valuation approach.

Mitchell and Carson [1981] question Bohm's [1971] conclusion on hypothetical bias based on a reinterpretation of his statistical evidence. Bohm's results showed that only one group out of six had different mean values when structured across different types of information and market actuality. The group that did exhibit higher willingness-to-pay amounts was also the group that had higher incomes, which, Mitchell and Carson argue, may account for the size of its mean willingness-to-pay bid. This same group also had one outlier that raised the mean bid considerably. If the outlier is removed, the mean payment is reduced to a level at which it is no longer a statistically significant difference in the means.

Bishop and Heberlein [1979] designed a mail survey that compared hypothetical willingness-to-pay amounts and actual willingness to sell. In this study respondents were mailed checks in randomly selected amounts and requested to sell a hunting license they had previously purchased. The authors found that the amounts the respondents were willing to accept for their hunting licenses when presented with an actual check were considerably less than the willingness-to-pay amounts they gave in the hypothetical bidding game portion of the experiment. However, the results of the hypothetical and simulated market experiment suggested that the hypothetical market underestimated willingness to pay relative to the actual estimates from the simulated market. The Bishop-Heberlein findings suggest hypothetical bias may be a significant problem in contingent valuation survey design, but the implications of their research may be limited by their experimental design.

Significantly, the results of several studies have indicated that hypothetical bias may contribute to the considerable variability in contingent valuation estimates of willingness to pay. For example, the Brookshire, Ives, and Schulze [1976] and Brookshire et al. [1979] air quality studies explain less than 10 percent of their bid variation by either socioeconomic variables or changes in the level of the environmental good that the survey was designed to measure.

While not invalidating the approach as a means of measuring consumers' willingness to pay, the potential for hypothetical bias in contingent valuation surveys indicates the need for considerable attention in the instrument design phase to provide a credible survey questionnaire. The respondent must be

able to perceive the experiment as a realistic approach to measuring the good under consideration. Aizen and Fishbien [1977] have shown that the more closely a hypothetical experiment corresponds with actual situations, the greater the chance of reducing hypothetical bias. Mitchell and Carson [1981] argue that reducing hypothetical bias in a contingent valuation survey instrument does not necessarily lead to increased probability of incurring strategic bias (where a respondent attempts to influence results) or other types of biases. Rather, they suggest that a hypothetical experiment in which the market realism is high and consequence realism is low will reduce or minimize each type of bias. That is, respondents will perceive that a hypothetical situation closely corresponds to a real market situation (high market realism), but they will not perceive the nature of the consequences of the hypothetical experiment (to themselves) to the extent that they will attempt to influence the outcome (low consequence realism).

The Mitchell and Carson position differs considerably from that of Schulze et al. [1981], who argue that the potential for strategic bias increases when hypothetical bias is reduced. Mitchell and Carson present a viable alternative to the Schulze position in showing that both biases can be overcome in survey design. Specifically, Mitchell and Carson were able to explain a considerably larger percentage of the variation in willingness to pay than could authors of most earlier contingent valuation studies and did not find evidence of strategic behavior on the part of respondents. Furthermore, the Mitchell and Carson results are particularly encouraging because their hypothetical market design offered national water quality as a product, an unconventional situation that should be particularly sensitive to hypothetical bias.

4.2.2 Strategic Bias

The concern for strategic bias is usually attributed to Samuelson [1954], who suggested that any attempt to value public goods will be plagued by incentives on the part of individuals or respondents to behave strategically. Samuelson argued that, if individuals perceive they will be able to obtain a public good and enjoy its consumption, they may indeed try to obtain this public good by not revealing their true preferences. The thrust of the Samuelson argument for questionnaire design is that, depending on how respondents perceive the consequences of the hypothetical experiment, they may behave strategically. For example, an environmentalist who thinks his bid might affect some environmental policy may bid higher than his true willingness to pay in order to increase the average bid, provided he knows he will not have to pay based on these bids. Alternatively, if an individual believes his payment will be based on responses given to the questions, there will be incentives to conceal true preferences provided the individual is reasonably sure the good will be provided.

The empirical evidence on strategic behavior in contingent valuation surveys has generally found that strategic behavior is not a major problem for interpreting willingness-to-pay amounts. For example, Brookshire, Ives, and Schulze [1976] and Rowe, d'Arge, and Brookshire [1980] attempted to design experiments that would indicate the existence of strategic bias. In these experiments, respondents were asked to reveal their willingness to pay for

changes in a public good, which, if provided, would in turn require them to pay their share of the mean of all bids. Brookshire et al. [1979] show that, for respondents to engage in strategic behavior in the type of situation used in the Brookshire and the Rowe, d'Arge, and Brookshire studies, they would have to know not only the amounts that other individuals had bid, but also the number of bidders who had already been asked and their mean bid. Both studies concluded that strategic bias was not evident in the sample data generated when respondents were told they would have to pay the mean of the sample. The Brookshire test for strategic bias examined the distribution of the bids, arguing that strategic bias leads to a bimodal distribution in which the means for environmentalists are concentrated in the high values of the distribution while the means for nonenvironmentalists fall primarily at the other extreme. The Rowe, d'Arge, and Brookshire test involved a more rigorous statistical analysis but found no support for strategic bias after problem bids were eliminated. This study also provided one group of respondents with information on the sample mean bid after it had made its bid and allowed it to change on the basis of this new information. The authors found that only one respondent desired to change an overall bid. The complexity of the survey questionnaire used in the Rowe study, as well as the methods used to screen observations omitting some bids from the sample, limits the generality of the study results. A study by Brookshire, Ives, and Schulze [1976] also found no evidence of strategic bias in an examination of the distribution of willingness-to-pay amounts.

Mitchell and Carson [1981] argue that the distribution test used to indicate strategic bias in these earlier studies is inappropriate because it is impossible for most willingness-to-pay distributions to have standard normal distributions. They argue that the likely distribution is a lognormal one, as shown in their empirical results. Unfortunately, there are two problems with the Mitchell and Carson results on strategic bias. First, their sample was subsegmented into groups by income levels, which could have influenced the hypothesized relationship between willingness to pay and income. Second, Mitchell and Carson's results were limited by a substantial number of zero bidders and protest bidders who, given the limitations of the experimental design, prevented them from eliciting additional information on true preferences.

A forthcoming report by Cronin [1982] on willingness to pay for improved water quality in the Potomac River suggests the existence of strategic bias. The design of this study partitioned respondents into groups based on whether they would actually have to pay their bid through increased local taxes based on the mean bid or would have to pay very little because the Federal government would pay for most of it. A comparison across the two groups showed statistically significant differences in the mean willingness-to-pay amounts that are consistent with the presence of strategic bias. Some caution is needed in interpreting the Cronin finding because of a poorly designed survey questionnaire and specification problems in the willingness-to-pay equation.

Based on the evidence that currently exists, strategic bias is not the pervasive problem that researchers originally feared. However, it may be a problem if the questionnaire design does not provide a low-degree-of-consequence realism. Mitchell and Carson [1981] conclude that effectively designed survey questionnaires can achieve the required degree of realism.

4.2.3 Payment Vehicle Bias

Payment vehicle bias occurs when a respondent is influenced by the method of payment selected for the contingent valuation study. A number of different payment methods comprise the range of payment vehicles: user fees, increases in utility bills, and higher consumer prices and taxes. To be effective, a payment vehicle must be realistic and familiar to respondents so they consider it plausible and realize the implications of the implied payment frequency for their total willingness to pay in a given time period. The ideal payment vehicle would combine believability with a wide range of alternative payment amounts.

The contingent valuation literature indicates very little about the influence of payment vehicle bias. In the only study that systematically examined this bias, Rowe, d'Arge, and Brookshire [1980] found that the type of payment vehicle--utility bill or payroll deduction--had a significant effect on willingness to pay. One likely consequence of a particular payment vehicle is that it may condition respondents to a range of values their responses are expected to take. For instance, when a user fee is selected as the payment vehicle, it is quite possible that the respondent will think in terms of a usual range for user fees. Thus, payment vehicle bias may actually show up as starting point bias, discussed below. On the other hand, general resentment of taxes could lead to "pure" payment vehicle bias, in which the respondent rejects the payment vehicle itself.

4.2.4 Starting Point Bias

The contingent valuation literature has devoted more attention to the question of starting point bias--the influence of the starting points used in iterative bidding (or any contingent valuation procedure that uses starting point "keys," such as the Mitchell-Carson [1981] payment card)--than it has to the other biases. In an evaluation of willingness to pay for air quality in the Farmington, New Mexico, area, for example, Rowe, d'Arge, and Brookshire [1980] found strong evidence of the effects of starting points, with a respondent's bid for improvements in visibility increasing by $0.60 for every $1.00 increase in the starting point.

Brookshire et al. [1979] also found starting point bias in some of their alternative bidding situations. However, their starting point bias tests are difficult to interpret because their study had very small sample sizes across the alternative starting points, ranging from 2 to 16 respondents. Combined with the substantial standard deviation for the mean responses, these small sample sizes make it difficult to reject the null hypothesis that starting point has no effect. Mitchell and Carson [1981] argue that the small sample size may have had a greater impact on the study's inability to detect starting point bias in the Brookshire et al. [1979] study than the researchers realized. In addition, Mitchell and Carson [unpublished 1982] have also suggested that the Greenley, Walsh, and Young [1981] study was also hindered by starting point bias. The payment vehicles chosen by Greenley, Walsh, and Young inadvertently set two different starting points for the bidding process.

Several other studies--including those by Brookshire and Randall [1978], Thayer and Schulze [1977], Randall et al. [1978], and Thayer [1981]--have also tested for starting point bias in various degrees. These studies found no evidence of influence on willingness to pay that could be attributed to different starting points. Unfortunately, the research design of some of these studies was inadequate to sufficiently test for starting point bias. The Randall study was not able to differentiate mean bids by starting points, and several of the other studies tested starting points whose relative amounts were too close to provide conclusive results.

In summary, the literature on starting point bias indicates that, when a bidding game is used to elicit willingness to pay, the results can be influenced by the starting point used in the bidding process, suggesting that tests for starting point bias should be included in the research design. The Thayer [1981] study provides both a simple test for the existence of starting point bias and an adjustment for willingness-to-pay bids if starting point bias exists. However, the assumptions implicit in Thayer's test may limit its practical application, since it assumes the respondent has a nonstochastic honest bid.

4.2.5 Information Bias

Information bias is the influence on an individual's valuation that is attributable to the amount of information given to respondents in the survey questionnaire. The literature provides very little evidence on the extent of information bias. Careful questionnaire design and thorough interviewer training to provide consistent and equal information to each respondent should minimize this bias.*

4.2.6 Interviewer Bias

Interviewer bias is attributable to the effect of using different interviewers to elicit individuals' valuations. This bias can stem from one interviewer being more effective than another, either in administering a bidding game or in establishing rapport with the respondent. In his seminal research on wilderness experiments in the Maine woods, Davis [1963] established a high level of rapport with the respondents but performed all of the interviews himself. A recent study by Cronin [1982] was able to test for the existence of interviewer bias and indicates that willingness to pay can be influenced by the interviewer. But the design of the test was not sufficiently robust for a conclusive result. The prospects for interviewer bias can be minimized with training sessions and by using experienced professional interviewers. Nonetheless, even when training is used, the research should examine the influence of using different interviewers because this may serve to identify other influences on the bids that were not previously recognized.

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*This is an example of a bias category that is not easily distinguished from the problems associated with "framing" the experiment.

Table 4-1. Summary of Biases in Contingent Valuation Experiments

Type of bias	Definition	Studies that have tested for bias	Summary of current results[a]
General			
Hypothetical	Error introduced by posing hypothetical conditions rather than actual conditions to an individual; response may not be a good guide to actual actions individual would take	One known test--Bishop-Heberlein [1979], Bohm [1971]	Some indication that hypothetical nature of question did influence responses, but could not distinguish this effect from instrument-related biases
Strategic	Attempt by respondents to influence outcome of study by systematically over- or under-bidding so action favors their true interests; strategic responses depend on how payment scheme is defined and whether it is believed	At least eight tests (see Schulze, d'Arge, and Brookshire [1981] for summary; Cronin [1982])	Very little evidence of strategic bias except for Cronin [1982]
Instrument related			
Starting point	Contingent valuation experiments using bidding game format have started with suggested payment and use yes or no responses to derive final willingness to pay; suggestion may be perceived as appropriate bid	At least five tests (see Schulze, d'Arge, and Brookshire [1981] and Rowe and Chestnut [1981])	Some differences in opinion over importance of starting point bias; Mitchell-Carson [1981] feel starting point bias is important, and Desvousges, Smith, and McGivney [1982] provide some support; Schulze, d'Arge, and Brookshire [1981] feel it is more limited
Vehicle	Characteristics of proposed mechanism for obtaining respondent's willingness to pay may influence responses	At least four tests (see Schulze, d'Arge, and Brookshire [1981] and Mitchell and Carson [1981])	Some evidence of effects in at least two studies
Information	Effect of information provided to respondent on costs of action under study or other dimensions of problem may affect responses	At least four tests (see Schulze, d'Arge, and Brookshire [1981] and Mitchell and Carson [1981])	Limited evidence of effects
Interviewer	Responses vary systematically according to interviewer	Two tests--Desvousges, Smith, and McGivney [1982] and Cronin [1982])	No evidence of bias Bias present

[a]The definitions and results summarized in this table are based on Schulze, d'Arge, and Brookshire [1981], Rowe and Chestnut [1981], and Mitchell and Carson [1981].

4.2.7 Summary and Implications for Contingent Valuation Research Design

Table 4-1 summarizes the relevant research on potential biases in contingent valuation studies discussed above. Based on this information, the Monongahela River contingent valuation study was designed to test for starting point bias. In addition, after the surveys were completed, the statistical analysis examined the prospects for interviewer bias. The structure of the survey attempted to control for information, vehicle, hypothetical and strategic biases in the survey questionnaire.

4.3 QUESTIONNAIRE DESIGN

Questionnaire design is the most critical task in a contingent valuation study. This section describes the questionnaire used to estimate the recreation and related benefits of water quality improvements for the Monongahela River in Pennsylvania. Specifically, building on the sampling plan and survey procedures discussion in Chapter 3 and on the contingent valuation survey biases discussion in Section 4.2, this section explains the treatment of potential biases either as an element in the questionnaire design or as an objective in the analysis of the resulting data.

4.3.1 Questionnaire Design: Part A

A key ingredient in successful contingent valuation surveys is establishing credibility for the survey objectives (see Appendix D for a complete copy of the questionnaire). The first component of the questionnaire has to achieve this objective without biasing or offending the respondent. Part A in the Monongahela River questionnaire attempted to achieve these goals by inquiring about recreation activities the respondent had engaged in during the last year. The first two questions dealt with boat ownership to determine if the respondent had easy access to a boat for recreation purposes through either ownership or "borrowing" rights. Ditton and Goodale [1973] found boat ownership to be a significant factor in recreation attitudes and activities in Green Bay, Wisconsin. This suggested a question that was unlikely to offend any respondent.

Following the boat ownership question, the interviewer presented the list of outdoor recreation activities shown in Figure 4-1 and asked if the respondent had participated in any of the activities within the past 12 months. The list contains a wide range of activities, including those usually associated with water recreation--boating, fishing, and swimming--and those that occur near water--picnicking, biking, and sightseeing. The list is a subset of the activities listed in the 1977 Federal Estate Survey data base used in estimating the travel cost model in Chapter 7. This activity matching was an attempt to provide additional compatibility between the methods.

A "no" answer to the participation question on the Monongahela questionnaire moved the respondent into the benefits section, while a "yes" response initiated the site/activity matrix, illustrated in Figure 4-2. The interviewer used the site/activity matrix to record the sites visited, the number of visits, and the activities in which the respondent participated. The interviewer provided the respondent with two additional visual aids to facilitate this

On or In Water	01	Canoeing, kayaking, or river running
	02	Other boating
	03	Sailing
	04	Water skiing
	05	Fishing
	06	Swimming outdoors or sunbathing
Near Water	07	Camping in a developed area
	08	Picnicking
	09	Walking to observe nature or bird watching; wildlife or bird photography
	10	Other walking for pleasure or jogging
	11	Bicycling
	12	Horseback riding
	13	Hunting
	14	Hiking or backpacking
	15	Attending outdoor sports events (do not include professional football or baseball)
	16	Other outdoor sports or games
	17	Driving vehicles or motorcycles off-road
	18	Driving for pleasure
	19	Sightseeing at historical sites or natural wonders

Figure 4-1. Activity card.

Site Names Not Listed	Site Codes	No. of Visits	CANOEING, KAYAKING, ETC.	OTHER BOATING	SAILING	WATER SKIING	FISHING	SWIMMING, SUNBATHING	CAMPING	PICNICKING	BIRD/WILDLIFE OBSERV/PHOTO	OTHER WALKING/JOGGING	BICYCLING	HORSEBACK RIDING	HUNTING	HIKING OR BACKPACKING	ATTEND SPORTS EVENTS	OTHER OUTDOOR SPORTS	OFF-ROAD DRIVING/RIDING	PLEASURE DRIVING	SIGHTSEEING
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19

Figure 4-2. Site activity matrix.

discussion--a colored pictorial map of the area shown in Figure 4-3 and a list of recreation sites (also shown on the map) displayed in Figure 4-4. The respondent described the information requested for these sites or any other sites visited. The data collected in Part A completed a recreation profile of the respondent that could be used in the analysis phase and established a rapport with him without influencing the main objective--benefit estimation. Part A also reinforced the idea that a wide range of recreation site services is influenced by water quality.

4.3.2 Benefits Measures: Part B

Part B of the Monongahela River questionnaire established the hypothetical market by describing its institutional arrangements. In other words, this part described the hypothetical market, the commodity to be valued, the payment vehicle, and enacted the valuation experiment. The first section introduced the setting for the hypothetical market:

> The next group of questions is about the quality of water in the Monongahela River. Congress passed water pollution control laws in 1972 and in 1977 to improve the nation's water quality. The States of Pennsylvania and West Virginia have also been involved in water quality improvement programs of their own. These programs have resulted in cleaner rivers that are better places for fishing, boating, and other outdoor activities which people take part in near water. We all pay for these water quality improvement programs both as taxpayers and as consumers.
>
> In this study we are concerned with the water quality of only the Monongahela River. Keep in mind that people take part in all of the activities on Card 1 (Figure 4-1) both on and near the water.

Following the introduction, the interviewer handed the respondent the key visual aid for the hypothetical market--the Resources for the Future (RFF) water quality ladder developed by Mitchell and Vaughan at RFF and used by Mitchell and Carson [1981] in their contingent valuation study of national water quality (see Figure 4-5). Appendix E provides details on its construction. The ladder's major attribute is that it easily establishes linkages between recreation activities and water quality based on an index of technical water quality measures and informed judgment. This type of linkage illustrates a crucial distinction between the contingent valuation method and indirect techniques for measuring the benefits of water quality. Specifically, rather than observing the actual behavior of recreationalists, who demand different site services depending on the level of water quality, it directly introduces the relationship between activities and different water quality levels into the hypothetical market.

After showing the key visual aid, the interviewer read the following text* to describe the ladder and establish the desired linkages:

---

*The words in all capitals are instructions for the interviewers only and were not read to the respondent. They are included in the discussion for completeness.

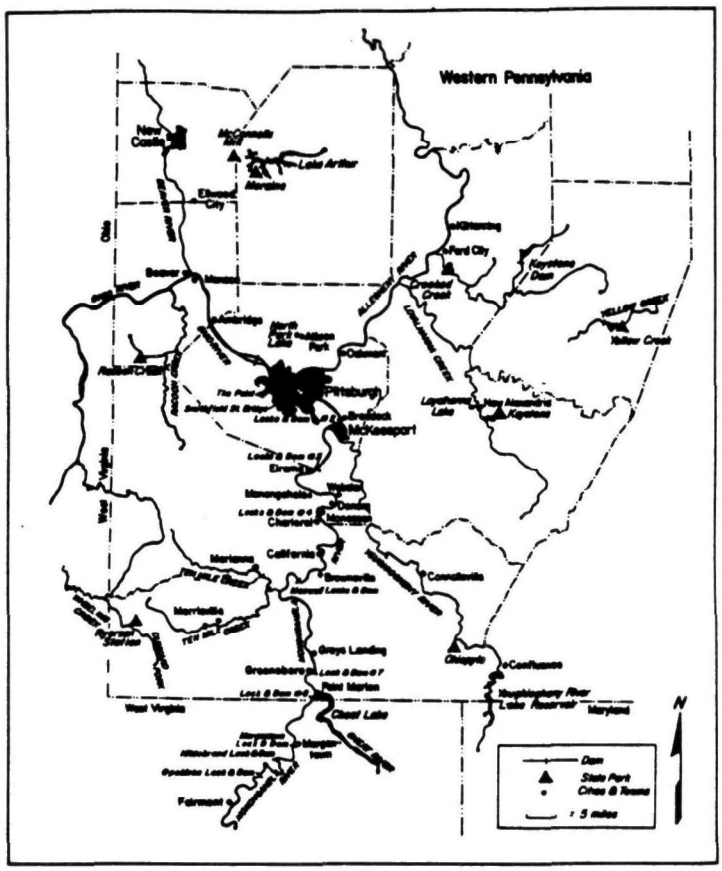

Figure 4-3. Map of Monongahela River and other recreation sites.

Allegheny River:

01 Near Kittanning
02 Near Oakmont
03 Where Beaver River and Ohio River meet
04 Crooked Creek Park
05 Loyalhanna Lake
06 Keystone Dam
07 Lake Arthur in Moraine State Park
08 Ohiopyle State Park
09 North Park Lake (Near Allison Park)
10 Racoon Creek State Park
11 Youghiogheny River Lake Reservoir
12 Cheat River Lake
13 Ryerson Station
14 Yellow Creek

Monongahela River Area:

15 Pittsburgh (The Point, Smithsfield Bridge, Braddock)
16 Where Monongahela and Youghiogheny meet near McKeesport
17 Elrama
18 The Town of Monongahela
19 Donora and Webster
20 Near Charleroi (Lock and Dam #4)
21 In the California-Brownsville Area
22 Maxwell Lock and Dam
23 Ten Mile Creek
24 Grays Landing—Greensboro (Lock and Dam #7)
25 Point Marion—Cheat River Area (Lock and Dam #8)
26 Morgantown
27 Hildebrand
28 Opekiska
29 Fairmont

Figure 4-4. Recreation sites.

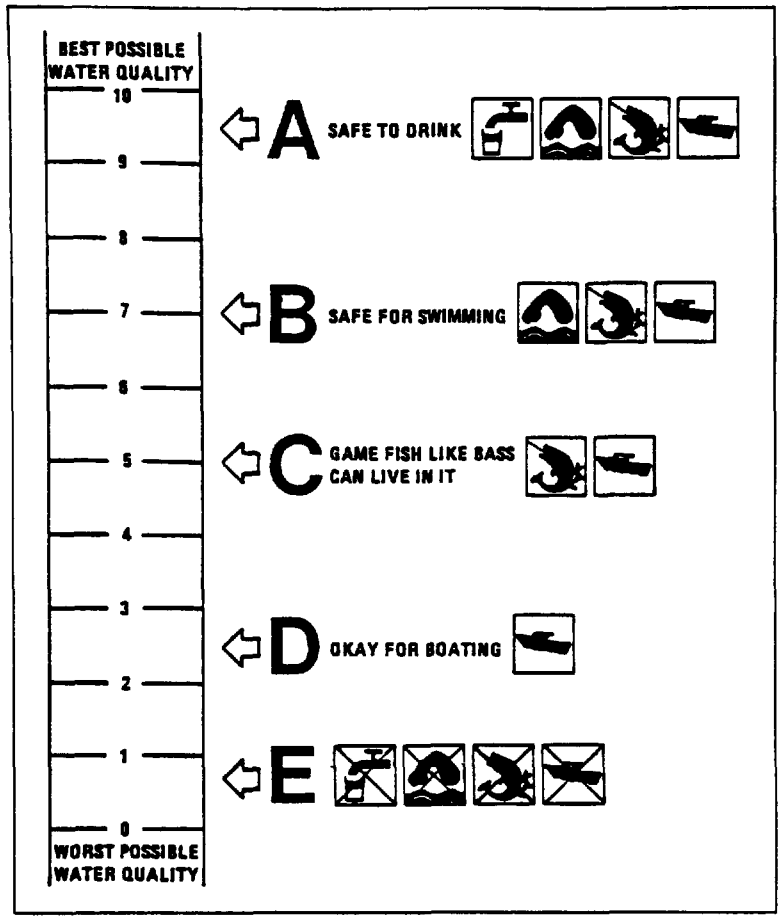

Figure 4-5. Water quality ladder.

Generally, the better the water quality, the better suited the water is for recreation activities and the more likely people will take part in outdoor recreation activities on or near the water. Here is a picture of a ladder that shows various levels of water quality. GIVE RESPONDENT CARD 4, "WATER QUALITY LADDER."

The top of the ladder stands for the best possible quality of water. The bottom of the ladder stands for the worst possible water quality. On the ladder you can see the different levels of the quality of the water. For example: (POINT TO EACH LEVEL--E, D, C, B, A--AS YOU READ THE STATEMENTS BELOW.)

> Level E (POINTING) is so polluted that it has oil, raw sewage and other things like trash in it; it has no plant or animal life and smells bad.
>
> Water at Level D is okay for boating but not fishing or swimming.

Level C shows where the water is clean enough so that gamefish like bass can live in it.

Level B shows where the water is clean enough so that people can swim in it safely.

And at Level A, the quality of the water is so good that it would be possible to drink directly from it if you wanted to.

Following this description, the interviewer asked the respondent to use the ladder to rate the water quality in the Monongahela River on a scale of 0 to 10 and to indicate whether the ranking was for a particular site, and, if so, to name it.

Question B-2 introduced the respondent to a key element in the hypothetical market: the distinction between user, option, and existence values. Specifically, the interviewer gave the respondent the value card shown in Figure 4-6 and described each type of value. An attitudinal question punctuated the descriptions of each type of value by inquiring how important the factors of actual use, potential use, and no use were in valuing water quality. The attitudinal responses to these questions--displayed on a five-point scale ranging from very important to not important at all--reinforced the concepts, provided a break in the discussion, and presented an additional check for the consistency in responses. The textual explanations for the three types of values are:

Why We Might Value Clean Water in the Monongahela River

I. Use

Swimming	Hiking
Fishing	Sitting by the shore
Boating	Hunting
Picnicking	Driving vehicles off road
Birdwatching	Jogging

II. Might Use

To have clean water in the river to use if you should decide in the future that you want to use it.

III. Just Because It's There

Preserve for future generations.
Satisfaction from knowing that there is a clean river.
Satisfaction from knowing that others can enjoy the river for recreation.

Figure 4-6. Value card.

Another important purpose of this study is to learn how much the quality of water of the Monongahela River is worth to the people who live in the river basin. In answering this question, there are three ways of thinking about water quality that might influence your decision. GIVE RESPONDENT CARD 5, "VALUE CARD." The three ways are shown on this card.

One, you might think about how much water quality is worth to you because you use the river for recreation. POINT TO PART I OF VALUE CARD AND GIVE RESPONDENT TIME TO READ THAT PART.

How important a factor is your actual use of the river in making a decision about how much clean water is worth to you? CIRCLE NUMBER.

VERY IMPORTANT.	01
SOMEWHAT IMPORTANT	02
NEITHER IMPORTANT NOR UNIMPORTANT.	03
NOT VERY IMPORTANT	04
NOT IMPORTANT AT ALL	05

Another way you might think about how much clean water is worth to you is that it is worth something to you to know that a clean water river is being maintained for your use if you should decide, in the future, that you want to use it. POINT TO PART II OF VALUE CARD AND GIVE RESPONDENT TIME TO READ THAT PART. For example, you might buy an advance ticket for the Steelers or Pirates just to be able to go to a home game if you later decide you want to go. Likewise, you might pay some amount each year to have a clean water river available to use if you should decide to use it.

In deciding how much clean water is worth to you, how important a factor is knowing that a clean water river is being maintained for your use, if you should decide to use it? CIRCLE NUMBER.

VERY IMPORTANT.	01
SOMEWHAT IMPORTANT	02
NEITHER IMPORTANT NOR UNIMPORTANT.	03
NOT VERY IMPORTANT	04
NOT IMPORTANT AT ALL	05

A third thing you might think about in deciding how much clean water is worth to you is the satisfaction of knowing that a clean water river is there. POINT TO PART III OF VALUE CARD AND GIVE RESPONDENT TIME TO READ THAT PART. For example, you might be willing to pay something to maintain a public park even though you know you won't use it. The same thing could be true for clean water in the Monongahela; that is, you might pay something just for the satisfaction of knowing that it is clean and that others can use it.

In deciding how much clean water is worth to you, how important is knowing that a clean water river is being maintained? CIRCLE NUMBER.

VERY IMPORTANT.	01
SOMEWHAT IMPORTANT	02
NEITHER IMPORTANT NOR UNIMPORTANT.	03
NOT VERY IMPORTANT	04
NOT IMPORTANT AT ALL	05

The first paragraph of Question B-3, which introduces the payment vehicle to the respondent, is presented below:

Now, we would like you to think about the relationship between improving the quality of water in the Monongahela River and what we all have to pay each year as taxpayers <u>and</u> as consumers. We all pay <u>directly</u> through our tax dollars each year for cleaning up all rivers. We also pay <u>indirectly</u> each year through higher prices for the products we buy because it costs companies money to clean up water they use in making their products. Thus, each year, we are paying directly and indirectly for improvements in the water quality of the Monongahela River.

I want to ask you a few questions about what amount of money you would be willing to pay each year for different levels of water quality in the Monongahela River. Please keep in mind that the amounts you would pay each year would be paid in the form of taxes or in the form of higher prices for the products that companies sell.

This payment vehicle was selected because it corresponds with how people actually pay for water quality, connotes no implicit starting point, and provides a vehicle that will bias the responses downward, if in any direction, because of public attitudes toward increased taxes and higher prices.

The introduction continues with a reference to the value card (see Figure 4-6) and requests that initial amounts be based on actual use and potential future use--user and option values but not existence values. The present overall level of water quality is described as Level D, where it is clean enough for boating.

Question B-3 embodies the comparison of the alternative contingent valuation methodologies. Specifically, by dividing the sample of 397 households into fourths and using a different color survey instrument for each quarter, Question B-3 compares the direct question method of eliciting willingness-to-pay amounts, both with and without a payment card (illustrated in Figure 4-7), to the iterative bidding games with $25 and $125 starting points. Thus, the questionnaire design provides an explicit test for starting point bias within the iterative bidding game, as well as a test for differences between direct questions and bidding games.

0	100	200	300	400	500	600	700
25	125	225	325	425	525	625	725
50	150	250	350	450	550	650	750
75	175	275	375	475	575	675	775

Figure 4-7. Payment card.

The payment card used in the direct question method was simply an array of numbers representing annual amounts from $0 to $775 per year. This is in contrast with the Mitchell and Carson [1981] payment card, which showed amounts individuals paid for various public goods adjusted to correspond with the respondent's income level. Mitchell and Carson split their sample to test for the effect of the different types of public goods provided, but the sample size in the Monongahela study was much smaller and already partitioned into four groups, so no anchoring amounts were listed on the payment card. Mitchell and Carson found no effect from the anchoring amounts, but this result may have been hampered by their adjustment of the amounts to correspond to the respondent's income level.

The hypothetical market queried the respondent for willingness-to-pay amounts for three water quality levels:

- Avoiding a decrease in water quality in the Monongahela River from D, boatable, to E, not suitable even for boating.
- Raising the water quality from D, boatable, to C, where gamefish could survive.
- Raising the water quality from C, fishable, to B, where people could swim in the water.

Table 4-2 summarizes the formats for eliciting the option prices in the contingent valuation questionnaire. (For details on question procedures, see Appendix D, which contains a complete copy of the survey questionnaire.)

Table 4-2. Summary of Option Price Question Formats by Interview Type

Interview type	Question format
Iterative bidding, $25	To you (and your family), would it be worth $25 each year in higher taxes and prices for products that companies sell to keep the water quality in the Monongahela River from slipping back from Level D to Level E?
Iterative bidding, $125	To you (and your family), would it be worth $125 each year in higher taxes and prices for products that companies sell to keep the water quality in the Monongahela River from slipping back from Level D to Level E?
Direct question	What is the most it is worth to you (and your family) on a yearly basis to keep the water quality in the Monongahela River from slipping back from Level D to Level E, where it is not even clean enough for boating?
Payment card	What is the most it is worth to you (and your family) on a yearly basis to keep the water quality in the Monongahela River from slipping back from Level D to Level E, where it is not even clean enough for boating?

The process for the direct question is very simple, with the interviewer asking the respondent for an amount for each level and stressing that additional amounts are being requested. The water quality ladder and the value card are in front of the respondent while the market process is initiated. The same procedure was used in the payment card format, with the only difference being that the payment card was given to the respondent.

Table 4-2 also summarizes the procedure for the bidding games with starting points. A similar procedure was used for both bidding games, the only difference being the starting points used. In the bidding game, the interviewer initiated the market process at the starting point and increased or decreased the requested amount until the respondent's maximum value was obtained. This was repeated for each of the water quality levels, with emphasis given to the additional nature of the amounts for the higher levels of water quality.

To conclude this part of the hypothetical market, the interviewer asked any respondent who gave a zero amount why that amount was given, as shown in the question below. The purpose of this question was to distinguish between a true zero amount and a zero that essentially represented a protest against either the experiment or some part of it, such as the payment vehicle.

We have found in studies of this type that people have a lot of different reasons for answering as they do. Some people felt they did not have enough information to give a dollar amount, some did not want to put dollar values on environmental quality, and some objected to the way the question was presented. Others gave a zero dollar amount because that was what it was worth to them.

Which of these reasons best describes why you answered the way you did? REPEAT REASONS IF NECESSARY AND CIRCLE NUMBER.

NOT ENOUGH INFORMATION.	01
DID NOT WANT TO PLACE DOLLAR VALUE	02
OBJECTED TO WAY QUESTION WAS PRESENTED. .	03
THAT IS WHAT IT IS WORTH	04
OTHER (SPECIFY).	05

The next section of the questionnaire attempted to break down the option price into its individual components of user and option values. The questions and results for option value are described in detail in the following chapter, so no additional discussion is provided in this chapter.

Part B contained two additional plausibility/consistency check questions that asked what effect improved water quality in the Monongahela River would have on visits to substitute sites and the Monongahela River sites. The answers to these questions were structured by choices ranging from a change (either increase or decrease) of more than five visits to no change or "don't know."*

The last question in Part B asked the respondent to perform a contingent ranking as specified by the text from the questionnaire. Figure 4-8 depicts one of the four combinations that the respondent was asked to rank. This particular card shows the combination of the lowest level of water quality and the lowest payment. Payment amounts of $50, $100, and $175 were paired with boatable, fishable, and swimmable levels of water quality, respectively. The survey design asked all respondents to rank the cards after participating in one of the other valuation exercises. This design is a compromise resulting from the limited resources available for sampling respondents and the objective to compare as many methods as possible. A complete comparison would have required an additional segmentation of the limited sample. Chapter 6 discusses the theory and results from the contingent ranking experiment.

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*These questions were suggested by the Office of Management and Budget (OMB) in its review of the survey questionnaire.

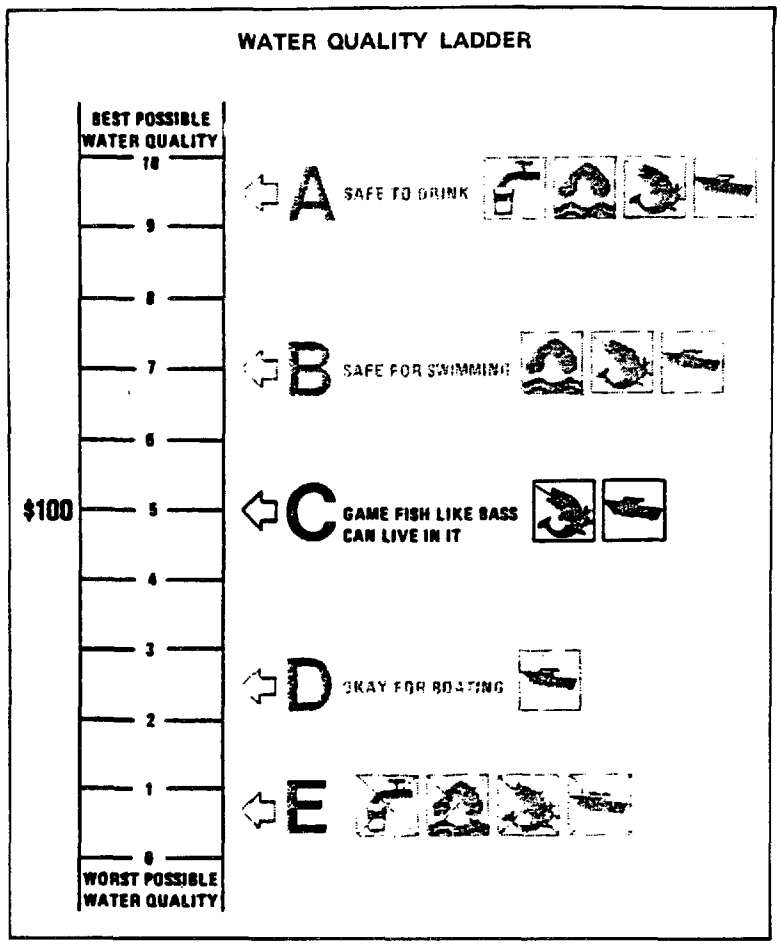

Figure 4-8. Rank order card.

4.4 PROFILES OF SURVEY RESPONDENTS

Respondents in a contingent valuation survey should represent the population of interest to provide plausible results. This section profiles the sample respondents from the Monongahela River basin area and compares these profiles with Census data for the area as a check for representativeness. Users, nonusers, zero bidders, and protest bidders are also profiled to assess the role of socioeconomic and attitudinal characteristics in influencing any of these groups.

Table 4-3 presents the characteristics of key groups of respondents in the Monongahela survey. These data are for the 301 completed questionnaires that provided valid responses. Two questionnaires were eliminated because the respondents were unable to complete the session. One person was 97 years old and had difficulty seeing the cards; the other had trouble hearing the interviewer.

Table 4-3. Characteristics of Key Respondent Groups

Characteristic	User			Nonuser			Zero			Nonzero			Protest Bids[a]			Total			Five county region in 1980	Sample
	Mean	Standard deviation	N	Mean	Standard deviation	N	Mean	Standard deviation	N	Mean	Standard deviation	N	Mean	Standard deviation	N	Mean	Standard deviation	N		
1=yes, 0=no for ownership or use of a boat	0.23	0.43	94	0.12	0.32	207	0.11	0.32	108	0.18	0.39	193	0.15	0.37	58	0.16	0.36	301		
1=yes, 0=no for participation in any outdoor recreation in the last year	0.95	0.23	94	0.38	0.49	207	0.38	0.49	108	0.86	0.48	193	0.50	0.50	58	0.56	0.50	301		
Numerical rating of the Monongahela River: 0=lowest, 10=highest	3.87	1.98	89	3.77	2.01	132	3.51	1.76	61	3.92	2.07	160	3.63	1.68	38	3.81	1.99	221		
1=yes, 0=no if rating is for a particular site	0.34	0.48	94	0.08	0.27	207	0.07	0.26	108	0.21	0.41	193	0.10	0.31	58	0.16	0.37	301		
Length of residence	6.83	0.95	94	6.80	1.02	207	6.82	0.95	108	6.80	1.02	193	6.74	1.18	58	6.81	1.00	301		
Years of education	13.06	1.96	86	12.61	2.12	177	12.38	2.20	86	12.93	1.99	177	12.77	1.73	47	12.75	2.07	263	10.96[b]	12.75
Race (1 if white)	0.88	0.32	94	0.91	0.29	206	0.94	0.23	107	0.88	0.33	193	0.93	0.26	57	0.90	0.30	300	.92	.90
Income	20,833	13,482	87	18,887	13,022	173	17,577	11,500	87	20,534	13,879	173	19,895	11,484	48	19,538	13,184	260	19,987[b]	19,538
Age	38.93	16.20	94	51.87	17.85	207	54.55	16.91	108	44.06	18.07	193	52.60	17.27	58	47.82	18.34	301	45.6	47.8
Sex (1 if male)	.31	.46	94	0.39	0.49	207	0.35	0.48	108	0.37	0.48	193	0.44	0.50	58	0.36	0.48	301	.47	.36

SOURCE: U.S. Bureau of the Census. 1980 Census of the Population and Housing. Washington, D.C. 1982.

[a]Protest bids are zero bids for reasons other than "all they could afford" or "that is what it is worth."

[b]Statewide statistics.

To develop a reasonably clear snapshot of the respondent group important for the analysis of survey results, no adjustments for outliers are included in the profile information. The first two columns of Table 4-3 compare users and nonusers of the Monongahela River. The users are broadly defined based on all respondents who reported a user value or visited one of the 13 Monongahela River sites. This broader definition of user can be contrasted with a narrow definition that includes only those respondents who visited a site. The broader definition is used throughout this report because it allows for the inclusion of some users who may have been prevented from visiting a Monongahela site within the 12 months between November 1981 and November 1982 for medical or other personal reasons but still had some user value for the services of the Monongahela. Tests indicated that the differences between the user definitions were insignificant. This broad definition explains why a few Monongahela River users had not participated in an outdoor recreation activity in the second row of Table 4-3.

Results of t-tests for differences between the means of users and nonusers (shown in Appendix C) highlight some important distinctions that continue throughout the survey results. Users of the Monongahela River are younger, are more likely to own a boat, and are more likely to have rated a particular Monongahela River site than their nonuser counterparts. The water quality ratings place the Monongahela above boatable, but a full point below fishable, on the Water Quality Ladder (see Figure 4-5); however, the ratings are not different between the two groups. There are no differences in education, income, race, sex, or length of residence between users and nonusers.*

For these two groups t-tests for differences in means between zero and nonzero bidders and a logit analysis comprise the analysis. Based on these results, nonzero bidders were on average younger than zero bidders, earned higher annual family incomes, were more likely to have rated the Monongahela at a particular site, and have participated in outdoor recreation during the last year. These results are consistent with the findings of Mitchell and Carson [1981]. In addition, no significant differences existed between the groups in terms of sex, education, water quality rating for the river, boat ownership, and length of residence in the area. The protest bidders who rejected some aspect of the contingent valuation approach had higher incomes and were more likely to have participated in outdoor recreation in the last year than were those with valid zero bids.

The questionnaire design also provided the respondent's reason for giving a zero bid. These responses are shown in Table 4-4 for the four elicitation methods. The direct question method without the payment card yielded most of the respondents who could not place a dollar value on water quality,

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*The percentage of woman respondents (64 percent) in the sample is somewhat higher than in other studies--a somewhat surprising result since the random procedure used to select the respondents should have given a more even distribution. The respondent was asked to respond for the household, which should reduce any potential bias.

Table 4-4. Reasons for Zero Bids by Elicitation Method

Reason for zero bid	Payment card	Direct question	$25 iterative bidding	$125 iterative bidding	Total
Not enough information	1	1	0	2	4
Cannot place dollar value	4	9	2	0	15
Objected to way question was presented	0	0	1	0	1
That is what it is worth	12	10	7	11	40
Other	1	5	5	5	16
All they could afford	1	3	1	5	10
Government waste or misuse of tax dollars	2	0	2	1	5
Industry pollutes so let them clean it up	3	2	3	0	8
Taxes are too high already	2	3	1	2	8
Desire no increase in taxes for something that does not affect respondent	1	0	0	0	1
Total	27	33	22	26	108

which roughly indicates the value of either the payment card or the starting value in the bidding process. Approximately 40 percent of the respondents bid zero because that is what they felt the water quality is worth. Some evidence of the consistency in the response is indicated by the 10 respondents who bid zero because that is all they could afford. These respondents tended to be elderly persons living on limited incomes.

Table 4-5 shows the attitudinal information broken down for user, nonuser, and zero bids. These responses on the importance of water quality were elicited during the discussion of the value card (see Figure 4-6) and prior to the elicitation of the willingness-to-pay amounts. These responses are very consistent with the earlier characteristics of the groups. Users and nonzero bidders were much more likely to have given very or somewhat important responses to the questions than were nonusers and zero bidders.

Table 4-6 completes the profiles of the three groups by highlighting the respondents' willingness to identify themselves by certain labels. Several interesting features are apparent from these attitudinal responses. The users and nonzero bidders were much more likely to identify themselves as outdoors persons than were nonusers and zero bidders. However, the differences between the groups is much smaller for the environmentalist label, with 26 per-

Table 4-5. Degree of Importance of Water Quality by Key Respondent Groups

Degree of importance of water quality	User		Nonuser		Zero bids		Nonzero bids		Protest bids[a]		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
For own recreation												
Very important	47	50.0	48	23.3	20	18.5	75	39.1	16	27.6	95	31.7
Somewhat important	28	29.7	36	17.5	14	13.0	50	26.0	9	15.5	64	21.3
Neither important nor unimportant	4	4.3	33	16.0	21	19.4	16	18.3	14	24.1	37	12.3
Not very important	10	10.6	46	22.3	25	23.1	31	16.1	11	19.0	56	18.7
Not important at all	5	5.3	43	20.9	28	25.9	20	10.4	8	13.8	48	16.0
Total	94		206		108		192		58		300	
For possible future use												
Very important	49	52.1	70	33.8	27	25.0	92	47.7	16	27.6	119	39.5
Somewhat important	34	36.2	53	25.6	21	19.4	66	34.2	14	24.1	87	28.9
Neither important nor unimportant	5	5.3	26	12.6	18	16.7	13	6.7	13	22.4	31	10.3
Not very important	3	3.2	33	15.9	23	21.3	13	6.7	9	15.5	36	12.0
Not important at all	3	3.2	25	12.1	19	17.6	9	4.7	6	10.3	28	9.3
Total	93		207		108		193		58		301	
Even if never use river												
Very important	49	52.7	74	35.7	27	25.0	96	50.0	19	32.8	123	41.0
Somewhat important	29	31.2	70	33.8	33	30.6	66	34.4	18	31.0	99	33.0
Neither important nor unimportant	7	7.5	21	10.1	15	13.9	13	6.8	9	15.5	28	9.3
Not very important	6	6.5	27	13.0	22	20.4	11	5.7	9	15.5	33	11.0
Not important at all	2	2.2	15	7.2	11	10.2	6	3.1	3	5.2	17	5.7
Total	93		207		108		192		58		300	

[a]Protest bids are zero bids for reasons other than "all they could afford" or "that is what it is worth."

Table 4-6. Respondent Attitudes About Self by Key Respondent Groups

Attitude	User		Nonuser		Zero bids		Nonzero bids		Protest bids[a]		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
An outdoors person												
A lot	42	44.7	50	24.2	29	26.9	63	32.6	20	34.5	92	30.6
Somewhat	24	25.5	56	27.1	23	21.3	57	29.5	12	21.0	80	26.6
A little	19	20.2	38	18.4	21	19.4	36	18.7	9	15.5	57	18.9
Not at all	9	9.6	63	30.4	35	32.4	37	19.2	17	29.3	72	23.9
No opinion	0	0	0	0	0	0	0	0	0	0	0	0
Total	94		207		108		193		58		301	
An environmentalist												
A lot	26	27.7	38	18.4	28	26.2	36	18.7	20	35.1	64	21.3
Somewhat	27	28.7	56	27.2	14	13.1	69	35.8	10	17.5	83	27.7
A little	30	31.9	51	24.8	24	22.4	57	29.5	10	17.5	81	27.0
Not at all	11	11.7	59	28.6	39	36.4	31	16.1	15	26.3	70	23.3
No opinion	0	0	2	1.0	2	1.9	0	0	2	3.5	2	0.7
Total	94		206		107		193		57		300	
Against nuclear power electric plants												
A lot	27	28.7	45	21.8	26	24.1	46	24.0	15	25.9	72	24.0
Somewhat	12	12.8	19	19.2	13	12.0	18	19.4	9	15.5	31	10.3
A little	15	16.0	23	11.2	8	7.4	30	15.6	3	5.2	38	12.7
Not at all	31	33.0	79	38.4	37	34.3	73	38.0	20	34.5	110	36.7
No opinion	9	9.6	40	19.4	24	22.2	25	13.0	11	19.0	49	16.3
Total	94		206		108		192		58		300	
Concerned about water pollution												
A lot	45	48.4	87	42.0	41	38.0	91	47.4	28	48.3	132	44.0
Somewhat	29	31.2	71	34.3	31	28.7	69	35.9	17	29.3	100	33.3
A little	15	16.1	29	14.0	18	16.7	26	13.5	8	13.8	44	14.7
Not at all	4	4.3	17	8.2	16	14.8	5	2.6	5	8.6	21	7.0
No opinion	0	0	3	1.4	2	1.8	1	0.5	0	0	3	1.0
Total	93		207		108		192		58		300	
Willing to pay the cost required to control water pollution												
A lot	19	20.4	31	15.0	8	7.5	42	21.9	6	10.5	50	16.7
Somewhat	42	45.2	59	28.6	18	16.8	83	43.2	10	17.5	101	33.8
A little	21	22.6	50	24.3	15	14.0	56	29.2	9	15.8	71	23.7
Not at all	10	10.8	58	28.2	58	54.2	10	5.2	28	49.1	68	22.7
No opinion	1	1.1	8	3.9	8	7.5	1	0.5	4	7.0	9	3.0
Total	93		206		107		192				299	

[a]Protest bids are zero bids for reasons other than "all they could afford" or "that is what it is worth."

cent of the zero bidders indicating the closest identity with the label. This is even more evident when only the protest zero bids are examined. Thirty-five percent gave the strongest response, which is consistent with the frequency responses shown in Table 4-4 for the reasons why people bid zero. The most dramatic differences between respondents are evident in the willingness to pay the cost required to control water pollution. Only 24 percent of the zero bidders were willing to identify with this descriptive statement. This consistency across different attitude responses suggests that the respondents correctly perceived the contingent valuation experiment and gave careful responses that would not have been given if hypothetical bias were present. It is also suggestive of the importance of attitudinal questions in contingent valuation studies both for analysis purposes and as consistency checks.

Table 4-7. Logit Estimation of Zero Bids[a]

Independent variable	Coefficient	t-ratio[b]	Derivative of the probability evaluated at the mean
Constant	-0.435	-0.251	
Sex	-0.522	-0.924	-0.042
Age	0.036	2.703[c]	0.003
Education	-0.108	-0.867	-0.009
Income	6.9×10^{-9}	0.326	0.59×10^{-6}
Version B	-0.319	-0.506	-0.026
Version C	-1.728	-2.407[c]	-0.113
Version D	-0.665	-1.099	-0.050
Willing to pay cost of water pollution (1 if very much or somewhat)	-1.622	-3.185[c]	-0.169
Interviewer #1	-0.625	-0.627	-0.044
Interviewer #2	1.095	1.318	0.128
Interviewer #3	-0.683	-0.807	-0.050
Interviewer #5	-1.158	-0.913	-0.072
Interviewer #7	-1.519	-1.175	-0.082
Interviewer #8	0.192	0.215	0.017
Interviewer #9	1.099	0.843	0.141

Note: Log of likelihood function = 65.511. Estimated marginal probabilities for mean value of dependent variables: Probability = 1, 0.095; probability = 0, 0.905.

[a]The dependent variable is equal to 1 if the individual bid zero dollars and zero otherwise. All protest bids were eliminated.

[b]The t-ratio is the ratio of the estimated parameter to the estimated standard error. Given the assumptions of the estimates are maintained, the maximum likelihood, logit parameter estimates are asymptotically normal. We have used a t-distribution in judging the significance of these parameter estimates.

[c]Significant at the 5-percent level.

Additional insight into zero bidders issues can be obtained from a logit analysis of valid zero bids (see Amemiya [1981]). To perform this analysis for the Monongahela study, the dependent variable was set equal to 1 if a nonprotest zero bid was given and equal to zero if a positive bid was given. Consequently, protest bids were eliminated from the analysis. For consistency, the explanatory variables used are the same as in the option price regression (as discussed in Section 4.5). The binary variable to denote Monongahela users and several interviewer dummies were eliminated due to a lack of variation.

The results of the logit analysis of zero bidders are shown in Table 4-7. This model requires a cautious interpretation of the estimated coefficients. In the logit procedure, the expected change in the probability of bidding zero is derived from the estimated equation where the probability of bidding zero depends on the value of the independent variables.

The results were encouraging, with no evidence of interviewers significantly affecting the odds of bidding zero. The performance of other variables is consistent with previous results and a priori reasoning. Increases in age significantly affected the likelihood of bidding zero. Each year's increase, evaluated at the mean, is expected to change the probability of bidding zero by 0.003. The results also indicate a relationship between zero bids and questionnaire version. When the respondent was presented with the $25 bidding game rather than the payment card, the probability of bidding zero decreased by 0.113. Also, the attitude toward cost was consistent, because those respondents who stated a willingness to pay a portion of cleanup cost had a lower probability of bidding zero.

The logit model was also used to explain why individuals protested the option price question. As shown in Appendix C, the results are very weak, with only the attitude toward cost variable significant and all other analysis variables insignificant.

4.5 OPTION PRICE RESULTS

The central element in a contingent valuation study is the valuation responses revealed in the hypothetical market situation. Much of the analysis in the early contingent valuation experiments focused on the fitting of a bid function to the willingness-to-pay bids. In this section, a linear approximation is used in a regression analysis to fit the bid function. However, the basic emphasis of the regression analysis is to organize the information presented and not to estimate the bid function.*

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*The willingness-to-pay data contain no negative bids which implies that they are truncated at zero. This can lead to biased parameter estimates with regression analysis, depending upon the distribution of bids. Since the sample excludes protest bidders, all responses should fall in the positive domain. Negative responses would be inconsistent with the group being described by the model. The difficulties posed by truncation could be handled in a variety of ways including: transforming the dependent variable (i.e., using the log

Specifically, this section summarizes the analytical basis of the option price and user amounts, the statistical procedures employed to analyze these estimates, the comparison of estimates between elicitation methods, and the results on starting point and interviewer bias. In addition, it also compares results with those from previous studies.

The amounts provided by the respondents represent their option prices rather than user willingness to pay, as measured in many previous contingent valuation studies. That is, the option price includes both the expected consumer surplus that respondents anticipate from future use of the site's services as well as a premium--the option value--that they are willing to pay to obtain these site services should they decide to use them. The premium can be attributed to uncertainty either in the respondents' future demand for the site and/or uncertainty in the supply of the site's services at given water quality levels. Chapter 5 explores these issues in more detail, but it is important to understand this distinction to correctly interpret the results.

As discussed in Chapter 2, the option price amounts are based on the Hicksian surplus measures, with the equivalent surplus measure used for the loss of the recreation services of the Monongahela River (Level D to Level E) and the compensating surplus measures used in measuring the option price for the improvements to fishable and swimmable water. The use of these measures corresponds to the existing property rights for the overall level of Monongahela recreation services, with the river currently supporting boating activities. It is important to note that several sections of the Monongahela have considerably higher water quality and are capable of supporting sport fishing due to the influence of tributaries. However, the boatable designation is a reasonable description of the overall water quality level.

Determining the treatment of outlying responses is an important step in a contingent valuation study. Randall, Hoehn, and Tolley [1981] suggest that, once the outliers are determined and removed, the contingent valuation method will provide a "core" of responses useful for analysis. In general, previous efforts have used subjective judgment in making this determination, with little or no discussion provided. For example, Rowe, d'Arge, and Brookshire [1980] follow the procedure mentioned in Randall, Ives, and Eastman [1974] of eliminating bids greater than 10 standard deviations from the mean. In neither case is much discussion provided on the judgments made in selecting this procedure. While the role of judgment will almost always loom large in these decisions, it is difficult to evaluate and transfer the methods used to evaluate the contingent valuation results unless a more systematic basis for the judgment is detailed.

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of the bids, if the zero bidders were dropped) and using an alternative estimator. For the purposes of the present analysis, these models are intended to be used only as a basis for judging the factors likely to influence bids and not necessarily to estimate the magnitude of their impact. Past evidence on the bias of ordinary least squares in presence of truncation effects indicates that it did not greatly affect these judgmental evaluations of specific variables.

Our approach relies on more formal use of statistical indexes of the influence of particular observations on a model's estimated parameters. Belsley, Kuh, and Welsch [1980] suggest a number of statistical procedures that can be used in prescreening data for outliers. The Monongahela study used a procedure that follows their discussion to identify outlier candidates. The Belsley-Kuh-Welsch statistic (DFBETA) measures the effect of each individual observation on each of the estimated coefficients in a regression model. It is estimated by Equation (4.1):

$$\text{DFBETA} \equiv b - b(i) = \frac{(X^T X)^{-1} \; x_i^T e_i}{1-h_i} , \qquad (4.1)$$

where

b = the estimated coefficient with all observations included

$b(i)$ = the estimated coefficient with one less observation

h_i = $x_i \, (X^T X)^{-1} x_i^T$

e_i = the ordinary least-squares residuals.

This statistic is not a formal statistical test. It is merely an index of the extent of influence of particular observations. It implicitly assumes that option prices can be related to economic characteristics. In this application, the statistics presented in the first column of Table 4-8 are expressed as percentage changes in the income coefficient of the final regression model discussed later in this chapter. The effect of income was selected because this variable is the only variable we know, based on economic theory, that should influence option price bids. Moreover, the relationship between option price and user value can be expected to be influenced by the role of income in an individual's indirect utility function. These changes represent approximations of elasticities described in Belsley, Kuh, and Welsch [1980].

Rather than employ one of the arbitrary statistical criteria suggested in Belsley, Kuh, and Welsch, the procedure was supplemented in this study with a judgment that (±) 30 percent was the cutoff point for outliers. An element of judgment is also required in selecting the regression model from which the Belsley-Kuh-Welsch statistic is calculated. After comparing models, the judgment was made to select the general model presented later in Table 4-11. However, in comparing the results between the models, the 16 outliers determined by the same cutoff point for another regression model (see Appendix G) were all included in the 32 outliers profiled in Table 4-8.

The results in Table 4-8 are striking in terms of the differences from the Randall, Ives, and Eastman [1974] criteria. Many of the outliers are small or zero bids that would have been retained in their procedure. In addition, the consistency in the characterization of the outliers is informative. For the respondents classified as outliers, 63 percent earned annual incomes of $2,500

Table 4-8. Profile of Outliers

Belsley-Kuh-Welsch statistic	Version	Option price: avoid loss of site (D to E) ($/yr)	Option price: improve water quality to swimmable ($/yr)	Income $/yr	Age (yr)	Sex	Education (yr)	User of Monongahela site	Boat ownership
-213.12	$125 bidding game	$125	$260	2,500	25	Male	12	No	No
-155.99	$125 bidding game	$125	200	2,500	20	Female	12	Yes	No
-100.04	direct question	$200	200	7,500	67	Male	12	No	No
-79.83	$125 bidding game	500	500	22,500	39	Male	14	No	Yes
-66.19	$125 bidding game	$125	220	7,500	43	Female	10	Yes	No
-63.25	$25 bidding game	25	5	2,500	70	Female	10	No	No
-62.95	payment card	450	200	17,500	37	Female	12	Yes	No
-56.70	$25 bidding game	60	85	2,500	23	Female	12	No	No
-54.98	direct question	0	10	2,500	82	Female	10	No	No
-49.68	payment card	50	250	7,500	40	Female	14	Yes	No
-44.62	$125 bidding game	155	250	12,500	57	Female	12	No	No
-43.80	$25 bidding game	5	5	2,500	69	Female	10	No	No
-43.16	$125 bidding game	155	250	12,500	44	Female	10	No	No
-37.34	$25 bidding game	5	5	2,500	62	Female	10	No	No
-36.46	$25 bidding game	25	0	2,500	46	Female	10	No	No
-36.03	$25 bidding game	0	0	2,500	76	Female	16	No	No
-31.40	direct question	200	300	27,500	21	Female	12	Yes	No
-30.43	$125 bidding game	200	285	22,500	66	Female	12	Yes	No
31.24	direct question	5	3	7,500	34	Male	12	No	No
33.98	$125 bidding game	0	0	12,500	38	Female	12	No	No
35.39	$125 bidding game	0	0	2,500	78	Female	0	No	No
37.77	payment card	75	10	2,500	59	Female	12	Yes	No
41.78	payment card	25	10	2,500	72	Female	12	No	No
47.15	$125 bidding game	5	130	2,500	61	Female	12	Yes	No
52.23	$125 bidding game	0	30	7,500	50	Female	12	Yes	No
52.86	payment card	0	0	2,500	43	Female	10	No	No
58.18	$125 bidding game	0	0	2,500	79	Female	10	No	No
65.70	$125 bidding game	0	10	2,500	66	Female	12	No	No
69.15	direct question	10	20	2,500	33	Female	12	Yes	No
79.58	$125 bidding game	55	0	2,500	71	Female	10	No	No
82.52	payment card	0	0	2,500	53	Female	12	No	No
112.04	payment card	0	25	2,500	26	Female	12	Yes	Yes

a year or less, and 78 percent earned less than $7,500 a year. Female respondents comprised 80 percent of the outliers, while only 4 respondents had more than a high school degree. The last element of interest is that 14 of the 32 outliers had received the $125 starting point bidding game--twice as many as the next version (the payment card). This last feature confounds the interpretation of starting point bias presented later in this and the following chapter.

In summary, the Belsley-Kuh-Welsch [1980] procedure is a systematic approach for identifying outlying bids within contingent valuation studies. It does not replace the need for judgment but gives a basis for making the judgments.

The results presented in this chapter are all based on two edits of the 301 completed survey questionnaires. The first edit removed the protest bids from the calculation of means and the regressions. Protest zeros were respondents who bid zero for reasons other than "that is all they could afford" or "that is what it was worth." This removal is consistent with practices of Randall, Ives, and Eastman [1974] and Rowe, d'Arge, and Brookshire [1980].

The second edit removed the outliers following the Belsley-Kuh-Welsch [1980] procedure. Appendix C presents the estimated means for both the full sample and the sample with only the protest bids excluded. Calculated t-statistics revealed no statistically significant differences between the means estimated from the full sample and those estimated with the protest bids excluded. The effects of omitting the outlier observations are discussed at the appropriate points in this and in the following chapter.

The salient questions to be answered from the survey results center on the comparison of the alternative methods used to elicit the option price amounts, while the plausibility of the results is substantiated by testing for potential biases in the responses. Table 4-9 presents the estimated means grouped by questionnaire version, with distinctions made between users and nonusers. The mean values are provided for the loss of the recreation services of the site (avoiding a decrease from Level D to Level E on the water quality ladder in Figure 4-5), for an improvement in water quality from boatable to fishable (Level D to Level C), and for an improvement in water quality from fishable to swimmable (Level C to Level B). Combined option prices are presented for the improvements in the level of water quality and for the improvements plus the loss of the services of the site.

One inference that can be drawn from Table 4-9 is that the option prices are sizable for the Monongahela River but are of the same order of magnitude regardless of the method used to elicit the amount. Option price amounts combined for all levels range from a mean of $54 per year for the bidding game with a $25 starting bid to $118 for the bidding game with a $125 starting bid. Mean bids for the combined amounts for the payment card and direct question equaled $94 and $56, respectively. The range of mean option price amounts is even narrower when only the bids for improvements are considered, varying from $25 per year to $60 per year for the two bidding games.

Table 4-9. Estimated Option Price for Changes in Water Quality: Effects of Instrument and Type of Respondent--Protest Bids and Outliers Excluded

Change in water quality	User			Nonuser			Combined		
	$\bar{X}$	s	n	$\bar{X}$	s	n	$\bar{X}$	s	n
1. Iterative bidding framework--starting point = $25 (Version C)									
D to E avoid	27.4	16.7	19	29.7	35.7	39	29.0	30.6	58
D to C	18.9	16.3	19	14.5	15.2	39	15.9	15.5	58
C to B	11.8	14.5	19	7.2	11.6	39	8.7	12.7	58
D to B[a]	32.1	27.1	19	21.7	24.0	39	25.1	25.3	58
Combined: all levels	59.5	38.1	19	51.4	53.1	39	54.1	48.5	58
2. Iterative bidding framework--starting point = $125 (Version D)									
D to E (avoid)	94.7	66.0	16	38.8	51.3	32	57.4	62.0	48
D to C	58.1	51.9	16	26.3	45.4	32	36.9	49.5	48
C to B	33.1	48.4	16	11.6	33.1	32	18.8	39.7	48
D to B	99.7	87.9	16	40.5	69.0	32	60.2	80.0	48
Combined: all levels	194.4	136.5	16	79.2	102.5	32	117.6	126.0	48
3. Direct question framework (Version B)									
D to E (avoid)	45.3	65.2	17	14.2	27.1	34	24.5	45.4	51
D to C	31.3	44.2	17	10.8	21.6	34	17.6	32.1	51
C to B	20.2	35.5	17	8.5	21.9	34	12.4	27.4	51
D to B	52.9	72.5	17	20.3	41.4	34	31.2	55.2	51
Combined: all levels	98.2	103.5	17	34.5	66.4	34	55.7	85.2	51
4. Direct question framework: payment card (Version A)									
D to E (avoid)	46.8	42.2	17	53.0	76.3	37	51.0	67.1	54
D to C	45.3	71.4	17	21.9	33.8	37	29.3	49.3	54
C to B	22.9	48.7	17	7.7	20.0	37	12.5	32.2	54
D to B	71.2	117.7	17	29.9	47.5	37	42.9	78.1	54
Combined: all levels	117.9	117.0	17	82.8	104.7	37	93.9	108.9	54

[a]D to B are the combined amounts for improvements only.

The results of the test for differences in means between methods for both users and nonusers are shown in Table 4-10. These results show that the differences do arise between the means in the bidding games, suggesting there may be a bias attributable to the difference in the starting points. The combined and user means are statistically different at the 5-percent level of significance for users and for the combined groups. However, the evidence is not completely conclusive because the differences in nonuser means are not significant. In addition, the regression results shown in Table 4-11 do not conclusively show a starting point bias problem. The regression model estimated without the outliers shows no statistically significant difference between the iterative bidding games. If the outliers are not removed, the model suggests starting point bias, as indicated in Appendix C. Thus, in the regression

Table 4-10. Student t-Test Results for Option Price--
Protests Bids and Outliers Excluded[a]

Means combined	User	Nonuser	Combined
Payment card vs. direct question			
D to E	--	2.806	2.353
E to B	--	2.300	1.991
Payment card vs. $25 iterative bidding			
D to E	--	--	2.263
D to C	--	--	1.954
E to B	2.061	--	2.530
Payment card vs. $125 iterative bidding			
D to E	-2.499	--	--
Direct question vs. $25 iterative bidding			
D to E	--	-2.074	--
Direct question vs. $125 iterative bidding			
D to E	-2.161	-2.453	-3.020
D to C	--	--	-2.308
E to B	-2.289	-2.117	-2.8786
D to B	--	--	-2.109
$25 iterative bidding vs. $125 iterative bidding			
D to E	-4.294	--	-3.072
D to C	-3.119	--	-3.046
E to B	-4.131	--	-3.539
D to B	-3.183	--	-3.159

[a]Only cases with statistically significant differences in the means at the 0.05 significance level are reported.

analysis, differences attributable to starting point cannot be distinguished from the influence of the outlier observations.

Some additional insights into differences in the elicitation method can be developed from the results in Tables 4-10 and 4-11. The mean option price for users of the Monongahela is significantly higher when the bidding game with the $125 starting point is used to elicit option price compared to either direct question technique. The differences are present for the aggregate option price and for the loss of site services, but no differences are detected for the incremental improvements to fishable and swimmable water quality levels.

The regression results from Table 4-11 are generally consistent with the means tests. Using the dummy variable technique to compare the payment card with the other three versions shows option price is significantly higher for the payment card than for the direct question and the $25 bidding game, while no differences exist between the payment card results and those for the

Table 4-11. Regression Results for Option Price Estimates--Protest Bids and Outliers Excluded[a]

Independent variables	Water quality changes: D to E (avoid)	D to C	C to B	Total, all levels	Total improvements only
Intercept	-34.512	-29.307	-5.430	-56.653	-22.141
	(-0.973)	(-1.098)	(-0.257)	(-0.916)	(-.517)
Sex (1 if male)	8.451	-0.672	-1.657	6.484	1.967
	(0.916)	(-0.097)	(-0.302)	(0.403)	(-0.177)
Age	-0.292	0.290	-0.265	-0.854	-0.562
	(-1.094)	(-1.440)	(1.668)	(-1.834)	(1.743)
Education	5.294	2.901	-5.27	8.066	2.773
	(2.071)[b]	(1.508)	(0.347)	(1.810)	(0.899)
Income	0.0006	0.0003	0.0003	0.0012	0.0006
	(1.652)	(1.151)	(1.260)	(1.832)	(1.278)
Direct question	-32.311	-14.372	-3.500	-50.734	-18.423
	(-2.771)[b]	(-1.638)	(0.505)	(-2.495)[b]	(-1.309)
Iterative bidding game ($25)	-20.623	-12.572	-5.657	-39.566	-18.943
	(1.852)	(-1.500)	(-.854)	(-2.037)[b]	(1.409)
Iterative bidding game ($125)	1.7522	6.639	0.739	31.089	13.568
	(1.421)	(0.716)	(0.101)	(1.446)	(0.912)
User (1 if user)	8.840	8.083	6.839	26.026	17.187
	(0.919)	(1.117)	(1.96)[b]	(1.552)	(1.481)
Willing to pay cost of water pollution (1 if very much or somewhat)	17.001	21.960	10.023	51.326	34.326
	(1.788)	(3.068)[b]	(1.772)	(3.095)[b]	(2.990)[b]
Interviewer #1	14.211	7.090	11.334	26.509	12.298
	(0.750)	(0.497)	(1.006)	(0.802)	(0.538)
Interviewer #2	1.723	12.242	16.849	24.719	22.996
	(0.099)	(0.938)	(1.634)	(0.817)	(1.099)
Interviewer #3	-22.833	21.141	17.578	9.292	32.125
	(-1.344)	(1.653)	(1.740)	(0.314)	(1.567)
Interviewer #4	-28.125	3.050	20.605	-12.334	15.791
	(-0.860)	(0.124)	(1.059)	(-0.216)	(0.400)
Interviewer #5	6.932	4.996	2.191	11.435	4.503
	(0.404)	(0.387)	(0.215)	(0.382)	(0.217)
Interviewer #6	47.012	95.513	66.288	198.450	151.439
	(0.887)	(2.394)[b]	(2.102)[b]	(2.146)[b]	(2.366)[b]
Interviewer #7	27.670	2.470	4.130	39.645	11.975
	(1.425)	(0.169)	(0.357)	(1.170)	(0.511)
Interviewer #8	14.022	29.961	19.871	58.063	44.041
	(0.801)	(2.274)[b]	(1.908)	(1.902)	(2.08)[b]
Interviewer #9	17.874	39.586	-7.935	37.330	19.456
	(0.454)	(1.336)	(-0.339)	(0.544)	(0.409)
R^2	0.334	0.284	0.166	0.366	0.269
F	3.78	3.00	1.50	4.36	0.278
Degrees of freedom	136	136	136	136	136

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

[b]Significant at the 0.05 level.

bidding game with the $125 starting point. The differences are significant only for the loss of site services and for the combined option price. When other influences are held constant in the regression analysis, respondents who received the payment card expressed aggregate option prices approximately $40 to $50 higher than those expressed by respondents in the $25 starting point bidding game and the direct question. It is possible to conclude that there are significant differences between methods but that all methods estimate option price at the same order of magnitude. The differences cannot be detected among the bids for improvements in water quality levels, possibly because the effects of the methods are limited to the initial amounts given. This may minimize the effect of the question format when incremental amounts are elicited. This conclusion should be viewed with some caution since the differences between methods could be difficult to detect simply because the

number of bids for the improvements is too small to offset the variation in the amounts expressed. The consistency in the results from the various tests, however, is particularly encouraging as a plausibility check against the influence of hypothetical bias in the contingent valuation design.

An examination of the regression results for option price combined over all water quality levels reinforces the plausibility of the results. The coefficients of the socioeconomic variables all have the expected signs, and the coefficients for age, education level, and income are significant at either the 0.05 level or very close to it. The results indicate a strong role for respondent attitude toward paying the cost of water pollution. Persons who identified themselves as either very much or somewhat willing to pay for water pollution control were willing to spend $50 more per year than persons who were not willing to pay the cost, with all other things held constant. This consistency of attitudes, combined with the performance of the socioeconomic variables and the ability of the model to explain almost 37 percent of the variation in option price, builds a strong case against the influence of hypothetical bias in the contingent valuation design.

The regression results in Table 4-11 also shed some light on the question of a bias in the willingness to pay that could be attributable to differences in interviewers. Using the dummy variable technique, the results indicate that the influence of interviewer bias is limited. Only for two interviewers are the coefficients statistically significant at the 0.05 level for some levels of water quality. One of the cases involved an interviewer who conducted only two interviews before being removed from the interviewing team. This interviewer did not take part in the training session and also conducted interviews only in the Latrobe area, which is a considerable distance from the Monongahela River. The second interviewer also conducted interviews in the Latrobe area and in one area very close to the river. These cases may simply reflect the model's inability to differentiate between an interviewer effect and some omitted variables. Thus, the effect of the interviewer is quite small and reinforces the importance of the training sessions that were conducted in Pittsburgh prior to the survey.*

Table 4-12 presents the results of student t-tests for differences in means between users of the Monongahela River and nonusers broken down by the technique used to elicit option price. The results show that users who received either the direct question or the $125 starting point bidding game expressed bids that were higher than those of nonusers. There were no statistically significant differences in means for either the payment card or the $25 starting point. This suggests that users have somewhat higher option prices,

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*To conclusively design a test for interviewer bias would require that interviewers be randomly assigned to different areas in the survey. The practical issue is that this could have a significant impact on data collection costs because of interviewers having to cover a substantial part of the survey area. In the Monongahela survey, interviewers were assigned areas based on the lowest travel costs to obtain the interview.

Table 4-12. Student t-Test Results for Option Price--
Protest Bids and Outliers Excluded

Means compared	User vs. nonuser	Means compared	User vs. nonuser
Payment card (A)		$25 iterative bidding (C)	
D to E	-0.313	D to E	-0.275
D to C	1.645	D to C	1.026
C to B	1.322	C to B	1.322
D to B	1.103	D to B	0.591
E to B	1.847	E to B	1.488
Direct question (B)		$125 iterative bidding (D)	
D to E	2.414[a]	D to E	3.231[a]
D to C	2.234[a]	D to C	2.186[a]
C to B	1.454	C to B	1.819
D to B	2.669[a]	D to B	3.279[a]
E to B	2.049[a]	E to B	2.555[a]

[a]Denotes significance at the 0.05 level.

but this difference is not pervasive. Thus, a survey of only the users of Monongahela River would have substantially underestimated the recreation and related benefits of water quality improvements. The full extent of these intrinsic benefits is developed in the following chapter.

4.6 USER VALUE RESULTS

Table 4-13 shows estimated user values, which resulted from respondents referring to the value card (see Figure 4-6) and breaking out the user value component of the option price. These values are comparable to those estimated in most of the previous contingent valuation efforts and are compared with the benefits estimated with the travel cost method in Chapter 8.

User value means are presented for users only and the means calculated for all respondents. Tests to determine whether the user values are statistically different from zero, shown in Appendix C, indicated that the user values for the D to E levels and combined over all levels are statistically different from zero at the 0.05 level of significance. The user values for improvements in water quality are only different from zero for the $25 bidding game and not for any other methods. Additional tests for differences in user values between methods, also contained in Appendix C, showed that means from the $25 bidding games were statistically different (lower) than those estimated with the $125 bidding game, but only for Levels D to E and the user values for all combined water quality levels. The differences for the user

Table 4-13. Estimated User Values--Protest Bids and Outliers Excluded

	User only			Combined		
	$\bar{X}$	s	n	$\bar{X}$	s	n
Iterative bidding framework						
$25 starting point (C)						
D to E	6.59	12.59	19	2.16	7.73	58
D to C	4.21	7.68	19	1.38	4.76	58
C to B	5.00	7.99	19	1.64	5.08	58
D to B	10.53	14.43	19	3.45	9.52	58
Combined: all levels	17.11	25.13	19	5.60	16.28	58
Iterative bidding framework						
$125 starting point (D)						
D to E	36.25	58.98	16	12.08	37.52	48
D to C	20.31	42.67	16	6.77	25.98	48
C to B	20.00	42.82	16	6.66	25.99	48
D to B	48.75	87.87	16	16.25	54.81	48
Combined: all levels	138.11	85.00	16	28.33	87.90	48
Direct question (B)						
D to E	19.71	37.85	17	6.57	23.38	51
D to C	21.18	42.22	17	7.06	25.93	51
C to B	10.00	29.10	17	3.33	17.14	51
D to B	31.18	64.63	17	10.39	39.46	51
Combined: all levels	50.88	77.46	17	16.96	50.07	51
Direct question: payment card (A)						
D to E	19.71	34.30	17	6.20	20.99	54
D to C	30.88	74.57	17	9.72	43.45	54
C to B	19.71	49.42	17	6.20	28.68	54
D to B	51.18	122.88	17	16.11	71.65	54
Combined: all levels	70.88	127.61	17	22.31	77.59	54

values combined for all respondents were the same as those for users, except for the comparison of bidding games, where the difference was significant only for the Level D to E change.

Table 4-14 presents the results for the regression models with the user values as the dependent variables. The models generally have less explanatory power than the option price models but do show some limited ability to explain variations in user value. Age and respondent attitude toward paying the cost of water pollution are the key variables in the model, and both have the expected signs.

Table 4-14. Regression Results for User Value Estimates of Water Quality Changes--Protest Bids and Outliers Excluded[a]

Independent variable	Water quality changes				
	D to E (avoid)	D to C	C to B	Total combined all levels	Total improvements only
Intercept	10.372	1.529	-2.143	6.686	17.058
	(0.551)	(0.070)	(-0.138)	(0.180)	(0.363)
Sex (1 if male)	1.070	-1.625	-0.107	0.121	1.191
(1 if male)	(0.218)	(-0.285)	(-0.026)	(0.013)	(0.097)
Age	-0.236	-0.264	-0.201	-0.507	-0.743
	(-1.761)	(-1.690)	(-1.817)	(-1.918)	(-2.220)[b]
Education	0.193	0.156	0.464	-0.063	0.130
	(0.142)	(0.098)	(0.412)	(-0.023)	(0.038)
Income	0.00001	0.0002	0.00003	0.0002	0.0003
	(0.073)	(0.740)	(0.167)	(0.607)	(0.508)
Direct question	-2.842	-5.766	-4.300	-11.536	-14.378
	(-0.456)	(-0.796)	(-0.836)	(-0.940)	(-0.925)
Iterative bidding game ($25)	-4.769	-10.724	-5.072	-15.588	-20.358
	(-0.803)	(-1.554)	(-1.035)	(-1.333)	(-1.374)
Iterative bidding game ($125)	6.665	-8.540	-3.006	-7.103	-0.438
	(1.014)	(-1.119)	(-0.554)	(-0.549)	(-0.027)
Willing to pay cost of water pollution (1 if very much or somewhat)	9.931	10.828	8.116	19.654	29.586
	(1.988)[b]	(1.866)	(1.969)[b]	(1.997)[b]	(2.374)[b]
Interviewer #1	-1.585	4.020	3.029	8.758	7.172
	(-0.157)	(0.343)	(0.364)	(0.441)	(0.285)
Interviewer #2	4.626	13.666	11.118	25.736	30.362
	(0.500)	(1.270)	(1.455)	(1.411)	(1.314)
Interviewer #3	-3.479	27.836	19.108	47.530	44.051
	(-0.395)	(2.721)[b]	(2.630)[b]	(2.740)	(2.005)[b]
Interviewer #4	-9.651	7.079	2.996	9.987	0.336
	(-0.553)	(0.349)	(0.208)	(0.290)	(0.008)
Interviewer #5	-5.724	1.410	-0.087	3.474	-2.250
	(-0.624)	(0.132)	(-0.012)	(0.192)	(-0.098)
Interviewer #6	-6.266	19.835	11.477	27.795	21.529
	(-0.221)	(0.602)	(0.491)	(0.498)	(0.305)
Interviewer #7	12.634	4.664	1.177	16.328	28.962
	(1.225)	(0.389)	(0.138)	(0.803)	(1.125)
Interviewer #8	-5.509	11.417	3.960	15.851	10.342
	(-0.589)	(1.050)	(0.513)	(0.860)	(0.528)
Interviewer #9	-18.707	-3.159	-3.381	-8.995	-27.702
	(-0.889)	(-0.129)	(-0.195)	(-0.217)	(-0.528)
R^2	0.13	0.14	0.14	0.14	0.15
F	1.22	1.34	1.28	1.34	1.44
Degrees of freedom	137	137	137	137	137

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

[b]Significant at the 0.05 level.

4.7 SUMMARY

The contingent valuation estimates of the option price for quality improvements are consistently plausible throughout the various analytical considerations. The empirical results indicate that the methods used to elicit the bid do have a statistically significant effect on the estimates of an individual's valuation. Payment cards and the bidding game with a $125 starting point produced higher willingness-to-pay estimates than either the direct question or the bidding game with a $25 starting point. There is some evidence

of a starting point bias in the bidding game, but the statistical analyses are not conclusive. The results comparing bidding games with nonbidding games indicated no differences when these combined comparisons are made. In terms of future contingent valuation experiments, the results imply that using bidding games to elicit willingness to pay requires a range of starting points to test for starting point bias. No statistical or analytical differences are apparent when nonbidding games are employed to elicit willingness to pay.

For the continued use of the contingent valuation method to estimate benefits of water quality improvements, the general prognosis from the results of the Monongahela River case study is a good one. The empirical models performed reasonably well in explaining variations in willingness to pay, with little indication that individual interviewers influenced the results. The consistently plausible signs and magnitudes of key economic variables suggest that the respondents perceived the realism of the survey and did not experience problems with the hypothetical nature. Moreover, the results came from a random sample of households from an area whose socioeconomic profile is not ideally suited for a contingent valuation survey: The respondents were older, less educated, and poorer than in previous contingent valuation studies.

CHAPTER 5

CONTINGENT VALUATION DESIGN AND RESULTS: OPTION AND EXISTENCE VALUES

5.1 INTRODUCTION

Over a decade ago, Krutilla [1967] emphasized the importance of nonuser benefits to the process of efficiently allocating natural environments. In his development of the special problems associated with valuing the services of natural environments, Krutilla identified several types of nonuser values. The objective of this chapter is to present survey results that attempt to measure directly two of the sources of benefits Krutilla identified--option value and existence value. It should be acknowledged at the outset that the first of these, option value, has received the greatest attention in the literature and is regarded as one of the most important components of nonuser values. As a consequence, the majority of this chapter is devoted to the theoretical and empirical problems associated with modeling and measuring option value.

The simplest approach to defining option value is to use an example. Consider an individual who is uncertain whether he will visit a recreation site on the Monongahela River in the future. Also, suppose this person is uncertain whether the facility will be available in the future should he decide to use it. This uncertainty over availability may arise because the individual either does not know whether the facility will permit any use or does not know the types of uses that will be permitted. (For example, a river may not permit any use, or it simply may not be available for swimming. Of course, the inability to support recreational swimming does not preclude the provision of sport fishing and boating services.) What is at issue is uncertainty over the character of the supply. This uncertainty can involve the all-or-none case, a concept conventionally used in the theoretical literature, or simply a change in the types of uses that can be supported in the future. Given these conditions, a rational individual may be willing to pay some amount for the right to use the facility's services in the future. This payment can be interpreted as a means of insuring access to the site's services. Of course, it does not eliminate the individual's uncertainty over whether he will actually decide to use the site's services.

In all discussions of option value, the payment is assumed to be constant regardless of whether or not the individual visits the site. The payment is usually described as the option price. The option value is defined as the difference between this payment and the individual's expected consumer surplus from having access to the site's services. In the extreme case, where the choice is use or no use, the expected consumer surplus is the weighted sum

(by the relevant probabilities) of the consumer surplus associated with access and use of the site plus that of access and no use. Of course, it must be recognized that this discussion assumes that markets do not exist for contingent claims that could handle the prospects for a future demand. Thus, there is no alternative mechanism (other than purchasing the option) available to the individual for diversifying the risk he experiences.

Researchers have generally agreed that this description of behavior is plausible. The literature, however, includes a wide array of arguments concerning the relationship between the maximum willingness to pay for the option and the expected consumer surplus. For example, Cicchetti and Freeman [1971] observed that option value existed as a direct result of risk-averse behavior and was therefore positive. By contrast, using a similar framework, Schmalensee [1972] concluded that option value may be positive or negative depending on the vantage point selected for evaluating the individual's choices. Subsequent contributions questioned Schmalensee's definition of risk aversion (Bohm [1975]); introduced time specifically into the analysis (Arrow and Fisher [1974]; Henry [1974]; and Conrad [1980]); and, more specifically, considered the mechanisms available to the individual for diversifying risk (Graham [1981]). The result has been a large and often confusing literature.

Understanding the past contributions in this area requires a clear description of three aspects of the role of uncertainty in each model. This characterization of uncertainty is most easily summarized by posing three questions:

- What is the source of the uncertainty in the individual's decision problem?
- How will the uncertainty in this decision problem ultimately be resolved?
- Is it possible to amend the decision process to accommodate new information that may resolve some of the uncertainty?

Each of the past analyses of option value provides implicit answers to these questions. Moreover, the answers help explain why these analyses yield such diverse conclusions.

Two recent papers have provided the elements necessary to integrate a significant portion of the literature. The first of these is a review article by Bishop [1982] that provides an excellent summary of past contributions and extends earlier work by amending Schmalensee's framework to delete the individual's demand uncertainty and to explicitly include supply uncertainty. In the second paper, Graham [1981] seeks to define the appropriate measure of benefits for benefit-cost analyses in the presence of uncertainty. He concludes, as Bohm [1975] did earlier, that option price <u>and not expected consumer surplus</u> is the appropriate valuation measure. Unfortunately, his evaluation of the problem tends to focus on cases where individuals face specific risks and have access to ideal markets in which to diversify these risks. For these cases, he quite correctly concludes option value is largely irrelevant.

Of course, most resource and environmental problems do not "fit" these assumptions. Nonetheless, his framework and evaluation of the case of collective risk provide another important insight into the appropriate treatment of option value.

Section 5.2 of this chapter reviews the modeling of uncertainty and, specifically, the use of a contingent claims framework. This review is necessary to understand the implications of alternative definitions of risk aversion. With this background it is possible in Section 5.3 to describe the "timeless" analyses of option value and to relate them to the recent contributions of Bishop [1982] and Graham [1981]. Section 5.4 briefly discusses the relationship between option value and quasi-option value introduced by Arrow and Fisher [1974].

Section 5.5 discusses three recent attempts to empirically estimate nonuser values--the Greenley, Walsh, and Young [1981] estimates of option value from potential water quality degradation in the South Platte River basin in Colorado; Mitchell and Carson's [1981] estimates of the total "intrinsic" values for improvements in national water quality; and the Schulze et al. [1981] analysis of visibility benefits for national parks in the Southwest.

Sections 5.6 through 5.8 describe the survey results for the Monongahela River basin. Section 5.6 describes the questions used to estimate option value and to determine its sensitivity to the character of the supply uncertainty. The survey has been structured so that it is possible to distinguish the estimates according to the question used, the level of supply uncertainty, and the character of the respondents. Respondents are grouped according to whether they have used the river for recreation purposes. Section 5.7 presents a summary of the empirical results and an evaluation of the effects of the questioning mode (as well as of the starting point for the iterative bidding scheme) used for the estimates. In addition to measuring option value, attempts were made to measure existence values independently. Section 5.8 discusses these efforts. Section 5.9 presents a summary of the primary findings of this research.

5.2 CONTINGENT CLAIMS MARKETS AND THE MODELING OF UNCERTAINTY*

The traditional approach to dealing with production and exchange decisions under uncertainty involves a definition of new commodities that specifies not only their physical characteristics, location, and date of availability, but also a particular state of the world that must be realized if the stipulated transaction is to take place. In terms of the example used in Section 5.1, one state of the world permits access to the Monongahela River recreation site and another does not. In this framework, uncertainty has the effect of expanding the commodity set available to the individual. For example, if, in

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*The theoretical analysis in this chapter is an expanded version of that reported in Smith [1983].

the absence of uncertainty, there are N commodities, and if uncertainty introduces K states of nature, a contingent claims model redefines the commodity set to be N·K contingent claims. Each is a claim to a good contingent upon the state of nature. In this framework, the model is describing how an individual's plans for activities are made rather than the actual activities themselves. These plans involve the selection of claims to goods, should the state of the world be realized. Thus, the individual must allocate his budget optimally among these claims before the state of the world is known.

Of course, defining optimality in this framework requires consideration of the rule that aggregates these claims. Because each of these new commodities involves both a good and a state of world, each outcome needs an associated probability. This permits the use of expected utility--justified in the early work of von Neumann and Morgenstern [1947]--as the rule for aggregating the values associated with these claims. That is, given the four postulates of rational choice, the utility of any set of contingent claims (e.g., a commodity considered over all states of nature) can be derived as the expected utility.* The most important of these postulates for understanding the literature on option value is the uniqueness postulate, which requires the expected utility of a set of claims to be independent of the "state labeling" of the commodities involved in these claims. That is, these commodities could be rearranged over all states of nature without changing the expected utility as long as each commodity is realized with the same probability.

Most analyses of option value drop this postulate by assuming that the individual has a different utility function depending on whether the services of a recreation site are demanded or not demanded. The presence of a positive level of demand for the site is not simply a reflection of a higher income or a lower price. With a given income and prices of substitute goods, conventional statements of an individual's demand function often assume that there is a price at which the services of a site will not be demanded. With a state-dependent demand specification it is unlikely that the reasons why the site will not be demanded can be fully explained. Rather, this specification is used simply to reflect a different set of preferences that depend on the existence of demand for the site. To emphasize this assumption, the following review summarizes the difference between the consumer's allocation decisions (among contingent claims) and the definition of risk aversion under the two frameworks--one that maintains the uniqueness postulate and one that does not.

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*The four postulates are: (1) ordering and preference direction--larger incomes are preferred to smaller incomes; (2) certainty equivalence--there is an amount, the certainty equivalent, that is intermediate in size to the largest and smallest consequences of a given prospect; (3) independence--a claim, designated as Z, can be substituted for its preference equivalent, say $\bar{Z}$, in any prospect into which $\bar{Z}$ enters and vice versa; and (4) uniqueness--the certainty equivalent of a prospect depends only on the magnitudes of the probabilities and incomes, not on their state designations. See Hirshleifer [1970, pp. 219-20] or Malinvaud [1972, pp. 285-90] for further discussion. Cook and Graham [1977] provide additional perspective for irreplaceable goods.

Consider the case of two contingent commodities (or claims), X_1 and X_2, corresponding to States 1 and 2 and having probabilities of p and (1-p), respectively. If the prices of these claims are r_1 and r_2, and if utility is dependent on the amount of X_i, such as $u(X_i)$, the individual's objective function, when the uniqueness postulate is satisfied, can be written as Equation (5.1):

$$V = p\mu(X_1) + (1-p)\mu(X_2) \quad , \tag{5.1}$$

where V is the expected utility. If the initial endowment of claims is $(\bar{X}_1, \bar{X}_2)$, the budget constraint limiting the individual's choices would be:

$$y = r_1\bar{X}_1 + r_2\bar{X}_2 = r_1X_1 + r_2X_2 \quad . \tag{5.2}$$

Maximizing Equation (5.1) subject to Equation (5.2) and solving the first-order conditions yields the familiar equality of relative prices and probability-weighted marginal utilities, as in Equation (5.3)*:

$$\frac{pu'(X_1)}{(1-p)u'(X_2)} = \frac{r_1}{r_2} \ . \tag{5.3}$$

This result is usually specialized further by consideration of a "fair" gamble case (i.e., where $p\ dX_1 + (1 - p)dX_2 = 0$). This case implies the equality of the probability ratio and the price ratio for the two contingent claims (i.e., $p/(1 - p) = r_1/r_2$).† Using this condition, Equation (5.3) can be rewritten as:

$$\frac{u'(X_1)}{u'(X_2)} = 1 \ . \tag{5.4}$$

The optimal allocation calls for equal claims in X_1 and X_2, as given by the point R in Figure 5-1. Thus, the selection in this case will fall along the certainty locus (both income and utility)--the 45° line in Figure 5-1.

The traditional definition of risk aversion for this framework maintains that risk-averse individuals require better than "fair" gambles before they will select these alternatives over a certain claim with the same expected income. Under the assumption of uniqueness there are two further implications

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*The second-order conditions are $d^2X_2/dX_1^2 > 0$. This can be shown, given uniqueness, to be implied by the assumption of concavity of u(.). That is: $d^2X_2/dX_1^2 = \partial/\partial X_1\ (dX_2/dX_1) + \partial/\partial X_2\ (dX_2/dX_1)\ [dX_2/dX_1]$, where $dX_2/dX_1 = -[p/(1-p)]\cdot[u'(X_1)\ /\ u'(X_2)]$ hence $d^2X_2\ /\ dX_1^2 = p\ u''(X_1)\ /\ (1-p)\ u'(X_2) - p^2(u'(X_1))^2u''(X_2)\ /\ (1-p)^2(u'(X_2))^3$. Concavity of u(.) implies that $u''(.) < 0$, and thus dX_2^2/dX_1^2 is positive, because p, (1-p), $u'(X_1)$, and $u'(X_2)$ are all positive.

†This conclusion is derived by recognizing the implications of a constant initial budget and the "fair" gamble for selections of contingent claims: A constant budget implies $r_1dX_1 + r_2dX_2 = 0$; a fair gamble implies $pdX_1 + (1-p)dX_2 = 0$; thus, a fair gamble implies $-dX_2/dX_1 = p/(1-p) = r_1/r_2$.

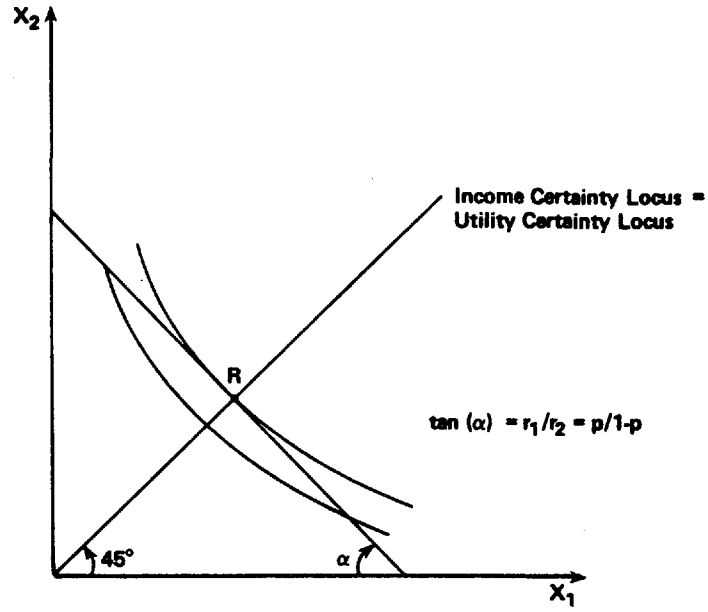

Figure 5-1. Optimal allocation of choice with contingent claims.

associated with risk-averse behavior. They are important because they provide the means for explaining the divergence between Schmalensee [1972] and Bohm [1975] in their respective interpretations of the appropriate definition of risk aversion. To understand these divergent interpretations, imagine a risk-averse individual subject to the choice of $\bar{X}$ with certainty versus the prospect of X_1 with probability p and X_2 with probability (1 - p). Assume $\bar{X} = pX_1 + (1 - p)X_2$. Then a risk-averse individual's choice would be consistent with a utility function that ranks these prospects as follows:

$$u(\bar{X}) \geq pu(X_1) + (1 - p)u(X_2) \tag{5.5}$$

Equation (5.5) will be realized if u(.) is concave. Thus, the concavity of u(.) is usually taken to imply risk aversion. In this study's analysis of "fair" gambles, as given in Equation (5.4), the risk-averse individual's choices can also be characterized as implying an allocation of resources among claims such as $u'(X_1) = u'(X_2)$. All individuals will allocate their resources among claims to States 1 and 2 so that these marginal utilities are equalized in the case of "fair" prices. Since risk aversion is defined by the concavity of u(.), the behavioral responses of a risk-averse individual will be determined by how he responds to a change in p. However, once the assumption of uniqueness is relaxed and state-specific utility functions are permitted, the condition for fair gambles implies only that the marginal utilities will be equalized and not that either the total utilities or the total monetary claims in each state will be equalized. Without uniqueness there will be a distinction between the locus of equal consumption (or income) over states (i.e., the 45° line defined as the income and utility "certainty" locus under the assumption of uniqueness) and the utility certainty locus, where $u_1(X_1) = u_2(X_2)$, as illustrated in Figure 5-2. Moreover, the optimal allocation will not necessarily lie on the utility certainty locus as it did under the assumption of uniqueness. Schmalensee [1972] mis-

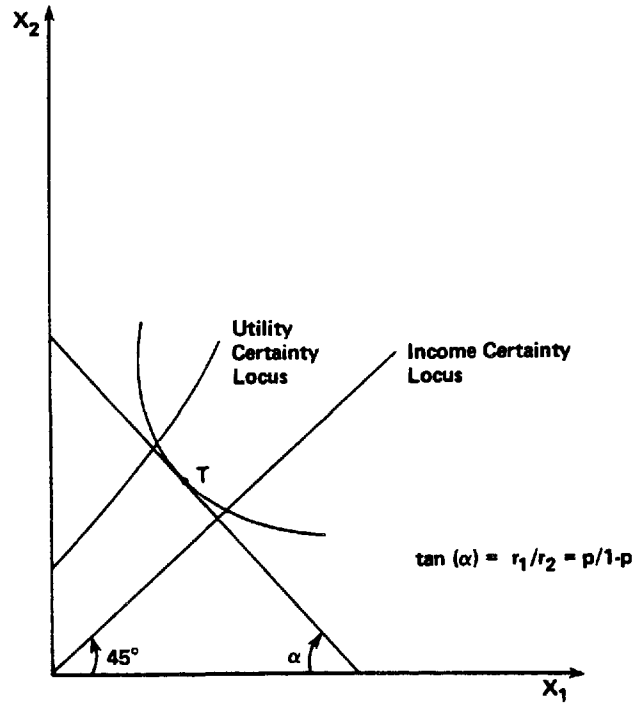

Figure 5-2. Optimal allocation of choices of contingent claims without uniqueness.

interpreted this possibility as an indication that concavity was an inappropriate definition of risk aversion and selected the equality of marginal utilities as the characteristic necessary to define risk-averse behavior in the case of state-dependent utility functions. In summary, the contingent claims model provides an analytical vehicle that will aid in deciphering the misunderstandings of option value that have developed in the research literature.

5.3 OPTION VALUE: THE "TIMELESS" ANALYSES

The first analytical evaluations of option value employed a "timeless" framework with the only source of uncertainty associated with the state of the individual's preference structure (see Cicchetti and Freeman [1971], Bohm [1975], and Schmalensee [1972, 1975]). To simplify the explanation of these analyses, assume that individual preferences can be described by just two states: State 1, which demands the services of the asset with $u_1(.)$, and State 2, which does not demand the services of the asset with $u_2(.)$. Each state's utility function will have two arguments--income, Y, and a variable indicating access to the asset's services, with d implying the services are available and $\bar{d}$ implying they are not. This argument can proceed using the compensating variation definitions of consumer surplus, option price, and option value, but comparable arguments can be developed using equivalent variation.

Equations (5.6) and (5.7) define consumer surplus for the ith state (SC_i) and option price (OP), respectively:

$$u_i(Y_i - SC_i, d) = u_i(Y_i, \bar{d}), \quad i=1,2 \tag{5.6}$$

$$\sum_{i=1}^{2} \pi_i \, u_i(Y_i - OP, d) = \sum_{i=1}^{2} \pi_i \, u_i(Y_i, \bar{d}) \tag{5.7}$$

where

$u_i(Y, d)$ = individual utility for State i with income Y_i and with access to the services of the asset

π_i = probability of utility State i ($\pi_2 = 1 - \pi_1$).

Substituting Equation (5.7) in Equation (5.6) and rearranging terms gives:

$$\sum_{i=1}^{2} \pi_i \, [u_i(Y_i - OP, d) - u_i(Y_i - SC_i, d)] = 0 \, . \tag{5.8}$$

Schmalensee [1972] proposed using concavity of the state-specific utility functions to expand Equation (5.8). That is, the inequalities given in Equations (5.9) and (5.10) hold for concave $u_i(.)$:*

$$u_i(Y_i - OP, d) - u_i(Y_i - SC_i, d) \geq (SC_i - OP) \, [\partial u_i/\partial Y_i \, (Y_i - OP, d)] \tag{5.9}$$

$$u_i(Y_i - OP, d) - u_i(Y_i - SC_i, d) \leq (SC_i - OP) \, [\partial u_i/\partial Y_i \, (Y_i - SC_i, d)]. \tag{5.10}$$

Substituting each into Equation (5.8) and rearranging terms gives inequalities for option price involving Bohm's [1975] weighted expected consumer surplus terms as Equations (5.11) and (5.12):

$$OP \geq \sum_{i=1}^{2} \pi_i \, SC_i \, [\partial u_i/\partial Y_i \, (Y_i - OP, d)] \, / \sum_{i=1}^{2} \pi_i [\partial u_i/\partial Y_i \, (Y_i - OP, d)] \, . \tag{5.11}$$

$$OP \leq \sum_{i=1}^{2} \pi_i \, SC_i \, [\partial u_i/\partial Y_i \, (Y_i - SC_i, d)] \, / \sum_{i=1}^{2} \pi_i [\partial u_i/\partial Y_i \, (Y_i - SC_i, d)]. \tag{5.12}$$

Because option value (OV) is defined as the difference between the option price (OP) and the expected consumer surplus (SC)--i.e., OV = OP

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*In the analysis that follows, the point of evaluation of the partial derivatives will be important to the interpretation given to each relationship. Therefore, $[\partial u_i/\partial Y \, (a,b)]$ will refer to the partial derivative of $u_i(.)$ with respect to Y evaluated at the point (a, b).

$-\left(\sum_{i=1}^{2} \pi_i \, SC_i\right)$--these inequalities offer the potential for determining the sign of the option value if it is possible to relate the weighted consumer surplus to the expected value of the consumer surplus.* Schmalensee's definition of risk aversion as equality of the marginal utilities of income across states (i.e., $\partial u_1/\partial Y_1 = \partial u_2/\partial Y_2$) provides the ability to make this association by making the weights in Equations (5.11) or (5.12) unity. That is, depending upon whether the equality is realized at Y_i - OP or Y_i - SC_i, option price will be greater or less than expected consumer surplus. Thus, Schmalensee concludes that the sign of option value depends on the point of evaluation.

As observed earlier, Bohm has correctly observed that this judgment is misleading for at least two reasons. First, the interesting expression is Equation (5.11) because the point of evaluation of the marginal utilities correctly assigns to the individual the relevant income/access conditions. This expression describes the relationship between option price and expected consumer

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*To illustrate this point let

$$w_1 = \frac{\pi_1 \frac{\partial u_1}{\partial Y_1} (Y_1\text{-OP, d})}{\sum_{i=1}^{2} \pi_i \frac{\partial u_i}{\partial Y_i} (Y_i\text{-OP, d})}$$

$$w_2 = \frac{\pi_2 \frac{\partial u_2}{\partial Y_2} (Y_2\text{-OP, d})}{\sum_{i=1}^{2} \pi_i \frac{\partial u_i}{\partial Y_i} (Y_i\text{-OP, d})}$$

This specification will imply $w_1 + w_2 = 1$. Consequently, Equation (5.11) can be rewritten as

$$OP \geq \sum_{i=1}^{2} w_i SC_i$$

To compare the specification with the expected consumer surplus $\left(\sum_{i=1}^{2} \pi_i \, SC_i\right)$ requires some knowledge about the relationship between w_i and π_i. For example, if it is assumed that $\frac{\partial u_1}{\partial Y_1}$ (Y_1 - OP, d) = $\frac{\partial u_2}{\partial Y_2}$ (Y_2 - OP, d) (the marginal utilities of income are equal in each period), then $w_i = \pi_i$ and Equation (5.11) allows option value to be signed.

surplus when the individual's income is reduced by the option price. As Bohm suggested:

> We are asking him how much he can abstain from today in terms of an OP and enter the future state, whatever it may be, with a disposable income of Y-OP without being worse off. He will be at Y-SC_i only if he does not pay an option price--and that is another story. We do not ask him about the maximum amount he is willing to pay provided he does not pay that amount. (Bohm [1975], p. 735)

The second consideration involves the Schmalensee definition of risk aversion. The previous section noted that the conventional definition of risk aversion, with the uniqueness assumption for state utility functions, simultaneously implies that:

- The utility function must be concave to admit such a response to a "fair" gamble.

- In response to a fair gamble the risk-averse individual will always select a point where marginal utilities of income are equal.

This latter point is a result of optimizing behavior in the presence of a fair gamble and concavity of the utility functions. Once the uniqueness assumption is relaxed and state-specific utility functions are permitted, the only plausible definition for risk aversion is by the concavity of the state-specific utility functions. Thus, when the correct point of evaluation (i.e., the inequality given in Equation [5.11]) and the appropriate definition of risk aversion are used, the sign of option value cannot be established. It may be positive, negative, or zero depending upon the relationship between the marginal utilities of income at each state.

Given these conclusions, how do Cicchetti and Freeman [1971] establish, apparently unambiguously, a positive sign for option value while Bohm does not? To answer this question, return to the example of a "fair" gamble with state-specific utility functions that was given in Figure 5-2. Schmalensee incorrectly interpreted this divergence to indicate the inadequacy of $u_i(.)$'s concavity as the sole basis for defining risk-averse behavior. However, Cicchetti and Freeman apparently intended to focus on a comparison along the utility certainty locus.* As Anderson [1981] has recently observed, they as-

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*Cicchetti and Freeman seem to have wanted to use the utility certainty locus to make the state-specific actions commensurate. This can be seen in their proposal that:

> To make the choice problem solvable, there must be some way of making the utilities of the two alternative mappings commensurable. We have proceeded as follows to derive a rule for comparing the utilities from the two alternative mappings. For any level of disposable income, if the individual did not demand the

sumed that the individual's income was equal across all states and that, when income was equal, total utilities in each state were also equal at the preferred price vector. In the present analysis, this would correspond to equal utility for conditions of access to the resource [i.e., $u_i(Y_i, d) = u_j(Y_j, d)$ for $Y_i = Y_j$]. Unfortunately, the Cicchetti-Freeman analysis did not correctly describe an individual's choices of Y and the services of the asset. While they proposed to consider a discrete choice similar to the d versus $\bar{d}$ description, they represented the services as continuously available, designed by X.

Figures 5-3 and 5-4 reproduce the Cicchetti-Freeman figures (III and IV) for the analysis. If Figure 5-4 is interpreted as an illustration of the "no-demand" case, the assertion that $u_8 = u_5$ at Y_0 is incorrect. If the relevant budget constraint, B_1, is considered, the individual will not choose to consume the same level of Y. In the "no-demand" case (i.e., u_8), the selected income will be Y_0, but the "demand" case will be Y_5 in Figure 5-3. Similar arguments can be developed for the assumption that $u_1 = u_6$ at $Y_0 - OP_1$, which indicates that the construction of Figure 5-4 is incorrect. To adequately deal with the equivalence of state-specific utility functions at equal income levels, a graphical analysis must be in terms of indirect utility functions as described by Bishop [1982]. In this case the ambiguity in the sign of option value is clearly demonstrated.

In Graham's [1981] recent attempt to use the Schmalensee framework to comment on the appropriate treatment of option value, he argues that the reasonableness of using option price for benefit-cost analyses will depend on the nature of the problem under study. More specifically, Graham concluded that:

- Option price is the appropriate benefit measure for project analysis when one can assume the individuals affected are similar and they all experience the same risk.

- Expected willingness to pay will be the appropriate measure for those cases with similar individuals but with risks specific to each.

These conclusions are derived using a generalization of the option price definition (Equation (5.7)). To understand them, Graham's arguments must be considered in detail. For the case of individual risks, he assumes that payments may be state specific. This is equivalent to the assumption that a complete set of markets for contingent claims exists. Under these assumptions, the definition of option price in Equation (5.7) would be replaced by Equation (5.13):

> good, he would choose a consumption point on the Y axis and experience a certain level of utility; if he were to demand the good (assuming that it is available), he would choose a tangency point on the budget line associated with that point, and experience a given level of utility. We assume that the alternative outcomes have the same utility. (Cicchetti and Freeman [1971], p. 534)

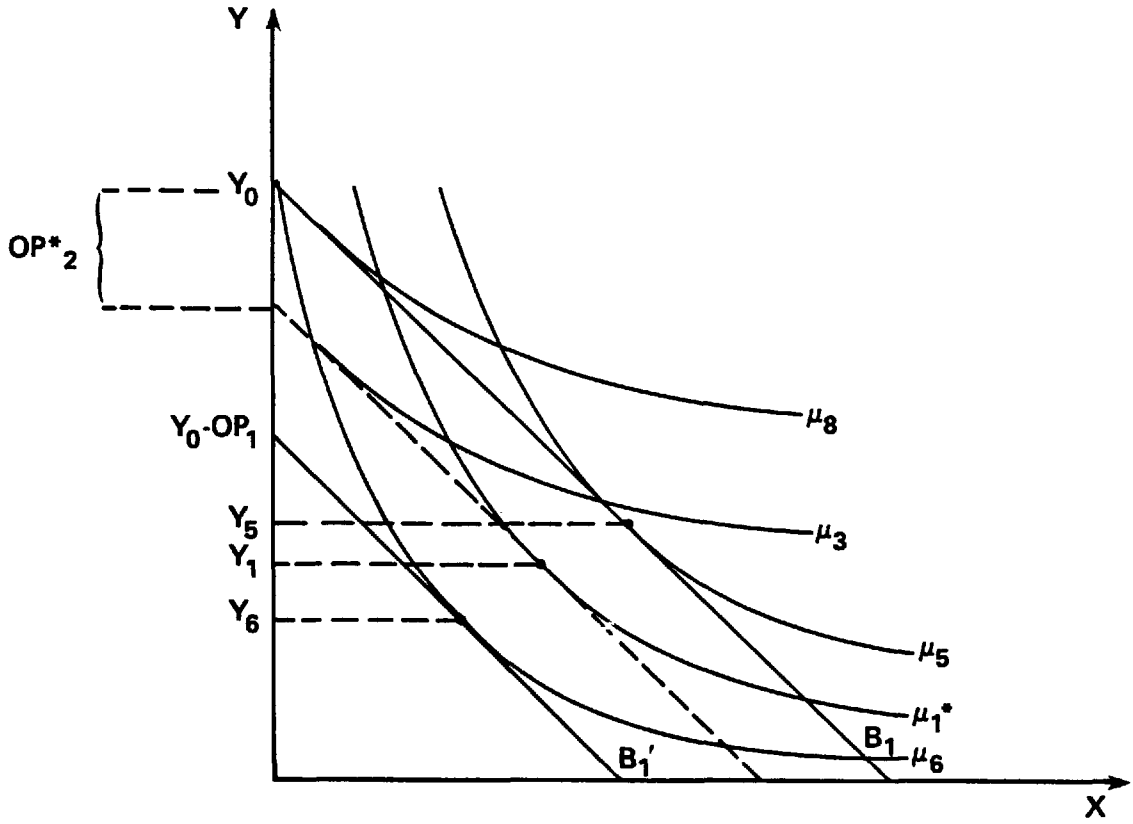

Figure 5-3. Option value in Cicchetti-Freeman's analysis.

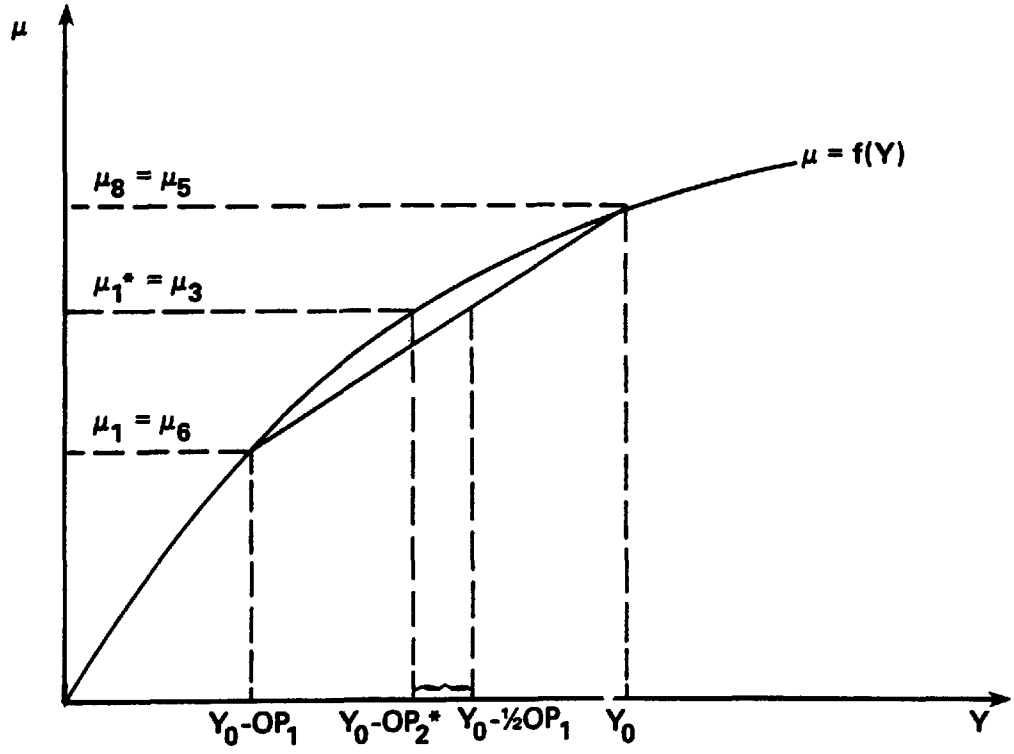

Figure 5-4. Option value in Cicchetti-Freeman's analysis with "no demand."

$$\sum_{i=1}^{2} \pi_i \, u_i(Y_i - P_i, d) = \sum_{i=1}^{2} \pi_i \, u_i(Y_i, \bar{d}) \, . \qquad (5.13)$$

Graham defines this relationship as the willingness-to-pay locus. The special case of $P_1 = P_2 = OP$ would yield the conventional definition of the option price. The locus also includes the point where $P_i = SC_i$ (by construction), as well as the fair-bet and the utility certainty points, as illustrated in Figure 5-5.

To illustrate some of the points on the locus, assume TT' corresponds to the individual's budget constraint where the prices of claims in States d and $\bar{d}$ correspond to the probabilities of each state. F will then designate the fair-bet point. When payments are constant, regardless of the state of nature, as with point P, the locus describes the willingness to pay under institutional conditions consistent with an option price, OP. Point S corresponds to the coordinates of the consumer surpluses for each state. To calculate the expected value of the consumer surplus, the budget constraint through S parallel to TT' is used (to reflect the state probabilities). The intersection of this new budget line, RR', with the 45° line defines the expected consumer surplus. For this example, option value is positive.

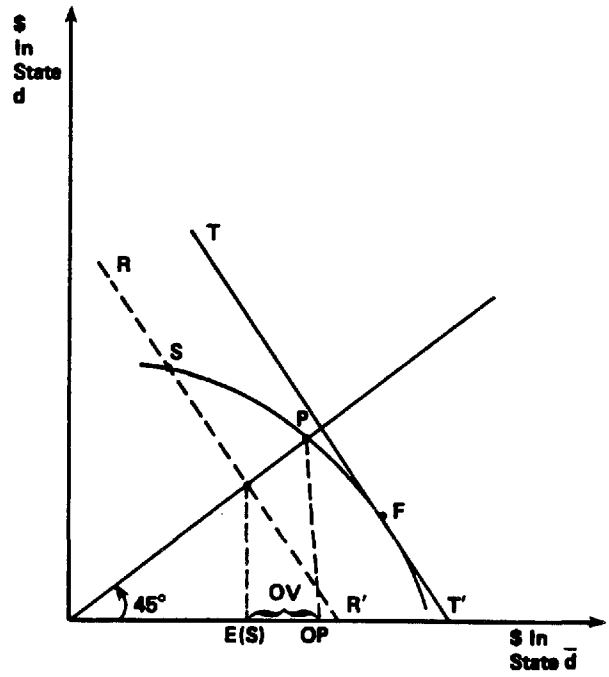

Figure 5-5. Option value with contingent claims in Graham's analysis.

Aggregating the willingness-to-pay loci across individuals, Graham argued that:

> Justification of the project hinges upon the question of whether or not contingent prices exist at which aggregate willingness to pay in each state exceeds the corresponding resource cost of the project. Should such prices exist, that point from an individual's locus which has the greatest value at these prices is the one relevant for cost-benefit analysis, and the corresponding value at these prices is the appropriate measure of benefit. (Graham [1981], p. 719)

To apply this approach in particular examples requires that one distinguish: (1) the benefits realized as a result of moving from an initial distribution of income to another that assures an efficient distribution of risk and (2) the benefits resulting from the project itself.

Graham's conclusions are based on two rather special cases. The first of these avoids the issue of an inefficient distribution of risk by assuming that individuals are alike and that they face identical risks. The second case also skirts this issue by assuming the existence of either complete contingent claims markets or an ideal, state-dependent tax collection scheme (tied to the project under evaluation). In either case, an efficient distribution of risk will be realized. Of course, neither of these sets of assumptions is plausible in most applications, where some attempt must be made to include a measure of the value of an option to use the services of an environmental resource. Consequently, as Graham acknowledges, one is left with option price as the "best" basis for measuring benefits. Thus, for practical purposes, Graham's analysis has strengthened Bohm's conclusion: Option price is the relevant focus for applied welfare economics.

Given these conclusions, why worry about the sign and magnitude of option value? One pragmatic reason arises with the difficulty in measuring each individual's option price. If it is possible for wide classes of assets and their associated prospective users to demonstrate that the corresponding option values of the assets would be positive, one would be safe in assuming that measures of the expected user benefits (i.e., as derived from an "ideal" consumer surplus calculation) would <u>understate</u> the total benefits provided by the asset.*

5.4 THE TIME-SEQUENCED ANALYSES

Time-sequenced evaluations of option value offer more specific answers to the three questions raised at the outset. That is, these analyses provide an explicit statement of the relationship between decisions over time. In general, the uncertainty is supply related. It is resolved with the passage of time, and decisions cannot be altered. The first of these models was devel-

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*This argument ignores the potential role of existence values as described by Krutilla [1967] and more recently discussed by Freeman [1981].

oped by Arrow and Fisher [1974], whose framework introduced a time-sequencing of decisions and, as a result, assumed there was a resolution of the uncertainty facing the decision process with the passage of time. Their model considered decisions to develop or preserve a fixed amount of land. Decisions to develop some fraction (or all) of the land were irreversible. Therefore, any information acquired with the passage of time could affect only the decisions made on the remaining stock of preserved land.

Arrow and Fisher's quasi-option value can be interpreted as the expected value of the information obtained through delay, as has been suggested by Conrad [1980] and, indeed, acknowledged earlier by Krutilla and Fisher [1975] in their overall evaluation of special problems associated with allocation decisions involving unique natural environments. For example, Krutilla and Fisher observed that:

> The key new element in Arrow and Fisher is a Bayesian information structure. The passage of time results in new information about the benefits of alternative uses of an environment, which can in turn be taken into account if a decision to devote it to development is deferred. Since development is not reversible, once a decision to develop is made, it cannot be affected by the presence of new information which suggests that it would be a mistake in the future. The main result of the analysis is then that there is an option value, or quasi-option value, to refraining from development--even on the assumption that there is no risk aversion, and only expected values matter. (Krutilla and Fisher [1975], pp. 70-71)

Conrad also suggested that option value could be interpreted as the expected value of perfect information. In so doing, he implicitly maintains that over time one progressively learns of and resolves the uncertainty. However, his conclusion is correct only if it is regarded as the only appropriate translation of the "timeless" analysis of option values into a time-sequenced decision process. Henry [1974] has drawn a similar conclusion in his evaluation of the importance of this transition, noting that:

> The relationship so established between risk aversion and option-price appears rather obvious when it is viewed as being encountered in a 'timeless world' where I [the individual] has one and only one decision to take; <u>in a world of this type any decision is just as irreversible as any other</u> [emphasis added] and it is impossible to introduce Krutilla's option value which is nothing but a risk premium in favour of 'irreplaceable assets'. Krutilla's idea can only be examined in a 'sequential world' where <u>I</u> [the individual] <u>really has a succession of decisions</u> to take. (Henry [1974], p. 92)

Thus, if it is assumed that uncertainty is resolved over time, that the asset under consideration is in some respect irreplaceable, and that the decisions are made sequentially with the benefit of the acquired information, there is clearly a positive option value. If, on the other hand, the resolution of the uncertainty is not allowed as a part of a set of decisions, option value will be a reflection of risk aversion, and its sign will depend on the nature of the state-specific utility functions.

This distinction has important implications for any attempts to develop estimates of option price. If a direct survey or contingent valuation method is used to obtain these estimates, the results will be based on hypothetical conditions in which it is unlikely that respondents can be given a means of obtaining information and reacting to it. That is, as a practical matter, it is probably safe to assume that questions designed to elicit an individual's option price will not be posed in a way that identifies mechanisms through which the individual can obtain information and alter decisions based on it. Thus, the timeless analyses are more likely to be the relevant models for understanding the empirical measurement of option value. However, this judgment does not imply that a careful description of the source of uncertainty and the means through which it is resolved can be ignored in question design. Rather, it simply recognizes that formulating questions that acknowledge the prospects for learning and that offer mechanisms for enhancing learning would likely increase the complexity of the instrument to a point where it was not usable.

Together with extensions of it in Smith [1983], this analysis suggests that supply uncertainty can be important to the sign of option value in a timeless framework. Accordingly, supply uncertainty should be acknowledged and explicitly identified in questionnaires designed to measure option price.

5.5 RECENT ESTIMATES OF NONUSER VALUES

There appears to have been only one published study estimating option values. This study by Greenley, Walsh, and Young [1981] attempts to measure the option value for the recreational use of preserved water quality in the South Platte River basin in Colorado. These authors used two payment vehicles--an increment to the sales tax and an increase in the monthly water-sewer fee--in a survey of a random sample of 202 residents of Denver and Fort Collins. Their study attempted to estimate specific components of the benefits of maintaining water quality, including option, user, existence, and bequest values. Their paper focuses on the results of the question for option value. Two aspects of their option value question are important. First, it seems to be eliciting an option price, not option value, and specifies a resolution of the supply uncertainty associated with the preservation of water quality. And, second, the question treats the two payment vehicles differently. The question is reproduced below:

> Given your chances of future recreational use, would you be willing to pay an additional _____ cents on the dollar in present sales taxes every year to postpone mining development? This postponement would permit information to become available enabling you to make a decision with near certainty in the future as to which option (recreational use or mining development) would be most beneficial to you. Would it be <u>reasonable</u> to add _____ to your water bill every month for this postponement? (Greenley, Walsh, and Young [1981], p. 666, emphasis added)

As discussed earlier, option value is the difference between an individual's option price and his expected consumer surplus. It would seem that this question is soliciting the option price. Unfortunately, the authors interpreted the responses as measures of the option value and asked a separate question intended to obtain user values. The Greenley, Walsh, and Young results with the sales tax payment vehicle indicate an average option value of approximately $23.00 per year (with the water fee payment vehicle, it was $8.90).*

The interpretation of these results has been somewhat controversial. Both questions used by Greenley, Walsh, and Young seem to be asking for an option price--the first under a timeless interpretation and the second under a time-sequenced format. Greenley, Walsh, and Young interpret one as a measure of expected consumer surplus and the other as option value. Mitchell and Carson [1981] appear to have been the first to question the interpretation of the Greenley, Walsh, and Young questions. While Mitchell and Carson did not relate their criticisms to the two conceptions of option value, they did argue that both questions measure option price. Moreover, they suggested that the Greenley, Walsh, and Young results indicate the possibility of a starting point bias, based on the differences in designated starting points used for each payment vehicle. In a recent unpublished response to the Mitchell-Carson comments, Greenley, Walsh, and Young [1983] argue that the interviewing process itself prevented interpretation of the questions as requesting option price. They observe that:

> Some confusion may arise when expected consumer surplus and option value questions are taken out of the context in which they are used because they often take the same general form as questions asking for option price. . . . The important distinction in this case [their study] is that a population of users was first asked to estimate their expected consumer surplus, and in addition, a separate estimate of option value. They were informed that these are separate and distinct values, and provided the opportunity to adjust values previously reported. The respondents provided well-focused estimates for each question. We conclude that the procedures employed in our study capture, reasonably accurately, the values necessary to assess the recreational benefits of improved water quality." (Greenley, Walsh, and Young [1983]).

While this may be the case, no explanation is offered of why the households adjust their two bids. If each is measuring what the authors intended, there would be no basis for adjustment. Equally important, one can judge the responses to a contingent valuation experiment based only on the questions posed. If they are not clearly connected to the concept desired, there is reason to question whether informal discussions between the interviewer and respondent will assure understanding. Finally, our evaluation of the questions (in contrast to Mitchell and Carson) leads to the conclusion that two different concepts of option price are in fact asked.

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*It should be noted that these summary statistics include all zero bids--both the "true" zero bids and the zero bids of those individuals who refused to participate in the bidding game.

Of course, in fairness to all participants in the exchange, there is no complete record of exactly what the interviewers discussed with survey respondents. Greenley, Walsh, and Young's [1983] recent notes on the Mitchell-Carson critique suggest that they were aware of the potential ambiguity in their questions. What is at issue is not only how successful the interviewers were in overcoming it but also that the terms of the contingent market may differ for each respondent (because of the interviewer effect) making the results problematical.

The second empirical study focusing on user and nonuser values was conducted by Mitchell and Carson [1981]. It sought to measure each individual's willingness to pay for cleaning up all rivers and lakes in the United States to a particular level. Since individuals were not classified according to whether or not they used these water resources, the responses must be assumed to include both use and nonuse values.* Indeed, Mitchell and Carson argue that it is beyond the capability of many respondents to reliably determine separate values for subcategories of water quality benefits. Their survey was based on a national probability sample of 1,576 individuals and was conducted as part of an opinion poll soliciting these individuals' responses to other questions associated with environmental attitudes. This study introduced the water quality ladder used in the survey conducted for the present study. In addition, it assumed that the household payment vehicle was through higher prices and taxes (the same vehicle used in this survey). Four versions of an anchored payment card were used, rather than an iterative bidding framework. They were differentiated according to the range of values reported on the cards and by the anchor points reported. The cards were distinguished by income class so that the anchored values on the card corresponded to the average of the actual payments made by members of each income group. The four sets of anchor points used in this study were:

Version

A Average household expenditures (through taxes) to the space program, highways, public education, and defense.

B Same four public goods as in Version A plus police and fire protection.

C The same four public goods as in Version A, but amounts increased by 25 percent for each income group over the levels used with Version A.

D The same four public goods and amounts as in Version A plus the estimated amount for water pollution control.

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*Since individuals do not conceive of using all rivers and lakes in the United States, it must be assumed that only a subset of these can be considered a part of the set actually used or planned for future use. To the extent that individuals express a willingness-to-pay bid for improved water quality at all water bodies, they are expressing expected user values, any option values (associated with uncertain future use), and existence values.

Table 5-1. Summary of Mitchell-Carson Estimated Mean Annual Willingness to Pay by Version and Water Quality[a]

Water quality category	Version of payment card		
	A (274)	B (255)	C (244)
Boatable	$168	$133	$161
Fishable	$214	$180	$198
Swimmable	$247	$212	$222

[a]This table was summarized from Mitchell and Carson's [1981] Table 5-1, p. 5-3. The numbers in parentheses are the numbers of respondents providing values to the water quality questions for each version in 1980 dollars.

For three of the four versions of the payment card, Table 5-1 reports the mean estimates for boatable, fishable, and swimmable water qualities.* While this study provided detailed analysis of potential survey biases, its questions relate to an abstract conception of the impacts of a water quality improvement for the individual. That is, while the water quality is described as improving to levels defined by the activities--swimmable, fishable, and boatable--the quality of the water already available to the individual is unknown. If the water bodies available to the individual have quality levels that permit the full range of his desired uses, the responses might be expected to reflect an existence value for all other sites. By contrast, if the available sites for water-based recreation do not permit all or some subset of these activities, the responses may reflect user values. Without knowledge of these site-specific features, Mitchell and Carson must average heterogeneous responses. That is, ideally, the responses based on user values and those associated with nonuser values should be distinguished. Moreover, the analysis should control the influence of the differential availability to individuals of sites with the desired water quality. The Mitchell-Carson method implicitly assumes all individuals will benefit equally from the uniform improvement of the water quality at all sites. This may not be correct. The benefit realized by each individual will depend on his access to sites with the desired water quality before the change.

Mitchell and Carson estimate the nonuser benefits of water quality improvements by assuming that the willingness-to-pay responses of surveyed

*The effects of knowing what was actually paid for water quality control (i.e., version D) were also reported by the authors. Forty-seven percent of the 354 respondents to version D said they were willing to pay the amount shown on the card that they were told would raise water quality to fishable in the next few years. For further details on these results, see Mitchell and Carson [1981, pp. 5-6 to 5-7]. The figures are not reported here since they reflect only that some people were willing to pay <u>at least</u> these amounts.

individuals who did not engage in in-stream recreation will be "almost purely intrinsic in nature." Even if this reasoning is correct, it does not imply that nonuser willingness to pay will be a reasonable estimate of option value. It may include existence values as well. Nonetheless, based on this logic, 39 percent of the respondents with willingess-to-pay data reported they had no in-stream use of freshwater in the past 2 years. The nonusers mean bid for fishable water was $111. The mean bid by users for the same water quality change was $237. Hence, by these estimates, intrinsic values were judged to be approximately 45 percent of total willingness to pay of users.

Rae [1981a, 1981b] has also reported estimates of option price for "clear" visibility conditions for future visits of current users in two separate onsite surveys in 1981 at the Mesa Verda National Park and Great Smoky National Park. His analysis was conducted along with a contingent ranking evaluation of the benefits of improving visibility conditions (see Chapter 6 for a more complete summary). A payment card was used as the instrument, and respondents were asked how much they would pay for an insurance policy to guarantee clear visibility conditions for all visits to the park. Prices on the card ranged from 0 to $10 in increments of $0.25. The average bid was $4.17 for Mesa Verda respondents and $5.96 for Great Smoky respondents (estimates in 1981 dollars). Rae interprets this as a present value option price, and uses estimates of current user values for visibility improvements derived from the contingent ranking framework to estimate option value.

To make Rae's interpretation requires assumptions concerning the individual's rate of time preference and probabilities of future visits. Rae uses different assumptions in estimating option value in the two studies. For the Mesa Verda case, he assumed a zero discount rate and one future visit while, with the Great Smoky case, he postulated an 8 percent discount rate and a 0.77 probability of one return visit after 5 years. The expected user values estimated for the two cases were $3.00 and $5.00, respectively. Both sets of assumptions assure a positive estimate of the option value.

In order to evaluate these estimates, the Rae methodology for estimating user values with the contingent ranking framework must be considered. In the next chapter we will discuss, in detail, the use of the contingent ranking approach for benefit measurement. Equally important, the formulation of the question for option price is somewhat vague in its specification of the terms of payment for the insurance. It has been interpreted as a one-time payment in the analysis. Given that all the other components of the survey related to fees associated with use, this distinction may not have been appreciated by the survey respondents.

Finally, the estimation of option value requires assumptions on the time horizon, future level of use, future probabilities of each level of use, and the individual rate of time preference. Rae's example calculation was intended to illustrate the required calculations. Unfortunately, there is little basis for assuming values for each of these variables for his survey respondents.

The last empirical effort at measuring nonuser benefits for an environmental amenity is the Schulze et al. [1981] analysis of visibility at four national parks. This survey was structured to distinguish users from nonusers of the Grand Canyon. Each group was asked different questions. The users were asked about the effects of visibility on their user values, while the nonusers were asked about preservation values. The questions related to visibility at four national parks, to the overall region, and to an evaluation of the willingness to pay to avoid a visible plume. The respondents were drawn from four cities: Los Angeles, Albuquerque, Denver, and Chicago. Questionnaires for users employed a park fee as the payment vehicle, while nonusers were queried about their willingness to pay for preservation values through electric utility bill increases.

Their results suggest a substantial preservation value (in 1980 $) ranging from $3.72 (the average value for preserving visibility at the Grand Canyon by Denver respondents) to $9.06 (the average for Chicago respondents) per month. These are substantially greater than the estimated user values, which ranged from $0.99 to $5.40 per visit for a comparable visibility scenario. If it is appropriate to compare these results across different individuals (i.e., implicitly assuming users would also have a preservation value), the estimated preservation values for preserving visibility conditions at unique natural environments, such as the Grand Canyon, may be much greater than the user values for the same visibility conditions. Unfortunately, the study does not attempt to divide the preservation benefit into an estimate of option price and an estimate of existence value. Thus, it is not directly comparable to either of the two studies discussed earlier in this section. Furthermore, the choice of two different payment vehicles may have introduced a starting point bias problem similar to that in the South Platte River study.

Thus, in summary, all past efforts at measuring nonuser values have met with only limited success. There has been controversy over whether option values were measured or it has not been possible to distinguish option price from other components of intrinsic values.

5.6 MEASURING OPTION VALUE: SURVEY DESIGN

As noted in Chapter 1, an important component of the Monongahela survey was the measurement of option price and user values. In addition, the question design permitted the implications of supply uncertainty for the estimates of option value to be examined. Since Chapter 3 described the sample survey design and Chapter 4 provided a summary of the features of the final sample, these will not be repeated here. Rather, this section will review the background information provided to each respondent and the form of the questions used to derive estimates of the option value associated with various water quality changes in the Monongahela survey.

As noted, the payment vehicle was described to be the taxes paid directly and the higher prices paid indirectly for improved water quality. This approach follows the format used by Mitchell and Carson [1981] with several important additions. Each interviewer was trained to explain carefully the mechanisms that underlie the payment vehicles. The objective of these explanations

was to ensure that respondents understood the nature of the payment vehicle and recognized that similar types of payments take place in practice as a result of government and private sector decisions. Each respondent was shown a map of the area highlighting the locations of recreation sites along the river. This map is reproduced as Figure 4-3. Before proceeding to the questions, the interviewer described the reasons why one might be interested in water quality for the Monongahela River. Using a value card (i.e., Figure 4-6), actual use, potential future use, and existence values were each identified as separate reasons for interest in the river water quality. Each was acknowledged to be a potential motivation for valuing water quality in the Monongahela River. The value card was explained at the outset of the interview and then shown again to each sample respondent as the questions designed to separate option price, expected consumer surplus, and existence values were asked. Thus, the value card translated the theoretical relationships relating option value, user value, and existence value into a format that linked them to respondents' experiences.

There are at least two ways to ask questions designed to measure the option values associated with water quality. The first of these involves proposing to respondents counterfactual situations that describe, in hypothetical terms, the probabilities and levels of use of the resource with different specified water quality levels. Each respondent is asked to value these plans. A second approach relies on the interviewer's ability to explain to the respondent why he might value water quality at a site, identifying the relationships between those reasons and a benefits taxonomy that isolates option value. With this explanation, the individual is then asked to bid in a way that separates the individual components of the values.

These methods contrast with a third approach employed by Mitchell and Carson, where a classification of individuals (as users or nonusers) assisted in decomposing benefits. That is, their classification, together with the assumption that nonusers were always nonusers and therefore could not have user values, allowed the willingness-to-pay estimates from nonusers to be interpreted as indicative of the intrinsic benefits held by users.

In the absence of the assumption that individuals are comparable (except in the decision between use or nonuse), the first two approaches to partitioning the benefits of a water quality improvement face problems. The first one attempts to "second guess" plausible demand conditions in its specification of the probabilities and levels of use that might be associated with a water quality level. Such specifications may actually bear little resemblance to what an individual would select. Thus, this approach was not used in this analysis.

The second approach relies on individuals' ability to "divide the benefits pie" consistently. Clearly, the estimates in this study depend not only upon how well each individual understood the concepts on the value card, but also upon how well he was able to (1) use them in classifying the contributions made to overall option price by expected user benefits and option values and (2) separate existence values as a distinct motive for valuing water quality improvements.

The survey questions elicited an option price--the individual's willingness to pay for the water quality change due to actual and potential use of the river. Following this question, the interviewer asked each person what amount of the option price was associated with actual use. This response has been interpreted as an estimate of the individual's expected consumer surplus. Thus, the difference between the reported option price and the value associated with use corresponds to this study's estimate of option value.

The questionnaire design allowed evaluation of two further issues in the measurement of option value: (1) the amount of the water quality change and (2) the mode of questioning. The design considered three levels of change in water quality as reproduced in the water quality ladder shown in Figure 4-5. The first question considered the willingness to pay to avoid having the water quality deteriorate from its current level, Level D, acceptable for boating, to Level E, at which no recreation activities would be possible. Individuals were also asked their willingness to pay for improvements from Level D to Level C, acceptable for sport fishing, and improvements from Level C to Level B, acceptable for swimming. As noted in the previous chapter, the water quality levels were defined based on Resources for the Future's water quality index (see Mitchell and Carson [1981]).

The second aspect of the questionnaire design involved the mechanism used to elicit the willingness-to-pay response. To investigate the effects of different questioning methods, the sample was divided into approximately four equal parts, each using a different questioning method--two different iterative bidding game procedures, a direct question procedure, and a procedure using a direct question with a payment card. Iterative bidding games, practiced in most early contingent valuation experiments (see Schulze, d'Arge, and Brookshire [1981] for a review), involve a sequential process in which an interviewer proposes a value (the starting point) to the respondent and asks whether it would be acceptable as a bid for the conditions described in the question. Based on the response, the interviewer raises or lowers the bid by a fixed amount until there is no change in the bid with repetition of the process. Two subsets of the sample used bidding game procedures; the first used a $25 starting point and a $5 increment, and the second used a $125 starting point and a $10 increment.

The third procedure used to elicit individual willingness to pay was a direct question with no suggestion of an amount. In the last component of the sample, respondents were asked to look at a payment card (see Figure 4-7) arraying alternative dollar values and to select one or any other amount as their willingness to pay. This last procedure is comparable to the Mitchell-Carson [1981] approach, with one modification. The values on the card were not identified as the individual's current spending on specific public sector activities. This practice of anchoring the values was not used because it was felt it would create the possibility of biased responses.

Each subsequent question for user values, supply uncertainty, and existence values repeated the amount given for willingness to pay and then asked the respondent to indicate what portion of the reported willingness to pay is

Table 5-2. Summary of Willingness-to-Pay Questions by Type of Interview

Type of interview	Question format
Iterative bidding $25	To you (and your family), would it be worth $25 each year in higher taxes and prices for products that companies sell to keep the water quality in the Monongahela River from slipping back from Level D to Level E?
Iterative bidding $125	To you (and your family), would it be worth $125 each year in higher taxes and prices for products that companies sell to keep the water quality in the Monongahela River from slipping back from Level D to Level E?
Direct question	What is the most it is worth to you (and your family) on a yearly basis to keep the water quality in the Monongahela River from slipping back from Level D to Level E, where it is not even clean enough for boating?
Payment card	What is the most it is worth to you (and your family) on a yearly basis to keep the water quality in the Monongahela River from slipping back from Level D to Level E, where it is not even clean enough for boating?

Table 5-3. Summary of User, Supply Uncertainty, and Existence Value Questions

Type of response	Question format
User value	In answering the next question(s), keep in mind your actual and possible future use of the Monongahela. You told me in the last section that it was worth $(AMOUNT) to keep the water quality from slipping from Level D to Level E. How much of this amount was based on your actual use of the river?
Supply uncertainty	If the water pollution laws were relaxed to the point that the water quality would decrease to Level E and the area would be closed 1/4 of the weekends of the year for activities on or in the water but would remain open for activities near the water, how much would you change this (READ TOTAL $ AMOUNT) to keep the area open all weekends for all activities?
Existence value	What is the most that you (and your family) would be willing to pay each year in the form of higher taxes and prices for the goods you buy for keeping the river at Level D where it is okay for boating, even if you would never use the river? Suppose the change could not be reversed for an even longer period of time than your lifetime. How much more than (READ AMOUNT FROM a.) would you (and your family) be willing to pay per year to keep the river at Level D, even if you would never use the river?

associated with each of the components of value or complications to the choice process. Table 5-2 reports the form of the willingness-to-pay questions used for the case of preventing deterioration from water quality Level D to Level E for each mode.

The questions used to measure the values associated with use, supply uncertainty, and existence values did not change with the type of interview and samples and are reported in Table 5-3. The examples correspond to the scenario used for the willingness-to-pay questions in Table 5-2. The responses to these questions form the basis for the results reported in the next section of this chapter.

5.7 SURVEY RESULTS--OPTION VALUE

The results for the empirical estimates of option value are divided into two parts. The first considers the conventional treatment of option value as a response to demand uncertainty. The second considers the sensitivity of these findings to changes in the conditions of access to the Monongahela River by varying the proposed likelihood of being able to use the site.

5.7.1 Option Value--Demand Uncertainty

Table 5-4 presents a summary of the sample mean estimate of option value for each water quality change based on each of the four types of interview frameworks. The estimates for each water quality change are the increments to the reported willingness to pay to prevent the water quality from deteriorating to the level given as E. Thus, each respondent was asked if he would be willing to pay more than the amount recorded for avoiding a movement from D to E. When an affirmative answer was given, the interviewer proceeded with the increments from D to C and from C to B. Since some individuals were unwilling to pay for further improvements, the "no" responses to subsequent improvements were treated as zeros in constructing the means.

Analysis of the survey responses revealed that two definitions of "users" were possible. The first of these would classify individuals according to whether they reported a user value or indicated that they had used the river for recreation activities in the previous year. This definition is the focus of attention in this chapter and is designated as the "broad definition" of users. The second defines users as only those individuals who indicated that they had used the Monongahela sites. This narrow definition focuses on a subset of the users under the first definition. Appendix C reports a sample of the results under the narrow definition.

The analysis performed for this study has considered both the sample means and linear regression models to summarize the survey results. Table 5-4 provides estimates for option value for different levels of water quality change according to the survey instrument used. Informal review of these estimates seems to indicate that the question format influences the magnitude of the estimates. Following the practices described in Chapter 4, these estimates are based on a restricted sample: Observations identified as either

Table 5-4. Estimated Option Values for Water Quality Change: Effects of Instrument and Type of Respondent-- Protest Bids and Outliers Excluded

Change in water quality	Type of respondent: User[a] $\bar{X}$	User[a] s	User[a] n	Nonuser $\bar{X}$	Nonuser s	Nonuser n
1. Iterative Bidding Framework, Starting Point = $25						
D to E (avoid)	20.79	16.61	19	29.74	36.69	39
D to C	14.74	13.99	19	14.49	15.17	39
C to B	6.84	10.70	19	7.18	11.63	39
D to B	21.58	22.05	19	21.67	24.04	39
2. Iterative Bidding Framework, Starting Point = $125						
D to E (avoid)	58.44	66.60	16	38.75	51.32	32
D to C	37.81	49.13	16	26.25	45.38	32
C to B	13.13	32.65	16	11.56	33.06	32
D to B	50.94	71.44	16	40.47	69.02	32
3. Direct Question Framework						
D to E (avoid)	25.59	43.04	17	14.18	27.12	34
D to C	10.12	24.45	17	10.82	21.56	34
C to B	10.18	24.49	17	8.47	21.87	34
D to B	21.77	48.57	17	20.32	41.45	34
4. Payment Card						
D to E (avoid)	27.06	33.12	17	52.97	76.31	37
D to C	14.41	20.38	17	21.89	33.80	37
C to B	3.26	8.28	17	7.70	19.99	37
D to B	20.00	25.06	17	29.87	47.54	37

[a]These results are based on the broad definition of users.

protest bids or as rejecting or misunderstanding the contingent valuation experiment were deleted. The latter were initially identified as outlying observations using regression diagnostics (see Belsley, Kuh, and Welsch [1980]). This statistical identification was followed by an evaluation of the features of the observations that made them distinct (see Table 4-8 and Section 4.5 for further discussion). To consider this issue, as well as the potential effects of being a user of the river, several null hypotheses have been chosen for testing using a student t-test for the difference of sample means. Equation (5.14) below provides the test-statistic used for these tests:

$$t = \frac{X_1 - X_2}{\sqrt{\frac{(n_1 - 1)\, s_1^2 + (n_2 - 1)\, s_2^2}{(n_1 + n_2 - 2)} \quad \frac{n_1 + n_2}{n_1 \cdot n_2}}} \tag{5.14}$$

where

$\bar{X}_i$ = sample mean for the ith grouping of individuals (e.g., users, nonusers, respondents with a particular question format, etc.),

s_i = sample standard deviation for ith grouping of individuals

n_i = sample size for the ith grouping of individuals.

All combinations of questioning format for each type of improvement in water quality were compared for users and nonusers. Overall, there were only a few cases where the estimated means were significantly different. As a rule these cases were associated with comparisons of the iterative bidding framework under the two starting points. Thus, there is some evidence of starting point bias with this approach to soliciting an individual's valuation of water quality. Indeed, these results for starting point bias would be strengthened if the observations that were deleted as invalid (from the diagnostic analysis) were included in the sample. In several cases it was not possible to distinguish the effect of the higher starting point (i.e., $125) as an explanation of the observation's role as an outlier from another characteristic of the survey respondent involved (see Chapter 4). Table 5-5 summarizes the cases where statistically significant differences in the mean values for option value were found.

Table 5-5. Student t-Test Results for Question Format[a]

Means compared	t-Ratios	
	User	Nonuser
Direct question vs. iterative bidding with $125 starting point D to C	-2.069	-2.452
Iterative bidding with $25 starting point vs. iterative bidding with $125 starting point D to E (avoid)	-2.384	--
Iterative bidding with $25 starting point vs. iterative bidding with $125 starting point D to C	-1.960	--
Direct question vs. iterative bidding with $125 starting point D to E	--	-2.035
Direct question vs. iterative bidding with $125 starting point D to B	--	-2.758

[a]This table reports only the cases where statistically significant differences in the means were found at the 0.05 significance level.

The responses of users and nonusers were also compared for each type of question and level of water quality change. Based on observation of values in Table 5-4, none of these cases indicated a significant difference in the means. Thus, despite the appearance of rather large differences for a few cases (e.g., payment card with Level D to Level E), the estimated means are not significantly different.

Table 5-6 reports the findings of a sample of the linear regression models considered in attempting to explain the determinants of the option value estimates using the survey respondents' economic and demographic characteristics. These models should not be interpreted as estimates of a behavioral model. Rather, they were estimated as summaries of the survey data in an attempt to

Table 5-6. Regression Results for Option Value Estimates--Protest Bids and Outliers Excluded[a]

	Water quality changes			
Independent variables	D to E (avoid)	D to C	C to B	D to B
Intercept	-17.014	-7.170	10.149	3.635
	(-0.540)	(-0.380)	(0.692)	(0.126)
Sex (1 if male)	4.121	-0.133	-2.332	-3.301
	(0.484)	(-0.026)	(0.589)	(-0.424)
Age	-0.411	-0.216	-0.131	-0.350
	(-1.637)	(-1.435)	(-1.120)	(-1.523)
User (1 if user)	-18.454	-10.609	-4.518	-15.761
	(-2.097)	(-2.011)	(-1.104)	(-1.958)
Education	4.830	2.084	-0.167	1.986
	(2.052)	(1.477)	(-0.152)	(0.922)
Income	0.0005	0.00005	0.0002	0.0002
	(1.384)	(0.210)	(1.035)	(0.532)
Direct question	-26.128	-7.472	3.335	-3.817
	(-2.356)	(-1.124)	(0.646)	(-0.376)
Iterative bidding game ($25)	-12.681	-0.274	1.773	0.339
	(1.188)	(-0.043)	(0.357)	(0.035)
Iterative bidding game ($125)	14.638	20.601	7.575	29.627
	(1.245)	(2.923)	(1.385)	(2.754)
Willing to pay cost of water pollution (1 if very much or somewhat)	16.069	16.611	4.510	23.229
	(1.842)	(3.176)	(1.111)	(2.910)
R^2	0.212	0.208	0.053	0.170
F	4.34	4.23	0.90	3.30
Degrees of freedom	155	155	155	155

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

improve the ability to describe the attributes of individual respondents that seemed to influence the estimates of option value. Thus, while these results have limited explanatory power, as measured by the R^2 of each equation, they do provide somewhat different insights into the role of the type of respondent than those offered by the analysis of sample means. The independent variables in the model included qualitative variables for sex, question format (with the payment card as the omitted questioning mode), user, and the individual's expressed attitude toward paying for water quality improvements. The last of these was coded as a 1 if the individual "strongly" or "somewhat" considered himself a person willing to pay the cost required to control water pollution. Otherwise, the variable was coded as zero (i.e., for individuals who had little or no such feelings or had no opinion on the matter).*

After the survey respondents' characteristics were controlled, users seemed to have lower option values than nonusers. No differences were found using tests based on sample means. Since the tests for the equality of means did not control for the respondents' characteristics, the difference in the two conclusions is not surprising. The regression results add further support to the conclusion for a starting point bias. Two of the four models in Table 5-6 indicate that the qualitative variable identifying the respondents who received the iterative bidding questionnaire with a $125 starting point was significantly different from zero. This implies that these responses are significantly different than those received using the payment card. The two most consistent determinants of the option value results in these models were the qualitative variables for user and for the individual's willingness to pay the costs required for water pollution control.

Overall, these results indicate that it is possible to estimate option value for water quality changes. In general, the estimates are significantly different from zero. The effects of payment vehicle suggest that there appears to be a starting point bias with several estimates of option value for specific water quality changes. Morever, with the ability to control for respondents' characteristics, the iterative bidding approach with a $125 starting point was found to increase option value estimates over the responses made using a payment card.

The results were not especially successful in isolating the effects of other individual characteristics on the option value estimates. Only the variable indicating the individual's attitude toward paying for water pollution control was a consistent determinant of the option value estimates for the water quality changes.

These estimates are all based on the assumption that access to the site is guaranteed. Accordingly, the implications of supply uncertainty for the respondents' option prices are considered next.

5.7.2 Option Value--Supply Uncertainty

Because the theoretical analysis of the sign of option value and the results in Smith [1983] suggest that individuals' assumptions regarding their

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*A more detailed description of these variables is provided in Chapter 4.

ability to gain access to the site--i.e., the degree of perceived supply uncertainty--may be important to the magnitude of option value, several questions were incorporated to attempt to measure its effects on individual's responses. Table 5-3 reported the question used to gauge the effects of supply uncertainty. Three variants of the question were posed, each of which referred to the amount an individual would be willing to pay to prevent water quality in the Monongahela River from deteriorating from boatable to unusable. Supply uncertainty was introduced by suggesting that the water quality deterioration would take place and that it would reduce the probability of having access to the river's recreation sites. The first question postulated that activities on or in the water would be precluded for one-fourth of the weekends in the year. The respondent was informed that it would not be known in advance which weekends would be involved. The fraction of weekends during which the sites were closed was progressively increased through two more steps to one-half and three-fourths of the weekends. Table 5-7 reports the estimated mean adjustments to the original bids made by users and nonusers. That is, each respondent was reminded of his bid to prevent water quality from deteriorating from Level B to Level E and then asked how much this amount would be altered to reflect the supply uncertainty.

These responses indicate that supply uncertainty clearly affects the option prices bid by users. The means for users under each of the three conditions of supply uncertainty are significantly different from zero at the 5-percent level. These results suggest that the option price would be reduced if the water quality level led to uncertain availability of the site. The mean adjustments to the option prices reported by nonusers were not significantly different from zero.

Table 5-7. Effects of Supply Uncertainty on Option Price[a]

Condition of water quality change	Summary statistics	User[b]	Nonuser[b]
Avoid a certain change B to E	$\bar{X}$	114.710	61.817
	s	112.501	85.40
	n	69	142
Experience water quality change to E, lose 1/4 weekends	$\bar{X}$	-14.552	-6.354
	s	52.328	39.891
	n	67	96
Experience water quality change to E, lose 1/2 weekends	$\bar{X}$	-22.537	-5.833
	s	58.331	43.996
	n	67	96
Experience water quality change to E, lose 3/4 weekends	$\bar{X}$	-26.866	-6.042
	s	68.500	46.220
	n	67	96

[a]These results are based on a sample that deletes protest bids and the observations identified as inconsistent with the contingent valuation framework.

[b]The difference in the number of observations between the certain case and the uncertain cases reflects missing observations.

Table 5-8. Student t-Tests for the Effects of Supply Uncertainty for Users

Means	t-Ratio
Water quality reduces access for:	
(1) 1/4 weekends vs. 1/2 weekends	0.834
(2) 1/4 weekends vs. 3/4 weekends	1.169
(3) 1/2 weekends vs. 3/4 weekends	0.394

Table 5-8 reports the results for tests of the differences in the mean adjustments with progressive increases in the degree of supply uncertainty. The results suggest that the mean adjustments are not significantly different with increases in the uncertainty in the availability of the site.

In summary, these empirical findings confirms the theoretical arguments developed earlier. Supply uncertainty can be expected to affect option value. Avoiding supply uncertainty and the associated risk is further basis for a positive option value.

5.8 EXISTENCE VALUE ESTIMATES

Since they were first introduced by Krutilla [1967], existence values have been given little attention within conventional models of consumer behavior.* The recent experimental findings of Schulze et al. [1981], discussed earlier in this chapter, have changed this perspective. Their estimates of preservation values for the Grand Canyon's visibility conditions indicate that the nonuser values for this unique natural environment are likely to be several times the magnitude of the user-associated benefits. While it is not unambiguously clear, preservation values can be expected to include option value, existence value, and, perhaps, bequest values. Each of these motivations for desiring the services of a unique natural environment was identified by Krutilla as values that would not necessarily be reflected in the private market transactions for the services of such resources.

As a result of these empirical findings, the attention given to modeling and measuring existence values has increased. Freeman's [1981] recent notes on the problems associated with defining and measuring existence values indicate at least two interpretations of an individual's reasons for valuing the existence of a resource. In the first note, Freeman designates a stewardship value (or motive), where the level of use of a resource affects the value derived. In this case, one's existence value would be reduced if the resource

*One notable exception is Miller and Menz's [1979] model for describing efficient allocation decisions involving wildlife preservation. These authors introduce species stock terms into individuals' utility functions as a source of value, without requiring that these values arise from consumptive uses. However, the authors do not explicitly identify the rationale for their specification in terms of existence value.

were not properly managed. Freeman's second proposed reason for existence value stems from a form of vicarious consumption. An individual derives benefit from the knowledge that other individuals can use a resource.

Freeman's analysis does not develop either of these frameworks in detail. They were suggested only as prospective explanations for values due to the existence of a resource and can be interpreted as defining different forms of consumption. Thus, they do not provide direct insight into how existence values might be measured. However, Freeman does suggest that attempts to measure existence value should carefully identify the likelihood of future use of the site and elicit an individual's user and nonuser values. In effect, he proposes that questions call for the sum of option price and existence value.

The design of the existence value questions for this survey attempted to use these insights. The sources of site valuation (on the value card used in the interviews) were separated into direct use, potential use, and existence motives. After reviewing these motivations, the interviewer asked each respondent how much he would be willing to pay to prevent the deterioration of water quality from boatable conditions to an unusable state even though he never would plan to use the river. Responses to these questions were regarded as tentative estimates of existence values. The situation is a difficult one for the respondent to conceptualize. Water quality is to remain at a boatable level, but the individual nonetheless will not use the river.

Table 5-9 presents these results for users and nonusers with the sample restricted to exclude protest bids and observations judged to be inconsistent with the contingent valuation framework. Both estimates are significantly different from zero. Users do exhibit significantly different estimated existence values from nonusers at the 5-percent level. These values are quite comparable to the estimates for the option price (aggregated over question mode), as reported in Table 4-9 for avoiding the loss of use of the river. Indeed, there is not a significant difference between the means for either users or nonusers. This finding, together with the fact that many respondents repeated their option price bids for the existence value question, suggests that these results should be interpreted with caution. Until the theoretical issues associated with describing the relationship between user and existence values is resolved, it cannot be concluded that these estimates represent independent sources of value for a water quality improvement.

Table 5-9. Estimated Existence Values

	User	Nonuser
Mean ($\bar{X}$)	65.985	42.115
Standard deviation(s)	92.824	64.023
n	66	139

5.9 SUMMARY

This chapter has reviewed the theory underlying the definition of option value, summarized the results of past efforts to measure option and other nonuser values, and presented the results of the Monongahela River survey that relate to nonuser values.

The findings provide clear support for a positive, statistically significant, and substantial option value for water quality improvements for the Monongahela River. The estimated option values for loss of the use of the area in its current condition (i.e., providing boating recreation activities) range from approximately $21 to $58 for users (and $14 to $53 for nonusers). The option price for users ranges from approximately $27 to $95. Thus, option value is a substantial fraction of the option price of users and generally exceeds their use values for a change in water quality. The Monongahela River is not a unique recreation site. Thus, these estimates may well require reconsideration of the conventional assumption that option value is small in comparison to use value for natural environments without unique attributes. Of course, it should also be acknowledged that the available estimates of option value are quite limited. Most can be criticized for problems in the research design, including possible flaws in the survey. The design of the Monongahela River study places heavy reliance on the use of a schematic classification of the sources of an individual's valuation of the river (i.e., the value card) in eliciting a division of user and nonuse benefits. Because this is the first application of this device, it was not possible to evaluate its effectiveness.

Users appear to have a somewhat lower option value than nonusers for most levels of change in water quality. For the most part, the respondents' socioeconomic characteristics were not useful in explaining the variation in estimated option values.

The limited analysis of the role of supply uncertainty for measures of option value clearly suggests it is an important influence on users' option price (and therefore on the derived option value). Assurance of supply is quite important to our positive estimates for option value.

Finally, this survey provided the ability to estimate existence values. While the findings suggest that these values are positive and statistically significant, prudence requires they be interpreted cautiously. It is not clear that respondents understood the distinction sought. Many bid the same amounts as their earlier option prices for a comparable change in water quality.

CHAPTER 6

CONTINGENT RANKING DESIGN AND RESULTS: OPTION PRICES*

6.1 INTRODUCTION

The purpose of this chapter is to report a set of water quality benefit estimates based on an analysis of the Monongahela survey respondents' rankings of four hypothetical combinations of water quality levels and amounts paid in the form of higher taxes and prices. The use of data including individuals' rankings of goods or services described in terms of the features of each of a set of possible alternatives together with an extension of the McFadden [1974] random utility model was first proposed by Beggs, Cardell, and Hausman [1981] as a method for measuring the potential demand for new goods. Rae [1981a, 1981b] has subsequently used this approach as an alternative means of estimating individuals' valuation of air quality improvements. The implicit assumption of the contingent ranking approach is that individuals are more likely to be capable of ordering hypothetical combinations of environmental amenities and fees than to directly reveal their willingness to pay for any specific change in these amenities. Unfortunately, past studies have tended to adopt only one or the other of these two approaches, and there has been little basis for comparing their respective estimates. As a result, the survey instrument for the Monongahela study was designed explicitly to include the use of contingent ranking as a method for measuring individuals' valuation of water quality improvements. All survey respondents were asked to rank four hypothetical combinations of water quality and payments to permit a comparison of contingent valuation and contingent ranking methods within the context of a common application.

To understand the economic basis for modeling consumer behavior using contingent rankings, the random utility model--widely applied to model consumer behavior that involves discrete choices--must first be considered. Section 6.2 provides some of this background by describing the features of the random utility model, and Section 6.3 discusses two possible methods for implementing the model. The first, an adaptation of the conditional logit model, can be derived under the assumption that the errors associated with the random utility function are additive and follow an extreme value distribution (i.e., the Weibull distribution). The second, a normal counterpart to the

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*Special acknowledgment is due Donald Waldman of the Department of Economics, University of North Carolina at Chapel Hill, who helped develop the maximum likelihood program for ordered logit analysis and provided a general program for estimating the Keener-Waldman ordered normal estimates. He also assisted in the estimation and discussed several aspects of these models with the authors.

ordered logit, was recently developed by Keener and Waldman [1981], who used numerical procedures to approximate the likelihood function associated with a random utility function having additive normal errors. With this background, Section 6.4 summarizes the results of Rae's survey applications of the contingent ranking approach to benefit estimation for visibility change; Section 6.5 discusses the question used for contingent ranking and the empirical estimates of random utility models; and Section 6.6 considers some of the theoretical issues associated with Rae's proposed approach for benefit estimation with the model and reports the results derived by applying it directly with the Monongahela survey data. Finally, Section 6.7 summarizes the chapter and proposes an alternative application of the random utility model.

6.2 CONSUMER BEHAVIOR AND THE CONTINGENT RANKING FRAMEWORK

The conventional economic description of consumer behavior generally maintains that each individual consumes some amount of every good or service that enters his utility function. The objective of these models is to describe the choices individuals make for marginal increments to their consumption levels. That is, individuals are usually portrayed as adding to previous consumption of goods or services from which they derive utility.* Of course, many consumer choices involve major purchases. In the purchase of an automobile or a house, the selection of an occupation, or the choice of an appliance, the consumer's decisions all require discrete choices. In these cases, the commodity often is durable and provides a stream of services over some time period or involves some commitment of the individual's time. Thus, the assumption of continuous incremental adjustment in the levels of consumption of each good or service that is implied in the conventional model of consumer behavior is not plausible for describing individuals' choices when they involve discrete selections.

Several types of modifications to conventional models have been proposed to make them more amenable to explaining such discrete choice problems. One involves an extension of the time horizon in the conventional model of consumer behavior. For example, on any particular day a commuter will select a travel mode to reach his job. Viewed on a daily basis, modal choice is discrete since fractions of the available travel modes cannot, as a rule, be consumed in a single trip to the workplace. However, over the course of a month or a year, the individual may well select a varied menu of transport modes. Thus, with this adaptation of lengthening the time horizon, the conventional model of consumer behavior may be more relevant to explaining these decisions.

A second proposed adaptation for dealing with discrete choices involves modeling consumer decisions as service flows rather than as the choice of any particular asset. For example, an individual purchases an auto for transportation services. These service decisions may be more amenable, under this interpretation of conventional theory, to modeling than the discrete choices of

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*Conventional models of consumer behavior assume positive levels of consumption of all goods and services to avoid dealing with corner solutions.

durable goods themselves. As a practical matter, however, most of the modifications to the conventional theory have enjoyed limited success. Information on the consumption rates for the services of durables is virtually nonexistent. Forecasts of the rates of use of travel modes based on aggregate information over long time spans cannot take account of the specific constraints facing individuals in making these decisions and, as a result, may be inadequate for many problems.

The random utility model has been proposed as one approach for dealing with discrete consumer choices. It generally replaces the assumption of a common behavioral objective function across individuals with the assumption of a distribution of objective functions. Attention is shifted from the intensive choice margin and the associated incremental analysis to individual decisionmaking at an extensive margin with discrete selections. As a result, random utility models are often quite simple in their description of the choice process. Individuals are assumed to have utility functions affected by (1) the objects of choice and their features and (2) the characteristics of the individuals making the decisions. The analyst is assumed to be capable of observing the distribution of individuals and their respective choices but does so without complete information. Thus, the observed behavior is assumed to be described as a trial--the drawing of one individual from a population; the recording of his attributes, the alternatives available, and their features; and the making of a choice. Because there is a distribution of individuals, the model describes the choice process using a conditional probability. Each alternative has some probability of being selected based on its characteristics, the other alternatives available and their features, and the attributes of the individual selected. Behavior is described by modeling these probabilities.

The random utility function provides the vehicle for modeling these conditional probabilities. In a random utility framework, the individual is assumed to select alternatives that provide the highest utility level. Thus, if Equation (6.1) describes a random utility function, then individual j's probability of selecting alternative k, given j's attributes, z_j, and in the presence of the set of alternatives defined by A, is defined by the probability that j's utility of k will exceed the utility of all other alternatives, as given in Equation (6.2) below:

$$U(a, z) = V(a, z) + \varepsilon(a, z) , \qquad (6.1)$$

where

$U(a, z)$ = utility provided by an alternative's vector of characteristics, a;

z = attributes of the individual;

$V(a, z)$ = nonstochastic component of utility, describing what constitutes representative tastes in the population; and

$\varepsilon(a, z)$ = stochastic effect reflecting the nondeterministic effects of taste on decisionmaking for an individual with attributes, z, facing an alternative with characteristics, a.

$$\text{Prob}\ [a_k\ z_j,\ A] = \text{Prob}\ [U_k > U_i \text{ for all } i \neq k] =$$
$$\text{Prob}\ [V(a_k,\ z_j) - V(a_i,\ z_j) > \varepsilon(a_i,\ z_j) - \varepsilon(a_k,\ z_j),\ \text{for all } i \neq k] \tag{6.2}$$

By making distributional assumptions to characterize the ε's, the probability statement in Equation (6.2) can be defined in terms of the characteristics of the alternatives and the features of the individual. For example, assuming that the ε's are independently, identically distributed with the Weibull distribution* allows the probability to be expressed as a logistic, as in Equation (6.3):

$$\text{Prob}[U_k > U_i \text{ for } i \neq k] = \frac{\exp(V_k)}{\exp(V_k) + \exp\ (V_i)} \tag{6.3}$$

Before the relationship of random utility functions to contingent ranking is explained, several observations on the nature of these functions should be noted. The description in Equation (6.1) is a conventional treatment (see McFadden [1974] or [1981]) that is completely general. In this general description there is no explicit treatment of the constraints to choice, such as an individual's income or market prices. To make these constraints clearer, it is completely consistent with the random utility model to view $V(\cdot)$ as the result of a constrained optimization process. Within such a framework, $V(\cdot)$ would be an indirect utility function, reflecting an individual's attributes, the characteristics of the choice alternatives (to the extent they are not reflected in market prices), the individual's income, and the prices of the alternatives available on organized markets.†

Thus, a random utility function framework does not imply that the conventional economic view of the consumer behavior be ignored. Indeed, as McFadden [1981] has suggested, $V(\cdot)$ can be regarded as an indirect utility function, even in applications where it has been specified as linear in its parameters. This interpretation is possible because any continuous function can be approximated to any desired degree of accuracy with a linear specification. The requirement that $V(\cdot)$ be homogeneous of degree zero in income and prices can be met by requiring that the variables in the linear approximation (in parameters) be homogeneous of degree zero. (This requirement is necessary for consumers to be free from "money illusion" and to respond only to changes in relative prices and income.)

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*The distribution function for the Weibull distribution is:

$$\text{Prob}(Z \leq t) = \exp(\exp\ (-(t-\sigma)/\theta))$$

The ordered logit is derived for a standardized form with $\sigma = 0$ and $\theta = 1$. This implies that variance of the errors will be 1.6449. See Chapter 20 of Johnson and Kotz [1970] for more details.

†This description admits the possibility of a model comparable to the hedonic framework used in modeling property values (see Rosen [1974]) or, more recently, adapted to a travel cost recreation demand framework by Brown and Mendelsohn [1980]

Alternatively, it is possible to assume that the indirect utility function is separable in all commodity prices but the ones of direct interest. Moreover, in principle, these prices can be replaced by a price index that can be assumed to normalize the incomes and the prices of goods and services of interest. However, it should also be acknowledged that this approach imposes quite restrictive assumptions on the structure of individual preferences.* The primary conclusion to be drawn from these general observations is that conventional neoclassical models of consumer behavior can be used as an integral part of random utility models when the utility functions are interpreted as indirect functions describing the outcomes of households' optimizing decisions.

A second feature of the models used in the random utility framework stems from the assumption of the independence of irrelevant alternatives. This assumption is important to the structure of any model in the framework because it implies that the odds of one alternative being chosen over a second alternative are not affected by any other alternatives. McFadden [1974] has conveniently summarized the implications of this assumption in discussing the limitations to the random utility model:

> The primary limitation of the model is that the independence of irrelevant alternatives axiom is implausible for alternative sets containing choices that are close substitutes. . . . application of the model should be limited to situations where the alternatives can plausibly be assumed to be distinct and weighed independently in the eyes of each decisionmaker. (McFadden [1974], p. 113)

With this background on the random utility model and its relationship to the conventional model of consumer behavior, it is possible to consider the contingent ranking methodology. The contingent ranking methodology maintains that individuals' valuation of environmental amenities, such as visibility or improved water quality, can be described within a random utility framework. Thus, an approach to estimating individuals' values for changes in these amenities could be developed by estimating the deterministic component of the random utility function--i.e., the $V(\cdot)$ in Equation (6.1). The process of collecting the information necessary to derive these estimates involves presenting individuals with a set of alternatives. Each alternative describes a specific state of the world in that it characterizes the features of the environmental resource and the cost to the individual of having access to the resource under the specified conditions. Individuals are then asked to order the alternatives from most to least preferred. If the determinants of $V(\cdot)$ are known and it can be approximated using models that are linear in parameters, the ranking of the alternatives provides sufficient information to estimate (relative to a scale factor) the parameters of these models.

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*Applications of these principles have been used by Hausman and Wise [1978]. The restrictive assumptions required are discussed in detail by Blackorby, Primont, and Russell [1978]. Based on their analysis (especially in Chapter 5), this approach--used by Hausman and Wise, for example--requires separability in commodity prices (called indirect separability by Blackorby, Primont, and Russell) and additive price aggregation. These assumptions imply that the utility function will exhibit homothetic separability.

The contingent ranking methodology provides an operational basis for benefit measurement. However, several factors should be considered in using this methodology to estimate benefits of environmental amenities. Consistent benefit measurement requires recognition of the constraints on individual choice. Thus, to define compensating variation or compensating surplus benefit measures, $V(\cdot)$ must be considered an indirect utility function. Moreover, when individuals are asked to rank alternatives that involve levels of an environmental amenity and a fee, the role of the fee must be considered within an optimizing model of consumer behavior. That is, the selection of the payment vehicle may have an important effect on the specification of the random utility function. For example, if the fee included in each alternative is a user charge associated with gaining access to the resource whose features are also being described, the fee would be treated as a price per unit of use of the resource. Therefore, it would enter the indirect utility function in a format comparable to any other price. By contrast, if the fee is described as an annual payment, regardless of how much the resource is used, it would be expected to enter as an adjustment of income rather than as a price per unit of use of the resource. The indirect utility function can be expected to be homogeneous of degree zero in income and prices. While assumptions that can simplify the form of the function and the number of distinct prices need to be considered, they impose significant restrictions on the types of features of demand relationships between the commodities consumed by the individual. These issues are discussed in more detail below.

The required assumption of independence of irrelevant alternatives limits the generality of the contingent ranking methodology for benefit estimation. The definition of the alternatives presented to individuals in a contingent ranking is largely arbitrary and is constructed to ensure a distinct ranking of the combinations presented. Indeed, the literature to date has not explicitly considered the issues associated with experimental design in selecting the alternatives used. While this problem does not arise in application of the model to alternatives defined by what is available in the real world, it may well be an important consideration when the alternatives are specified to represent feasible alternatives or defined to provide the "best" estimates of an individual's compensating surplus for a change in an environmental amenity.

The framework used for benefit estimation (and described later in this chapter) implies that the level of environmental quality and proposed fee are subject to continuous tradeoffs as each varies over predefined ranges. This presumption is quite different from those cases for which McFadden [1981] argued the random utility function is best suited. Thus, even a brief consideration of the economic theory and assumptions underlying conventional formulations of the random utility model indicates there may be problems with its use in the contingent ranking methodology as a procedure for benefit estimation. Equally important, economic theory offers some guidance in selecting the most appropriate specification in empirical applications of the model.

6.3 ESTIMATION OF RANDOM UTILITY MODELS WITH ORDERED ALTERNATIVES

The random utility model can be estimated using the information provided in contingent rankings with a maximum likelihood estimator. That is, once the additive error associated with each individual's utility function is assumed to follow a probability distribution, the decision rule given in Equation (6.2) describing how each individual orders the available alternatives provides the information necessary to describe the probability of a specific ordering of alternatives. Of course, for some assumptions concerning the probability distribution for $\varepsilon(\cdot)$, the form is simpler than it is for others. Nonetheless, in principle, any assumed probability distribution provides the basis for describing this probability, which is the basic ingredient in the definition of the likelihood function (i.e., the joint probability of observing all the orderings given in a specific sample as a function of the parameters of the utility function). The criteria of maximum likelihood estimation can then be used to derive estimates of the parameters (relative to a scale factor) of the deterministic portion of the utility function.

The discussions to this point as well as the existing applications of the contingent ranking methodology have assumed, for analytical convenience, that the errors follow a Weibull distribution in deriving an ordered logit estimator for the parameters of the function specified to represent (or to approximate) $V(\cdot)$. Because the logic underlying this derivation has been outlined in Beggs, Cardell, and Hausman [1981], some features of the estimator are simply highlighted here as they relate to the logit model applied to problems involving discrete choices (as given in Equation (6.3)) versus those based on an ordering of several alternatives.

A closed form expression for the probability of an ordering of the alternatives can be derived using the properties of the Weibull distribution. More specifically, the conditional probability $\text{Prob}(U_j \leq t \; U_j > U_k, \text{ for } j \neq k)$ differs only in its location parameter from the unconditional distribution, as illustrated for this two-alternative case in Equations (6.4a) and (6.4b):

$$\text{Prob}(U_j \leq t) = \exp\left(-\exp(-(U_j - V_j))\right), \text{ unconditional distribution.} \tag{6.4a}$$

$$\text{Prob}(U_j \leq t \; U_j > U_k \text{ for } j \neq k) = \exp\left(-\exp(-(U - \log(e^{V_j} + e^{V_k}))\right). \tag{6.4b}$$

Beggs, Cardell, and Hausman [1981] have outlined how this result can be used to derive the probability of an ordering of alternatives as given in Equation (6.5):

$$\text{Prob}(U_1 > U_2 > U_3 > \ldots > U_h) = \prod_{k=1}^{H} \left[\frac{e^{V_k}}{\sum_{i=k}^{H} e^{V_i}} \right], \tag{6.5}$$

where

H = the number of alternatives.

Equation (6.5) describes for any individual the probability of an observed ordering of alternatives. Under the assumption that each individual's decisions on ordering the alternatives are independent of all others, the likelihood function can be defined for a sample of T individuals as:

$$L = \prod_{j=1}^{T} \prod_{k=1}^{H} \left[\frac{e^{V_{jk}}}{\sum_{i=k}^{H} e^{V_{ji}}} \right] \tag{6.6}$$

By specifying the determinants of V_{jk}, the likelihood function, L, can be expressed in terms of unknown, estimatable parameters. Thus, for example, if V_{jk} is described by Equation (6.7), the likelihood function can, for a given sample, be expressed in terms of the unobservable parameters, β:*

$$V_{jk} = Z_{ik}\,\beta\ , \tag{6.7}$$

where

Z_{ik} = vector (1×K) describing the individual's characteristics, attributes of alternatives being ranked, and other variables as detailed by economic model used to describe behavioral choice

β = vector K×1 of parameters to be estimated.

Substituting Equation (6.7) into Equation (6.6) and taking the logarithm yields the log-likelihood function for the ordered logit estimator.† Maximum likelihood estimation involves solving this function for the value of β, which maximizes the log-likelihood function. In most cases, this solution involves numerical optimization procedures. Our analysis of the logit estimator used the Davidon, Fletcher, and Powell [1963] (DFP) algorithm with numerical partial derivations.

The second estimator for use with information from contingent ranking was developed by Keener and Waldman [1981] and follows the same behavioral model. In the Keener and Waldman framework, the errors associated with the

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*See Section 6.3, above, for a description of the relationship between a general form for the Weibull and the standardized form that underlies the Beggs, Cardell, and Hausman [1981] derivations.

†This estimator is actually the same method proposed by Cox [1972] for dealing with duration problems. That is, Cox proposed a conditional likelihood model based on ordering the variable of interest. His framework maintains a proportional hazard formulation of the problem. The two likelihood functions will be identical in the absence of ties (i.e., Cox's analysis allows for ties in the ordering of the dependent variable, while the ranked logit does not).

random utility function were assumed to follow independent normal distributions. The probability of an ordering of alternatives is described by the multivariate, normal cumulative distribution function evaluated at $Z_{r(\ell+1)}\beta - Z_{r(\ell)}\beta$, $\ell = 1, 2, \ldots, H-1$, where $r(\ell)$ is the index of the component of the vector of utilities for a given individual with rank ℓ. In general, the solution to the likelihood function for the normal distribution would pose a difficult numerical integration problem. However, Keener and Waldman observe that the error covariance matrix is tridiagonal and propose a computationally tractable method of numerically evaluating the probabilities composing the likelihood function. Thus, the likelihood function for the ranked normal estimator is derived by numerically integrating these functions to obtain the probabilities of the orderings provided by each sample respondent. Numerical maximization of this function yields the Keener-Waldman estimates. The DFP algorithm was also used to maximize the likelihood function associated with this estimator. Because ranked logit is globably concave, most experience with the method indicates it converges rapidly. Thus, estimation with the ordered logit framework is comparatively inexpensive. By contrast, as the above description implies, the maximum likelihood estimator based on the assumption of normality can be an expensive approach. Consequently, the ranked logit method has been used here to examine a wide array of alternative specifications for the deterministic component of the random utility function and the ranked normal for the subset of those models that were judged to be the "best."

6.4 PAST APPLICATIONS OF CONTINGENT RANKING

The use of contingent ranking procedures for benefit estimation with environmental amenities has been a recent development. The applications have been exclusively conducted by Douglas Rae of Charles River Associates and have focused on valuing visibility changes. Our review considers two unpublished reports (Rae [1981a, 1981b]) describing applications of the methodology.* Because the studies were largely motivated by concern over the benefits associated with defining alternative visibility standards for Class I areas (as mandated under the 1977 Amendments to the Clean Air Act), the surveys have been conducted at fairly unique recreational areas--the Mesa Verde National Park and the Great Smoky National Park.

The experimental design used in the two surveys was quite similar. In each case, a sample of users of a park was asked to rank a set of alternatives. The set was composed of two types of alternatives. One type specified combinations of conditions for the park where the survey was being conducted. These conditions included different visibility conditions (using photographs to display an integral vista within the park), a recreational quality measure (generally measured by waiting time at a key landmark or availability of activities at a park service center), and a per vehicle entry fee. The second type of alternative included other sites. The reports are not clear as to

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*Since the draft version of this report was prepared, a third application (Rae [1982]) to visibility changes in Cincinnati has been undertaken, but is not considered in this review. Future references will use the author's name [Rae] and will refer to these 1981 reports.

whether comparable attributes were reported on the cards used to describe these other sites or whether the evaluation of the characteristics of these sites was left to the respondents. Table 6-1 describes the features and selected results for each of these studies.

Each respondent was asked to provide two rankings. The information detailed in Table 6-1 is based on the rankings for deterministic conditions. That is, in the cases shown in Table 6-1, the alternatives were explained as having constant visibility at the level prescribed. In addition to these rankings, individuals in each study were asked about alternatives that included deterministic and probabilistic descriptions of visibility conditions (i.e., three probabilistic cases and four with constant visibility prescribed). The probabilistic cases specified the percentage of summer daylight hours when one of four conditions could be expected to prevail. Unfortunately, no attempt was made to take account of the different probability structures used in describing the visibility conditions in the estimation of the random utility functions from these rankings.

As Table 6-1 indicates, the empirical results from these studies are mixed. The entry fee was found to be a significant determinant of the ranking of alternatives in both studies. However, the qualitative variables for visibility conditions were not significant determinants of utility. The Great Smoky results were somewhat more definitive. They indicated that serious impairments in visibility had a negative and significant impact on the level of utility. However, at lower levels of impairment the results for some specifications of the model contradict a priori expectations.

These studies are important because they demonstrate an alternative approach for soliciting individuals' preferences and organizing them to test hypotheses. Nonetheless, they are subject to some shortcomings.

The most important problem arises with the specification and interpretation of the random utility function estimated in these analyses. As a rule, the model specifications used in Rae's analyses of the respondents' rankings include income, the suggested price for use of the area (i.e., the fee included as an attribute of each alternative that is ranked), and one or more measures of the postulated visibility conditions. It is thus clear from context, though never explicit in the studies, that the functions are to be interpreted as indirect utility functions. As a rule, an indirect utility function would include the prices of all the goods and services consumed by the individual, not simply the fee proposed for use of the relevant recreation site. Since these prices have been omitted from the models, it must be concluded that an implicit assumption consistent with one of the appropriate forms of aggregation has been made. There are two possibilities--that all remaining goods can be treated as a Hicksian composite commodity (see Deaton and Muellbauer [1980] pp. 120-122 for discussion) or that the utility function exhibits homothetic separability in two groups of commodities. The first group of commodities consists of the services of the site under evaluation and the second includes all other goods and services.

Table 6-1. Summary of Rae/CRA Contingent Ranking Studies

Study	Sample size	Description of environmental amenity	Character of fee	Recreational quality	Number of alternatives	Area specific alternatives	Design choice	Empirical findings[a]	Benefit estimates[b] (1981 dollars)
Mesa Verde	205	Visibility conditions: intense plume intense haze moderate haze clear	Entry fee per vehicle, $2 to $20 (existing fee, $2)	Congestion as measured by waiting time at landmark on site	13	8	22 possible combinations of alternatives; 1 of 10 sets of 8 cards randomly given to survey respondents; combinations of alternatives always include current conditions; no clearly dominant alternative included in combinations	Entry fee, negative and significant; qualitative variables for poor visibility, negative and insignificant; absence of congestion, positive and significant	Intense haze to clear, $0.73 to $0.79 intense plume to clear, $1.03 to $1.13
Great Smoky	213	Visibility conditions: intense haze moderate haze slight haze clear	Entry fee per vehicle, $0 to $30 (existing fee, $0)	Availability of full program of visitor center	14	8	29 possible combina- of alternatives; 1 of 10 sets of 8 cards randomly given to survey respondents; alternatives always include current conditions; no clearly dominant alternative included in combinations	Entry fee, negative and significant; qualitative variables for visibility provide some evidence for valuation of better visibility; intense haze, negative and significant; absence of program not important	Intense haze to clear, $7.39 to $11.22 intense haze to slight haze, $11.03 to $14.86

[a]These results are based on aggregate models and use conventional criteria for significance at the 5 percent level with asymptotic t-statistics.

[b]Based on the aggregate model.

Under the first aggregation assumption, the prices of all goods and services (other than the site under study) are assumed to change in constant proportion, and this proportion, say k, would be the relevant argument in the indirect utility function. In this case, because of the nature of the assumed pattern of price movements, an individual's preference for one good in the set cannot be distinguished from his preference for any other. Ideally, to define and estimate an indirect utility function consistent with theory requires a sample consistent both with the assumption of proportionality in the price movements of all goods and with some variation in the proportionality constant, k. Since both of these conditions are not often realized in practice, the Hicksian composite commodity theorem is difficult to use in empirical applications.* For the Rae analyses, there is no way either to know whether the prices of all other goods and services change in a proportional relationship across all individual respondents or to measure the magnitude of these proportionality constants. These unknowns are important because proceeding under the assumption that a Hicksian composite can be defined and then arbitrarily assuming a constant value for it across all individuals in a cross-sectional data base is equivalent to assuming that there is no change in prices across individuals. If the respondents all come from a single geographic area (i.e., in a region immediately around the site), this assumption may be reasonable. However, based on evidence of substantial regional variation in prices, this implicit assumption is untenable for sites that draw visitors from around the nation. Moreover, to the extent the price variation is not simply by a constant multiple for all goods and services, the assumptions of the composite commodity approach to aggregation would be violated.†

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*It can be used in controlled experiments where the prices confronting an economic agent (i.e., household or firm) are selected by the analyst. For the most part it has been an analytical device used in theoretical analysis. Indeed, Deaton and Muellbauer [1980] raise comparable reservations, noting that:

> The usefulness of this theorem [i.e., the Hicksian composite commodity theorem] in constructing commodity groupings for empirical analysis is likely to be somewhat limited. . . . in an open economy with a floating exchange rate, considerable fluctuation in relative prices can be expected and even without this, it is not clear that we could justify the types of aggregates that are usually available. (pp. 121-122).

They do, however, note that greater justification is available for use of the theorem with single period aggregation.

†The Bureau of Labor Statistics (BLS) data used to derive regional cost of living indexes provide evidence of both variation in the levels of prices by region and differential patterns of change among these prices for different goods and services.

The second approach to structuring an indirect utility function so that it approximates the models in Rae's analyses would involve assuming that the direct utility function exhibits weak separability. That is, a given general utility function $U(\bar{X}_1, \bar{X}_2, \ldots, \bar{X}_n)$, with $\bar{X}_i$ the ith vector of goods and services, can be written as $U(U_1(\bar{X}_1), U_2(\bar{X}_2), \ldots, U_n(\bar{X}_n)))$, with each of the subfunctions $(U_i(\cdot))$ a homothetic function. This specification implies that the indirect utility function can be expressed in terms of the price (or fee) for the site's services, income, and a price index for all other goods and services. This price index can be normalized at unity for a given set of values for the prices of all other goods and services. However, if it is assumed to be unity for all respondents, it is implicitly assumed that all respondents face the same prices (or different price sets that always lead to a unitary value for the index). As in the case of the composite commodity aggregate, the plausibility of this assumption--i.e., holding the price index at a constant value for all individuals--depends upon whether or not respondents come from a small region surrounding the site. Otherwise, some variation can be expected, both in price and in the value of the price index.

Aside from this issue, the use of the homothetic separability assumption also restricts the nature of the income effects for goods within each grouping--i.e., subfunction as given earlier as $U_i(\bar{X}_i)$--and the nature of the substitution effects for commodities involved in different groupings. To illustrate the nature of these constraints, consider the case of Rae's applications where the utility function is assumed to be composed of two groups of commodities--the services of the site under study and the set of all other goods and services. It is convenient to use the framework of conditional demand functions to illustrate the demand effects of the separability assumptions.* For example, the income elasticity of demand for any commodity in the set of goods and services (other than the site) can be defined as a product of the income elasticity of demand in the conditional demand function† and the elasticity of the expenditures on this set of goods with respect to income. More formally, let q_i designate the quantity demanded for the ith commodity in this set; e, the expenditures on all commodities in the set; and y, the individual income. Thus, if q_s is the use of the relevant site's services and p_s is the price per unit of use,

$$e = y - p_s \cdot q_s \quad . \tag{6.8}$$

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*For a discussion of conditional demand functions, see Pollak [1969, 1971]. Summaries of his work are available in Deaton and Muellbauer [1980].

†This elasticity is the percentage change in the quantity demanded of the good with respect to a percentage change in the expenditures on all goods in the set. These expenditures play the same role in conditional demand functions as income would in a conventional demand function. In general, the determination of these expenditure levels will be a function of the level of income and the prices of all goods and services. See Blackorby, Primont, and Russell [1978] and Pollak [1971] for further discussion.

The conditional demand function for q_i will be related to the prices of all goods in its group, $\bar{P}_i$, and the expenditures on this group (i.e., $q_i = f_i(\bar{P}_i, e)$) will be responsive to income and the prices of all goods. This association can be used to derive the following relationship between demand responses:

$$\frac{\partial q_i}{\partial y} = \frac{\partial f_i}{\partial e} \cdot \frac{\partial e}{\partial y} \quad . \tag{6.9}$$

In elasticity terms, Equation (6.9) can be written as:

$$\frac{y}{q_i} \frac{\partial q_i}{\partial y} = \left(\frac{e}{q_i} \frac{\partial f_i}{\partial e}\right)\left(\frac{y}{e} \frac{\partial e}{\partial y}\right) \quad . \tag{6.10}$$

Homotheticity of this subfunction that reflects decisions about all other goods implies that the income elasticity in the conditional demand functions for these goods will be unity. Thus, the first term on the right side of Equation (6.10) will be one. Thus, Rae's model implicitly maintains that all goods consumed by the individual (aside from site services) have equal income elasticities and are equal to the expenditure elasticity with respect to income.

This analysis can be extended one step further. Budget exhaustion implies that the share weighted sum of the income elasticities will be unity, as in Equation (6.11)

$$K_s \cdot \varepsilon_{sy} + \sum_{i=1}^{n} K_i \, \varepsilon_{iy} = 1 \quad , \tag{6.11}$$

where

K_s = share of income spent on the site's services

K_i = share of income spent on the ith commodity

ε_{sy} = income elasticity of demand for a site's services

ε_{iy} = income elasticity of demand for the ith commodity.

Using Equation (6.10) to substitute for ε_{iy} in Equation (6.11) gives

$$K_s \, \varepsilon_{sy} + \varepsilon_{ey} \sum_{i=1}^{n} K_i = 1 \quad , \tag{6.12}$$

where

$$\varepsilon_{ey} = \frac{y}{e} \frac{\partial e}{\partial y} \quad .$$

While homothetic separability of the utility function does not in general restrict ε_{sy}, it does have implications for the cases in which it would be likely to be plausible. Rearranging the terms in Equation (6.12) gives

$$\varepsilon_{sy} = \frac{1 - \varepsilon_{ey} \sum_{i=1}^{n} K_i}{K_s} \quad . \tag{6.13}$$

Since the grouping implicitly required for Rae's model involves all other goods in the set designated as q_i, i=1,2, . . ., n, it is reasonable to expect that ε_{ey} would be close to unity. That is, expenditures on the majority of the items in the individual's budget are likely to change in percentage terms as income does. This implies that the income elasticity of demand for site services will also have to be close to unity to satisfy the adding-up condition on income elasticities (i.e., Equation (6.11)). Equation (6.13) illustrates this conclusion.

Of course, this conclusion is a judgment. Indeed, the appraisal of the plausibility of using the composite commodity to explain Rae's models was also based on a judgment. What is at issue is an evaluation of the implicit assumptions of a model's specification for the properties of its results (or conclusions). The forgoing appraisal suggests that the assumptions necessary to interpret Rae's model as an indirect utility function are fairly stringent. Both sites attract visitors from substantial distances. Thus, omitting the relevant price aggregate for other goods may be an important consideration for the properties of the estimates of compensating surplus derived from Rae's indirect utility functions.

Regardless of how one judges the plausibility of the assumptions required to ignore other goods and services, there is a further issue arising from Rae's definition of the compensating variation. To illustrate the problem, consider an example. Assume that Equation (6.14) defines the deterministic component (V) of the random utility model, which is assumed to be a function of the individual's income (Y), the entry fee (F), and the specified level of visibility (v):

$$V = \alpha_1 Y + \alpha_2 F + \alpha_3 v \quad . \tag{6.14}$$

Rae's proposed benefit measure is the increment to fee that must accompany a change in visibility to hold utility constant. When Rae assumes that dY = 0, this increment is given for the example by Equation (6.15):*

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*Assuming dY = 0, this is derived by totally differentiating Equation (6.14) as:

$$dV = \alpha_1 dY + \alpha_2 dF + \alpha_3 dv \quad .$$

Holding utility constant in expected value, dV = 0, or

$$\alpha_2 dF + \alpha_3 dv = 0 \quad .$$

Solving for dF gives:

$$dF = - \frac{\alpha_3}{\alpha_2} dv \quad .$$

$$dF = -\frac{\alpha_3 dv}{\alpha_2} . \tag{6.15}$$

Equation (6.15) is not compensating variation. This Hicksian measure of consumer surplus is defined (see page 2-4) to be the income change required to hold utility constant in the presence of a change in the quantity of a good or service, such as visibility.

Thus, the interpretation of these benefit measures depends upon the type of fee. If it is a fee per unit of use, Equation 6.15, strictly speaking, does not measure compensating variation. Of course, the extent of error depends upon the level of repeated use. If, for example, users are expected to visit the site only once, Rae's measure should not be appreciably different from one based on the income changes. However, if there are repeat visitors, it may be a source of error in the benefit estimates. In pragmatic terms, as shown below, the use of price versus income for measuring the benefits associated with a specified change in water quality markedly affected the results. Moreover, in the present study, the fee was described as an annual payment rather than a price per unit of use.*

There are several additional problems with these studies. The Rae applications fail to include respondents' characteristics in the estimated utility functions. Presumably, this approach was adopted because two models were estimated. The first was specified under the assumption of constant parameters across all respondents (the "aggregate" form). The second permitted these parameters to be different for each individual. Thus, this second format provides the flexibility of permitting all individuals to be different in their determinants of utility. However, to estimate a model with this flexibility, a reasonably large number of ranked alternatives is required. It is not clear that this general framework is helpful to interpreting the results. Detailed analysis of the parameter estimates across different groups of individuals would be necessary to understand the importance of an individual's attributes in determining his preferences for water quality.

Despite these qualifications, Rae's applications have been valuable. They have identified a new approach for evaluating individuals' preferences for nonmarketed goods and services, and they have contributed to an understanding of the issues associated with using the random utility model for consistent benefit measurement.

6.5 MONONGAHELA CONTINGENT RANKING EXPERIMENT: DESIGN AND ESTIMATES

Since the Monongahela survey was designed to compare approaches for measuring the benefits of water quality improvements, one section of the ques-

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*Since Rae's approach has been followed, and since the role of the prices of other goods and services has been ignored, the problems raised earlier as judgmental issues may also have contributed to these findings.

tionnaire included questions designed to elicit contingent rankings. There are several important distinctions between the Monongahela survey's contingent ranking component and the procedures used by Rae.

For the Monongahela survey, individuals were given a smaller number of alternatives to rank: four combinations of water quality and annual payments in the form of higher taxes and prices. This number is approximately one-third that in Rae's experiments and affects the Monongahela survey's ability to estimate what Rae describes as "individual" models.* Equally important, while all the Monongahela survey respondents received the same four sets of alternatives, individuals in the Mesa Verde and Great Smoky experiments were randomly assigned one of ten different sets of alternatives to be ranked. Sufficient experience has not yet been acquired with the estimators of these models to judge the implications of this difference in experimental design.

A further distinction arises in the composition of each set of alternatives to be ranked. The procedure used in the Monongahela survey includes four sets of conditions for the Monongahela River. Table 6-2 details the combinations used, and Figure 6-1 provides an example of the cards presented to each respondent for ranking. In contrast, the Rae surveys included other sites in the set of alternatives to be ranked. Specifically, the Mesa Verde study included 5 of the 13 alternatives as other sites, and 6 of 14 alternatives in the Great Smoky study were other sites. The rationale for this practice was described as an attempt to:

> reflect the fact that alternative sites are available and to cause respondents to focus broadly on all the characteristics of a site that contribute to overall enjoyment of National Parks and outdoor recreation areas. (Rae [1981b], p. 3-1)

Of course, to the extent that one accepts the assumption of independence of irrelevant alternatives that underlies the random utility models used in these applications, these other sites should not be important to the rankings provided by survey respondents.†

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*The ordered logit estimator permits the estimation of different alternative-specific effects for each individual in the sample if there are sufficient alternatives ranked. See Beggs, Cardell, and Hausman [1981] for a discussion of the identification problem in such cases.

Rae refers to a constant parameter model for all individuals as the "aggregate" model and to the model that allows variation in the parameters describing the effects of the characteristics of alternatives across individuals as the "individual" model.

†The procedure used in the Mesa Verde study involved asking respondents first to rank the Mesa Verde alternatives and then to place the non-Mesa Verde alternatives within the ranking. Presumably, the same procedure was used in the Great Smoky study.

Table 6-2. Combinations of Water Quality and Payment for Monongahela Contingent Ranking Survey

Alternative	Water quality level	Annual payment
1	E RFF water quality index = 0.8 No recreation possible	$5
2	D RFF water quality index = 2.5 Boating possible	$50
3	C RFF water quality index = 5.0 Boating and fishing possible	$100
4	B RFF water quality index = 7.0 Boating, fishing, and swimming possible	$175

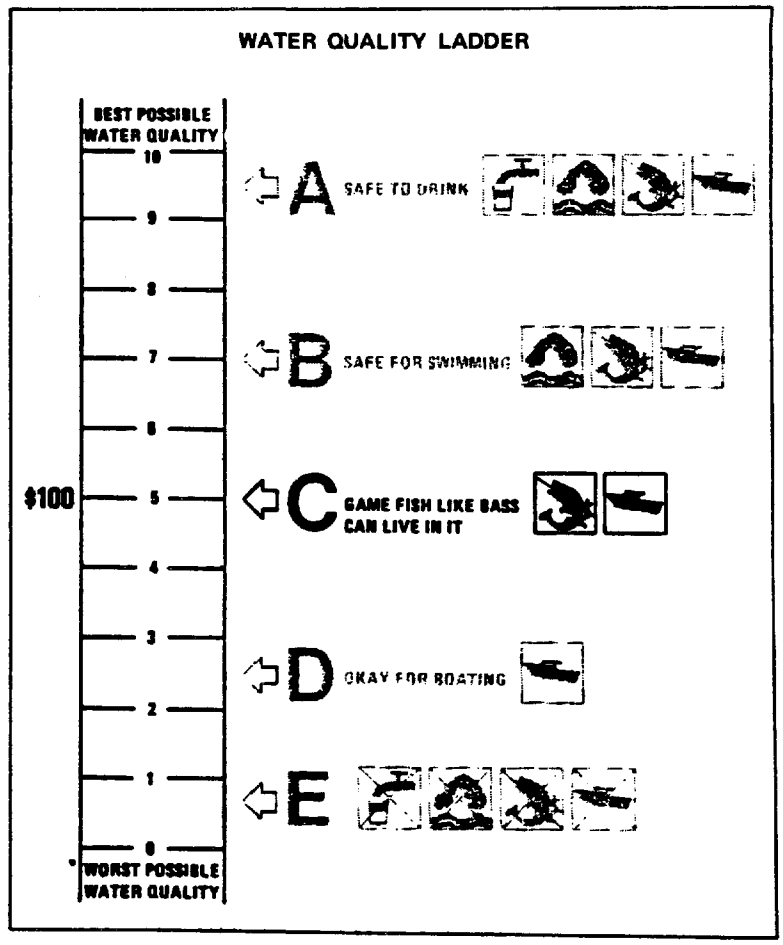

Figure 6-1. Rank order card.

Finally, the payment vehicle included in the rankings conducted by Rae was a price per unit of use--an entry fee to the park. By contrast, the payment vehicle in the Monongahela survey was independent of the use made of the river. It is therefore an adjustment to income. This distinction affects, as we noted earlier, the interpretation of the specifications for the random utility model.

The rank order cards used to describe each alternative included the RFF water quality ladder as described earlier in Chapter 4 and repeated in Figure 6-1. All survey respondents were asked to rank the four alternatives summarized in Table 6-2. In making these judgments, interviewers were instructed to refer to the value card (see Figure 4-6 in Chapter 4) and to ask individuals to consider actual and anticipated use of the river. The specific question used was:

> First, I would like you to rank the combinations of water quality levels and amounts you might be willing to pay to obtain those levels in order from the card, or combination, that you most prefer to the one you least prefer. I would like you to do this based only on your use and possible use in the future of the Monongahela River. That is, keeping in mind <u>only</u> Parts I and II of the value card.

Two hundred thirteen of the 301 survey respondents provided usable rankings and family income information. Thus, they provide the basis for the empirical analysis. We have followed Rae's implicit assumptions and interpreted our model as an approximation to an underlying indirect utility function. However, given the incomplete information on an individual's other consumption choices, we have not attempted to include the prices of other goods or to impose restrictions on the nature of the function estimated. A variety of specifications for the model were considered under this general format and the "best" selected based on the ability of the model to "fit" the data and agreement of the signs of the estimated parameters to <u>a priori</u> expectations. The final section of this chapter discusses the implications of extending the model to consider the role of other prices in the indirect utility function.

As noted earlier in this chapter, two estimators have been developed for random utility functions. One of them, an ordered logit estimator, was used in Rae's analysis of the Mesa Verde and Great Smoky contingent ranking results. Because it exhibited rapid convergence and performed reasonably well in unpublished Monte Carlo experiments performed by V. K. Smith and D. Waldman to evaluate the estimators, the logit has been used to screen alternative specifications for the random utility model.* The second estimator

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*To evaluate the relative performance of the ordered logit and ordered normal models, Smith and Waldman [1982] conducted a limited number of sampling studies. In general, each estimator performed best with the experiments using the estimator's assumed error (i.e., Weibull for ordered logit, normal for ordered normal). However, the ordered normal was close to comparable to the ordered logit with the Weibull distribution.

based on a normal specification for the errors in the utility function has much greater computational costs and was therefore applied to only the "final" model specifications for comparative purposes.*

Table 6-3 reports a selected set of results for the random utility model with the ordered logit model. Variables describing the alternatives ranked and the features of the individual respondent were included in the model. The models are distinguished according to the variable used to interact with features of respondents (payments or water quality); the specified form of the relationship between family income and payment in the model; and the attributes of respondents included in the model. Water quality was measured using the RFF index scale as it appeared on the rank order cards presented to survey respondents. The income measure is family income in thousands of dollars. Age (in years), education (in years), race (1 = white), and sex (1 = male) qualitative variables were also considered. Three additional qualitative variables were also included in some of these models: boat ownership (Boat own = 1 for owners); participation in any outdoor recreation in the past year (participate = 1 if yes); and the individual's attitude toward paying for the costs of controlling water pollution (attitude = 1 if individual considers himself very or somewhat willing).

This study's results provided stronger support for the methodology than Rae's findings. Both the payment and water quality measure are statistically significant and correctly signed in most of the model specifications. The experimental design induced a high correlation between payment and water quality (simple correlation = 0.99), and this may explain the results for specification (2) in the table. Each equation in the table has three columns to identify whether it is an individual-specific variable entered individually in the model (the first column) or a respondent-specific variable entered in interaction form with either the payment (the second column) or water quality (the third column). Respondent-specific variables must be entered in interaction form because the rankings are modeled as a function of the differences between the values of the deterministic portion of the random utility function for each of the alternatives being ranked. Consider a simple example. Let V_{ij} designate the utility individual i derives from alternative j. Individual i will rank alternative j superior to alternative k if $V_{ij} > V_{ik}$. Thus, the probability that alternative j is ranked ahead of k will be equal to the probability that $V_{ij} > V_{ik}$. If it is assumed that the deterministic component of V is a linear function of one individual characteristic (Z_{1_i}) and one variable describing the alternative (Z_{2_j}), V_{ij} can be rewritten as:

$$V_{ij} = a_0 + a_1 Z_{1_i} + a_2 Z_{2_j} + \varepsilon_{ij} \qquad (6.16)$$

Using the same relationship to describe V_{ik} gives the following expression for $V_{ij}-V_{ik}$:

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*Comparability between the results of logit and probit models for bivariate dichotomous problems, as found in Hausman and Wise [1978], do not necessarily apply. The two error assumptions will yield approaches that are equally comparable with ranked data.

Table 6-3. Selected Results for the Random Utility Model with Ranked Logit Estimator[a]

	Model and alternative-specific interaction											
	(1)			(2)			(3)			(4)		
		Interaction with individual-specific variables[b]			Interaction with individual-specific variables[b]			Interaction with individual-specific variables[b]			Interaction with individual-specific variables[b]	
Independent variables	Alternative specific	P	WQ	Alternative specific	P	WQ	Alternative specific	P	WQ	Alternative specific	P	WQ
Alternative specific												
Payment (P)				-0.044 (-0.236)			-0.046 (-8.922)			-0.067 (-3.957)		
Water quality (WQ)	-0.151 (-1.437)			0.030 (3.025)			1.364 (8.931)			1.919 (4.121)		
P × WQ				-0.006 (-9.342)								
Individual specific[c]												
Income (×)		-0.10×10^{-3} (-1.760)			0.42×10^{-5} (-0.002)			0.15×10^{-4} (0.900)		0.25×10^{-3} (0.581)	-0.43×10^{-2} (-0.370)	
Income (÷)												
Participate (×)			0.150 (3.384)									
Boat own (×)					-0.055 (-0.967)			0.005 (0.949)		-0.137 (-0.942)	0.402 (1.022)	
Age (×)			-0.002 (-1.280)					-0.004 (-3.342)		0.0004 (1.435)	-0.015 (-1.846)	
Sex (×)			0.077 (1.911)					0.075 (1.732)				
Education (×)			0.016 (2.762)		0.017 (2.530)							
Race (×)			-0.015 (-0.247)									
Attitude (×)					0.380 (7.455)							
Log (L)		-656.25			-550.69			-628.03			-628.28	

[a]The numbers in parentheses below the estimated parameters are the asymptotic t-ratios for the null hypothesis of no association; n = 213.

(continued)

[b]The columns (i.e., P or WQ) indicate which interaction is used in each model specification.

[c]The multiplication signs (×) indicate that the individual-specific variable is entered in multiplicative interaction with either the payment or water quality. The division sign (÷) indicates that income is entered in as a division.

Table 6-3. (continued)

Independent variables	Model and alternative-specific interaction (5) Alternative specific	(5) Interaction with individual-specific variables[b] P	(5) Interaction with individual-specific variables[b] WQ	(6) Alternative specific	(6) Interaction with individual-specific variables[b] P	(6) Interaction with individual-specific variables[b] WQ	(7) Alternative specific	(7) Interaction with individual-specific variables[b] P	(7) Interaction with individual-specific variables[b] WQ	(8) Alternative specific	(8) Interaction with individual-specific variables[b] P	(8) Interaction with individual-specific variables[b] WQ
Alternative specific												
Payment (P)	-0.062 (-9.769)			-0.053 (-8.215)			-0.048 (-8.101)			-0.043 (-7.764)		
Water quality (WQ)	1.300 (9.113)			0.999 (6.572)			0.959 (6.520)			0.706 (5.230)		
P × WQ												
Individual specific[c]												
Income (×)	-0.20×10^{-5} (0.035)											
Income (÷)					-0.280 (-7.000)			-0.273 (-6.926)			-0.280 (-7.000)	
Participate (×)												
Boat own (×)		-0.002 (-0.877)			-0.003 (-1.700)							-0.094 (-1.709)
Age (×)												
Sex (×)								-0.0001 (-0.066)				
Education (×)		0.0006 (2.476)			0.0004 (2.000)			0.0006 (3.374)				0.010 (1.667)
Race (×)												
Attitude (×)		0.012 (7.316)			0.013 (6.944)							0.351 (7.468)
Log (L)		-600.19			-571.69			-598.44			-567.99	

[a]The numbers in parentheses below the estimated parameters are the asymptotic t-ratios for the null hypothesis of no association; n = 213.

[b]The columns (i.e., P or WQ) indicate which interaction is used in each model specification.

[c]The multiplication signs (×) indicate that the individual-specific variable is entered in multiplicative interaction with either the payment or water quality. The division sign (÷) indicates that income is entered in as a division.

$$V_{ij} - V_{ik} = (a_0 + a_1 Z_{1_i} + a_2 Z_{2_j} + \varepsilon_{ij}) - (a_0 + a_1 Z_{1_i} + a_2 Z_{2_k} + \varepsilon_{ik}) \quad (6.17)$$

Simplified, this expression is:

$$V_{ij} - V_{ik} = a_2(Z_{2_j} - Z_{2_k}) + \varepsilon_{ij} - \varepsilon_{ik} \quad . \quad (6.18)$$

Thus, the variables describing each individual are not involved in describing how that individual ranks alternatives since they will remain constant for all alternatives.*

One of the most puzzling aspects of the results is the effect of the income variable. Because the payment vehicle was constant regardless of the level of use, the multiplicative interactions between income and the payment or between income and water quality would have been expected to provide better results than income divided by payment. However, the results indicate that the income divided by payment form is a significant determinant of the utility function implied by the rankings, while the other forms are not. In all cases, the signs for the estimated parameters are difficult to interpret. A priori expectations would have suggested that income relative to payment be a positive determinant of utility and not negative.

Of the remaining determinants considered, only education and the attitude toward paying for the costs of controlling water pollution were consistently significant determinants of utility. Both variables' parameters are consistent with a priori expectations. Based on the value of the log-likelihood function at the maximum (LOG[L]) and the significance and consistency of the estimated parameters, Specification (8) was selected as the final model. It was reestimated with the Keener-Waldman [1981] ordered normal maximum likelihood estimator. Table 6-4 reports these results along with estimates for Model (7) for comparison purposes and repeats the ordered logit estimates for convenience in comparing the two estimators with each of these specifications.

The two estimators yield quite similar results. The signs and significance of estimated parameters are comparable for the final model and for Specification (7). In general, the Keener-Waldman [1981] estimated parameters are smaller in absolute magnitude than the ordered logit. There are no specific implications of this difference, because both estimators involve scaled coefficients and the estimated parameters do not correspond to the marginal effects of individual variables on the level of utility. These difficulties in evaluating the effects of the estimator on the conclusions drawn from these methods suggest that the Rae measure of the benefits associated with a water quality improvement should be calculated with each of the estimator results for the final model (i.e., Specification [8]). These results will be considered in the next section of this chapter.

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*See Beggs, Cardell, and Hausman [1981] for further discussion of the limitations in specifying models based on ordered data.

Table 6-4. Comparison of Ordered Logit and Keener-Waldman Ordered Normal ML Estimator[a]

Independent variable	(7)[b]		(8)[c]	
	Ordered logit	Keener-Waldman	Ordered logit	Keener-Waldman
Alternative specific				
Payment (P)	-0.048 (-8.101)	-0.039 (-7.073)	-0.043 (-7.764)	-0.033 (-7.196)
Water quality	0.959 (6.520)	0.760 (5.630)	0.706 (5.230)	0.510 (3.400)
Individual specific				
Income/p	-0.273 (-6.926)	-0.070 (-5.667)	-0.280 (-7.000)	-0.170 (-4.250)
Boat own	--	--	-0.094 (-1.709)	-0.039 (-0.796)
Education	0.0006 (3.374)	0.0006 (3.000)	0.010 (1.667)	0.010 (2.000)
Sex	-0.0001 (-0.066)	0.0009 (0.643)	--	
Attitude	--	--	0.351 (7.468)	0.330 (8.462)
Log (L)	-598.44	-619.46	-567.99	-582.34

[a]The numbers in parentheses below the estimated coefficients are asymptotic t-ratios for the null hypothesis of no association.

[b]This specification involves payment interaction with the individual-specific variables.

[c]This specification involves water quality interaction with the individual-specific variables.

6.6 BENEFIT ESTIMATES WITH CONTINGENT RANKING MODELS

Using ranked data, both estimators for the random utility model provide scaled values of the parameters. As a consequence, the estimates do not permit direct evaluation of the utility change associated with a change in water quality. It is nonetheless possible, given that the function is interpreted as an indirect utility function, to define the compensating surplus associated with changes in water quality. Compensating surplus would correspond to the change in income that just offsets the increment to utility associated with the water quality change. Thus, it could be derived by taking the total differential of the estimated random utility function with respect to income and water quality and by solving for the income change that would be equivalent (in its effects on utility) to any water quality change. This approach is directly analogous to the definition of compensating surplus in terms of the expenditure function.* Thus, in principle, the model can be used to derive a theoretically consistent benefit measure for changes in environmental amenities. However, as noted earlier, this procedure implicitly assumes that the indirect utility function is theoretically well behaved.†

Rae's procedure defines benefits as the change in entry fee that would offset a change in the environmental amenity (see Equation [6.15). The benefit measure for the Monongahela survey was also defined in terms of a total differential, measuring the change in payment that will offset a water quality change. As we noted earlier, since the payment vehicle is not a fee per unit of use but an adjustment to income, regardless of the individual's use of the river, the measure of compensating surplus should be invariant to the use of income or of the payment in the total differential equation. If the indirect utility function is theoretically consistent, the two measures should be equal and opposite in sign.

Of course, it should be acknowledged that the Monongahela application has maintained Rae's basic model and therefore implicitly assumes that all other goods and services are either part of a Hicksian composite commodity or included in a separable homothetic subfunction. To the extent neither of these assumptions provides a plausible basis for treating other goods' and services' prices, estimates of compensating surplus will likely be affected. One area seems to be an especially clear example of the limitations of this assumption. The Monongahela respondents may well have used other water-based sites in the region. These sites provide services that substitute for what is

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*See Hause [1975]; Freeman [1979a]; and Just, Hueth, and Schmitz [1982] for further details.

†The properties of an indirect utility function (IDF) include:

- IDF is continuous in prices and income,
- IDF is nonincreasing in prices and nondecreasing in income,
- IDF is quasi-convex in prices, and
- IDF is homogeneous of degree zero in prices and income.

See Varian [1978], pp. 89-92.

proposed for the Monongahela sites under the various hypothetical water quality scenarios. It must be expected that they will have a different substitution influence than the remaining goods and services consumed by these individuals. This would suggest that, at a minimum, measures of the "prices" (i.e., travel and time costs) of trips to these sites should be included in the specification of the indirect utility functions for recreationists in the sample.* In addition, it implies the need for careful consideration of the relationship between whether the individual was a user of the sites along the Monongahela and the corresponding specification of the indirect utility function. Since the models used in this study do not reflect these considerations, they should be treated as fairly crude approximations of the indirect utility functions required for benefit estimation.†

The exact nature of the estimating equation for benefits will depend upon whether the individual-specific variables enter the model as interactions with water quality or with the proposed payment. To illustrate the difference, consider two simple specifications for the random utility function. In Equation (6.19), the model includes payment (P), water quality (WQ), and an individual-specific variable (Z) using a payment interaction, whereas Equation (6.20) uses the water quality interaction. Equations (6.21) and (6.22) report the corresponding equations for measuring the payment increase equivalent to water quality improvements for each:

$$V^a = \alpha_1 P + \alpha_2 WQ + \alpha_3 P \cdot Z \ . \tag{6.19}$$

$$V^b = \beta_1 P + \beta_2 WQ + \beta_3 WQ \cdot Z \ . \tag{6.20}$$

$$dP = - \frac{\alpha_2 dWQ}{(\alpha_1 + \alpha_3 Z)} \text{ (payment interaction format).} \tag{6.21}$$

$$dP = - \frac{(\beta_2 + \beta_3 Z) dWQ}{\beta_1} \text{ (water quality interaction format).} \tag{6.22}$$

It is clear from the specifications that, in either Equations (6.21) or (6.22), the benefit estimates will vary with the individual--depending on the individual-specific variables entering the final model used to summarize the respondents' rankings. Table 6-5 reports the average and range of benefit estimates for the final specification (i.e., with the water quality interactions) of the random utility model for using both the ordered logit and ordered normal models. Because the final specification included a term with income measured relative to the payment, the estimated benefits for specified water

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*These issues are currently being considered in followup research.

†It should also be acknowledged that the benefit measures calculated with the income change were several orders of magnitude greater than the price change and had the wrong sign. These results would be expected because the estimated parameter for the income variable had an incorrect sign in all models.

Table 6-5. Benefit Estimates from Contingent Ranking Models[a]

Estimator[b]	Average	Range
I	Payment = 5	Water quality change = Boatable to fishable
Ordered logit	-1.45	-72.46 to 208.67
Ordered normal	-17.72	-136.87 to 156.83
II	Payment = 50	Water quality change = Boatable to fishable
Ordered logit	62.76	39.74 to 83.31
Ordered normal	64.30	38.54 to 85.51
III	Payment = 100	Water quality change = Boatable to fishable
Ordered logit	60.04	36.74 to 74.40
Ordered normal	62.12	36.27 to 78.40
IV	Payment = 175	Water quality change = Boatable to fishable
Ordered logit	59.47	36.12 to 72.66
Ordered normal	61.65	35.80 to 76.96
V	Payment = 5	Water quality change = Boatable to swimmable
Ordered logit	-2.62	-130.42 to 375.61
Ordered normal	-30.91	-246.37 to 282.30
VI	Payment = 50	Water quality change = Boatable to swimmable
Ordered logit	112.97	71.53 to 149.96
Ordered normal	115.75	69.38 to 153.91
VII	Payment = 100	Water quality change = Boatable to swimmable
Ordered logit	108.06	66.12 to 133.92
Ordered normal	111.81	65.29 to 141.12
VIII	Payment = 175	Water quality change = Boatable to swimmable
Ordered logit	107.04	65.02 to 130.78
Ordered normal	110.97	64.44 to 138.53

[a]These estimates are based on the 213 observations used to estimate the random utility functions.

[b]For final model, Specification (8).

quality improvements will change with the payment level at which $\frac{dP}{dWQ}$ is evaluated. The results in Table 6-5 are presented for each of the four payment levels indicated on the rank order cards, as well as for each of two water quality changes--boatable to fishable water quality and boatable to swimmable (using the RFF index on the rank order cards). The results are clearly implausible for the lowest payment level (i.e., P = 5). Because the water quality change represents an improvement, negative values imply that improved water quality decreases individual well-being. However, for payment levels ranging from $50 to $175, the benefit estimates are stable for each water quality change (i.e., boatable to fishable and boatable to swimmable) and are approximately the same order of magnitude as the values derived from direct questioning of survey respondents. (More details on these types of comparisons are provided in the next chapter.) These estimates should be interpreted as being comparable to an option price for each water quality change, because the question identified both use and anticipated use as the basis for the ranking solicited from survey respondents.

The benefit estimates derived from the order normal model seem slightly higher than the ordered logit and exhibit a consistently wider range. Finally, the estimates remain quite stable as the payment level increases from 50 to 175. In Appendix C, comparable benefit estimates are reported for a model using payment interactions for the individual specific variables (see Equation [7] in Table 6-3). For this case, the results are also implausible at the lowest payment level. There is a somewhat larger difference between the ordered logit and normal estimates, with the averages for logit ranging from $49.17 to $51.40 for a change in water quality from boatable to fishable (and payments from $50 to $175) versus $68.75 to $72.45 for the ordered normal. Nonetheless, these changes are rather modest overall. The estimated benefits seem quite stable across the alternative specifications of the random utility model.

6.7 IMPLICATIONS AND FURTHER RESEARCH

This chapter has described and applied the contingent ranking methodology for evaluating the benefits from changes in environmental amenities such as water quality. In the process of developing the background for this approach, the first applications of the approach by Rae were evaluated. This appraisal indicated that the empirical results yielded a relatively weak association between visibility and the individual's ranking of the alternatives describing conditions at either the Mesa Verde or Great Smoky Parks. The empirical results for the Monongahela study provide much stronger support for the method. However, analysis of the theoretical foundations of the method Rae used for benefit estimation indicated it required quite stringent assumptions to be treated as an approximation of a theoretically appropriate benefit measure. It should be acknowledged that the evaluation of Rae's approach was based on an attempt to infer the implicit assumptions for his models. The underlying behavioral model and assumptions were not explicitly described in either report. Thus, this interpretation should not be attributed to his reports.

The analysis performed here has begun the development of the behavioral underpinnings for the random utility models applied to contingent rankings of alternatives involving environmental amenities, but the process is not complete. Models estimated with samples composed of users and nonusers of the Monongahela River sites have been used. A priori expectations would suggest that nonusers may require specifications for their indirect utility functions that are different from those of users. The latter should include the prices (i.e., travel costs) for all the relevant substitute sites and the payment as an adjustment to income. By contrast, nonusers' indirect utility functions would not include these travel cost arguments.

Extensive analysis of this alternative framework for modeling respondents' rankings of the water-quality/payment alternatives was beyond the scope of the current project. The primary intention of this analysis has been to apply and evaluate the Rae/Charles River Associates methodology for benefit estimation. The analysis considered the appropriate interpretation of their proposed benefit estimator, defined an approach to benefit estimation that more closely approximated a theoretically consistent measure, and evaluated several models with two estimators of the random utility framework.

In an attempt to gauge whether these model revisions would be important, the models used were reestimated for a subset of the respondents--those individuals who used only one of the sites on the Monongahela River (i.e., eliminating nonusers and those who used more than one site). For this sample (a total of 49 observations), the implications of treating all sites as perfect substitutes were considered, and, therefore, only the travel cost of the particular site used was entered. The results with the ordered logit estimator for models estimated with this sample under these assumptions were rather poor and suggest that the full sample of users and a more complete specification of the model will be required to judge the potential importance of the theoretical arguments calling for different random utility models for users and nonusers.

CHAPTER 7

A GENERALIZED TRAVEL COST MODEL FOR MEASURING THE RECREATION BENEFITS OF WATER QUALITY IMPROVEMENTS

7.1 INTRODUCTION

While previous chapters have considered "direct" methods of eliciting individuals' valuations of water quality changes, all of which require that individuals be directly asked about their willingness to pay for water quality, this chapter describes an "indirect" method for benefit estimation. This method uses individuals' actions and a behavioral model that describes individuals' decisions in order to infer water quality values. Specifically, using a generalization of the travel cost model to describe recreation site demand, this approach involves describing the influence of recreation site characteristics, such as water quality, on the demand for a site's services. To accommodate variations in demand for each site's services, the generalized travel cost model uses variations in site attributes across a large number of water-based recreation facilities.

In the process of developing the model, the analysis has attempted to consider a number of the problems associated with the travel cost framework, including the following:

- The estimation of the opportunity cost of the time spent traveling to a site.
- The treatment of time spent at the site during each trip in relationship to additional trips to the site.
- The specification of the model, including the prospects for biased results from conventional statistical approaches.
- The implications of multiple-purpose trips for the validity of the model.
- The estimation of the specific effects of site attributes on the nature of each site's demand function.

This chapter discusses each of these issues in detail. Specifically, Section 7.2 reviews the economic basis for the travel cost model using Becker's [1965] household production framework, and Section 7.3 generalizes the conventional treatment of the travel cost model as a derived demand, assuming site services are inputs to the production of recreation activities. In particular, Section 7.3 considers the problem of modeling site attributes in developing an appropriate

quantity index for site services, and it proposes a variant of Saxonhouse's [1977] generalized least-squares estimator to implement the model. Section 7.4 describes the recreation choice and site attribute data used to estimate the travel cost model, and Sections 7.5 and 7.6 present and evaluate results from individual site demand models. In these two sections, as throughout the chapter generally, a major objective is to gauge the implications of modeling decisions for each site demand model used to develop the generalized travel cost model. Section 7.7 presents the generalized travel cost model, and Section 7.8 describes its use to estimate benefits with survey data from users of the recreation sites along the Monongahela River in Pennsylvania. Finally, Section 7.9 presents a brief summary.

7.2 TRAVEL COST MODEL

The travel cost model is widely used to describe demand for recreation facility services (see Dwyer, Kelly, and Bowes [1977] for a review). Indeed, the most recent Water Resources Council [1979] guidelines for benefit-cost analysis call for travel cost methods to estimate the economic value of recreation sites. Although the travel cost model is usually credited to a suggestion made by Harold Hotelling to the Director of the National Park Service (that distance traveled can indicate the implicit "price" recreationists pay for using a particular facility), Clawson [1959] and Clawson and Knetsch [1966] were the first to develop empirical models based on it. The travel cost model has been refined since this early literature, and it is now recognized as an important indirect methodology for valuing environmental amenities, especially water quality (see Freeman [1979a], Chapter 8, and Feenberg and Mills [1980]).

Of course, recognition of the travel cost model has not come without the parallel development of a behavioral model for the demand patterns it describes. For example, Becker's [1965] household production model can analyze individuals' recreation choices.* While the household production model does not imply new testable hypotheses (see Pollak and Wachter [1975]), it does offer a useful conceptual framework to describe household behavior, especially with respect to outdoor recreation.†

The absence of uniform types of household recreation data and the lack of organized markets for most recreation site services have compounded the problems of describing consumer demand. Therefore, a framework that can be constructed using the available recreation data has distinct advantages over frameworks that do not. Because these advantages have elsewhere been discussed in detail (see Smith [1975a]; Deyak and Smith [1978]; Cicchetti,

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*In what follows <u>individual</u> and <u>household</u> are used synonymously. Based on Becker's [1974] work, such conventions do not require models specifying a dictatorial decision process for the household. Rather, households can be seen to act as if guided by a single utility maximizer when altruistic behavior is recognized as an integral component of the social interactions of family members (see Becker [1981] for more details).

†It can also provide a basis for consistent welfare measurement. See Bockstael and McConnell [forthcoming].

Fisher, and Smith [1976]; and Bockstael and McConnell [1981]), they will not be developed here.

The basic distinction between the household production framework and other approaches stems from its portrayal of the household as both producer and consumer. That is, the household is assumed to consume only services that it produces. For convenience, these services will be designated as final service flows. As with any other production process, these services require inputs. In this case, however, the inputs involve the household's time, as well as market-purchased goods and services. Thus, the framework considers the purchased goods as an indirect means to maximize utility.

The household production framework has two steps or stages, which, though purely logical abstractions, can explain how households make decisions. The first step involves selecting market goods and services and allocating available household time to minimize the costs of each possible set of final service flows. In the second step, based on the outcomes of the first step, the household defines for itself the "shadow prices," or marginal costs, of each of the final service flows. Thus, along with the relevant "full" income budget, marginal costs are implied by the selection process for final service flows.

For this study, constrained utility maximization in the household production framework highlights several important aspects of the travel cost model, the first of which is the distinction between the recreation activities undertaken by a household--such as boating, fishing, or swimming--and the usage level of a particular recreation site. To readily identify the implicit price of services of a recreation facility, the former are best treated as measures of household recreation final service flows, and the latter are best treated as an input to the production of such service flows.

Furthermore, the household production framework can readily identify the various ways site services are used. That is, the framework can distinguish whether an individual uses more of a site's services by visiting it a greater number of times during a recreation season or by spending more time at the site during fewer visits. This choice implies a simultaneity problem in modeling household decisions on visits and onsite time per trip. Past efforts have implicitly avoided this problem by assuming that all visits (across all users) are of fixed length (see Cicchetti, Fisher, and Smith [1976]) or by estimating separate models for each trip length (Brown and Mendelsohn [1980]).

Finally, the household production framework permits a general discussion of a household's use of multiple recreation sites that produce identical recreation activities, thus allowing the incorporation of site attributes as determinants of the differences in the demands for the services of multiple sites.

In its simplest form, the household production model can describe recreation decisions by simply distinguishing two types of final service flows produced and consumed by households. The first is the recreation service flow, Z_r, and the second is a nonrecreation service flow, Z_{nr}. Because

sets of service flows can be expanded without fundamental changes in the implications of the model, the present analysis has been confined to this simple case. Following earlier developments of the model (see Cicchetti, Fisher, and Smith [1976] as an example), the production function for recreation services can be specified in terms of five inputs: the purchased goods associated with recreation (e.g., equipment for fishing, boating, camping, etc.), X_r; the number of visits to each of two distinct recreation sites, V_1 and V_2; and the time per visit to each site, t_{V_1} and t_{V_2}. It is important to note that this specification greatly simplifies the analysis by maintaining that onsite time per visit is the same for all visits to a given facility.

Equation (7.1) provides a general functional representation of the recreation services production function:

$$Z_r = f_r(X_r, V_1, V_2, t_{V_1}, t_{V_2}) . \tag{7.1}$$

The time horizon for production activities is often unspecified. However, the household must be assumed to make decisions over some predefined time horizon that involves a full recreation season (or some fraction) during which multiple visits to different sites are possible.

The production function in Equation (7.1) implicitly maintains that each (V_i, t_{V_i}) pair ideally measures the services provided by each site. Thus, this function effectively skirts a significant index number problem* because differences in the productivity of one site's services for the recreation service flow are embedded in the function itself. The next section adds further assumptions to this function to investigate the rationale for skirting the index number problem.

Because the focus here is on decisions related to recreation activities, the nonrecreation service flow can be expressed in rather simple terms as related to nonrecreation-related purchased goods, X_n, and household time spent on the nonrecreation service flow, t_n, as in Equation (7.2):

$$Z_{nr} = f_{nr}(X_n, t_n) . \tag{7.2}$$

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*Index number problems are commonplace in the application of microeconomic theory to real-world problems. For example, measures of the quantity of housing pose index number problems because houses are differentiated by number of rooms, floor space, character of external construction (wood frame, brick, etc.), as well as a variety of other features. Because it would not reflect these differences, simply counting the number of houses is insufficient to accurately reflect consumer demand. Similarly, in the case of coffee, multiple end products--ground, instant, "freeze-dried," decaffinated (as well as combinations of these attributes)--makes adding pounds of coffee consumed an insufficient way to reflect either how these coffee end products are used or the corresponding features of consumer demand.

In terms of its relationship to practical applications of the travel cost model, one of the most important aspects of the household production framework arises with the definition of the household's budget constraint. Following Becker's [1965] original suggestions, the household is assumed to face a "full income" constraint, Y, including wages, wt_w, nonwage income, R, and foregone income, L. However, it is not assumed that the household necessarily treats the market wage as the opportunity cost of its time in all household production activities. This formulation can be seen as a generalization to that proposed in Cicchetti, Fisher, and Smith [1976]. Equation (7.3) defines this budget constraint:

$$Y = wt_w + R + L = P_r X_r + P_n X_n + (T \cdot d_1 + rt_1 + w_1 t_{v_1}) V_1 + (T \cdot d_2 + rt_2 + w_2 t_{v_2}) V_2 + wt_n \,, \tag{7.3}$$

where

P_r, P_n = the prices of market-purchased recreation-and nonrecreation-related goods

T = the travel cost per mile

d_i = the roundtrip mileage to the ith site

r = the individual's opportunity cost of traveling time

t_i = time for each roundtrip to the ith site

w_i = the individual's opportunity cost for onsite time at the ith site.

Equation (7.3) identifies three important components of the unit cost of each visit: the travel costs associated with the vehicle used to reach the site, the time costs of the trip, and the opportunity costs of time spent on the site. Only the last of these costs is a choice variable, because the distance and time to reach a recreation facility are defined by the location of that facility in relation to the individual's origin point. Because the model assumes that these locational choices are already determined, their costs are outside the individual's control.*

*Of course, this statement assumes that the individual's opportunity cost of traveling, r, is treated as a fixed parameter to the recreation decision process.

The past literature has devoted considerable attention to the appropriate treatment of the travel and time costs of a trip in the formulation of travel cost demand models. Cesario and Knetsch [1970, 1976] have suggested that the opportunity cost of travel time, r, is less than the wage rate, w, and, in some cases, that travel and time costs may not be additive. The latter component of the Cesario-Knetsch argument has been difficult to substantiate without dropping the assumption that the opportunity cost of travel time is a parameter in the individual's decision process.

For practical purposes, the travel cost literature has tended to focus on the relationship between the cost of travel time, r, and the wage rate, w. Cesario, for example, has suggested that since the cost of travel time involved in urban transportation decisions likely falls between one-fourth and one-half the wage rate (see Cesario [1976], p. 37), one-third might be used as a reasonable approximation for travel cost models. In contrast, McConnell and Strand [1981] have estimated the fraction to be six-tenths for sports fishermen in the Chesapeake Bay region. Their model assumes that the opportunity cost of travel time is a parameter estimated from the data and that travel costs and time costs of travel have equivalent effects on the demand for a site's services. McConnell and Strand caution that this parameter may vary among regions and sites.

The only notable exception to the treatment of r as a multiple of the wage rate arises in Wilman's [1980] recent attempt to compare the Cesario and McConnell approaches for estimating the costs of recreation trips. Wilman's analysis sought to distinguish "scarcity" and "commodity" values for time in modeling the relationship between trips taken and onsite time per trip to produce recreation service flows.* The Wilman model specifies utility as a function of goods and services requiring time, goods and services not requiring time, and two measures of a recreation site's use--the number of visits of a given length to a site and the number of roundtrips to that site. Roundtrips are intended to reflect any satisfaction derived from traveling to the recreation site. By assuming that the time and budget requirements are fixed multiples of the number of visits and roundtrips, Wilman links these choice variables to the household's time and income constraints.

The basis for Wilman's derivation of a different implicit valuation of travel and onsite times is an assumption that the number of trips and visits to a site are equal. The resulting first order conditions require equality between the sum of the marginal utilities of trips and visits and the corresponding goods and time costs of each (weighted by the appropriate Lagrangian multipliers).

Wilman's definition of commodity and scarcity values of time is simply a rearrangement in this allocation condition for visits and trips in an attempt to

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*It should be noted that Wilman did not explicitly adopt a household production framework. However, with relatively minor amendments, her analysis could be cast in these terms.

account for the potential utility derived from travel time. It is important to recognize that the framework maintains that trips and visits are delivered jointly on a one-to-one basis in this version of her model. They must be treated as a single commodity, and any cost allocation between them is arbitrary. Indeed, once the equality assumption between trips and visits is dropped, Wilman's model implies that both types of time should be valued at their scarcity value (see Wilman [1980], Equation [24]). Thus, the existing recreation literature does not provide an unambiguous theoretical justification for distinguishing the valuation assigned to the travel and onsite time components of a recreation experience.

The household production framework and the procedures used to compile the data for an empirical estimation of travel time costs permit direct investigation of the relationship between the travel time costs and the onsite time costs of the trip. Therefore, the generalized statement of distinct opportunity costs for each time of travel can be accommodated within the empirical model.

To complete the model it is necessary to maintain that the household's utility is a function of the levels of the two final service flows produced as $U(Z_r, Z_{nr})$. Maximizing this utility function subject to the budget and production constraints yields a set of conditions that can be manipulated to suggest that the marginal utility product of each input (i.e., the product of the marginal utility of a service flow times the marginal product of the input in the production of that service flow) relative to its market price, or implicit unit cost, would be equalized over all inputs. More formally, this result is given in Equation (7.4):

$$\frac{MU_{Z_r}\dfrac{\partial Z_r}{\partial V_1}}{(T\cdot d_1 + r\cdot t_1 + w_1 t_{V_1})} = \frac{MU_{Z_r}\dfrac{\partial Z_r}{\partial t_{V_1}}}{w_1 V_1} = \frac{MU_{Z_r}\dfrac{\partial Z_r}{\partial V_2}}{(T\cdot d_2 + r\cdot t_2 + w_2 t_{V_2})}$$

$$= \frac{MU_{Z_r}\dfrac{\partial Z_r}{\partial t_{V_2}}}{w_2 V_2} = \frac{MU_{Z_r}\dfrac{\partial Z_r}{\partial X_r}}{P_r} = \frac{MU_{Z_n}\dfrac{\partial Z_n}{\partial X_n}}{P_n} \qquad (7.4)$$

$$= \frac{MU_{Z_n}\dfrac{\partial Z_n}{\partial t_n}}{w}$$

There are two important aspects of these marginal conditions. First, the assumption that r and w_i are parameters allows all aspects of the costs of an additional visit to each site to be added (i.e., the full cost of a visit to the ith site is $T\cdot d_i + r\cdot t_i + w_i t_{V_i}$) and treated as the "price" of that visit. Second, the joint determination of trips and onsite time implied by this formu-

lation is clearly apparent in the dependency of the unit costs of each of these inputs on the selected levels of the other.*

Solving the necessary conditions of a utility maximum for the optimal number of visits to each site as a function of the parameters in the optimization problem provides the analytical counterpart to the travel cost demand model. These derived demand equations can be written in general form as Equations (7.5) and 7.6):

$$V_1 = L_1(wt_w, R, L, P_r, P_n, T \cdot d_1 + rt_1, T \cdot d_2 + rt_2, w_1, w_2, w), \quad (7.5)$$

$$V_2 = L_2(wt_w, R, L, P_r, P_n, T \cdot d_2 + rt_2, T \cdot d_1 + rd_1, w_1, w_2, w). \quad (7.6)$$

The relationships in Equations (7.5) and (7.6) are clearly more general than the conventional travel cost demand model. Empirical estimation of these relationships, however, requires several simplifying assumptions. Specifically, full income ($wt_w + R + L$) is assumed to be approximated by family income, and choices of market-purchased recreation and nonrecreation goods, as well as time used in nonrecreation final service flows, are treated as separable decisions in the consumer's budget allocation process. These assumptions reduce the input demand equations to a format more closely resembling the travel cost specifications. In the case of the first site, for example, Equation (7.7) would result:

$$V_1 = H_1^*(\tilde{Y}, T \cdot d_1 + rt_1, T \cdot d_2 + rt_2, w_1, w_2) , \quad (7.7)$$

where

$\tilde{Y}$ = family income as a proxy measure for full income (Y) defined in Equation (7.3).

Before turning to further refinements in this model to accommodate the introduction of specific features of recreation sites as determinants of the variation in the site demand functions, it may be useful to relate the amended travel cost model to some of the existing travel cost studies. (A comprehensive review is available in Dwyer, Kelly, and Bowes [1977].) It is acknowledged at the outset that the features of the existing work can often be explained by inadequacies in the data available on the usage of recreation sites. Indeed, many travel cost studies have been based on aggregate visit patterns rather than on information on the behavior of individual households. These data are typically the result of automobile surveys or the aggregation of user permit information at specific recreational sites. However, information is now available on the number of visitors to a specified site from a set of

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*This framework can also be extended to consider an alternative basis for deriving a relationship between the opportunity cost of travel time and the wage rate by assuming that individuals face different types of time constraints. See Smith, Desvousges, and McGivney [1983] for details.

origin zones (often counties) around the site. With such information, the measure of site usage is generally expressed as a visitor rate (i.e., number of visits relative to county population) and is interpreted as an expected "rate of usage" for the "representative" individual in the county. County summary statistics are used as indicators of the economic and demographic characteristics of this "representative" individual. As a consequence, there is often no information with which to estimate the individual's wage rate.

In the presence of these limitations, researchers have taken either of two approaches. The first assumes a constant wage rate for all individuals in all origin zones. The second, somewhat more desirable, uses an estimate based on the wage implied by average family income in the origin zone (i.e., family income divided by an estimate of hours worked per year). Clearly, neither of these options provides a discriminating index of an individual's wage rate. However, the crude nature of the approximations required by the data explain in part Cesario's [1976] willingness to propose a "rule of thumb" for estimating the opportunity cost of travel time.

There are several other problems that arise with travel cost models based on limited data sets. The first of these stems from controlling for trips of different lengths with an aggregate data set. In some cases, researchers have separated data into weekend and weekday visits to ameliorate the problem (see Cicchetti, Fisher, and Smith [1976]). An assumption of constant onsite time is otherwise invoked without empirical justification. Equally important, the nature of the trips may be quite different as the distance from the site increases. That is, the trips may have multiple objectives that would imply the full cost of the trip is not an implicit price for the use of the recreation site but, rather, provides other services as well.*

Recent empirical analyses of the stability of the travel cost model using data aggregated as distance from a site increases suggest it may be possible to detect when violations of these assumptions are severe (see Smith and Kopp [1980]). Of course, this analysis requires the assumptions of constant onsite time across aggregated visits and single-purpose trips, which are more untenable as the distance from the site increases.

The second type of data available for travel cost models involves site-specific user surveys. While these data are in principle superior to the aggregate visit data, incomplete design of the surveys has limited their ultimate usefulness. One especially important omission involves the treatment of usage patterns for recreation facilities that might be considered substitutes for the one whose users are questioned.

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*Haspel and Johnson [1982] have considered this issue for a survey of users of the Bryce Canyon National Park and found that for this site the assumption of single-purpose trips for visitors was inappropriate. Their findings suggest that it would lead to substantial differences in the estimated travel cost demand functions.

The micro-level data from the surveys, however, have permitted the investigation of a number of issues in modeling recreation demand, including the treatment of: travel costs, the time costs of travel, and the costs of onsite time. Unfortunately, these efforts have not been entirely successful. For example, McConnell and Strand [1981] assume that increases in travel cost and in the time costs of travel should have the same effect on site demand to infer the relationships between the opportunity cost of travel time, r in this study's notation, and the wage rate, w. Their data do not include wage rates that require estimation from family income. The resulting demand equations can exhibit difficulties in estimating precise (i.e., statistically significant) separate estimates of the "price" and income effects on site demand.

The most recent attempt to include both travel cost and the time costs of travel with micro-level data by Allen, Stevens, and Barrett [1981] concludes that it is difficult to distinguish separate effects for these two variables when time is entered without attempting to estimate its opportunity cost (see especially pp. 178-179). The authors suggest collinearity would seem to prevent precise estimation of separate effects of the two variables. Their conclusions contrast with earlier suggestions by Brown and Nawas [1973] and Gum and Martin [1975] that disaggregation would help to resolve these estimation problems.

Theory does imply that travel time should be valued by an opportunity cost. Thus, the Allen, Stevens, and Barrett findings may simply be a reflection of a failure to use all available information from theory. Moreover, the McConnell-Strand empirical results support this optimism.

One important aspect of any attempt to include both travel time and onsite time costs of a trip will be estimation of micro-level wage rates in a way that accurately reflects individual rates of compensation and does not preclude the use of family income as a proxy variable. Such a method is developed in Section 7.4 of this chapter.

The last remaining facet of the idealized travel cost model given in Equation (7.7) involves the treatment of the influence of substitute sites on the demand for any one site's services. This model explicitly identifies sites that can contribute to the production of the recreation service flow, and it thus requires an approach that treats the effects of other sites. A variety of methods have evolved to incorporate the influence of substitute sites on demand. Because these approaches provide a natural introduction to the extended travel cost model, which allows a site's characteristics to be determinants of intersite demand variation, they are considered as a part of the introduction to the proposed model in Section 7.3.

7.3 THE TRAVEL COST MODEL FOR HETEROGENEOUS RECREATION SITES

As noted in the previous section, the travel cost methodology seeks to model the demand for a recreation site's services. In general, the operational forms of travel cost models focus on estimating site-specific demand functions,

and additional sites are considered only to the extent they might provide substitute services for a particular site under study. Conventional practice has incorporated the role of these substitute services using one of three methods:

- Incorporation of an index of the relative attractiveness and availability of other recreation sites into the relevant site's demand function (see Ravenscraft and Dwyer [1978] and Talhelm [1978]).

- Specification of the recreation demand models to include the prices (i.e., travel costs and time costs of travel) of other substitute recreation sites (see Burt and Brewer [1971] and Cicchetti, Fisher, and Smith [1976]).

- Respecification of the utility function in terms of the attributes of recreation sites so that use patterns are assumed to be in response to utility maximizing selections of these attributes (see Morey [1981]).

Of the three methods, the first is probably the least desirable. It implicitly assumes that an arbitrary index can account for substitute sites in the demand for any given recreation site. Of course, the definition of such an attractiveness index not only requires knowledge of the exact nature of the substitute relationships but also assumes that the index form would be a simple function of the other site's attributes. Thus, this approach requires the very information it is attempting to derive.

The remaining approaches are consistent with economic models of recreation demand. The second approach can be interpreted as an empirical statement of the model given in Equation (7.7), which assumes that the effects of substitute sites on any one site's demand can be captured through the specification that these other sites' "prices" affect the demand for the site of interest. Because the demand for each site is measured individually, the second approach avoids the quantity and price aggregation issues that would impede the consistent definition of the attractiveness index proposed for the first approach.

The last approach addresses the quantity and price aggregation issues directly by assuming a specific format for them in the site attribute specification of the recreationist's utility function. All recreationists are assumed to have the same preferences. This method can be limited by the plausibility of the specification of the utility function.

However, none of these methods offers the ability to consistently relate conventional travel cost site demands to the site features that produce recreation services. That is, while the specification of the household production function for Z_r in terms of several sites implicitly reflects the prospects for substituting one site's services for another's, there is no direct means for explaining the reasons for the degree of substitution observed between any pair of sites. This inability to explain the source of, or reasons for, these

substitution possibilities is not a limitation for many applications. As noted earlier, when sample information identifies the set of sites considered by individuals as well as their respective patterns of use, cross-price elasticities of demand can be used to estimate measures of the substitution possibilities. Unfortunately, this information is not uniformly available in all recreation surveys. Indeed, this study's data set, described in the next section, is a survey of users at specific recreation sites, without information on the other recreation facilities respondents may have used or considered using. In such cases, the reasons why substitution prospects exist between recreation sites must be analyzed and some attempt made to reflect them in the modeling of the overall demand for these sites. In simple terms, what is required is the addition of further structure to the household production functions--assumptions that serve to explain why individual site services contribute differentially to the production of recreation service flows and, in turn, why they substitute at different rates.

Before the analysis is formally developed, its implications must be described. This study's approach maintains that each site has a set of characteristics (e.g., size, water quality, camping facilities, scenic terrain, etc.) and that these attributes contribute to site productivity as inputs to recreation service flow production functions. If the nature of these contributions is restricted to a specific form, originally defined as the simple repackaging hypothesis in problems associated with constructing quality adjusted price and quantity indexes for consumer demand (see Fisher and Shell [1968] and Muellbauer [1974]), the measurement of the role of site characteristics as determinants of the features of site demand will provide an explanation of the substitution. As Lau [1982] has demonstrated in another context, the simple repackaging hypothesis implies that site services can be converted into equivalent units based only on their respective characteristics. Thus, after adjustment for their attributes (with Lau's conversion functions), all site services are perfect substitutes for each other.* If this description is plausible, a model of site demand that omits consideration of the role of potential substitute sites will not be biased. Of course, it should be acknowledged that this assumption is a stringent one and that the models developed from it may be limited should the assumption prove to be a poor approximation of processes giving rise to substitution.

To begin the formal development of this model, the original specification of the household production function for recreation service flows (i.e., Equation [7.1]) is replaced with one that includes the characteristics of the recreation site, Equation (7.8):

$$Z_r = f_r\,(X_r,\ V_i,\ t_{V_i}\ ,\ a_i)\ , \qquad (7.8)$$

*Berndt [1983] has also recently used this framework to describe the effects of input quality in neoclassical production models.

where

X_r = recreation-related market goods

V_i = number of trips to the ith recreation site

t_{V_i} = time per trip to the ith recreation site (assumed to be constant across all trips)

a_i = vector of attributes for the ith recreation site.

In this form, the relationship between V_i, t_{V_i}, and a_i in the household production function for recreation service flows determines the appropriate index for transforming one site's services into their equivalents for another site. More specifically, given strict monotonicity of the household production function, Equation (7.8) can be solved for V_i.* This resulting function might be designated a site-service requirements function and would be given (in general form) by Equation (7.9):

$$V_i = h(Z_r, X_r, t_{V_i}, a_i) \ . \tag{7.9}$$

Thus, to convert one site's services into equivalent units of another site, the ratio of the equivalent h(.) functions for each site is needed.† For example, if there are two sites (designated with subscripts 1 and 2), and if the differences in the production technologies for Z_r using each site can be captured with a_i, the equivalence between trips to each is given by Equation (7.10):

$$V_1 = \frac{h(Z_r, X_r, t_{V_1}, a_1)}{h(Z_r, X_r, t_{V_2}, a_2)} \cdot V_2 \ . \tag{7.10}$$

This relationship can be further simplified if the ratio V_1/V_2 is assumed to be independent of Z_r, X_r, and t_{V_i} (i = 1,2).‡ Under this assumption, the

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*A monotonic function implies that there is a one-to-one association between the set of independent variables and the dependent variable. In the context of a production function this assumption implies that, if an output Q can be produced with a certain input bundle x, the same output can be produced with more of every input (provided it is possible to costlessly dispose of what is not needed).

†This analysis of the role of site characteristics adapts work recently developed by Lau [1982] for the definition and measurement of a raw materials aggregate within neoclassical models of production.

‡The assumption of independence of t_{V_i} can be easily modified by incorporating it as one of the set of attributes assumed to be available with each visit to the site. Indeed, this format is equivalent to the assumption made earlier that onsite time is the same for all visits.

site-service requirements function would be given as Equation (7.11), and the household production function corresponding to it by Equation (7.12):

$$V_i = \bar{h}\ (Z_r,\ X_r,\ t_{V_i}) \cdot R(a_i)\ , \tag{7.11}$$

$$Z_r = \bar{f}_r\ (X_r,\ t_{V_i},\ R(a_i) \cdot V_i)\ , \tag{7.12}$$

where $R(a_i)$ = the augmentation function.

$R(a_i)$, the augmentation function, provides a specific index that permits each site's services to be transformed into equivalent units. It maintains that this transformation will be constant regardless of the level of the site's services used and will only vary with changes in the attributes (the a_i's) for a site. Consequently, the augmentation function describes how sites would substitute for each other in the production of the recreation service flow, Z_r. This form of the household production function--used in the following discussion--implies that the effects of a site's characteristics on household demands for that site's services can be derived if households can be viewed as engaged in a two-step optimization process to allocate their time and resources.* One of these steps involves minimizing the costs of producing a given output, suggesting that the patterns of trips to recreation sites will be adjusted so the relative unit costs of a trip to any pair of sites would be proportionate to their respective marginal products in contributing to the recreation final service flow. In other words, the effective price of a site's services will be equalized across all recreation facilities considered for use in the production of the recreation service flow.

If the prices of site services are equalized across sites, the augmentation function, $R(a_i)$, provides the means of relating each site's marginal product. Thus, for example, using the augmentation function to compare two sites with different levels of water quality (one with levels permitting recreation fishing and the other permitting only boating), this distinction is captured analytically by a higher augmentation coefficient for the site with cleaner water. Designating the sum of the travel costs and time costs of travel by P_i (i.e., $P_i = T \cdot d_i + r \cdot t_i$) then yields:†

$$\frac{P_1}{R(a_1)} = \frac{P_2}{R(a_2)}\ , \tag{7.13}$$

or the equivalent of a hedonic price function for sites' services:

$$P_i = g(a_i)\ . \tag{7.14}$$

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*For further discussion of the application of the household production model to modeling outdoor recreation behavior, see Deyak and Smith [1978] and Bockstael and McConnell [1981].

†This relationship assumes that onsite time is constant and equal for both sites and that the opportunity costs of onsite time are equal for the two sites.

This approach is simply an alternative derivation of the first-stage estimating equation for the Brown-Mendelsohn (1980) hedonic travel cost model. It does not, however, necessarily imply that the marginal prices of attributes will be constant.*

A second implication of the above approach is that the household's cost function for producing Z_r will be a function of the site's attributes. Moreover, the attribute augmentation function, $R(a_i)$, will adjust the effective price of the site's services in the household's cost function, as in Equation (7.15):

$$C = C(Z_r, P_r, w_i, P_i/R(a_i)) , \tag{7.15}$$

where

P_r = price of recreation related commodities

w_i = price of onsite time.

This cost function provides the basis for a generalized travel cost model.

It is assumed that a given recreation site's attributes do not change during a recreation season. Thus, estimates of a travel cost recreation demand for a single site cannot isolate the role of these attributes. Nonetheless, these characteristics should, in principle, affect the form of these demand functions across sites, as seen when Equation (7.15) is differentiated with respect to the site's price, P_i. Following Shephard's [1953] lemma, the partial derivative is the individual's demand for the site's services. Equation (7.16) illustrates that this demand must be a function of the site's characteristics:†

$$V_i^* = \frac{\partial C}{\partial P_i} = \frac{1}{R(a_i)} C_4(Z_r, P_r, w_i, P_i/R(a_i)) . \tag{7.16}$$

To make the framework in Equation (7.16) operational, a number of complications must be considered. The first of these issues involves the recreation service flow, Z_r, for which there is no measure. As a rule, the

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*The Brown-Mendelsohn [1980] hedonic travel cost model proposes a two-stage framework. In the first stage, the hedonic price function is estimated for each origin zone by considering the set of recreation sites available to users in that zone, their respective travel and time costs for trips, and their attributes. With these data a separate hedonic price function can, in principle, be estimated for each zone. The partial derivatives of these price functions (which are assumed to be linear in their application) define the implicit prices of the sites' attributes for users in each zone. Using the recreation site choices, their implied levels of attributes, and these implicit prices for attributes, Brown and Mendelsohn then estimate demand functions for each attribute across all origin zones.

†$C_4(\cdot)$ is a short-hand expression for the partial derivative of the cost function, $C(\cdot)$, with respect to its fourth argument, $P_i/R(a_i)$.

flows are not part of travel cost demand models--an exclusion that is justified if the production technology is homothetic and if the levels of production are uncorrelated with other determinants of the demand for a site's services.* That is, the first assumption implies Equation (7.16) can be rewritten as:

$$V_i^* = H(Z_r) \cdot g(P_r, w_i, P_i/R(a_i), R(a_i)) \ . \qquad (7.17)$$

Rewriting Equation (7.17) in logarithmic form yields:

$$\ln V_i^* = \ln H(Z_r) + \ln(g(P_r, w_i, P_i/R(a_i), R(a_i))) \ . \qquad (7.18)$$

When Z_r is uncorrelated with the arguments of g(.), and when ln(g(.)) is linear in parameters, the ordinary least-squares estimates of these parameters will be unbiased.† Of course, this framework assumes that all individuals produce the same types of activities.‡

The second complication arises from the treatment of onsite time. The model developed in Section 7.2 described the cost of a site's service by considering the travel and time costs of traveling to the site and the time spent at the site per visit. For simplicity, the time spent onsite was assumed constant for all visits. Thus, the full cost, C_i, of all trips to the ith facility is given as:

$$C_i = (T \cdot d_i + rt_i + w_i t_{v_i}) \ V_i \ , \qquad (7.19)$$

where

T = travel cost per mile (operating costs for an automobile)

d_i = roundtrip distance in miles

r = opportunity cost of traveling time

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*Any production function that can be written as a monotonic, increasing function of a homogeneous function is a homothetic function. This specification implies that the marginal technical rate of substitution between all pairs of inputs will be constant along rays from the origin. In terms of the cost function corresponding to this production function, the returns to scale (as measured by the elasticity of cost with respect to output) will be a function of the output level.

†To make this judgment, it has been implicitly assumed that the site demand equations include an additive, classically well-behaved error.

‡The framework implicitly assumes that approximately the same mix of recreation activities is undertaken by users. The rationale follows from the assumption that users have comparable household production functions (or that the factors leading to differences in household production technologies can be specified). The assumption on the mix of recreation activities is equivalent to treating Z_r as an aggregate index of all of the recreation undertaken at the site.

t_i = travel time to and from the facility

w_i = opportunity cost of onsite time.

A change of one trip involves a full cost of $T \cdot d_i + rt_i + w_i t_{v_i}$. The first two components of these costs are given to each individual once the recreation site is selected. However, this same conclusion does not follow for $w_i t_{v_i}$. The time spent at the site, t_{v_i}, is a choice variable. Thus, if onsite costs are included in a travel cost demand model, amending Equation (7.17) to reflect the restriction implicit in the previously described definition of the price of a trip, the estimation of the model must reflect simultaneity in the choice of V_i and t_{v_i}. In past studies, this issue has been avoided by assuming that onsite time was constant for all trips.* Section 7.6 evaluates the importance of this simultaneity for the recreation sites in this study.

The measurement of the opportunity cost of travel time, r, and of onsite time, w_i, is also a difficult issue. As noted in the previous section, there has been considerable controversy over the appropriate treatment of the first of these implicit prices. Cesario and Knetsch [1970, 1976] and Cesario [1976] have argued that the wage rate is not an appropriate index of the first of these costs. Rather, based on individual travel choice studies, they have proposed that the opportunity cost of traveling time is a fraction of the wage rate. In this study's sample, the wage rate is estimated based on a wage model derived from the 1978 Current Population Survey that permits specific wage predictions to be made for each individual. These predictions take account of the individual's background, including education, age, occupation, sex, race, and other socioeconomic characteristics. As a result, it is possible to separate the estimation of the wage rate from the respondent's reported family income. The next section provides more complete details on the wage model and its predictions for the sample of recreationists.

Finally, the theoretical model does not offer explicit guidelines as to how a site's attributes affect the derived demand functions for that site's services. The analysis assumes that all of the demand parameters can be affected by a site's features. With the natural log of visits specificied as a function of the travel and time costs of visiting the site, income, and a variety of other determinants,† using a semilog specification gives the generalized travel cost specification in its simplest form as:

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*This assumption was one of the reasons offered by Smith and Kopp [1980] for a spatial limit to travel cost models estimated from aggregate visit rate information by origin zone.

†Earlier attempts to discriminate between the popular specifications for the travel cost model have not met with great success. Using tests for nonnested models, Smith [1975b] found a slight preference for the semi-log with aggregate visit rate data. Ziemer, Musser, and Hill [1980] have also found support for the semilog specification. However, neither set of results could be regarded as definitive.

$$\ln V_{ij} = \alpha_0(a_{1i}, a_{2i}, \ldots, a_{ki}) + \alpha_1(a_{1i}, a_{2i}, \ldots, a_{ki}) P_{ij} + \alpha_2(a_{1i}, a_{2i}, \ldots, a_{ki}) Y_j . \quad (7.20)$$

The double subscript for V_{ij} and P_{ij} permits the identification of the site (i) and the individual recreationist (j). Thus, V_{ij} is the number of trips to the ith site by the jth individual, P_{ij} is the travel and time costs per trip for the jth individual, and Y_j is that individual's income. Significantly, each parameter of the demand equation is specified as a function of the site attributes. Thus, for individuals using the services of a single site, the demand function's parameters are assumed to be constant. Nonetheless, this model has the ability to describe how the demand for a site's services changes with the attributes of that facility. Thus, separate estimates of the demands for individual recreation sites together with measures of their characteristics provide, in principle, the information needed to determine the demand for new sites or for existing sites that experience changes in their available characteristics. These changes might include improvements in water quality, capital additions increasing access points, or improvements to the camping facilities. Thus, this analysis demonstrates that the observed variation in the estimated parameters of travel cost site demand models across sites may be the result of differences in these sites' characteristics. It therefore provides the basis for evaluating the implications of water quality for recreation behavior. Indeed, as suggested in Section 7.7, the estimates of travel cost demand models together with the attributes explaining the variation in the estimated parameters of these models can be used to construct the demand relationships required for a benefits analysis of water quality changes.

It is also important to recognize that the structure of the model provides sufficient information to permit efficient estimation of the role of site attributes for the parameters of site demand. To illustrate this point, consider a general statement of the site demand model:

$$Y_i = X_i\beta_i + \varepsilon_i , \quad (7.21)$$

where

Y_i = N × 1 vector of the measures of the quantity demanded for the ith site's services by each of N individuals

X_i = N × K matrix of demand determinants for the N sampled users of the ith site

β_i = K × 1 parameter vector for the ith site

ε_i = N × 1 vector of stochastic errors for the ith site.

Operationalizing the theoretical specification given in Equation (7.20) is equivalent to assuming that variations in the vector of parameter estimates, β_i, can be explained by the attributes of each recreation site, as in Equation (7.22):

$$\beta_i = \theta A_i \ , \tag{7.22}$$

where

θ = K × M matrix of parameters describing the effects of site attributes on the parameters of the site demand equations

A_i = M × 1 vector of the M characteristics of the ith site.

The specification for the determinants of site demand parameters will affect the form of the efficient estimator of this two-component model. Under the present specification, a two-step estimation scheme can be considered. The first would involve the estimation of each site demand equation. Assuming there are S sites, the process yields S vectors of estimates for each of the parameters in the β_i vector. Consider the ith such estimate. If ε_i is classically well behaved, the ordinary least-squares estimate, $\hat{\beta}_i$, of β_i will be unbiased. It can be written as:

$$\hat{\beta}_i = (X_i^T X_i)^{-1} X_i^T Y_i \ . \tag{7.23}$$

Or, substituting for Y_i from Equation (7.21) yields:

$$\hat{\beta}_i = \beta_i + (X_i^T X_i)^{-1} X_i^T \varepsilon_i \ . \tag{7.24}$$

Because β_i is not observed, it is necessary to consider the use of estimates in its place. The ordinary least-squares estimate, $\hat{\beta}_i$, is one such possibility. If the model given in Equation (7.21) has classically well-behaved errors and nonstochastic independent variables as determinants, $\hat{\beta}_i$ is the best linear unbiased estimate of β_i. Substituting for β_i in Equation (7.22) using Equation (7.24) provides the basis for a second-step estimator:

$$\beta_i = \hat{\beta}_i - (X_i^T X_i)^{-1} X_i^T \varepsilon_i = \theta A_i \ . \tag{7.25}$$

Rearranging terms yields:

$$\hat{\beta}_i = \theta A_i + (X_i^T X_i)^{-1} X_i^T \varepsilon_i \ . \tag{7.26}$$

Equation (7.26) clearly suggests that, even if $E(\varepsilon_i^2) = \sigma^2$ for all sites (i.e., i = 1 to S), efficient second-stage estimates require a generalized least-squares estimator. That is, the model given in Equation (7.26) must be estimated taking into account the relative precision of estimation of the $\hat{\beta}_i$

vector across sites. This will be given in each case by the corresponding diagonal elements of Equation (7.27):

$$E(\hat{\beta}_i - \beta_i)(\hat{\beta}_i - \beta_i)^T = \sigma^2(X_i^T X_i)^{-1} . \tag{7.27}$$

The $(X_i^T X_i)^{-1}$ will not be identical across sites, even if the error variances are constant and equal.

Unlike many instances, the nonspherical errors in this framework provide a consistent estimate of the covariance matrix needed for generalized least-squares estimation of the models in terms of $\hat{\beta}_i$. These estimates are contained in the ordinary least-squares estimates of the respective parameter estimates' covariance matrices (i.e., Equation [7.27]).

The generalized travel cost model can be efficiently estimated with a two-step procedure. Each site demand model is estimated with ordinary least-squares (ignoring for the moment any potential simultaneity introduced by the onsite time costs variable). The estimated parameters in these models, together with their estimated variances, provide the basis for the second-step, generalized least-squares estimates of the role of site attributes as determinants of the individual demand parameters. If the jth member of $\hat{\beta}_i$ for $i = 1, 2, \ldots, S$, if the vector of these estimates is b_j (an $S \times 1$ vector of the ordinary least-squares estimates for the jth parameter in the original β_i vector), and if $\hat{\sigma}_{jj}^2$ is the corresponding diagonal element for $\hat{\sigma}_i^2 (X_i^T X_i)^{-1}$, the generalized least-squares estimator of θ_j (the sth row of θ) is given as follows:

$$\hat{\theta}_j^T = (A^T\hat{\Sigma}^{-1}A)^{-1} A^T\hat{\Sigma}^{-1}b_j , \tag{7.28}$$

where

$$\Sigma = \begin{bmatrix} \hat{\sigma}_{11}^2 & & & & 0 \\ & \hat{\sigma}_{22}^2 & & & \\ & & \cdot & & \\ & & & \cdot & \\ & & & & \cdot \\ 0 & & & & \hat{\sigma}_{ss}^2 \end{bmatrix}$$

A = SXM matrix of A_i^S for each of S sites .

This estimator is somewhat different from that described by Saxonhouse [1977]. However, the overall logic is completely parallel. The two generalized

least-squares estimators differ in two respects. Saxonhouse [1977] assumes that the first stage models will be jointly estimated with a Zellner [1962] seemingly unrelated regressions estimator. This approach is more efficient than ordinary least-squares estimates of the individual equations when there is contemporaneous correlation between the stochastic errors across the equations and when the independent variables in all models together are not highly correlated.* As originally formulated, the Zellner estimator maintains that there is an equal number of observations for all models. While Schmidt [1977] has developed variations on the estimator that relaxes this assumption, there is no reason in this application to expect contemporaneous correlation between the errors of the site demand equations. Each will be based on independent surveys of users with little prospect that the same individuals would use more than one site. In the absence of this contemporaneous correlation, there is no advantage to the Zellner estimator. It is identical to the ordinary least-squares estimates for each equation.

The second distinction arises in the specification of the covariance structure for the second step estimates. Saxonhouse's model assumes that Equation (7.22) includes a stochastic error. By maintaining that these errors are independent of the site demand errors, it is possible to develop consistent estimates of the required covariance matrix using the residuals from ordinary least-squares estimates of the second-step models. Saxonhouse's approach can be viewed as a generalized random coefficient model because the parameters of the site demand models are treated as random variables. However, the observed variation in these parameters (across sites) arises from both systematic (i.e., the differences in each site's characteristics) and random influences. This interpretation has been avoided here in preference for a framework that treats the demand parameters as constants that change with site attributes. Because the true parameters are unobservable, estimates of them must be used to determine the role of these attributes. Thus, random influences enter the framework through the estimates of these parameters and not as an inherent component of the demand model.

In summary, it has been argued that it is possible to develop a theoretically consistent method for determining the effects of a recreation site's characteristics on the features of the demand for that site's services. Moreover, the framework developed here does not require information on all recreation sites considered by each potential user. This is an important distinction between the approach developed here and the Brown-Mendelsohn [1980] hedonic travel cost model. Equally important, it is possible, using a straightforward, two-step estimation procedure, to provide efficient estimates of the model.

It should be acknowledged that the approach presented here is not new. Freeman [1979a] suggested such a scheme (without explicit consideration of

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*Of course, it is important to recognize that the models discussed here may be biased as a result of the assumption that all sites' services can be transformed into common units using conversion functions in terms of their respective attributes. This framework maintains that, after adjustment for these characteristics, all sites are perfect substitutes in the production of recreation service flows.

the estimation problems) as one of a number of ad hoc approaches to treating water quality effects in modeling the demand for recreation sites. This framework has extented Freeman's suggestion by demonstrating that it is not ad hoc. Rather, it is completely consistent with a household production framework of recreation participation patterns and with the theory of adjusting quantity and price indexes for quality changes in goods and services.

7.4 SOURCES OF DATA

The 1977 Nationwide Outdoor Recreation Survey was conducted by the Heritage Conservation and Recreation Service as part of the Department of Interior's mandate to periodically develop National Recreation Plans. In contrast to past recreation surveys, which only included a general population component, the 1977 survey included general population and site-specific user surveys.

The Federal Estate Survey component of the survey, the primary basis of this study, consists of interviews with recreationists at each of a set of recreation facilities. All federally owned areas with public outdoor recreation were considered to comprise the Federal Estate, and sites were chosen on a basis of specific agency control. The majority of interviews were conducted in areas managed by the National Park Service, the National Forest Service, the U.S. Army Corps of Engineers, and the Fish and Wildlife Service. Each agency was then stratified by Federal Planning Regions, and areas were randomly chosen with weight given to annual visitation in 1975.

Interviewing time at each site was based on visitation, which also determined the number of interviews. The final Federal Estate Survey contains 13,729 interviews over 155 recreation areas. Information collected included socioeconomic characteristics, current outdoor recreation activities, and attitudes toward recreation for each respondent. Data requirements for developing travel cost models that describe demand for individual recreation sites are met by the Federal Estate Survey.

Given that the scope of this study is water-based recreation and that the analysis requires detailed descriptions of the activities at each site, only U.S. Army Corps of Engineer sites were chosen for modeling. These 46 sites also ensured consistent management of recreation activities. Three were eliminated from the analysis because of data inconsistency or ambiguous interview site locations.

A number of the sites selected for analysis from the Federal Estate Survey had observations with incomplete information. Rather than being eliminated from the sample, these observations were classified according to whether or not the missing information affected either the measurements of the use of the relevant recreation sites or the travel and time costs of that use versus the socioeconomic characteristics of the individuals involved. Observations that did not permit evaluation of recreation choices (i.e., those missing the use and travel information) were eliminated. The remaining incomplete observations were replaced by the mean values of the relevant variables at that site because the demand models were estimated at the site level. This procedure corresponds to the zero-order method for treating missing observations.

Section 7.6 discusses the results of using regression diagnostics to evaluate the sensitivity of each site's estimates to sample composition. In addition to gauging the sensitivity of the estimates to the assumptions of our models, this index also provided a means to evaluate the implications of the procedures used for missing observations.

Several variables in the Federal Estate Survey were reported by discrete intervals. Answers to questions concerning time spent at site, number of visits to site, travel hours to site, and annual income were treated as continuous variables. In all cases the interval's midpoint was used. Open-ended intervals were converted using the previous interval, with the difference between the previous interval's midpoint and minimum value added to the open-ended minimum value.

One component of the model described in Section 7.3 is the travel cost of a trip, which is defined as the number of miles traveled multiplied by a per mile cost. An independent estimate of travel cost was developed by measuring each respondent's actual road distance traveled to a site based on his reported zip code. All distances were calculated with the Standard Highway Mileage Guide [Rand McNally, 1978], which lists road miles between 1,100 cities. National interstate highways and primary roads were used in all calculations. Other routes were used only for the distance to the nearest primary road. In cases where cities have multiple zip codes, the center of the city was used as the origin.

The second part of the travel cost calculation requires a per mile cost of a trip. The marginal cost of operating an automobile in 1976 is estimated to be approximatley $0.08 per mile. This estimate is based on costs of repairs and maintenance, tires, gasoline, and oil as reported by the U.S. Census Bureau in the U.S. Statistical Abstract [1978]. Mileage costs for operating an average automobile were then calculated by using the round trip miles to the site multiplied by $0.08. This assumes that the respondent drove directly to the site using the routes in the Standard Highway Mileage Guide. Unfortunately, information was not available on the primary purpose of the respondents' trip or further driving plans.

The Federal Estate Survey includes annual household income of respondents but does not indicate any hourly wage rate. Because the use of reported income in calculating opportunity cost of time precludes determination of income's role in the site demand models, an independent estimate of each individual's wage rate is important to a complete specification of the model.

A hedonic wage model estimated from the 1978 Current Population Survey (CPS) was used to derive these estimates. This model specifies the market clearing wage rates to be a function of individual-, job-, and location-specific characteristics. The specific model was developed by Smith [forthcoming, 1983]. By substituting each individual's characteristics (including location-specific and occupation-specific variables), predicted wage rates were derived. Equation (7.29) provides a general statement of the procedure, with X_{ij} the determinants of the wage rate:

$$\hat{W}_i = \exp\left(\sum_{j=1}^{N} \hat{B}_j X_{ij}\right) , \qquad (7.29)$$

where

$\hat{W}_i$ = the predicted wage rate for the ith individual

$\hat{B}_j$ = the estimated coefficient of the jth variable

X_{ij} = the ith individual's value of the jth variable

N = the number of explanatory variables.

Explanatory variables usually include age, sex, education, occupation, and various other job- and location-specific characteristics.

The estimates made in this study should be regarded as proxy measures for actual wage rates. Since the wage model is a semilog, the predictions can be expected to understate the estimated conditional expectation for the wage rate. While Goldberger's [1968] proposed unbiased estimator for this conditional expectation would be superior for large degrees of freedom (the CPS sample contained 9,077 for males and 7,067 for females) and for a small error variance of the estimated model, the bias in this study's estimates will be small. A 10-percent discrepancy would be a generous outer bound on the magnitude of the percentage difference between the direct predictions of these wage rates and the estimates based on Goldberger's method. Indeed, in most large sample applications (see the examples in Goldberger [1968] and Giles [1982]), the actual differences are under 5 percent. Thus, despite this limitation, these estimates provide a better set of proxy measures for wage rates than the available alternatives since they take explicit account of individual and job characteristics. In specifying and estimating the wage model, consideration was also given to measures of job risks, air pollution, climate, crime, access to cultural and sporting activities, and local labor market conditions.

The nominal wage model includes a cost-of-living variable as one of the determinants of wages. Smith used the Bureau of Labor Statistics budget-cost-of-living index for this variable. In the Standard Metropolitan Statistical Areas (SMSAs) where the index was not known, information available for 27 SMSAs was used to model the determinants of variations in the cost of living. As shown in Equation (7.30), the index, C_j, was related to population density, D_j; the size of the SMSA population in 1975 in thousands, POP_j; and the percent of the population under 125 percent of the poverty standard, $POOR_j$. The t-ratios for the hypothesis of no association are shown in parentheses:

$$C_j = \underset{(37.73)}{111.81} + \underset{(7.38)}{0.005}\, D_j - \underset{(-2.40)}{0.001}\, POP_j - \underset{(-4.36)}{1.30}\, POOR_j$$

$$R^2 = 0.787$$

$$F(3,\ 23) = 28.34 \ . \qquad (7.30)$$

The Federal Estate Survey does not directly identify respondents' SMSA. Thus, a cost of living variable was generated at the State level to minimize computation cost. This index was calculated as the average of the SMSAs within each State, avoiding the need to match each respondent to an SMSA.

The estimated 1977 nominal wages for the recreationists at each site were developed using the equations in Table 7-1. The characteristics necessary for the model were generally available in the Federal Estate Survey, and classifications between the model and the survey were compatible. Problems do arise, however, for respondents who were not labor force participants at the time of the survey. For example, students and housewives could not be considered in the sample used to estimate the hedonic wage model. In these cases, the wages were treated as an opportunity cost estimated to be the mean value by sex of the predicted wage rates in the recreation survey. Table 7-2 provides a summary of predicted hourly wage rates by income and occupation of the respondents. The predicted wage rate is used to calculate the opportunity cost of both onsite time and travel time. For at least two reasons, there are substantial differences in these estimates for the upper income members of the sample. The first stems from the coding of the wage measure in the Current Population Survey. Specifically, the reporting format limits the reported usual weekly earnings (the basis for the hourly wage rate--usual weekly earnings divided by usual hours worked) to $999. Thus, there is censoring in wages for individuals above approximately $52,000 per year. The second reason is that family income can reflect the effects of nonwage income and the impact of dual earner households. Unfortunately, the extent of these influences cannot be sufficiently determined to improve wage rate estimates for individuals in these higher income households.

The U.S. Army Corps of Engineers maintains the Recreation Resource Management System for evaluation and planning. Data from this system are compatible with the sites chosen for the Federal Estate Survey and have been available since 1978. Information is collected annually on each water resource project with 5,000 or more recreation days of use. For 1978, this information included financial statistics, facilities available, natural attributes, recreation participation, and number of employees.

The Recreation Resource Management System is used to define attributes of the 43 Federal Estate Survey sites. Attributes of an area considered include land area, shore miles, pool elevation, the number of multipurpose recreation areas, and facilities provided. Table 7-3 provides descriptive statistics for both the characteristics of the sites and of a selected set of variables for the survey respondents at these sites.

The National Water Data Exchange (NAWDEX) is a membership of water-oriented organizations and is a major source of water quality information. The NAWDEX system is under the direction of the U.S. Geological Survey, and its primary function is to exchange data from various organizations. Major sources of information are usually State agencies, the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the U.S. Environmental

Table 7-1. Hedonic Wage Models

Variable[a]	Male		Female	
	Coefficient	t-statistics (of no association)	Coefficient	t-statistics (of no association)
Intercept	0.631	8.71	0.179	2.03
Education	0.030	4.01	0.028	2.61
Education squared	0.001	3.45	0.001	2.15
Experience	0.031	25.83	0.018	15.91
Experience squared	-0.001	-22.35	-0.0002	-11.83
Race	0.113	8.75	-0.024	-1.73
Veteran	0.035	3.50	---	---
Unemployment	-0.012	-3.51	0.002	0.57
Professional	0.086	2.76	0.563	19.17
Managerial	0.142	4.48	0.521	16.15
Sales	-0.0003	-0.01	0.199	6.30
Clerical	-0.099	-3.01	0.390	15.38
Craftsman	0.015	0.48	0.445	8.68
Operative	-0.149	-4.47	0.235	8.09
Transport equipment	-0.118	-3.35	0.366	5.34
Nonfarm labor	-0.131	-3.87	0.199	3.97
Service worker	-0.251	-7.70	0.166	6.26
Injury rate	0.011	10.40	0.012	7.67
Cancer	0.299	2.93	0.105	0.86
TSP	0.0007	2.31	0.0003	0.97
Household head	0.229	16.75	0.069	6.01
Union member	0.178	17.52	0.191	13.81
OJT × Experience	-0.002	-1.64	-0.001	-0.54
Crime rate	0.000005	1.89	-0.000008	2.39
Percent sunshine	-0.002	-2.31	0.0001	0.12
Dual job holder	-0.042	-1.75	-0.025	-0.81
Know × Cancer	3.77	4.58	5.727	4.24
Log (cost of living index)	0.559	7.22	0.606	6.56
	R^2 = 0.47 degrees of freedom = 9,077 F ratio = 292.92		R^2 = 0.33 degrees of freedom = 7,067 F ratio = 135.52	

SOURCE: Smith [1983].

[a]The variable definitions are as follows:

(1) Education--measured as the years corresponding to the highest grade of school attended (this variable is entered in linear and quadratic terms).

(2) Experience--measured using the conventional proxy of age minus years of education minus six (this variable is entered in linear and quadratic terms).

(3) Socioeconomic qualitative variables--dummy variables for race (white = 1), sex (male = 1), veteran status (veteran = 1 and relevant only for males), member of a union (yes = 1), head of the household (yes = 1), and dual job holder (yes = 1).

(4) Occupational qualitative variables--dummy variables to define the respondents occupation as: professional, managerial, sales, clerical, craftsman, operative, transport equipment operator, nonfarm labor, or service worker.

(5) Cancer--index of exposure to carcinogens.

(6) TSP--average suspended particulates in 1978.

(7) OJT--on-the-job training program available.

(8) Know--relative number of workers within an industry covered by collective bargaining with health and safety provisions.

The omitted occupational category was defined to correspond to a composite of those occupations that might lead the estimated hourly wage to understate actual earnings. The omitted occupations were farm laborers and private household workers.

A measure of price uncertainty was constructed to provide some basis for adjusting the experience measure to reflect the different levels of provision of on-the-job training (OJT) across firms. To evaluate the importance of these effects, price uncertainty was measured as the unexplained variation (i.e., $1-R^2$) for linear trend models fit to monthly wholesale price indexes for each of 14 product categories for each year over the period 1976 through 1978. After evaluating each year's index, 1977 was selected for this analysis. The indexes were assigned to individuals according to their industry of employment in an attempt to match products as closely as possible. The variable was entered as an interaction term with experience.

Table 7-2. Summary of Predicted Hourly Wage Rates (1977 $)

	Total sample	Male	Female
Overall mean	5.44	6.27	4.34
Number of observations	3,460	1,971	1,489
Mean by annual household income[a]			
Under 5,999	5.08	5.79	4.06
6,000 to 9,999	4.92	5.49	4.10
10,000 to 14,999	5.32	6.01	4.38
15,000 to 24,999	5.72	6.70	4.39
25,000 to 49,999	5.98	7.17	4.65
50,000 or more	5.73	6.53	4.65
Mean by occupation of respondent[b]			
Professional, technical, and kindred workers	7.05	7.89	5.65
Farmers	5.15	5.71	2.75
Managers, officials, and proprietors	7.17	7.74	4.94
Clerical and kindred workers	4.34	5.94	4.10
Sales workers	5.18	6.24	3.29
Craftsmen, foremen, and kindred workers	5.89	6.05	4.31
Operatives and kindred workers	4.97	5.15	3.56
Service workers	4.11	4.71	3.18
Laborers, except farm and mine	4.44	4.74	3.11
Retired widows	5.92	6.27	4.34
Students	5.30	6.27	4.34
Unemployed	5.46	6.27	4.34
Housewives	4.37	6.27	4.34
Other	5.71	6.27	4.34
No occupation given	5.49	6.27	4.34

[a]Total number of observations is 3,282.

[b]Total number of observations is 3,460.

Protection Agency (EPA). All water quality data used in the analysis were retrieved from NAWDEX in a series of steps. Collection of useful water quality data was completed by identifying potential monitoring stations and by then obtaining actual data. Potential monitoring stations were identified by defining the recreation area in terms of latitude and longitude. A general retrieval was then obtained that listed station name, location, parameter collected, years of data collection, and agency responsible for the data collection.

Table 7-3. The Characteristics of the Sites and the Survey Respondents Selected from the Federal Estate Survey

Project name	Site characteristics: Property code	Site characteristics: Recreation days	Site characteristics: Shore miles	Site characteristics: Area acres	Characteristics of survey respondents: Predicted wage rate $\bar{X}$	Predicted wage rate σ	Household Income $\bar{X}$	Household Income σ	Visits $\bar{X}$	Visits σ	(T+M) Cost $\bar{X}$	(T+M) Cost σ	Miles[a] $\bar{X}$	Miles[a] σ	Number of observations[b]
Allegheny River System, PA	300	-	-	-	5.45	1.65	15,667	8,625	2.6	2.5	45.19	28.30	106	57	69
Arkabutla Lake, MS	301	2,011,700	134	52,549	5.23	1.45	13,184	8,974	5.4	2.7	20.04	27.94	45	90	61
Lock & Dam No. 2 (Arkansas River Navigation System), AR	302	343,700	96	32,415	5.24	1.03	10,409	3,991	6.8	2.0	3.04	13.01	55	33	41
Beaver Lake, AR	303	4,882,600	449	40,463	5.59	1.70	18,150	9,946	3.5	3.0	94.55	88.64	266	296	226
Belton Lake, TX	304	2,507,000	136	30,789	5.52	1.51	17,279	11,913	6.0	2.8	33.18	52.35	67	142	53
Benbrook Lake, TX	305	1,978,000	37	11,295	5.00	1.21	19,135	10,065	2.3	1.2	30.23	58.93	73	223	46
Berlin Reservoir, OH	306	1,179,000	70	7,990	5.44	1.24	16,459	10,161	5.2	2.9	21.15	26.63	40	130	96
Blakely Mt. Dam, Lake Ouachita, AR	307	2,104,300	690	82,373	5.24	1.53	17,144	9,524	4.3	2.8	45.39	49.31	121	139	91
Canton Lake, OK	308	3,416,500	45	19,797	5.09	1.54	17,392	10,553	4.6	3.2	32.30	22.97	95	99	74
Clearwater Lake, MO	309	888,000	27	18,715	5.43	1.38	17,943	8,456	4.0	2.7	50.51	42.24	140	192	74
Cordell Hull Dam & Reservoir, TX	310	2,167,900	381	32,822	5.43	1.58	15,491	9,215	5.7	2.9	29.65	34.70	60	87	104
DeGray Lake, AR	311	1,659,700	207	31,800	5.17	1.58	19,235	10,612	4.8	2.7	42.04	43.42	115	164	49
Dewey Lake, KY	312	1,116,800	52	13,602	5.83	2.10	18,021	9,559	2.4	2.0	90.75	122.44	243	519	46
Fort Randall, Lake Francis Case, SD	313	4,756,000	540	133,047	5.43	1.69	20,696	11,705	3.3	3.1	100.29	93.59	260	295	50
Grapevine Lake, TX	314	5,139,100	60	17,828	5.20	1.58	19,309	10,992	6.3	2.6	38.45	64.32	92	217	92
Greers Ferry Lake, AR	315	4,407,000	276	45,548	5.15	1.45	15,890	8,562	4.7	3.0	54.16	70.00	154	306	217
Grenada Lake, MS	316	2,553,900	148	86,826	5.13	1.56	9,199	4,833	6.4	2.6	24.57	32.90	65	165	75
Hords Creek Lake, TX	317	359,500	11	3,027	5.26	1.42	16,263	9,699	4.4	3.0	39.46	48.25	108	170	54
Isabella Lake, CA	318	1,489,200	38	15,977	5.64	1.48	15,938	11,445	3.3	2.5	55.59	45.54	127	100	48
Lake Okeechobee and Waterway, FL	319	2,894,584	402	451,000	5.38	1.20	13,849	9,541	4.1	3.0	24.91	11.03	76	258	30
Lake Washington Ship Canal, WA	320	712,900	80	169	6.26	2.07	16,686	5,815	3.3	3.0	98.63	130.14	338	605	37
Leech Lake, MN	321	950,600	316	162,100	5.90	1.40	18,886	10,986	2.5	1.8	104.08	84.35	268	313	48
Melvern Lake, KS	322	2,034,600	101	24,543	5.69	1.65	18,087	9,015	4.3	3.0	31.48	29.39	84	137	45
Millwood Lake, AR	323	2,042,300	65	142,100	5.49	1.87	18,630	1,319	5.6	3.0	37.62	55.21	90	176	53
Mississippi River Pool No. 3, MN	324	1,323,700	37	20,350	6.36	2.23	29,571	10,895	3.0	2.4	99.20	79.14	196	288	49
Mississippi River Pool No. 6, MN	325	645,500	55	11,292	5.79	1.42	19,589	10,693	4.8	3.0	52.23	55.19	141	240	70
Navarro Mills Lake, TX	327	1,111,500	38	14,286	5.16	1.41	13,739	4,652	4.6	2.8	27.68	30.29	61	70	42
New Hogan Lake, CA	328	335,200	44	6,162	5.57	1.28	18,954	11,270	4.0	3.1	34.10	14.55	72	29	41
New Savannah Bluff Lock & Dam, GA	329	207,600	32	2,030	5.28	1.13	12,609	9,414	5.8	2.7	18.65	23.78	37	77	39
Norfork Lake, AR	330	3,066,500	380	54,193	5.65	1.61	17,667	8,889	3.2	2.5	94.89	59.65	268	75	42
Ozark Lake, AR	331	1,102,000	173	39,251	5.02	1.22	12,654	7,568	4.9	3.0	58.71	98.54	199	433	52
Perry Lake, KS	332	3,388,000	160	41,769	5.52	1.48	16,565	6,925	4.7	2.7	28.79	24.02	79	109	28
Philpott Lake, VA	333	1,454,900	100	9,600	5.33	1.55	14,268	6,668	5.8	2.6	26.09	46.00	47	100	38
Pine River, MN	334	1,615,100	119	22,177	5.95	1.80	20,097	9,370	2.1	1.4	69.80	50.54	178	188	75
Pokegama Lake, MN	335	948,300	53	66,542	5.70	1.46	16,816	9,476	3.3	2.7	100.63	122.30	376	590	68
Pomona Lake, KS	336	1,460,400	52	12,301	5.42	1.36	17,265	7,330	5.4	2.8	25.38	23.33	65	115	31
Proctor Lake, TX	337	975,200	27	15,956	5.49	1.63	17,510	11,167	5.4	2.9	46.08	40.96	109	103	52
Rathbun Reservoir, TX	338	2,332,200	156	36,072	5.74	1.56	20,543	7,473	4.3	2.9	41.78	29.18	96	41	31
Sam Rayburn Dam & Reservoir, TX	339	2,728,700	560	176,869	5.32	1.35	19,515	11,331	4.1	2.7	40.23	31.90	85	74	67
Sardis Lake, MS	340	2,488,900	110	98,590	5.41	1.31	13,141	7,223	6.5	2.3	36.08	42.17	123	234	205
Waco Lake, TX	343	3,371,600	60	21,342	5.46	1.25	16,396	12,454	6.9	2.2	33.02	45.10	99	263	61
Whitney Lake, TX	344	1,976,400	170	53,230	5.25	1.29	18,688	11,651	5.0	2.8	35.40	38.03	96	195	201
Youghiogheny River Lake, PA	345	1,122,600	38	4,035	5.56	1.59	16,682	11,051	5.4	2.9	24.67	9.48	47	58	31

[a]One-way distance to the site.

[b]Number of observations are based on the final models estimated for site.

NOTES: $\bar{X}$ is the arithmetic mean.
σ is the standard deviation.
(T+M) cost is the sum of vehicle and time-related costs of a visit.

One major problem in the data collection process is the identification of appropriate monitoring sites. Ideally, monitoring stations should be located in the area where recreation occurs. Monitoring sites could only be identified by obscure station names. Furthermore, information is not available according to area names used by survey respondents. Proximity of a water quality monitor to actual recreation could not be determined.

Monitoring sites that could be identified as relevant were then chosen, and the actual water quality data were obtained through NAWDEX. Several problems are inherent in this type of data collection. A brief discussion of the data collection process and some problems encountered follow. The reader is referred to Appendix E for a more detailed discussion of water quality.

Water quality parameters were selected on a basis of previous use and availability among sites. The parameters collected are temperature, pH, dissolved oxygen, biological oxygen demand, turbidity, nitrates, phosphates, fecal coliform, dissolved solids, flow, and Secchi-disk transparency. Of the 43 sites, 16 had no data due to a lack of known monitoring sites.

Actual water quality data were collected for 27 sites for the years 1972 to 1981. Most of these sites were missing information for the year the survey was completed. As a result, calculations were carried out using 1972 to 1981 data. Monthly means for each site were calculated for June through September. An overall mean was also calculated using the four monthly means. In cases where sites were completely missing a parameter, the mean for all sites was used.

Individual parameters and indexes are used in the analysis, including both monthly values and a summer average. Index methods include the National Sanitation Foundation and the Resources for the Future measures. Linear combinations of parameters were also tested, although the degree of correlation between parameters was regarded with caution.

The treatment of missing values for these variables led to a lack of variation between sites. This is caused by two factors. First, the averaging of several years distorts the actual water quality for a particular year. Consideration is not given to improvements or deterioration of water quality. Secondly, replacing missing observations with the means smooths out the variation between sites. Any predictions of water quality benefits with the travel cost model will become more reliable as missing observations are replaced with actual data.

The choice of parameters to be measured at a monitoring site varies according to a water body's local characteristics and the agency collecting the sample. This inconsistency in data collection may cause problems when the 43 Army Corps of Engineers' areas are compared. For example, if suspended solids are not considered a problem in an area, they are not likely to be measured. Consequently, several parameters were not available in all areas or during the appropriate time.

In summary, three generally compatible data sources were used. Data obtained from each source are consistently defined across sites.

7.5 EMPIRICAL RESULTS FOR SITE-SPECIFIC TRAVEL COST MODELS

The theoretical model of the consumer's recreation decisions identified three aspects of the process that may influence the use of the travel cost model for an analysis of the benefits (or costs) of a change in the attributes of a recreation site. Two of these aspects arise in defining the relevant measure of site usage and the associated cost to the individual for a "unit" of the site's services (assuming an ideal quantity index could be derived). In the formal model of household choice, the individual was able to produce additional units of the recreation service flow with more trips of a given length or by increasing the time spent onsite during a fixed number of trips. The household production framework did not specify these choices as perfect substitutes, but it did admit the possibility of substitution. This type of input substitution is plausible because the time horizon for production has been interpreted to be the recreation season. This specification of the problem implies that the number of visits to a given site and the times spent onsite per visit will be jointly determined variables. Indeed, the demand model for visits (i.e., Equation [7.7]) was expressed as a reduced form equation. Of course, the specific analytical model simplified the issues involved by assuming the time spent onsite was the same for all the visits in a given season. Actual behavior is more complex, with the prospects for different amounts of time spent onsite for every visit. There are several aspects of this problem described below in greater detail. The discussion portrays the treatment of each issue in this analysis and how this treatment compares with earlier literature.

The second aspect of modeling an individual's recreation choices arises in the definition of the cost of a visit to a given recreation site. The analytical model indicated that this cost would be composed of the costs of transportation to the site (i.e., the product of roundtrip mileage and a vehicle operating cost per mile) and the opportunity costs associated with the time spent traveling to the facility. As noted earlier, the appropriate definition of these opportunity costs has been addressed in several papers in the past literature. The model identifies the cost as r and does not attempt to relate it to the individual's wage rate. Of course, in practice r is unknown and requires estimation. Since the treatment of this variable has important implications for the estimated costs of a trip, the issues involved in this study's modeling choices are detailed below.

Finally, the third aspect of the representation of recreation decisions stems from this chapter's overall objective, which is to evaluate the influence of site characteristics on the demand for the services of a recreation facility. As developed in Section 7.3, some analytical restrictions on the role of site attributes for the production of recreation service flows, together with a diversity of these features across sites, provide sufficient information to estimate the relationship between each site's demand model and its attributes. To estimate this relationship, however, requires the adoption of a common demand specification for all the individual site demand equations. While the sample sites provide the ability to engage in an approximately comparable set of recreation activities, this is not a sufficient reason, in itself, for expecting the site demand models to be comparable. Thus, before turning to the generalized least-squares models for explaining the variation in an individual

site's estimated demand parameters, the implications of using a common specification must also be considered. To adequately treat these three issues, a fairly detailed set of statistical analyses of site demand models was undertaken.

The explanation of these results will be developed in this and the next two sections of this chapter. This exposition begins with a more detailed discussion of the conceptual dimensions of each of these issues in the first three subsections of this section. The ordinary least-squares estimates for the general model applied to all 43 sites follow that discussion. The remainder of this section discusses the implications of using conventional pretesting criteria for selecting individual specifications for each site demand, as well as the influence of different approaches for treating the opportunity cost of travel time to each site. Section 7.6 discusses the results of the analysis of onsite time and visits within a simultaneous equation model and the several specific statistical issues that arise for travel cost models because of the nature of the available measures of site usage. The final component of the model is developed in Section 7.7, where the results of the generalized least-squares model for the determinants of the features of recreational site demand equations are presented.

7.5.1 The Treatment of Onsite Time

Ideally, the measurement of site demand models would involve both the number of trips to a particular site and the time spent onsite for each trip. Unfortunately, in practice this information is rarely available.* The source of data for this analysis (the Federal Estate Survey) includes information on the amount of time spent at the site during the trip in which the respondent was interviewed and not the corresponding information for all trips taken during the season. Thus, any attempt to deal with the relationship between onsite time and visits will require further assumptions.

There have generally been two treatments of onsite time in the recreation demand literature. The first of these corresponds to the most common practice in the literature--onsite time is assumed to be constant across trips and across individuals. In this case, the number of visits is a consistent index of the use of a site's services. With this approach, the onsite time (or cost) term is dropped from the travel cost model (and thus the wage rate would not enter Equation [7.7]).†

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*Brown and Mendelsohn [1980] is one notable exception.

†This practice is, strictly speaking, not correct. Even though onsite time is constant and not considered a choice variable, it does influence the cost of a trip (see Equation [7.4]). Moreover, it cannot be treated as a constant displacement to the demand model's intercept because the opportunity costs of time can be expected to vary across individuals.

We considered a role for onsite time under the assumptions that adjustment for simultaneity was unnecessary and that the results were uniformly unsatisfactory. Without an explicit recognition of the simultaneity between visits and onsite time costs, ordinary least-squares estimates of the role of onsite time costs would lead to the conclusion that these costs were unimportant influences on the demand for each site's services.

The second approach specifies the travel cost demand function for each site to include the costs of onsite time for the trip in which the individual was interviewed. This case implicitly assumes that the time spent onsite is constant for all trips but may well be different across individuals. Thus, the empirical model corresponds to the theoretical structure developed at the outset of this chapter. The first approach corresponds to the basic model and is reported in this section. The second approach is used to gauge the implications of ignoring onsite costs. These results are summarized in Section 7.6.

7.5.2 The Opportunity Cost of Travel Time

As noted earlier, it has often been argued that the opportunity cost of travel time is less than the wage rate. If this cost is known, theory suggests that travel costs and the cost of travel time have equivalent effects on the demand for the site's services (i.e., their parameters in a linear demand model would be equal). In the absence of information on these opportunity costs, and if it is possible to assume they are a constant fraction of every individual's wage rate, separate effects can be identified for travel cost and the cost of travel time. The relationship between the estimated parameters provides one basis for estimating the constant--essentially the McConnell-Strand [1981] approach. Of course, to apply this approach, independent estimates of roundtrip distance to the site and travel time must be available. Since few travel cost studies have had access to this type of information, many studies accept Cesario's [1976] suggestion that the opportunity cost of travel time is a multiple of the wage rate ranging from one-fourth to one-half and use it in calculating the cost of a trip. In these cases, travel costs and travel time are both based on roundtrip distance. Of course, the latter also requires an assumed velocity of travel, a wage rate, and the Cesario constant to estimate the opportunity cost of travel time.

Since the Federal Estate Survey reports travel time and the Zip codes of each respondent's residential location, it was possible to develop independent estimates of both components of the cost of a trip. Thus, tests for each model evaluate the appropriate treatment of travel costs and the costs of travel time. These tests simply translate the economic issues and ad hoc practices into restrictions on the parameters of the site demand models.

7.5.3 Results for the Basic Model

Table 7-4 provides the ordinary least-squares estimates for the semilog specification of our travel cost demand models. The general form for the model is given in Equation (7.31) below:

$$\ln(V_i) = \alpha_0 + \alpha_1(TC_i+MC_i) + \alpha_3\ INC_i + \varepsilon_i\ , \qquad (7.31)$$

where

V_i = number of visits during the recreation season for the ith respondent

Table 7-4. Regression Results of General Model, by Site

$$LN\ VISITS = \alpha_0 + \alpha_1\ (T+M)\ COSTS^a + \alpha_3\ INCOME^b$$

Site	Site number	Intercept		T + M cost		Income		R^2	DF	F-ratio
Allegheny River System, PA	300	0.53	(2.04)	-0.0005	(-0.13)	8.2×10^{-6}	(0.74)	0.01	66	0.29
Arkabutla Lake, MS	301	1.58	(9.99)	-0.0093	(-3.09)	6.2×10^{-6}	(0.67)	0.15	58	4.93
Lock and Dam No. 2 (Arkansas River Navigation System), AR	302	2.31	(9.76)	-0.0125	(-2.30)	-1.8×10^{-5}	(-1.08)	0.14	38	3.11
Beaver Lake, AR	303	1.61	(16.07)	-0.0066	(-12.77)	-3.5×10^{-6}	(-0.78)	0.43	224	86.07
Belton Lake, TX	304	1.69	(9.38)	-0.0052	(-2.47)	2.6×10^{-6}	(0.29)	0.12	50	3.39
Benbrook Lake, TX	305	1.83	(10.70)	-0.0054	(-4.11)	6.0×10^{-6}	(0.80)	0.30	43	9.11
Berlin Reservoir, OH	306	1.40	(8.47)	0.0014	(0.43)	-4.1×10^{-7}	(-0.05)	0.01	93	0.09
Blakely Mt. Dam, Lake Ouachita, AR	307	1.70	(10.08)	-0.0079	(-5.14)	-7.6×10^{-6}	(-0.98)	0.24	88	13.67
Canton Lake, OK	308	1.77	(8.61)	-0.0206	(-5.28)	7.1×10^{-6}	(0.86)	0.28	71	13.98
Clearwater Lake, MO	309	1.51	(5.97)	-0.0032	(-1.42)	-1.0×10^{-5}	(-1.21)	0.04	71	1.61
Cordell Hull Dam and Reservoir, TN	310	1.86	(14.13)	-0.0139	(-6.00)	-1.2×10^{-8}	(-0.01)	0.34	101	25.57
DeGray Lake, AR	311	1.79	(7.71)	-0.0070	(-3.00)	-6.9×10^{-5}	(-0.73)	0.17	46	4.68
Dewey Lake, KY	312	0.42	(2.27)	-0.0024	(-2.95)	2.0×10^{-5}	(2.02)	0.18	43	4.72
Ft. Randall, Lake Francis Case, SD	313	1.32	(6.00)	-0.0066	(-5.93)	7.5×10^{-6}	(0.91)	0.43	47	17.61
Grapevine Lake, TX	314	1.80	(16.12)	-0.0073	(-8.80)	8.5×10^{-6}	(1.70)	0.47	89	39.12
Greers Ferry Lake, AR	315	1.48	(14.08)	-0.0065	(-9.02)	8.4×10^{-6}	(1.42)	0.28	214	40.79
Grenada Lake, MS	316	2.04	(12.61)	-0.0095	(-4.36)	-1.0×10^{-5}	(-0.68)	0.22	73	10.02
Hords Creek Lake, TX	317	1.73	(8.22)	-0.0050	(-2.11)	-2.1×10^{-5}	(-1.76)	0.19	51	5.95
Isabella Lake, CA	318	1.26	(5.55)	-0.0073	(-3.15)	7.9×10^{-6}	(0.81)	0.20	45	5.47
Lake Okeechobee and Waterway, FL	319	1.68	(3.68)	-0.0268	(-1.72)	1.9×10^{-7}	(0.01)	0.10	27	1.56
Lake Washington Ship Canal, WA	320	0.96	(2.69)	-0.0037	(-3.79)	1.7×10^{-5}	(0.84)	0.26	41	7.18

DF = Degrees of freedom.

(continued)

[a] T+M represents the respondents' round trip cost. It is composed of travel time cost (TCOST) and a constant per mile cost of operating an automobile (MCOST).

[b] t-values of no association are shown in parentheses.

Table 7-4. (continued)

Site	Site number	Intercept		T + M cost		Income		R^2	DF	F-ratio
Leech Lake, MN	321	0.87	(3.88)	-0.0022	(-1.83)	3.5×10^{-6}	(0.37)	0.07	45	1.68
Melvern Lake, KS	322	1.30	(4.47)	-0.0079	(-1.66)	4.1×10^{-6}	(0.32)	0.06	42	1.37
Millwood Lake, AR	323	1.43	(7.94)	-0.0081	(-3.99)	1.8×10^{-5}	(2.14)	0.25	50	8.26
Mississippi River Pool No. 3, MN	324	1.33	(4.20)	-0.0057	(-4.62)	4.7×10^{-6}	(0.54)	0.34	46	11.67
Mississippi River Pool No. 6, MN	325	1.41	(7.45)	-0.0074	(-4.39)	1.3×10^{-5}	(1.53)	0.22	68	9.68
Navarro Mills Lake, TX	327	1.66	(6.40)	-0.0057	(-1.39)	-1.4×10^{-5}	(-1.14)	0.06	39	1.33
New Hogan Lake, CA	328	1.04	(2.58)	-0.0040	(-0.41)	7.1×10^{-6}	(0.60)	0.01	38	0.23
New Savannah Bluff Lock & Dam, GA	329	1.88	(8.39)	-0.0067	(-1.44)	-9.8×10^{-6}	(-0.70)	0.06	36	1.25
Norfork Lake, AR	330	1.13	(4.27)	-0.0047	(-2.55)	9.3×10^{-5}	(0.79)	0.14	39	3.30
Ozark Lake, AR	331	1.66	(8.52)	-0.0046	(-4.44)	-8.8×10^{-6}	(-0.66)	0.31	49	11.18
Perry Lake, KS	332	1.50	(4.17)	-0.0042	(-0.74)	-1.0×10^{-5}	(-0.68)	0.03	25	0.41
Philpott Lake, VA	333	1.90	(9.28)	-0.0087	(-4.40)	-1.7×10^{-6}	(-0.13)	0.36	35	10.03
Pine River, MN	334	0.81	(4.65)	-0.0017	(-1.27)	-6.4×10^{-6}	(-0.91)	0.04	72	1.39
Pokegama Lake, MN	335	1.44	(7.28)	-0.0033	(-4.46)	-1.4×10^{-5}	(-1.57)	0.24	67	10.36
Pomona Lake, KS	336	1.54	(5.35)	-0.0058	(-1.11)	8.4×10^{-6}	(0.62)	0.13	28	1.35
Proctor Lake, TX	337	2.06	(13.61)	-0.0134	(-7.50)	1.2×10^{-6}	(0.19)	0.54	49	28.39
Rathbun Reservoir, TX	338	0.77	(1.85)	-0.0015	(-0.27)	1.4×10^{-5}	(0.82)	0.02	28	0.34
Sam Rayburn Dam & Reservoir, TX	339	1.46	(7.06)	-0.0094	(-2.83)	1.0×10^{-6}	(0.13)	0.11	64	4.10
Sardis Lake, MS	340	1.81	(20.73)	-0.0030	(-3.17)	4.3×10^{-6}	(0.78)	0.05	202	5.22
Waco Lake, TX	343	1.95	(15.04)	-0.0006	(-0.32)	-7.4×10^{-6}	(-1.25)	0.03	58	0.93
Whitney Lake, TX	344	1.41	(13.07)	-0.0025	(-1.80)	3.2×10^{-6}	(0.72)	0.02	201	1.80
Youghiogheny River Lake, PA	345	0.29	(0.60)	0.0263	(1.61)	1.7×10^{-5}	(1.55)	0.14	28	2.35

DF = Degrees of freedom.

[a]T+M represents the respondents' round trip cost. It is composed of travel time cost (TCOST) and a constant per mile cost of operating an automobile (MCOST).

[b]t-values of no association are shown in parentheses.

TC_i = time costs of travel for the ith respondent, defined as product of the estimated wage rate for the person (see Section 7.6) and the roundtrip travel time

MC_i = travel costs for the ith respondent

INC_i = family income for the ith respondent

ε_i = stochastic error for ith respondent.

Several alternative functional forms were considered. However, the results uniformly favored the semilog form based on the ability to precisely estimate the site demand parameters. Moreover, this specification is generally selected in evaluations of functional forms for the travel cost model (see Smith [1975a], Smith and Kopp [1980], and Ziemer, Musser, and Hill [1980]).

In general the implicit price (TC+MC) of a trip to the site is statistically significant and correctly signed. There is a fairly large range for values for the estimated parameters for the implicit price--ranging from -0.0005 to -0.0139. Only one site exhibited a positive coefficient for the implicit price, and in this case the coefficient would not be judged to be significantly different from zero. In the balance of the models, 27 sites had coefficient estimates that would lead to the judgment of a demand effect significantly different from zero at least at the 5-percent level. The balance of the estimated price coefficients is negative and in many cases is also statistically different from zero at a higher significance level--i.e., 10 percent.

The effect of income is poorly measured in all of these models. In most cases the parameter estimates would lead to the conclusion that income is not a significant determinant of the demands for these sites. Indeed, in a number of the models the estimated parameters were negative. However, these estimated parameters would lead to the conclusion that income's effect was not significantly different from zero.

At first, the lack of significance of income may seem surprising. However, when it is considered in comparison to other recreation applications of the travel cost framework, it is more plausible. For the most part these sites provide high-density camping, swimming, boating, etc. These are activities where the participation decision and level of use decisions were either somewhat insensitive to family income or where income's marginal effect increased and then decreased with increases in the level of income. Table 7-5 summarizes the role of income in the Cicchetti, Seneca, and Davidson [1969] analysis of recreation participation decisions. Of course, it should be acknowledged that these participation models are reduced form equations reflecting the influence of both demand and supply influences (see Smith [1975a] and Deyak and Smith [1978] for further discussion of these approaches). Nonetheless, they provide some information based on the likely implications of the mix of activities a site can support for the nature of the demand for that site's services.

Table 7-5. Summary of Cicchetti, Seneca, and Davidson [1969] Participation Models

Activity	Equations[a]	
	Probability of participation	Level of participation
Water-based		
Swimming	Marginal effect of income on probability changes with level of income	Effect sensitive to region of residence
Water skiing	Constant marginal effect[b]	Income not a significant determinant
Other boating	Constant marginal effect[b]	Marginal effect of income changes with level of income
Canoeing	Constant marginal effect[b]	Income not a significant determinant
Other Activities		
Camping developed	Income not a significant determinant	Constant marginal effect of income

[a]These results are based on the estimates reported in Chapter 5 of Cicchetti, Seneca, and Davidson [1969].

[b]These estimated parameters were substantially smaller in numerical magnitude than the estimated parameter for income in the probability equation for fishing.

Finally the overall explanatory power, as measured by R^2, is also quite variable across sites. In some cases, such as sites 303 (Beaver Lake, Arkansas), 313 (Ft. Randall, Lake Francis Case, South Dakota), 314 (Grapevine Lake, Texas), and 337 (Proctor Lake, Texas), the R^2 is comparable to most cross-sectional analyses. For the remainder it is somewhat low, indicating that there may be other major factors influencing these site demands.

7.5.4 Results for the Tailored Models

It should be acknowledged that while the basic model provides a plausible specification for a site demand equation, there may well be a number of other determinants of these demands. Indeed, the low R^2 would certainly support this conclusion. Since the overall objective is to develop a general model for projecting the effects of changes in any water-based site's characteristics on the site demand, site demand equations must adhere to a common

specification. Nonetheless, this does not prevent an appraisal of the sensitivity of the basic model's parameter estimates to the inclusion of additional variables. As a consequence, the analysis plan considered a wide array of alternative specifications of each demand function. These models include additional socioeconomic information--age, sex, education, and race--as well as an attitudinal variable (coded as zero and 1), with 1 designating individuals who regarded outdoor recreation as very important in comparison to their other interests (RECIMP).

Table 7-6. Comparison of Basic Model With Tailored Model: Coefficient for (TC+MC)

Site name	Site No.	Basic model	Range of estimates tailored models
Lock and Dam No. 2 (Arkansas River Navigation System), AR	302	-0.0125	-0.010 to -0.013
Beaver Lake, AR	303	-0.0066	-0.0060 to -0.0070
Blakely Mt. Dam, Lake Ouachita, AR	307	-0.0079	-0.0070 to -0.0080
Cordell Hull Dam and Reservoir, TN	310	-0.0139	-0.0013 to -0.0015
Dewey Lake, AR	312	-0.0024	-0.0020 to -0.0030
Grapevine Lake, TX	314	-0.0073	-0.0060 to -0.0090
Greers Ferry Lake, AR	315	-0.0065	-0.0060 to -0.0070
Genada Lake, MS	316	-0.0095	-0.0080 to -0.0100
Lake Washington Ship Canal, WA	320	-0.0037	-0.0030 to -0.0400
Melvern Lake, KS	322	-0.0079	-0.0070 to -0.0090
Millwood Lake, AR	323	-0.0081	-0.0070 to -0.0090
Mississippi River Pool No. 3, MN	324	-0.0057	-0.0050 to -0.0060
Mississippi River Pool No. 6, MN	325	-0.0074	-0.0070
Ozark Lake, AR	331	-0.0046	-0.0030 to -0.0050
Philpott Lake, VA	333	-0.0087	-0.0070 to -0.0090
Pine River, MN	334	-0.0017	-0.0010 to -0.0020
Proctor Lake, TN	337	-0.0134	-0.0013 to -0.0014
Sardis Lake, MS	340	-0.0030	-0.0030 to -0.0040
Whitney Lake, TX	344	-0.0025	-0.0020 to -0.0030

Table F-5 in Appendix F presents a sample of these models for a selected set of the 43 sites. These cases represent the site demands where one or more alternative specifications would have been regarded as equivalent or better to the basic model. In evaluating these models, the focus was on the estimated parameters for variables that were common between the basic model and each variation to it. In general, the most important parameter--the coefficient for the implicit price--was remarkably stable. Table 7-6 provides a comparison of these estimates from the tailored specifications with the basic model estimates reported in Table 7-4.

Since it is widely acknowledged in the econometrics literature that pretesting and sequential estimation practices affect the kinds of inferences that can be drawn concerning the properties (i.e., unbiasedness, efficiency, etc.) of the "final" model's estimated parameters, these types of sensitivity analyses gauge whether the decisions required to select the final models were important to the parameters of central importance to the overall objectives.* The general criteria used for selecting the specifications reported in Table 7-4 were based on three considerations: (1) agreement between the sign of the estimated parameters with what was expected from economic theory; (2) statistical significance of the estimates using conventional criteria as appropriate indexes of the precision of the estimates; and (3) robustness of the measured effects for important variables (such as TC+MC) to model specifications.

7.5.5 Evaluation of Measures of the Opportunity Cost of Travel Time

Tables 7-7 and 7-8 report the results of two sets of tests for the basic model and tailored models, respectively. The tests have been structured to evaluate alternative definitions of the opportunity cost of travel time. The two models can be readily described. The first maintains that the wage rate is the most appropriate measure. This would imply that the measure of the time costs of travel, TC, can be added to the travel costs as in Equation (7.31). Alternatively, if, as several authors have argued, the opportunity cost is a different, constant multiple of the wage, the model should be written as:

$$\ln V_i = \bar{\alpha}_0 + \bar{\alpha}_1 TC_i + \bar{\alpha}_2 MC_i + \bar{\alpha}_3 INC_i + \varepsilon \ . \qquad (7.32)$$

Thus, if the wage rate is the appropriate measure of the opportunity cost of travel time, $\bar{\alpha}_1$ should equal $\bar{\alpha}_2$. Rejection of this null hypothesis would therefore provide support for the arguments against the use of the wage rate as the opportunity cost. The sixth column of Table 7-7 reports the relevant F-statistic and significance levels for this hypothesis using the basic model. Overall the hypothesis is rejected for 9 of the 43 sites with the basic model at the 5-percent significance level. These decisions are generally repeated with the tailored models for the sites reported in both cases.

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*This approach is clearly in the spirit of the suggestion made by Klein et al. [1978] for dealing with estimation problems.

Table 7-7. F-Test for Restriction of General Model

Hypothesis 1, Full-Time Cost: LN Visits = $\alpha_0 + \alpha_1$ (T + M) Cost + α_3 Income

Hypothesis 2, Cesario Hypothesis:[a] LN Visits = $\tilde{\alpha}_0 + \tilde{\alpha}_1$ (T 1/3 + M) Cost + $\tilde{\alpha}_3$ Income

Unrestricted model: LN Visits = $\bar{\alpha}_0 + \bar{\alpha}_1$ T Cost + $\bar{\alpha}_2$ M Cost + $\bar{\alpha}_3$ Income

Site	Site number	Sum of squared residuals, Hypothesis 1	Sum of squared residuals, Hypothesis 2	Sum of squared residuals, unrestricted model	F-statistic level of significance	
					Ho: $\bar{\alpha}_1 = \bar{\alpha}_2$	Ho: $\bar{\alpha} = 1/3\bar{\alpha}_2$
Allegheny River System, PA	300	45.27	45.27	44.99	0.53	0.53
Arkabutla Lake, MS	301	24.84	24.12	23.93	0.14	0.50
Lock and Dam No. 2 (Arkansas River Navigation System), AR	302	7.58	8.02	6.91	0.07	0.02
Beaver Lake, AR	303	104.64	109.61	104.09	0.27	0.01
Belton Lake, TX	304	25.90	25.82	23.71	0.04	0.04
Benbrook Lake, TX	305	11.52	11.29	11.20	0.28	0.56
Berlin Reservoir, OH	306	62.13	61.93	61.70	0.43	0.56
Blakely Mt. Dam, Lake Ouachita, AR	307	45.00	44.02	43.96	0.15	0.73
Canton Lake, OK	308	41.48	43.49	41.25	0.53	0.06
Clearwater Lake, MO	309	45.84	45.51	45.37	0.40	0.64
Cordell Hull Dam and Reservoir, TN	310	47.11	46.18	46.18	0.16	0.99
DeGray Lake, AR	311	22.45	22.62	22.45	0.99	0.56
Dewey Lake, AR	312	16.03	16.45	15.91	0.58	0.24
Ft. Randall, Lake Francis Case, SD	313	24.34	26.34	24.05	0.46	0.04
Grapevine Lake, TX	314	22.64	25.40	21.34	0.02	0.01

[a](T 1/3 + M) cost represents the total cost of a round trip where travel time is evaluated at one-third of the predicted wage rate.

(continued)

Table 7-7. (continued)

Hypothesis 1, Full-Time Cost: LN Visits = $\alpha_0 + \alpha_1$ (T + M) Cost + α_3 Income

Hypothesis 2, Cesario Hypothesis:[a] LN Visits = $\tilde{\alpha}_0 + \tilde{\alpha}_1$ (T 1/3 + M) Cost + $\tilde{\alpha}_3$ Income

Unrestricted model: LN Visits = $\bar{\alpha}_0 + \bar{\alpha}_1$ T Cost + $\bar{\alpha}_2$ M Cost + $\bar{\alpha}_3$ Income

Site	Site number	Sum of squared residuals, Hypothesis 1	Sum of squared residuals, Hypothesis 2	Sum of squared residuals, unrestricted model	F-statistic level of significance	
					Ho: $\bar{\alpha}_1 = \bar{\alpha}_2$	Ho: $\bar{\alpha} = 1/3\bar{\alpha}_2$
Greers Ferry Lake, AR	315	110.96	120.65	104.06	0.01	0.01
Genada Lake, MS	316	27.65	27.39	27.39	0.41	0.99
Hords Creek Lake, TX	317	30.61	30.32	30.18	0.40	0.63
Isabella Lake, CA	318	23.59	23.45	23.45	0.61	0.99
Lake Okeechobee and Waterway, FL	319	21.84	22.71	21.59	0.59	0.26
Lake Washington Ship Canal, WA	320	26.22	28.31	24.90	0.15	0.02
Leech Lake, MN	321	21.18	20.78	20.64	0.29	0.59
Melvern Lake, KS	322	31.37	31.16	31.15	0.59	0.91
Millwood Lake, AR	323	28.67	28.36	28.35	0.46	0.90
Mississippi River Pool No. 3, MN	324	20.68	22.59	20.63	0.74	0.04
Mississippi River Pool No. 6, MN	325	37.73	39.47	37.49	0.51	0.06
Navarro Mills Lake, TX	327	23.44	23.59	23.30	0.64	0.50
New Hogan Lake, CA	328	30.71	30.76	30.60	0.72	0.66
New Savannah Bluff Lock & Dam, GA	329	16.67	16.65	16.44	0.49	0.51
Norfork Lake, AR	330	18.45	19.58	17.53	0.17	0.04
Ozark Lake, AR	331	24.31	25.53	21.93	0.03	0.01
Perry Lake, KS	332	12.06	12.01	12.00	0.73	0.89

[a](T 1/3 + M) cost represents the total cost of a round trip where travel time is evaluated at one-third of the predicted wage rate.

(continued)

Table 7-7. (continued)

Hypothesis 1, Full-Time Cost: LN Visits = $\alpha_0 + \alpha_1$ (T + M) Cost + α_3 Income

Hypothesis 2, Cesario Hypothesis:[a] LN Visits = $\tilde{\alpha}_0 + \tilde{\alpha}_1$ (T 1/3 + M) Cost + $\tilde{\alpha}_3$ Income

Unrestricted model: LN Visits = $\bar{\alpha}_0 + \bar{\alpha}_1$ T Cost + $\bar{\alpha}_2$ M Cost + $\bar{\alpha}_3$ Income

Site	Site number	Sum of squared residuals, Hypothesis 1	Sum of squared residuals, Hypothesis 2	Sum of squared residuals, unrestricted model	F-statistic level of significance	
					Ho: $\bar{\alpha}_1 = \bar{\alpha}_2$	Ho: $\bar{\alpha} = 1/3\bar{\alpha}_2$
Philpott Lake, VA	333	10.42	9.97	9.85	0.17	0.52
Pine River, MN	334	22.96	23.44	21.25	0.02	0.01
Pokegama Lake, MN	335	37.31	38.26	36.81	0.35	0.11
Pomona Lake, KS	336	14.42	14.18	13.27	0.13	0.18
Proctor Lake, TN	337	13.25	12.41	12.24	0.05	0.42
Rathbun Reservoir, IO	338	21.70	20.83	17.29	0.01	0.03
Sam Rayburn Dam & Reservoir, TX	339	34.21	33.16	33.15	0.16	0.89
Sardis Lake, MS	340	64.10	66.42	52.76	0.01	0.01
Waco Lake, TX	343	20.07	20.02	17.23	0.01	0.01
Whitney Lake, TX	344	113.80	115.40	96.77	0.01	0.01
Youghiogheny River Lake, PA	345	20.17	21.35	18.17	0.10	0.04

[a](T 1/3 + M) cost represents the total cost of a round trip where travel time is evaluated at one-third of the predicted wage rate.

Table 7-8. F-Test for Restriction of Tailored Models[a]

Site	Site number	F-statistic level of significance				
		Model 1	Model 2	Model 3	Model 4	Model 5
Lock and Dam No. 2 (Arkansas River Navigation System), AR	302	0.07	0.07	0.05	0.03	0.05
Beaver Lake, AR	303	0.29	0.32	0.06	0.20	0.34
Blakely Mt. Dam, Lake Ouachita, AR	307	0.18	0.13	0.17	0.30	0.30
Cordell Hull Dam and Reservoir, TN	310	0.20	0.20	0.46	0.16	0.22
Dewey Lake, KY	312	0.49	0.63	0.16	0.58	0.87
Grapevine Lake, TX	314	0.03	0.04	0.02	0.03	0.05
Greers Ferry Lake, AR	315	0.01	0.01	0.01	0.01	0.02
Grenada Lake, MS	316	0.35	0.47	0.36	0.35	0.20
Lake Washington Ship Canal, WA	320	0.59	0.20	0.10	0.18	0.16
Melvern Lake, KS	322	0.41	0.61	0.46	0.61	0.99
Millwood Lake, AR	323	0.49	0.46	0.84	0.46	0.46
Mississippi River Pool No. 3, MN	324	0.99	0.88	0.88	0.64	0.75
Mississippi River Pool No. 6, MN	325	0.54	0.28	0.56	0.76	0.55
Ozark Lake, AR	331	0.03	0.02	0.03	0.03	0.13
Philpott Lake, WA	333	0.16	0.08	0.17	0.14	0.04
Pine River, MN	334	0.03	0.03	0.02	0.02	0.02
Proctor Lake, TX	337	0.06	0.09	0.16	0.07	0.05
Sardis Lake, MS	340	0.01	0.01	0.01	0.01	0.01
Whitney Lake, TX	344	0.01	0.01	0.01	0.01	0.01

[a]F-tests are calculated using the five restricted models in Table 7-6 against unrestricted models where travel time and mileage cost are separate.

The second hypothesis considers Cesario's suggestion that the opportunity cost is a multiple of the wage rate. The explanation for the parametric treatment of this hypothesis stems from the definitions of the components of the cost of a trip. TC, the time costs of travel, is defined as the predicted wage rate, say $\hat{w}$, times the travel time, t, or $\hat{w}t$. If the opportunity cost of travel time is some multiple, k ($k < 1$) of the wage rate and can be assumed to be constant across individuals, the true measure of TC (designated $\widetilde{TC}$) should be $k\hat{w}t$. Both travel costs and the time costs of travel should, when the latter is correctly measured, have the same effect on the demand for a site's services. Thus, if the maintained hypothesis ($\widetilde{TC} = k\hat{w}t$) is correct, α_1 can be expected to be equal to α_2. However, k cannot be measured. By using $\hat{w}t$ as a proxy and assuming that k is constant, the estimates of $\bar{\alpha}_1$ in the model using $TC = \hat{w}t$ can be expected to be $\bar{\alpha}_1 = k\alpha_1$. Since it is expected that $\bar{\alpha}_1 = \alpha_1$ and that $\bar{\alpha}_2$ will, under ideal conditions, equal α_2, the Cesario suggestion can be treated as the hypothesis that $\bar{\alpha}_1 = k\bar{\alpha}_2$ in terms of Equation (7.32). Since Cesario's specific suggestion was that $k = 1/3$, the second hypothesis is $\bar{\alpha}_1 = 1/3\ \bar{\alpha}_2$. The seventh column of Table 7-7 reports the results for this test. Nearly twice as many sites (16) reject this null hypothesis with the basic model.

Thus, there is greater support for the use of the wage rate as a measure of the opportunity cost of travel time than the Cesario one-third adjustment to the wage. However, there is no unambiguous choice, because some sites fail to reject both sets of restrictions.

7.6 FURTHER EVALUATION OF THE TRAVEL COST MODELS

Section 7.5 presented estimates of the final models for each of 43 recreation sites. As noted earlier, the methodology developed in this chapter requires that the individual site demand equations adopt the same specification. In some cases this specification would have been adopted as "best," and, for others, the choice was not as clearcut. As a consequence, it was necessary to evaluate the sensitivity of important demand parameter estimates to the model specification. There are several additional aspects of these travel cost models that require further consideration. Therefore, this section collects the results of the further evaluations of these models. This analysis was conducted in an attempt to identify potential shortcomings with the models and to appraise their importance for the estimated values. Most of these difficulties arise from either econometric problems with the model or limitations that would be expected based on the economic model of consumer behavior developed at the outset of the chapter.

The first aspect of these travel cost models requiring further consideration arises from the data and the model specification themselves. The visit measure used in this analysis is a positive integer by definition. This raises a number of potential econometric problems. For the purpose of this study these problems have been ignored.* However, where possible, appraisals have been made

*The implications of these features for the site demand models and benefit estimates are currently being evaluated using appropriately structured maximum likelihood estimators and recent method of moments approximations proposed by Greene [1983].

of the potential implications of one of the most important aspects of the sample--that it observes only the behavior of individuals who have visited each site at least once. To evaluate the potential importance of the bias in ordinary least-squares estimates as a result of the truncated form of the measure of site usage, Olsen's [1980] method of moments approximation of the maximum likelihood estimates for models with truncated dependent variables has been used.

The Olsen method relies on approximating the mean of the conditional distribution for the dependent variable (i.e., $E(y \mid y > 0)$). His proposed scaling factors use a first-order approximation to derive a relationship between the ordinary least-squares estimates of a model's parameters and the maximum likelihood estimates. They can be estimated from the moments of the incomplete (i.e., truncated) distribution. These scaling factors are used to gauge the magnitude of the differences between an approximate maximum likelihood estimator and ordinary least squares. Thus, as Olsen suggests, they provide a crude index of the potential severity of the problems with truncation. Greene [1981] has also proposed an approach for adjusting ordinary least-squares estimates in the present Tobit and truncated dependent variable models. He found that Olsen's approximation tends to overstate the bias. Olsen's approximation will be closest to Greene's approach for models with small coefficients of determination (i.e., R^2). As R^2 increases the Olsen adjustment will tend to overstate the extent of bias. Thus, this study's screening of estimated site demand models provides a fairly conservative basis for gauging the bias due to the truncation of the measure of site usage. Table 7-9 reports these scaling factors for the 33 sites in which the general model performed well.

The scaling factors in the fourth column of Table 7-9 can be interpreted as the multiplicative adjustment coefficients required for the ordinary least-squares parameter estimates to approximate the maximum likelihood estimates (based on the assumption of a truncated distribution). Thus, for site No. 301, the maximum likelihood estimates would be 15 percent greater than the ordinary least-squares parameter estimates in absolute magnitude. These comparisons suggest that several sites exhibit pronounced truncation effects. For at least 11 of these sites, the bias associated with the ordinary least-squares estimates may well be quite substantial. As a consequence, the potential for differential bias in the estimates of these site demand functions is accounted for in the final model. That is, the generalized least-squares estimates relating the features of each site demand function to the site's characteristics have been derived using two samples--one including all sites with complete data (i.e., sites with plausible demand models and complete information on water quality and other site characteristics) and a second omitting those sites with potentially important truncation effects.

A second source of qualification to the travel cost demand model arises from the assumption that all users of each individual site have the same derived demand for that site's services. In most cases, disparities in onsite time could not be accounted for. Moreover, it has not been possible to adjust for the different mixes of activities undertaken by different individuals at the

Table 7-9. Effects of Truncation on the Travel Cost Models' Estimates

Site name	Site number	Incomplete mean/ standard deviation	Olsen ML scaling factor[a]
Arkabutla Lake, MS	301	2.115	1.15
Lock & Dam No. 2 (Arkansas River Navigation System), AR	302	4.115	1.01
Beaver Lake, AR	303[b]	0.975	13.55
Belton Lake, TX	304	2.080	1.18
Benbrook Lake, TX	305	3.001	1.01
Blakely Mt. Dam, Lake Ouachita, AR	307	1.425	2.18
Canton Lake, OK	308	1.299	2.92
Cordell Hull Dam & Reservoir, TX	310	1.855	1.29
DeGray Lake, AR	311	1.818	1.34
Dewey Lake, KY	312[b]	0.866	13.55
Ft. Randall, Lake Francis Case, SD	313[b]	0.817	13.55
Grapevine Lake, TX	314	2.458	1.05
Greers Ferry Lake, AR	315	1.493	1.85
Grenada Lake, MS	316	2.401	1.07
Hords Creek Lake, TX	317	1.374	2.44
Isabella Lake, CA	318[b]	1.169	5.33
Lake Okeechobee and Waterway, FL	319[b]	1.119	7.87
Lake Washington Ship Canal, WA	320[b]	0.876	13.55
Leech Lake, MN	321[b]	0.994	13.55
Melvern Lake, MS	322	1.269	3.30
Millwood Lake, AR	323	1.739	1.39
Mississippi River Pool No. 3, MN	324[b]	1.020	13.55
Mississippi River Pool No. 6, MN	325	1.557	1.75
New Savannah Bluff Lock & Dam, GA	329	2.137	1.15
Norfork Lake, AR	330[b]	1.139	6.69
Ozark Lake, AR	331	1.577	1.67
Philpott Lake, VA	333	2.413	1.07
Pine River, MN	334[b]	0.949	13.55
Pokegama Lake, MN	335[b]	1.018	13.55
Proctor Lake, TX	337	1.960	1.25
Sam Rayburn Dam & Reservoir, TX	339	1.474	1.95
Sardis Lake, MS	340	3.107	1.01
Whitney Lake, TX	344	1.821	1.34

[a]These scaling factors are assigned approximately using Olsen's Table I by selecting the closest value for the reported mean to standard deviation with the incomplete distribution.

[b]These sites were omitted for truncation bias in second estimation of the model.

same site.* Thus, it might be conjectured that the same demand model is not equally well suited to all survey respondents. Such a hypothesis would imply that the parameter estimates would be sensitive to sample composition. That is, deleting individual observations associated with individuals with especially long onsite time or rather different sets of activities may well have a pronounced effect on the ordinary least-squares estimates of the model's parameters. Moreover, this impact may be differentially important to subsets of the sites considered for this analysis because there are substantial differences in the number of respondents for these sites.

To investigate this issue, DFBETA was calculated (Belsley, Kuh, and Welsch's [1980] regression diagnostic). This index was designed to act as an aid in identifying influential or outlying observations. It is not a statistical test. It has been used to judge the "influence" of specific observations on this study's estimates of site demand parameters. With this evaluation, it is then possible to consider the features of these survey respondents to evaluate whether there are economic reasons for expecting that the demand patterns of these individuals must be explained in a different framework. The specific index used is defined as the difference between the ordinary least-squares estimate for each parameter based on the complete sample and the corresponding estimate based on the sample with the omission of one observation. These indexes were calculated for each parameter and each observation. A review of these estimates indicated that no single observation had an important effect on the estimated parameters. This conclusion was found for all sites, including those with a somewhat limited number of sampled recreationists. While this finding does not guarantee that the effects of onsite time and the mix of recreation activities are inconsequential influences on site demand, it does suggest that they are unlikely to have pronounced effects on these estimates.

The final aspect of the travel cost models that requires further consideration stems from the relationship between decisions on the number of trips to each recreation facility and the amount of time spent onsite per trip. As noted previously, the onsite time measure relates to the trip each respondent was undertaking at the time that he was interviewed, but there is no information as to how representative this trip was. That is, the survey does not identify for all visits during the season the amount of time spent onsite per trip. Thus, the analyses of travel and onsite time costs (both the time and the distance components) implicitly assume that the onsite time for the current trip is a good indicator of the onsite time for all past trips.

If this assumption is reasonable, then it is also plausible to consider the prospects for a simultaneous equation model to describe the decisions for visits to a site and the time on the site per trip. When using simultaneous equation models with the Federal Estate Survey data, two aspects of consistency in recreation choices must be considered.

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*The feasibility of including measures of the activities undertaken into the second stage models for the estimated site demand parameters is currently being investigated.

First, individuals may decide the amount of time to be spent onsite--first based on the activities they wish to undertake and then based on the number of visits to a site to engage in these activities. Within this decision framework, onsite time can be treated as exogenously determined. Visits may be conditional upon these onsite time choices. This would not imply that onsite time was not important to decisions on visits to a recreation facility. Rather, it would suggest that they are not joint decisions. Indeed, for some cases it may be necessary to segment the samples of users according to their lengths of stay on the site.*

Secondly, the onsite time may not be constant for all trips, and thus the measure available for per-trip time onsite is inappropriate. These prospective difficulties in evaluating the relationship between visit and onsite time decisions will therefore influence any effort to model their respective roles in recreation site demand functions. Nonetheless, in an attempt to account for these simultaneous equation effects, onsite time has been treated as an endogenous variable, and a variety of specifications have been considered for it as well as for the site demand models themselves. In general, this study has attempted to instrumentalize the measures of the variable costs of onsite time. More specifically, onsite cost is specified as a nonlinear combination of exogenous and endogenous variables as a result of the respective roles for the opportunity cost of time and onsite time.

Following conventional practice (see Kelejian [1971]), the combination is treated as a right-hand-site endogenous variable and the models were estimated with two-stage least squares.† The first-stage instruments were composed of the included predetermined variables in each specification for the travel cost model along with age, sex, and a qualitative variable to reflect whether the recreation activities included camping. Several variations in these instruments were considered. However, this set of variables provided acceptable models for the largest set of site demands. Table 7-10 reports the two-stage estimates for 21 of the sites.‡ As with earlier results (i.e., using ordinary least squares and ignoring onsite time), the role of income appears quite limited for nearly all sites. Only one site demand, Millwood Lake, Arkansas (No. 323) yields a statistically significant estimate for the coefficient of family income. The results for onsite time are encouraging but certainly not clearcut. As suggested by the theoretical model, onsite time (SCOST) affects the "price" of a trip to the site (since the model assumes all trips have the same onsite time), and it also contributes to the production of recreation service flows.

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*Our analysis with regression diagnostics indicated that these problems were unlikely to be present in our models because the results were not sensitive to deleting individual observations.

†Ideally, the Kelejian method calls for polynomials in the predetermined variables as first-stage instruments. This was not attempted in our case because of the limited number of observations for several of the sample recreation sites.

‡The 21 sites are the result of two screenings of the 43 sites in the survey. The first screening eliminates 10 sites with implausible demand functions. The second eliminates 12 sites that experienced truncation bias.

Based on the first of these impacts, it would be expected to have a negative impact on the demand for visits to a site. It is a component of the price of a visit. In addition, however, increases in the time spent onsite provide one means of substituting for visits. Thus, one might hypothesize a positive "substitution" effect on the demand for trips to a recreation site. Of course, the demand model reflects a composite of these two influences.

The empirical results are consistent with the presence of these opposing influences on site demand. For some sites, the effect of SCOST is positive, while, for others, it is negative. Five of the 21 site demands exhibit statistically significant estimates for onsite costs, based on the asymptotic t-ratios. In all of these cases the estimated coefficients are negative.

Table 7-10. Two-Stage Least-Squares Estimates for Selected Travel Cost Site Demand Models

		Estimated travel cost models[a]					
Site Name	Site No.	Intercept	TC+MC	SCOST	INC	AGE	R^2
Beaver Lake, AR	303	1.705	-0.0056	-0.0003	-0.000003	-0.0009	0.42
		(11.45)	(-8.12)	(-2.21)	(-0.61)	(-0.27)	
Benbrook Lake, TX	305	1.999	-0.0052	-0.0001	0.000003	-0.0020	0.31
		(6.05)	(-3.84)	(-0.55)	(0.34)	(-0.29)	
Blakely Mt. Dam, Lake Ouachita, AR	307	1.721	-0.0081	-0.0002	-0.000009	0.0048	0.21
		(3.077)	(-4.57)	(-0.40)	(-0.81)	(0.78)	
Canton Lake, OK	308	1.787	-0.0172	-0.0008	0.000005	0.0043	0.26
		(5.83)	(-2.83)	(-0.80)	(0.47)	(0.58)	
Cordell Hull Dam & Reservoir, TX	310	1.603	-0.0137	-0.0002	0.000003	0.0072	0.35
		(7.58)	(-4.53)	(-0.48)	(0.35)	(1.71)	
DeGray Lake, KY	311	1.587	-0.0083	-0.0004	-0.000002	0.0104	0.21
		(4.51)	(-3.24)	(-1.38)	(-0.21)	(1.44)	
Ft. Randall, Lake Francis Case, SD	313	1.778	-0.0042	-0.0021	0.000009	-0.0087	0.38
		(4.74)	(-2.43)	(-2.28)	(0.79)	(-0.94)	
Grapevine Lake, TX	314	2.154	-0.0053	-0.0001	0.000009	-0.0129	0.50
		(12.73)	(-5.06)	(-2.31)	(1.72)	(-2.91)	
Greers Ferry Lake, AR	315	1.607	-0.0066	0.00002	0.000009	-0.0045	0.28
		(10.60)	(-7.70)	(0.08)	(1.48)	(-1.09)	
Grenada Lake, MS	316	1.551	-0.0073	-0.0016	0.00001	0.0100	0.26
		(5.06)	(-2.86)	(-2.64)	(0.71)	(1.99)	
Hords Creek Lake, TX	317	1.938	-0.0050	-0.0001	-0.00002	-0.0030	0.20
		(5.81)	(-2.06)	(-0.19)	(-1.77)	(-0.36)	
Lake Washington Ship Canal, WA	320	0.505	-0.0038	0.0465	0.00002	-0.0018	0.21
		(0.66)	(-2.40)	(1.07)	(0.78)	(-0.15)	
Leech Lake, MN	321	0.293	-0.0032	0.0004	0.000011	0.0069	0.17
		(0.79)	(-2.33)	(1.26)	(0.95)	(0.93)	
Millwood Lake, AR	323	0.829	-0.0091	0.000009	0.00002	0.0134	0.30
		(2.33)	(-3.88)	(0.02)	(2.54)	(1.88)	
Mississippi River Pool, No. 6, MN	325	1.198	-0.0062	-0.0006	0.00002	0.0070	0.24
		(3.81)	(-3.24)	(-1.66)	(1.95)	(0.97)	
Norfork Lake, AR	330	0.666	-0.0055	-0.0008	0.00001	0.0149	0.20
		(1.65)	(-2.85)	(-0.28)	(0.91)	(1.55)	
Philpott Lake, MN	333	2.209	-0.0074	-0.0007	0.000002	-0.0082	0.47
		(7.21)	(-3.75)	(-1.49)	(0.18)	(-1.07)	
Pokegama Lake, MN	335	1.344	-0.0030	-0.0004	-0.000009	0.0020	0.24
		(3.62)	(-3.54)	(-1.32)	(-0.86)	(0.34)	
Proctor Lake, TX	337	1.783	-0.0149	0.0003	0.000002	0.0049	0.56
		(6.47)	(-5.99)	(0.84)	(0.33)	(1.01)	
Sam Rayburn Dam & Reservoir, TX	339	1.157	-0.0098	-0.0001	0.000002	0.0102	0.17
		(3.38)	(-2.92)	(-0.29)	(0.19)	(2.00)	
Whitney Lake, TX	344	1.527	-0.0027	-0.0009	0.000006	0.0078	0.10
		(8.30)	(-1.44)	(-4.15)	(1.11)	(1.88)	

[a]The numbers in parentheses below the estimated coefficients are asymptotic t-ratios for the null hypothesis of no association.

The remaining sites also were modeled within a simultaneous framework. However, in these cases the parameters estimates were inferior to those derived using ordinary least squares under the assumption of constant onsite time. As a rule, the estimated effect of travel cost (TC+MC) was not statistically significant and, in some cases, suggested a positive effect on site demand. Moreover, the estimated effects of onsite costs were generally statistically insignificant. Thus, the models reported in Table 7-10 are the cases in which the simultaneous estimates were judged to be equivalent or better than the ordinary least-squares results reported in Section 7.5.

These results are important for two reasons. They attempt to deal with onsite time costs and travel costs within a single demand framework. Most authors (see Brown and Mendelsohn [1980] as a notable example) have either attempted to partition their samples according to the time spent onsite and estimate separate demand models for each grouping or have assumed that onsite time was not important to the decisions for trips to a recreation facility. This latter assumption might be the result of features of the recreation activities undertaken and site selected or simply because the time onsite was approximately constant across trips.

Table 7-11. Comparison of Ordinary Least-Squares and Two-Stage Least-Squares Estimates of Travel Cost (TC_i + MC_i) Parameters

Site name	Site No.	Ordinary least-squares estimate	Two-stage least-squares estimate
Beaver Lake, AR	303	-0.0066	-0.0056
Benbrook Lake, TX	305	-0.0054	-0.0052
Blakely Mt. Dam, Lake Ouachita, AR	307	-0.0079	-0.0081
Canton Lake, OK	308	-0.0206	-0.0172
Cordell Hull Dam & Reservoir, TX	310	-0.0139	-0.0137
De Gray Lake, AR	311	-0.0070	-0.0083
Ft. Randall, Lake Francis Case, SD	313	-0.0066	-0.0042
Grapevine Lake, TX	314	-0.0073	-0.0053
Greers Ferry Lake, AR	315	-0.0065	-0.0066
Grenada Lake, MS	316	-0.0095	-0.0073
Hords Creek Lake, TX	317	-0.0050	-0.0050
Lake Washington Ship Canal, WA	320	-0.0037	-0.0038
Leech Lake, MN	321	-0.0022	-0.0032
Millwood Lake, AR	323	-0.0081	-0.0091
Mississippi River Pool No. 6, MN	325	-0.0074	-0.0062
Norfork Lake, AR	330	-0.0047	-0.0055
Philpott Lake, VA	333	-0.0087	-0.0074
Pokegama Lake, MN	335	-0.0033	-0.0030
Proctor Lake, TX	337	-0.0134	-0.0149
Sam Rayburn Dam & Reservoir, TX	339	-0.0094	-0.0098
Whitney Lake, TX	344	-0.0025	-0.0027

Table 7-12. Hausman Test for Differences Between Two-Stage Least-Squares and Ordinary Least-Squares Estimates

Site	$\hat{\alpha}_1^{2SLS}-\hat{\alpha}_1^{OLS}$	$\hat{\alpha}_1^{2SLS}$	$\hat{\alpha}_1^{OLS}$	$VAR_{2SLS}-VAR_{OLS}$	t-statistic
303	-0.0010	0.0000005	0.0000003	0.000447	2.237
305	0.0002	0.0000018	0.0000017	0.000316	0.633
307	-0.0002	0.0000031	0.0000024	0.000837	-0.239
308	0.0034	0.0000368	0.0000152	0.004648	0.731
310	0.0002	0.0000092	0.0000054	0.001949	0.103
311	-0.0013	0.0000066	0.0000054	0.001095	-1.187
313	0.0024	0.0000030	0.0000012	0.001342	1.788
314	0.0020	0.0000011	0.0000007	0.000633	3.160
315	-0.0001	0.0000007	0.0000005	0.000447	-0.224
316	0.0022	0.0000065	0.0000047	0.001342	1.639
317	-0.0000248	0.0000058	0.0000056	0.000447	-0.05
320	-0.0001	0.0000027	0.0000010	0.001304	-0.077
321	-0.0010	0.0000018	0.0000014	0.000633	-1.580
323	-0.0010	0.0000055	0.0000041	0.001183	-0.845
325	0.0012	0.0000037	0.0000028	0.000949	1.264
330	-0.0008	0.0000037	0.0000034	0.000548	-1.460
333	0.0013	0.000003859	0.000003895	NA	NA
335	0.0003	0.0000007	0.0000005	0.000447	0.671
337	-0.0015	0.0000062	0.0000032	0.001732	-0.866
339	-0.0004	0.0000112	0.000011	0.000447	-0.894
344	-0.0002	0.0000034	0.0000019	0.001225	-0.163

Notes:

NA = The t-statistic could not be calculated as the variance since the ordinary least-squares estimate was greater than the two-stage least-squares estimate.

$\hat{\alpha}_1$ = the estimated coefficient of the travel plus mileage cost variable.

VAR = the variance of $\hat{\alpha}_1$.

2SLS = the two-stage least-squares model.

OLS = the ordinary least-squares model.

Of course, this perspective is implicitly adopted for the results in the previous section. Thus, the second potential use of these findings is to gauge how important an error the failure to take account of simultaneity might be for the use of the general models to derive a benefit estimation framework. Table 7-11 reports a comparison of the ordinary least-squares estimates of the travel cost parameter versus the two-stage results for each of the sites where the two-stage least squares were judged to be at least as good as the ordinary least-squares models. Overall the results are quite similar. There are two types of comparisons that can be made between these estimates. As a practical matter, for benefit estimation, the numerical differences between the ordinary least squares and two-stage least-squares estimates are of concern. For the most part, the two sets of estimates for the (TC_i + MC_i) parameter are quite comparable. A second comparison involves considering whether the null hypothesis that the parameters for the travel and time cost variable were equal in the two models would be rejected based on these estimates. It is possible to develop an asymptotic test for this hypothesis using Hausman's [1978] approach to specification tests. Hausman derives an expression for the variance of the difference between two estimators of the same parameter. These estimators are defined for two hypotheses. It must be assumed that one is a consistent estimator under both the null and alternative hypotheses and that the second estimator is asymptotically efficient under the null but inconsistent under the alternative hypothesis. Given asymptotic normality and these assumptions, the variance of the difference between the estimators is the difference in their respective variances. This application considers the difference between the two-stage least-squares and ordinary least-squares estimates of the coefficient for the travel cost variable. Constructing the corresponding t-ratio gives the following:

$$t = \frac{\hat{\alpha}_1^{2SLS} - \hat{\alpha}_1^{OLS}}{\sqrt{VAR(\hat{\alpha}_1^{2SLS}) - VAR(\hat{\alpha}_1^{OLS})}} . \tag{7.33}$$

Table 7-12 reports the details of the calculation of these test statistics. The t-ratio will follow an asymptotically normal distribution. Considering these statistics as an approximate basis for testing the difference between these coefficient estimates gives only two cases (Sites 303 and 314) in which the null hypothesis of equality would be rejected at the 5-percent significance level. Thus, these findings largely confirm the informal judgmental inspection and indicate that the ordinary least-squares models, which assume onsite costs to be constant, are unlikely to have serious errors because of this assumption.

7.7 ANALYZING THE ROLE OF WATER QUALITY FOR RECREATION DEMAND

The last step in the empirical modeling involves estimating the role of water quality and other site attributes in the demands for a site's services. The structure of the model has been detailed in Section 7.3. Thus, what remains to be presented is a specific description of the results of the application. The overall objective is to attempt to explain the observed variation in

each of the estimated demand parameters across sites by the characteristics of those sites. With such a model, it is possible, in principle, to characterize the change in a site's demand in response to a change in any of the factors influencing those demand parameters. Thus, it would be feasible to evaluate the implications of a change in water quality for the demand for the site's services, even though the change has not been experienced. This ability arises from the fact that this model provides a general description of the factors that influence the features of site demands within a single framework.

The model has been derived from two subsets of the 43 site demand models described in Section 7.5 above. The first of these included 33 sites with plausible site demand functions.* The second restricts the sample further by eliminating 11 of these sites, based on estimates of the Olsen scaling factors reported in Table 7-9. As noted earlier, these scaling factors provide some indication of the prospects for bias due to the truncation in the measures of site usage. These 11 sites exhibited the largest values of the estimated scaling factor, ranging from 5.33 to 13.55. The specific sites eliminated from the sample are footnoted in Table 7-9 on page 7-45.

To develop estimates of the influence of site characteristics on the parameters describing a site's demand function, the attributes involved must be identified. As indicated in Section 7.4, the information on the site characteristics was obtained from U.S. Army Corps of Engineers. These data were augmented with information on water quality from the U.S. Geological Survey. As a rule, the Corps of Engineers data were measures of the size of the area and types of equipment available. The water quality information consisted of monthly readings from June through September of the year of the survey for seven measures of water quality, including dissolved oxygen, fecal coliform density, pH, biochemical oxygen demand, phosphates, turbidity, and total suspended solids. Two water quality indexes were also developed from these data for each month--the RFF water quality index (see Vaughan in Mitchell and Carson [1981]) and the NSF index. Since the specific features of these indexes were described in Section 7.4, their definitions will not be repeated here. Table 7-13 summarizes the primary site characteristics considered from the Corps of Engineers data.

Unfortunately, there are few a priori insights one can derive from economic theory regarding which subset of these variables is most likely to influence the estimated parameters of site demand models. While the primary focus was on the water quality measures, the analysis considered a number of alternative specifications, including subsets of the site characteristics reported in Table 7-13. The variables with the most consistent association with the demand parameters over the specifications considered included a measure of the size of the site (i.e., SHORMILE), its access points (i.e., MULTI + ACCESS), and the size of the water body relative to the overall site size (i.e., AREAP/AREAT). This selection does not seem particularly surprising. Each variable can be interpreted as a crude measure of the capacity of the

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*Appendix F presents the benefit estimates if all 33 sites are used in the model.

Table 7-13. Description of U.S. Army Corps of Engineers Data on Site Characteristics

Variable name	Description
SHORMILE	Total shoreline miles at the site during peak visitation period
AREAT	Total site area, land and water in acres
AREAP	Pool surface acreage on fee and easement lands during peak visitation period
MULTI	Number of developed, multipurpose recreation areas onsite
ACCESS	Number of developed onsite access areas
CORPICK	Number of Corps-managed onsite picnic locations
OTH PICK	Number of other agency-managed onsite picnic locations
CORCMPD	Number of Corps-managed developed camp sites
OTH CMPD	Number of other agency-managed developed camp sites
CORLN	Number of Corps-managed onsite boat launching lanes
OTH LN	Number of other agency-managed onsite boat launching lanes
DOCK PR	Number of onsite private boat docks
DOCKCO	Number of onsite community docks
FLOAT	Number of onsite floating facilities (e.g., water ski jump, swimming floats, fishing floats, etc.)

site to provide services that would support different types of recreation service flows.

It was more difficult to isolate measures of water quality that appeared to influence the estimated site demand parameters. While the final generalized least-squares estimates for the determinants of site demand parameters seem exceptionally good, there are a number of reasons for caution in interpreting these findings, as shown by a review of the approaches used to develop them.

The modeling of the role of water quality considered a wide array of potential specifications of its effects, including each of the following:

- The monthly and average (across the 4 months of the summer season) readings for the two water quality indexes and measures of the variation in the index over the 4 months were considered.

- The monthly and average readings for specific components of the index (i.e., dissolved oxygen, total suspended solids, etc.) were considered individually and in sets using existing information, where possible, to avoid the joint presence variables that might be measuring common phenomena.

- Temporal effects of individual pollutants were considered in an attempt to isolate "best" or most relevant indexes of water quality.

With a few notable exceptions these results led to either insignificant or unstable estimates of the effects of water quality on the site demand parameters.

Only in the case of dissolved oxygen did this pretesting of model specifications lead to a stable and statistically significant association between the variation in the estimated site demand parameters and the mean and variance in the level of dissolved oxygen over the summer period. This association is more clearcut with the smallest samples. Clearly, these findings are consistent with the earlier Vaughan-Russell [1981] and Nielsen [1980] analyses supporting the use of dissolved oxygen as an ideal measure of water quality for evaluating recreation fishing. Nonetheless, it should be acknowledged that the missing data problem is especially important for this study's water quality variables (see Section 7.4 above). The procedure has been to use the sample mean for those sites with missing water quality information. Thus, a smaller number of actual readings on water quality are what should be regarded as the basis of the measured association between water quality and the estimated site demand parameters. This does not imply that the use of means was inappropriate. Rather, it indicates that there was little observed variation in any of the water quality variables to associate with the estimated demand parameters.*

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*The indexes of water quality (i.e., the RFF and NSF) tend to reduce the variation present in their components. Thus, there was very little variation in these indexes across sites.

Approximately half of the 22 sites in the restricted sample had complete water quality information. Thus, the preference for the dissolved oxygen measure might well be altered with more complete water quality data.

Table 7-14 reports the generalized least-squares estimates for the final model with both samples.* The parameters, α_0, α_1, and α_3, correspond to the general model specifications as given in Equation (7.31). These results clearly favor the model based on the restricted sample. Increases in the average level of dissolved oxygen would be improvements in water quality. The results using this restricted sample indicate that such increases would increase the demand at all implicit prices (i.e., travel costs) and would also increase the degree of inelasticity in the demand curve. This second effect simply reflects the site's ability to support a wider range of recreation activities with the improved water quality.

Given the poor performance of income as a determinant of the demand for any one of the site's services, it is not surprising that the second step model for the income parameter is incapable of explaining the variation in the site demand parameters.

The most striking difference between the results estimated with the two samples arises with the estimated coefficients for the travel cost variable. The estimated effects of the site attributes, including the water quality measures, are all significantly different from zero and generally consistent in sign with a priori expectations. The differences between the two samples would seem to provide indirect evidence of the importance of truncation effects on the travel cost site demand models.

These generalized least-squares results do not include R^2 measures of goodness of fit because the coventional R^2 statistic is no longer confined to the 0 to 1 interval when calculated based on the generalized least-squares residuals. Thus, it does not have the same interpretation as the R^2 statistics reported with the ordinary least-squares results (see Cicchetti and Smith [1976] Appendix B for more details).

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*See Section 7.3 for a detailed discussion of the construction of the generalized least-squares estimator. It should be noted that Vaughan and Russell [1981] have used a similar methodology in their valuation of recreation fishing days. However, their approach combined the two equations by substituting the second step model for the determinants of site demand parameters (Equation 7.22) into Equation (7.21) to derive:

$$Y_i = X_i \theta A_i + \varepsilon_i \ .$$

This model includes interaction terms in the determinants of site demands and site attributes. It provides an equivalent description of the two-step approach used in this study. However, there is one advantage to the two-step approach in specification analysis of the models. It allows the specification of the determinants of site demand to be treated separately from the determinants of variations in site demand parameters. Each specification for the combined model includes assumptions about both.

Table 7-14. Generalized Least-Squares Estimates of Determinants of Site Demand Parameters[a]

Independent variable	$\hat{\alpha}_0$		$\hat{\alpha}_1$		$\hat{\alpha}_3$	
	33 site	22 site	33 site	22 site	33 site	22 site
Intercept	1.2959 (3.768)	1.5106 (4.081)	0.0005 (0.203)	-0.0246 (-9.480)	0.53×10^{-5} (0.330)	0.54×10^{-5} (0.308)
SHORMILE	-0.0003 (-1.304)	0.0003 (1.250)	0.47×10^{-6} (0.256)	-0.13×10^{-4} (-6.763)	-0.14×10^{-7} (-1.408)	0.97×10^{-9} (0.089)
(MULTI + ACCESS)	0.0017 (0.464)	-0.0059 (-1.502)	-0.41×10^{-4} (-1.586)	0.77×10^{-4} (2.810)	0.22×10^{-6} (1.299)	0.47×10^{-6} (2.562)
AREAP/AREAT	-0.1686 (-1.116)	-0.3950 (-1.752)	-0.0025 (-2.190)	0.0033 (2.273)	0.10×10^{-4} (1.423)	-0.19×10^{-5} (-0.181)
Mean dissolved oxygen	0.0049 (1.220)	0.0045 (1.065)	-4.2×10^{-4} (-1.514)	0.0002 (5.992)	-0.12×10^{-6} (-0.642)	-0.12×10^{-6} (-0.604)
Variance in dissolved oxygen	0.0003 (1.131)	0.0005 (1.862)	-0.17×10^{-5} (-0.751)	0.98×10^{-5} (4.077)	-0.73×10^{-8} (-0.617)	0.94×10^{-10} (0.007)

[a]The numbers in parentheses below the estimated coefficients are the asymptotic t-ratios for the null hypothesis of no association.

7.8 A MEASURE OF THE BENEFITS OF A WATER QUALITY CHANGE

The objective of the analysis of recreation behavior has been to develop a model capable of measuring the benefits associated with improving the water quality for any site that provides water-based recreation activities. Given information on the site characteristics found to be important determinants of site demand, it is possible to use the model for each demand parameter to estimate a "representative individual's" demand function for the desired water-based facility. Consequently, this section reports the results of such an application using information on the 13 sites along the Monongahela River that were used by the contingent valuation survey respondents.

Table 7-15 provides a description of these sites and their attributes. The model estimates the representative individual's demand for each site's services. Because the survey asked each respondent about his use of the river, including an identification of the site (or sites) used, it is possible to develop an estimate of these demand functions for each site. Moreover, because the model includes water quality information, the change in these demands can be estimated to accompany each of the water quality changes used in the survey instrument. In Chapter 8, this information provides the basis for a comparison of direct and indirect methods for measuring the

Table 7-15. Recreation Sites on the Monongahela River

Site name	Identification number	SHORMILE	MULTI + ACCESS	AREAP/ AREAT
Pittsburgh area	15	2	1	0.99
The confluence of the Youghiogheny and Monongahela Rivers	16	2	2	0.99
Elrama	17	2	2	0.99
Town of Monongahela	18	3	4	0.99
Donora and Webster	19	2	1	0.99
Near Charleroi	20	3	4	0.96
California and Brownsville	21	12	6	0.96
Maxwell Lock and Dam	23	2	7	0.93
Point Marion	25	2	1	0.99
Morgantown	26	4	2	0.77
Fairmont	29	3	1	0.67
9th Street Bridge	37	1	1	0.99
Cooper's Rock	44	2	1	0.99

SOURCE: U.S. Army Corps of Engineers Resource Management System.

benefits from a water quality improvement. The direct methods correspond to the results from the survey, while the indirect methods use the information on the survey respondents' recreation behavior together with the generalized travel cost model developed in this chapter.

Seventy-five of the survey respondents were users of 1 or more of the 13 sites along this section of the Monongahela River. Because several individuals used more than one site, there are a total of 94 observations identified as an individual/site combination. These data provide the basis for constructing 94 separate demand models to evaluate the implications of water quality changes as measured by dissolved oxygen. For example, the model implied that the estimated price elasticities of demand (at the average travel costs for users in the survey used for the contingent valuation experiment) for the 13 recreation sites along the Monongahela River--the area for the contingent valuation survey--ranged from -0.069 to -0.075 at current water quality levels. Improving the water quality to permit game fishing would imply a change in DO from 45 to 64 (percent saturation). These changes reduce the absolute magnitude of the estimated demand elasticities to -0.052 to -0.059.

The benefits from a water quality improvement are measured by the increment to the ordinary consumer surplus experienced by each individual.* This increment can be defined for each individual user as follows:

$$B_{jk} = \int_{P_{jk}}^{P^*_{jk}} F_{jk}(p, WQ^*)dp - \int_{P_{jk}}^{P^*_{jk}} F_{jk}(p, WQ)\, dp \qquad (7.34)$$

where:

P_{jk} = travel cost (mileage plus travel time) experienced by the jth user to kth site

P^*_{jk} = maximum price the jth user would be willing to pay for the kth site's services (i.e. where the quantity demanded is zero)

WQ^* = improved water quality level

WQ = initial water quality level (i.e., $WQ^* > WQ$)

$F_{jk}(.)$ = demand function for the kth site's services by the jth user.

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*The measurement of the benefits from water quality improvement has ignored the potential for congestion effects. It has been assumed that congestion is negligible both before and after the change in water quality. Without this assumption, the implications of management practices would need to be considered in the definition of the benefit measure (see McConnell and Sutinen [1983]).

Implementation of this benefit estimator required several amendments. The specification of the site demand functions in semilog terms implies that they will not have a price intercept. Rather, they asymptotically approach the horizontal (price) axis. To estimate a finite consumer surplus, a maximum for the price, P^*_{jk}, was selected to correspond to the maximum travel cost paid by any of the survey users of any Monongahela site. The specific value was $22.65 for a roundtrip, including both the mileage and time costs of travel.* This modification implies the benefit estimates for the water quality improvement will be ABCD as given in Figure 7-1, with P_j corresponding to the jth user's travel costs and P* the maximum value for the travel cost.

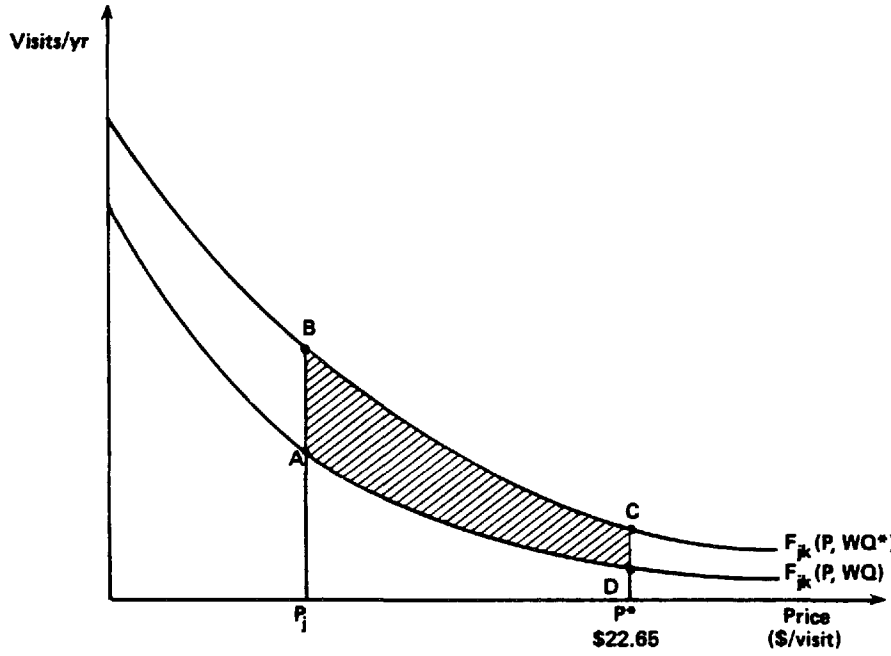

Figure 7-1. Measurement of consumer surplus increment due to water quality improvement (WQ to WQ*).

Table 7-16 details the dissolved oxygen levels associated with each of three use designations (see Vaughan in Mitchell and Carson [1981]) employed in the calculations rather than the actual water quality levels for the sites along the river. The reason for this approach follows from the key project objective--to compare benefit estimates based on the travel cost models with those based on the survey responses. All survey respondents were told that the water quality was consistent with boatable conditions. Thus, the corresponding value for dissolved oxygen was used as the base value for the estimates. Because the model requires a mean level of dissolved oxygen for the

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*This maximum travel cost is generally smaller than the maximum travel costs experienced by the Federal Estate Survey respondents used to estimate the generalized travel cost model. Indeed, it is less than the majority of the sample means of the FES travel costs (see Table 7-3).

Table 7-16. Dissolved Oxygen Levels for Recreation Activities[a]

Use designation	Assumed level of dissolved oxygen required
Boatable water conditions	45
Fishable water conditions	64
Swimmable water conditions	83

[a]These estimates for dissolved oxygen are based on Vaughan in Mitchell and Carson [1981].

summer recreation season, the means were assumed to correpond to each of the levels given in Table 7-16. The variance in monthly levels of dissolved oxygen was set at the sample mean for the sites used to estimate the model--8.187--and was assumed to be unaffected by water quality changes.

Table 7-17 presents the mean values for the incremental benefits associated with three types of changes in water quality conditions:

- An assumed deterioration in water quality making it unavailable for boating or other recreation activities.
- An improvement in water quality from boatable conditions to fishable conditions.
- An improvement in water quality from boatable conditions to swimmable conditions.

All three of these changes were assumed to take place at all 13 of the Monongahela sites. The first was treated as the equivalent of losing the use of the recreation site completely. The benefit loss was measured as the consumer surplus associated with the site under boatable conditions--P_jADP^* in Figure 7-1.

The remaining two scenarios correspond to different levels of the new demand functions for the water quality associated with fishable and swimmable conditions. Table 7-17 presents the mean consumer surplus increment for each of the three changes for our 94 user-site combinations. It also reports the range of values for the increment to consumer surplus. The mean benefits correspond to the increase in an "average" individual's willingness to pay over the recreation season. The average user in the survey used one or more Monongahela sites 7.22 times. Thus, the loss of the site completely translates to a loss of $7.39 per unit in 1977 dollars, or $11.46 in 1981 dollars, the date of the contingent valuation survey.*

*This adjustment used the consumer price index (CPI) for all commodities. Using a 1967 base, the 1977 CPI for all items was 181.5. In 1981 it closed the year at 281.5. See Economic Report of the President 1982, Council of Economic Advisors [1982].

Table 7-17. Mean and Range of Benefit Estimates for Water Quality Scenarios[a]

Water quality change	Mean[b]	Minimum value	Maximum value
Scenario (1) Loss of use of site under boatable conditions	$53.35 (7.39)	$0.00	$70.80
Scenario (2) Improvement of water quality from boatable to fishable conditions	$4.52 (0.63)	$0.00	$8.60
Scenario (3) Improvement of water quality from boatable to swimmable conditions	$9.49 (1.31)	$0.00	$18.30

[a]These calculations are in 1977 dollars, the year of the Federal Estate Survey.

[b]The numbers in parentheses below the overall increment report the corresponding consumer surplus increment on a per visit basis.

Because these benefits estimates are available for each of the 94 user/site combinations, the estimates in several classifications were also tabulated--by size of family income reported by the respondents and by the magnitude of their travel costs. The results for the consumer surplus loss due to loss of the use of the river for boating are given in Tables 7-18 and 7-19. The results for each of the two increments to water quality compared with income are given in Tables 7-20 and 7-21. It should be noted that the income levels are in 1981 dollars while the consumer surplus increment is in 1977 dollars. Scaling the latter by 1.55 will convert them to equivalent dollars. Since it was a simple multiple of the estimates and would not change the distributions, they were not converted for these tables.

These results indicate that it is possible to use a generalized form of the travel cost model to estimate the benefits from a water quality change. By using the recreation use patterns for a number of sites, it was possible to develop a general model that, in principle, is capable of being used to estimate the recreation benefits associated with water quality changes at any site providing similar water-based recreation activities.

Table 7-18. Consumer Surplus Loss Due to Loss of Use of the Monongahela River by Survey Users' Income

Income (1981 dollars)	Consumers surplus loss (1977 dollars)[a]								
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	Total
0-5,000	--	--	1	2	--	4	3	--	10
5,000-10,000	--	--	--	--	--	2	7	2	11
10,000-15,000	--	--	--	--	--	2	6	--	8
15,000-20,000	--	1	1	2	--	3	11	--	18
20,000-25,000	1	1	1	--	1	1	1	--	6
25,000-30,000	1	--	2	2	3	8	6	--	22
30,000-35,000	--	--	--	3	--	2	2	--	7
35,000-40,000	--	--	--	--	--	2	1	--	3
40,000-45,000	--	--	--	1	1	--	1	--	3
45,000-50,000	--	--	--	--	--	3	1	--	4
50,000 and above	--	--	--	--	--	2	--	--	2
Total	2	2	5	10	5	29	39	2	94

[a]To convert to 1981 dollars multiply the endpoints of the benefit scale by 1.55.

Table 7-19. Consumer Surplus Loss Due to Loss of Use of the Monongahela River by Survey Users' Travel Cost

Travel cost (1977 dollars)	Consumer surplus loss (1977 dollars)								
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	Total
0-5	-	-	-	-	-	19	39	2	60
5-10	-	-	-	2	5	10	-	-	17
10-15	-	-	4	8	-	-	-	-	12
15-20	-	2	1	-	-	-	-	-	3
20-25	2	-	-	-	-	-	-	-	2
Total	2	2	5	10	5	29	39	2	94

Table 7-20. Consumer Surplus Increments Due to Water Quality Improvement--Boatable to Fishable by Survey Users' Income

Income (1981 dollars)	Consumer surplus increment (1977 dollars)[a]				
	0-10	10-20	20-30	30-40	Total
0-5,000	-	-	3	7	10
5,000-10,000	-	-	-	11	11
10,000-15,000	-	-	-	8	8
15,000-20,000	-	2	16	-	18
20,000-25,000	1	2	3	-	6
25,000-30,000	1	3	18	-	22
30,000-35,000	-	4	3	-	7
35,000-40,000	-	3	-	-	3
40,000-45,000	-	3	-	-	3
45,000-50,000	-	4	-	-	4
50,000 and above	2	-	-	-	2
Total	4	21	43	26	94

[a]To convert to 1981 dollars multiply the endpoints of the benefit scale by 1.55.

Table 7-21. Consumer Surplus Increment Due to Water Quality Improvement--Boatable to Swimmable by Survey Users' Income

Income (1981 dollars)	Consumer surplus increment (1977 dollars)[a]							
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	Total
0-5,000	-	-	-	1	1	2	6	10
5,000-10,000	-	-	-	-	-	2	9	11
10,000-15,000	-	-	-	-	-	8	-	8
15,000-20,000	-	-	1	3	6	8	-	18
20,000-25,000	1	-	2	1	2	-	-	6
25,000-30,000	-	1	3	18	-	-	-	22
30,000-35,000	-	-	3	4	-	-	-	7
35,000-40,000	-	-	3	-	-	-	-	3
40,000-45,000	-	-	3	-	-	-	-	3
45,000-50,000	-	4	-	-	-	-	-	4
50,000 and above	2	-	-	-	-	-	-	2
Total	3	5	15	27	9	20	15	94

[a]To convert to 1981 dollars, multiply the endpoints of the benefit scale by 1.55.

7.9 SUMMARY

The findings from the application of the travel cost approach are of equal, if not greater, importance. The research in this project developed a generalized travel cost model that predicts the recreation benefits of water quality improvements at a recreation site. Estimating the benefits for users of the Monongahela River, the travel cost model predicted benefits of $83 per year for a user if a decrease in water quality is avoided. Water quality improvements to swimmable water in the Monongahela were estimated at $15 per year (in 1981 dollars).

Two features of the generalized travel cost model are of particular importance. The model can be applied to predict the value of water quality improvements for a substantial range of sites, and it is especially relevant for a large number of water quality standards applications. Including the effect of key site features in addition to water quality--like access and facilities--and relying on data frequently available in the public domain makes the model a viable tool for future benefits applications.

CHAPTER 8

A COMPARISON OF THE ALTERNATIVE APPROACHES FOR ESTIMATING RECREATION AND RELATED BENEFITS

8.1 INTRODUCTION

One of the primary objectives of this research has been to compare available methods for measuring benefits of water quality improvement. Of course, the "true" value of benefits associated with a specific increment of water quality can never be known, and a comparison of measurement methods cannot be interpreted as a validation of any one of them. Nonetheless, it is important to recognize that contingent valuation methods for estimating the benefits of environmental quality improvements are viewed with considerable skepticism by many (if not most) economists. Presumably, these economists assume that individuals will experience difficulty in responding to valuation questions for nonpriced goods and that their responses will exhibit significant strategic bias. By contrast, indirect methods have been more favorably regarded by most economists, and this study's use of benefit estimates derived from one indirect method--the travel cost recreation demand model--as a benchmark for the contingent valuation estimates reflects this perspective. Of course, it should be recognized that indirect and direct benefits measurement approaches can be distinguished according to the assumptions each makes and that a comparison of them reflects in part the plausibility of their assumptions as descriptions of real-world behavior and constraints.

To aid in the interpretation of the comparisons of benefit estimation approaches, this chapter highlights the specific features of the approaches and how they are applied in this study. The Monongahela River case study provides the basis for the evaluation of the approaches. The types of possible evaluations are bounded by its scope. More specifically, Section 8.2 of this chapter introduces the conceptual basis for a comparative evaluation of benefit estimation approaches. Following this discussion, Section 8.2 also relates the evaluation scheme used in this chapter to that used in earlier comparisons, including those of Knetsch and Davis [1966], Bishop and Heberlein [1979], and Brookshire et al. [1982]. Section 8.3 discusses the results of the comparison of approaches, including the findings of a numerical comparison of the mean estimates of the user and intrinsic components of benefits for specific water quality changes by methodology. This discussion is followed by pairwise comparisons of the contingent valuation and travel cost methods and of the contingent valuation and contingent ranking methods. Finally, Section 8.4 summarizes the findings and discusses their implications for the practical use of benefit measurement approaches.

8.2 THE CONCEPTUAL FRAMEWORK FOR A COMPARISON OF RECREATION BENEFIT ESTIMATION APPROACHES

8.2.1 Background

Improvements in water quality associated with water bodies that support recreation activities can lead to both user and intrinsic nonuse benefits. User benefits arise because water quality can be expected to affect the types of recreation activities at the site experiencing the changes. Individuals who wish to participate in activities made possible by the improvement will be able to, thus enhancing their levels of economic well-being. User benefit estimates of water quality improvements attempt to measure the magnitude of these changes in well-being. Intrinsic benefits, on the other hand, arise either because individuals are uncertain of their potential use of a site or because they experience enhanced utility merely from knowing of improved site conditions. The first recognition of the importance of intrinsic benefits has most often been associated with Krutilla's [1967] discussion of the rationale for public involvement in the management of natural environments. Intrinsic benefits have been identified under a variety of classification schemes to include option and existence values.

Because preceding chapters have presented detailed discussions of both user and intrinsic benefits, the definitions of each are not repeated here. Rather, this chapter considers the relationship between benefit estimation approaches and the two benefit classes. This relationship is important because it affects the types of comparisons that can be undertaken across approaches.

The measurement of the economic benefits of water quality improvement requires a mechanism for linking the water quality change to a consistent measure of benefits. As noted in Chapter 2, this linkage provides one basis for classifying methods used to measure benefits of a change in any environmental amenity not exchanged in an organized market. While Chapter 2 identifies several types of assumptions that provide these links, two classes of assumptions are especially relevant to the approaches considered in this project for benefit measurement.

The first relevant class of assumptions involves the use of the technical association between water quality and recreation site services. Use of a water body's recreation services involves a corresponding (and, indeed, simultaneous) use of the water quality at the site. Thus, the types of activities that can be undertaken at a particular site are affected by the site's water quality (a point explicitly made throughout the analysis in Chapters 4 through 7). Given both a behavioral model to describe how individuals allocate their resources and exogenous measures of their use of recreation sites with differing levels of water quality, this approach maintains that it may be possible to estimate individuals' willingness to pay for water quality indirectly. This recognition is, of course, the basis for the approach used in the generalized travel cost model developed in Chapter 7.* However, more important for comparing measurement approaches

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*This model assumes that each set of users for each of the sites included in our sample from the Federal Estate Survey acts as the "representative" individual would under the circumstances defined by the site's availability and the survey respondent's economic characteristics.

is that this approach--using "indirect" technical linkages between water quality and recreation site services--only measures user values.

The second relevant class of assumptions, identified in Chapter 2 as institutional assumptions, explicitly recognizes that ideal markets would provide the benefit measures required for any good or service, providing the good could be exchanged in them. However, attempts to estimate the valuation of such environmental amenities as water quality face difficulties because ideal markets are not available. Thus, the contingent valuation approach--using "direct" institutional linkages--assumes that, if individuals are confronted with a hypothetical market (in the form a survey questionnaire) for these amenities, their responses will measure their true valuation of the resources (or amenities) involved. Thus, the contingent valuation approach assumes it is possible to mimic the outcomes of ideal markets by completely describing the conditions of exchange in a hypothetical market for the service to be valued. As a result, these methods assume that an individual's responses to the conditions presented in this hypothetical market will be equivalent to the actual responses that would be made if the exchanges took place in actual markets. Since the market is simply an institution, a hypothetical market can be defined to suit any particular nonmarketed service and does not require that it actually be feasible to exchange the services described. Thus, contingent valuation methods can measure both user and intrinsic benefits.

In comparing the two classes of assumptions and the approaches for benefit measurement arising from them, it is important not to confuse the flexibility of the approaches using institutional restrictions with judgments that these approaches require less stringent assumptions.* Alternative approaches require different assumptions. Therefore, appraisals of the severity of one approach's assumptions relative to another's should be regarded as individual judgments, not necessarily as objective comparisons.

8.2.2 Research Design and Comparative Analysis

The research design of this project permits several types of comparisons. Chapters reporting each approach's estimates have discussed the first type--those within a benefit estimation framework. For example, the contingent valuation survey was designed to consider five different approaches for eliciting an individual's valuation of water quality changes. In four of these approaches, only the valuation question differed:

- A direction question
- A question using a payment card

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*The classification scheme for benefit estimation methods given by Schulze, d'Arge, and Brookshire [1981], pp. 154-155, is somewhat misleading in that it implies the contingent valuation approach has the least a priori assumptions. While this is true as a description of the assumptions concerning constraints to actual behavior, it ignores the implicit assumption that responses to hypothetical institutions will provide a good guide to the responses made to the actual institutional arrangements implied by their "constructed" markets.

- The conventional iterative bidding framework with a $25 starting point

- The conventional iterative bidding framework with a $125 starting point.

Each questioning format was applied to an approximately equal proportion of the sample and provides independent estimates of an individual's valuation of the specified water quality changes. Because the design of the questions elicited the individual's option price and user values, comparisons of these questioning formats were undertaken for the estimates of option price, user value, and option value with the results described in detail in Chapters 4 and 5.

This chapter focuses on comparisons between benefit estimates across methodologies--e.g., travel cost vs. contingent valuation. These comparisons will also involve the effect of question format, but the effect of format may differ from the within methodologies comparison because the standards for the comparisons are different. Equally important, the comparisons across methods cannot consider each method's performance in measuring combined user plus intrinsic benefit (i.e., option price) as well as their separate estimates (e.g., in form of option value). The travel cost method measures only user value, and the contingent ranking only a composite of the two.

The specific details of the within method comparison involved two types of evaluations:

- Statistical tests for the differences in means between all pairs of question formats for the full sample and for users and non-users of the Monongahela River.

- Multivariate regression analysis, including dummy variables for the question formats along with other prospective determinants of the relevant dependent variables.

The option price results exhibit the most differences among question formats, with some evidence of a starting point bias. The regression models also exhibit the most cases of significant effects for the question format variables in this case. This finding contrasts with several (but not all) of the past contingent valuation studies.* With the option value estimates there is also some evidence of starting point bias, but these findings are not as pronounced as in the analysis of the option price estimates. These differences are not necessarily surprising since only the first stage of the individual's response (i.e., the option price) had distinct questioning formats. Thereafter, the questions calling for separation of the option price into components (i.e., user values) were (by practical necessity) direct questions.

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*The Schulze, d'Arge, and Brookshire [1981] summary concludes, based on an analysis of several contingent valuation experiments, that starting point bias is not a serious problem. Our results do not conform to this conclusion and indicate that the prescreening of data used to eliminate inconsistent observations may affect their conclusions. Of course, it should also be emphasized that our results relate only to a single experiment.

Finally, the results are quite sensitive to the screening of observations judged to be refusal to participate in, or inconsistent with, the contingent valuation framework. As noted in Chapter 4, while procedures used to identify these observations are based on a statistical index of the influence of each individual observation (and are therefore capable of replication), the effects of specific socioeconomic characteristics of the survey respondents cannot be distinguished from the question format (see Table 4-8 in Chapter 4). Thus, the results for starting point bias and for other pairs of question formats (iterative bidding with $125 starting point) would have been more pronounced with the inclusion of the observations judged to be inconsistent with the contingent valuation framework.

Comparisons across approaches are limited because the methods do not uniformly measure the same components of the benefits associated with a water quality improvement. As we noted earlier, the contingent valuation method design measures both user and intrinsic benefits and permits these estimates to be separated. By contrast, the travel cost and contingent ranking methods are more limited. The travel cost approach measures only user values (i.e. ordinary consumer surplus). The contingent ranking design measures option price but does not divide the estimates into the user value and option value. Therefore, comparisons here are limited to examining the relationship between the user value estimates of the contingent valuation and travel cost approaches and the option price estimates for contingent valuation and contingent ranking.*

The comparison of the estimated user values derived using the contingent valuation approach (with all four question formats) and the consumer surplus estimates derived from the generalized travel cost model is the most interesting comparison. It provides an extension to the recent work of Brookshire et al. [1982] for the valuation of air quality using hedonic property value and contingent valuation methods.

Using a subset of the survey respondents who visited specific Monongahela River sites to derive consumer surplus estimates from the generalized travel cost model (presented in Chapter 7) allowed a matching of each respondent's expressed user value for a comparable water quality change with the values predicted from the travel cost model. This comparison of the travel cost and contingent valuation methods can be made for each user in this survey, in contrast to the Brookshire et al. [1982] analysis.† Thus, both the mean estimates derived from the two approaches and the association in the estimates can be compared across individual users.

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*For the sake of simplicity in the use of terms in this chapter contingent valuation is used to refer to the four question formats in the contingent valuation survey. While contingent ranking is a subset of contingent valuation (and this distinction was made in Chapter 1), the easier terminology of contingent ranking vs. contingent valuation is used in this comparison chapter.

†This is one of the aspects of our extension over this work. A second involves replacing the broad bounds for contingent valuation estimates with a potentially more restrictive upper threshold.

Several features limit the ability to compare the estimates derived from the travel cost and contingent valuation methods. The simplest of these features is different dollar values in each method because the travel cost model was developed with 1977 dollars and the contingent valuation estimates was developed with 1981 dollars. Using the consumer price index, an adjustment can approximately account for this difference. A more important reason for differences stems from what is being measured. The user values derived using contingent valuation methods estimate an individual's expected willingness to pay or compensating surplus (for improvements in water quality), while the generalized travel cost model estimates ordinary consumer surplus. A long literature on the theoretical foundations of consumer surplus estimates has suggested that there are good reasons why these two measures should diverge.* However, for price (Willig [1976]) and quantity (Randall and Stoll [1980]) changes, the difference between the two measures can be bounded under specific conditions (see Chapter 2 for a brief review).

At first, the comparison of welfare measures in this project might seem to involve a case that falls outside the scope of the bounds, because it involves a change in water quality rather than a price or quantity change. Fortunately, this conclusion is premature. One of the assumptions used to develop the generalized travel cost model--that water quality augments the effect of a recreation site's services in the production of recreation activities (see Equations (7.11) and (7.12) in Chapter 7)--implies that a water quality change can be translated into an equivalent change in either the quantity of a site's services or in the "effective" price of using the site (see Equations (7.12) and (7.13), respectively).† Therefore, for changes in water quality

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*See Just, Hueth, and Schmitz [1982] for further discussion.

†In general terms the consumer surplus increment due to a water quality change, w, with a demand function Q = F(P,w) (P = price, Q = quantity) is given as

$$CS_i = \int_{P_i}^{P^*} F(p_i, w_2)dp - \int_{P_i}^{P^*} F(p_i, w_1)dp \quad ,$$

where

CS_i = consumer surplus for individual facing price P_i

P^* = price at which the quantity demanded would be zero

w_2 = improved level of water quality

w_1 = existing level of water quality.

The form of the household production technology assumed in the development of our travel cost model implies that a change in water quality can be considered equivalent to a change in the quantity of or price of a site's services. This implies that the change from w_1 to w_2 can be treated as equivalent to some change in the price of a site's services from $P(w_1)$ to $P(w_2)$.

that translate into relatively small price (quantity) changes, the Willig (Randall and Stoll) bounds can be applied to judge the relationship between Marshallian consumer surplus and the willingness to pay for a water quality change.

From a practical perspective, one might assume that the discrepancies between the Marshallian consumer surplus and the willingness to pay for a water quality change associated with recreation water sites would be small. Most households' expenditures on water-based recreation activities would be a very small fraction of their income. This judgment is also supported by the estimated travel cost demands developed for this study in that they imply income is not a significant determinant of the demand for the services of water-based sites comparable to sites on the Monongahela River. Thus, the difference between the willingness to pay and the consumer surplus for a comparable change in water quality can be expected to be less than 5 percent.* The evidence necessary for judging the implications of income for survey respondents who were users of the Monongahela River can be derived using the same type of information required by the travel cost model.† That is, because individual estimates of the ordinary consumer surplus require travel cost and income information, these variables were combined with the respondents' reported use patterns for the Monongahela sites, thus treating all 13 sites as if they shared a common demand function, even though the generalized travel cost model does not require this assumption. These data permit the estimation of a travel cost model for the Monongahela in its current state. The results are given in Equation (8.1) below:

$$\ln V = \underset{(3.153)}{0.7983} - \underset{(-0.785)}{0.0195}\,(T+M)\text{ cost} + \underset{(1.636)}{0.000015}\text{ income} \qquad (8.1)$$

$$R^2 = 0.032$$

The numbers in parentheses are the t-ratios for the null hypothesis of no association. These results indicate that income is not a significant determinant of user trips to the Monongahela sites. Therefore, these findings would be consistent with judgments based on the generalized travel cost model, and willingness to pay would be expected to be less than the Marshallian consumer surplus for water quality improvements (the equivalent, in the generalized

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*See Freeman [1979a] or Just, Hueth, and Schmitz [1982] for a complete discussion of the implications of the Willig [1976] bounds for applied benefit analysis.

†The generalized travel cost model assumes that a water quality change can be translated into either an equivalent price or quantity change. Thus, the site demand equation is the relevant basis for judging income responsiveness. Survey responses for compensating surplus (referred to as user value in Chapter 5) are expected to provide equivalent results if these two sets of information provide consistent descriptions of the individuals' demand characteristics. An examination of the role of income in the user value equations confirms this a priori expectation. The coefficients estimated for income are never judged to be statistically significant determinants of user values.

travel cost model, of price decreases for the site's services or quantity increases). However, these estimates of income effects imply that the difference between willingness to pay and consumer surplus should be small.

These results can also be compared with the predicted demands for each of the 13 Monongahela sites based on the generalized travel cost model and the characteristics of each of these sites. Of course, this comparison cannot be treated as an evaluation. The estimates given in Equation (8.1) are pooled across sites and assume the demand parameters are invariant with respect to site attributes. Nonetheless, the comparison may serve to identify whether the implied demand features are completely incompatible with these crude estimates available as a byproduct of the survey data. The focus is on the parameters of greatest influence for estimates of consumer surplus change in response to a water quality change. Table 8-1 reports these predicted parameters for the intercept and coefficient of (T+M) cost for each of the 13 sites under the assumption of boatable water quality. The absolute magnitude of the price coefficient is in all cases smaller than any estimates based on the survey, but they are reasonably close to the survey estimates. The intercept predictions are substantially larger than the survey estimates.

The second comparison across benefit methodologies involves the contingent valuation and contingent ranking approaches. Because all survey respondents were asked one of the four types of contingent valuation questions and the contingent ranking, the estimates from these approaches are not independent estimates of the option prices for water quality changes. Indeed, it is possible that an individual's responses to the contingent valuation questions, which preceded the ranking questions on the survey instrument, influenced the rankings. Therefore, this comparison reflects both the effects of the methods used to estimate benefits and an individual's consistency in responding to comparable water quality increments in different formats.

Table 8-1. Predicted Demand Parameters for Monongahela Sites

Site	Intercept	Coefficient for T+M cost
Pittsburgh area	1.323	-0.0133
Confluence of the Youghiogheny and Monongahela Rivers	1.317	-0.0132
Elrama	1.317	-0.0132
Town of Monongahela	1.306	-0.0131
Donora and Webster	1.323	-0.0133
Near Charleroi	1.317	-0.0132
California and Brownsville	1.308	-0.0131
Maxwell Lock and Dam	1.311	-0.0130
Point Marion	1.323	-0.0133
Morgantown	1.404	-0.0140
Fairmont	1.449	-0.0144
9th Street Bridge	1.323	-0.0133
Cooper's Rock	1.323	-0.0133

8.2.3 Past Comparisons of Benefit Estimation Methods

Comparisons of the results of benefit estimation methodologies within the context of a common problem have been quite limited. The first such comparison was undertaken by Knetsch and Davis [1966] and involved a bidding game version of what is now commonly referred to as contingent valuation and a form of the travel cost model. The survey was based on a sample of 185 users of a forest recreation area in northern Maine. With the iterative bidding game, respondents were asked their willingness to pay (as increased cost to visit the area). A similar format was used to elicit willingness to drive to the area. Individuals were also asked the actual distance they traveled to the site.

Knetsch and Davis compared three approaches for estimating the aggregate benefits from the site. The first used a willingness-to-pay equation based on the survey results to estimate a willingness-to-pay schedule for the user population in the area surrounding the site. The two sets of distance measures were each valued at $.05 per mile and used to derive aggregate schedules for the user population. The aggregate benefit estimates derived for each approach provided the basis for comparing the methods:

Contingent valuation	$71,461
Willingness to drive	$63,690
Travel cost	$69,450

Because the contingent valuation approach measures willingness to pay and travel cost measures the ordinary consumer surplus, the latter would be expected to exceed the former at an individual level. However, it is difficult to gauge the expected nature of the differences between the two methods for these calculations because they involve the aggregate schedule over all individuals and relate to changes in the price of the site comparable to a loss of its availability for this population. As Bockstael and McConnell [1980] observe, the Willig bounds may not hold where the analysis involves the removal of the site. They observed that:

> it is difficult to find single valued functions, $x = f(p,m)$ [where x = quantity demanded, p = price and m = income], decreasing in p and increasing in m, such that:
>
> 1. $\dfrac{m \frac{\partial x}{\partial m}}{x}$ is finite for all values of p and
>
> 2. the function $f(p,m)$ must tend to zero rapidly enough with increases in p that the integral of $f(p,m)$ will be bounded when evaluted as p goes to infinity. (p. 61)

Because Knetch and Davis do not present demand equation estimates with their travel cost findings, it is difficult to evaluate the relationship between their willingness to pay and consumer surplus estimates on an individual basis. Their benefit estimates based on the willingness-to-travel responses are diffi-

Table 8-2. Bishop-Heberlein Comparative Results for Benefit Approaches[a]

	Method	Average benefit estimate per permit
I.	Actual case offers	$ 63
II.	Hypothetical responses	
	(a) willingness to sell	$101
	(b) willingness to pay	$ 21
III.	Travel cost ordinary consumer surplus (variation associated with valuation of travel time from 0 to ½ median income rate)	$11 to $45

[a]These estimates are taken from Table 1 in Bishop and Heberlein [1979], p. 929.

cult to interpret within the conventional welfare economics framework and thus cannot be directly associated with either of the other benefit estimates. Thus, while this study offered the first evaluation of benefit estimation approaches, it did not permit a detailed comparative analysis of them.

The second comparative analysis was conducted by Bishop and Heberlein [1979] and was primarily intended to evaluate the relationship between hypothetical and actual responses to willingness-to-sell questions.* Their analysis was conducted using goose hunting permits for hunters in Wisconsin. Three samples of hunters were used in their analysis. The first sample received actual cash offers for their permits (ranging from $1 to $200); a second sample received questionnaires asking the individual's willingness to pay for (and willingness to sell) their permits; and a third sample received questionnaires designed to permit the estimation of a traval cost demand equation. Table 8-2 summarizes the Bishop and Heberlein estimates per permit for each of the ap-

*Bishop and Heberlein describe a number of potential biases that might distinguish hypothetical and actual responses to willingness-to-pay questions. Some of these problems conform to the definitions used in the papers reporting contingent valuation survey results. The most directly comparable case is strategic bias. However, the Bishop-Heberlein approach does not attempt to induce differential responses from individuals, by giving them, for example, different information about the uses that will be made of their bids to hypothetical changes. This approach has been the most common method for investigating the potential for strategic bias in the contingent valuation experiments (see Schulze, d'Arge, and Brookshire [1981]). Rather, their comparison of actual and hypothetical responses will reflect a composite of any such biases due to the "framing" of their hypothetical survey instrument and to the distinction between hypothetical and real conditions.

proaches considered. Their findings suggest that hypothetical willingness-to-sell estimates overstate actual responses. Moreover, Bishop and Heberlein argue that hypothetical willingness to pay and ordinary consumer surplus estimated with the travel cost demand model understate the actual willingness-to-sell by more than the Willig bounds would imply.

The Bishop and Heberlein results, while limited to a single experiment, have potentially important implications for the relationship between hypothetical and actual estimates of willingness to sell. They do not offer as much guidance on the comparative properties of the benefit estimation methodologies themselves. The authors' benefit estimates made with the travel cost model can be interpreted (for one value for the opportunity cost of travel time) as quite close to the hypothetical willingness to pay. However, because the selection of an opportunity cost for travel time is treated as judgmental, more specific conclusions are not possible. Finally, the Bishop-Heberlein research design (i.e., the selection of independent samples for the hypothetical and travel cost surveys) did not permit comparison of the hypothetical willingness to pay and ordinary consumer surplus on an individual basis.

Most recently, Brookshire et al. [1982] provided comparative analysis of benefit estimation methods, maintaining it as a validation analysis of the contingent valuation methodology. As observed earlier, this reflects the interpretation given to contingent valuation versus indirect benefit estimation methods by many economists and is somewhat unfortunate. Each of the methods involved in the Brookshire et al. [1982] comparative evaluation is based on <u>different</u> assumptions concerning the economic behavior of households and the role of environmental amenities (i.e., air quality) in their decisionmaking. Neither method provides the "true" benefit estimates for air quality improvements.

The Brookshire et al. [1982] analysis compares a hedonic property value model to a contingent valuation approach for measuring the willingness to pay for reductions in air pollution. The authors interpret the hedonic model as providing an upper bound for willingness to pay and argue that the assumptions of the model are approximately satisfied for the Los Angeles area. At issue in their comparison, however, is whether direct questions can be believed. They demonstrate if each method conforms to its respective assumptions, the annual rent differential for pollution should exceed estimates of the annual willingness to pay.

Using paired areas in Los Angeles selected to be homogeneous with respect to socioeconomic, housing, and community characteristics but with variation in air pollution, Brookshire et al. [1982] tested two hypotheses:

- The rent differential for pollution should exceed estimates of annual willingness to pay.
- Willingness to pay estimated from the contingent valuation survey bids are different from zero.

The design for the test used a hedonic property model that was estimated with sales of single-family houses in these areas and the contingent valuation

experiment conducted with households selected from the same areas. Overall, the Brookshire et al. [1982] findings supported the presence of positive bids for air pollution reductions in all areas, as well as the ranking of rent differentials over bids in 10 of the 11 communities. Thus, the Brookshire et al. [1982] analysis provides the first evidence that benefit estimates derived from survey procedures fall within the theoretical bounds for willingness to pay. Nonetheless, the comparison is based on average responses within the selected communities and not estimates at an individual level.

In summary, past efforts (especially those of Bishop and Heberlein [1979] and Brookshire et al. [1982]) directed toward comparative evaluations of benefit methodologies are complementary to those available from the comparative analysis of this study. The comparison of the travel cost and contingent valuation is especially important because of the ability to compare benefits estimated for the same users.

8.3 A COMPARATIVE EVALUATION OF THE CONTINGENT VALUATION, TRAVEL COST, AND CONTINGENT RANKING BENEFIT ESTIMATION METHODS

Mean estimates are provided in Table 8-3 for each component of the benefits associated with three water quality changes:

- Deterioration in water quality leading to the loss of the recreational use of the area for water-based activities
- Improvement in water quality from its present state (boatable conditions) to fishable conditions
- Improvement from boatable to swimmable conditions.

The estimates include the option price and its components--user value and option value. These results are based on different subsets of the Monongahela survey respondents and are measured in 1981 dollars. The contingent valuation estimates are based on the full sample, excluding protest bids and those respondents identified as outliers in the survey (i.e., using the Belsley, Kuh, and Welsch [1980] regression diagnostics, as detailed in Chapter 4). The travel cost estimates were derived for the survey respondents who were users of sites along the Monongahela River.* Finally, the contingent ranking estimates relate to those survey respondents who reported complete ranking information and income. Thus, this group includes some individuals who were judged outliers in the contingent valuation survey.

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*The travel cost results include all survey respondents who were users of sites along the Monongahela River, whether or not they were identified as protest bids or Belsley, Kuh, and Welsch [1980] outliers. Table C-18 in Appendix C provides the regression comparisons of contingent valuation and travel cost estimates with these individuals deleted from the sample. The deletion of these respondents does change any of our conclusions.

Table 8-3. A Comparison of Benefit Estimates for Water Quality Improvements (1981 Dollars)

Methodology	ΔWQ = Loss of use			ΔWQ = Boatable to fishable			ΔWQ = Boatable to swimmable		
	Option price	User value[a]	Option value	Option price	User value[a]	Option value	Option price	User value[a]	Option value
I. Contingent valuation[b]									
Direct question	24.55	6.57 (19.71)	17.98	17.65	7.06 (21.18)	10.59	31.20	13.61 (31.18)	20.80
Payment card	51.00	6.20 (19.71)	44.82	29.26	9.72 (30.88)	19.54	42.87	15.92 (51.18)	26.76
Iterative bidding ($25)	28.97	2.16 (6.58)	26.81	15.95	1.38 (4.21)	14.57	25.09	3.12 (10.53)	21.64
Iterative bidding ($125)	57.40	12.08 (36.25)	45.31	36.88	6.77 (20.31)	30.10	60.20	13.43 (48.75)	43.96
II. Contingent ranking[c]									
Ordered logit	-	-	-	60.03	-	-	108.06	-	-
Ordered normal	-	-	-	62.12	-	-	111.81	-	-
III. Generalized travel cost[d]	-	82.65	-	-	7.01	-	-	14.71	-

[a]The numbers in parentheses below the estimated user values report average user values for users only. Since nonusers have a zero user value, the combined mean understates user values.

[b]These estimates are for the combined sample including users and nonusers. It excludes protest bids and outliers detected using the Belsley, Kuh, and Welsch regression diagnostics.

[c]These estimates are for the sample of respondents with usable ranks and reported family income. Estimates evaluated at the intermediate payment level.

[d]These estimates are for survey respondents using Monongahela sites and have been converted to 1981 dollars using the consumer price index.

Table 8-3 clearly illustrates the pairwise comparisons possible with these three methods. Because contingent valuation provides the most complete set of estimates, it can be compared to both of the other methods for several components of the benefits from a water quality change.

Simple comparisons of the means in Table 8-3 indicate that the relationship between the methods depends on the type of change in water quality being considered. For example, in the case of user values, contingent valuation estimates would be expected to be less than the travel cost estimates of ordinary consumer surplus for improvements in water quality. However, based on the arguments developed in the previous section of this chapter, these differences would likely be slight. This relationship does not seem to have been upheld for improvements in water quality when the mean willingness to pay for users (reported in parentheses in Table 8-3) is compared with the ordinary consumer surplus increments. Three of the four contingent valuation approaches contrast with this expectation for both of the water changes. Only the mean for the iterative bidding format with the $25 starting point is less than the ordinary consumer surplus estimate. Moreover, the differences in some cases are greater than the theoretical arguments would have implied. Because the largest of these estimates is not associated with the iterative bidding framework with a $125 starting point, the discrepancy cannot be attributed to starting point bias. These comparisons are <u>not</u> statistical tests, and the contingent valuation estimates exhibit considerable variability. Indeed, the travel cost estimates do fall, for both levels of improvement in water quality, in the range of estimates provided by the various approaches to contingent valuation.

The comparison between the means for the contingent valuation and travel cost estimates is consistent with theoretical expectations for a reduction in water quality that leads to the loss of the area. In this case, the ordinary consumer surplus is more than twice the size of the largest of the contingent valuation estimates. The size of this difference was somewhat unexpected based on the simple theoretical arguments discussed earlier. Accordingly, it serves to highlight the potential importance of each methodology's assumptions in comparing their respective estimates. One explanation of this large difference arises from an assumption implicit in the travel cost model. The data required that the travel cost demand model ignore the effects of substitute sites as determinants of the demand for any one site's services. However, judging the potential effects of this limitation on the estimates from the generalized travel cost model are difficult. The model developed in Chapter 7 assumes that each individual considered only site attributes in judging the degree of substitutability between sites. Indeed, it was based on the assumption that all sites' services could be measured on a common scale reflecting these attributes. To the extent this assumption is either inappropriate or a relatively weak approximation of each individual's perceptions of the relationship between sites, there will be two types of effects on the demand model. First, the omission of variables reflecting the prospective role of these substitution effects in any site's demand function is a specification error that may bias estimates of the other variables' effects on demand. Equally important, the differential accessibility of substitute sites of comparable or higher quality will tend to mitigate the impact of any deterioration in water quality at a given

duce the incremental benefits from improvements. Thus, it is difficult to predict with certainty the impacts of the treatment of the role of substitutes for benefit estimates derived from the generalized travel cost model.

Nontheless, it does seem reasonable to expect that the use of a model that ignores the role of substitutes may not seriously affect the benefit estimates associated with the increments to water quality that serve to enhance the activities supported by a recreation site. By contrast, this judgment is not as readily accepted for the loss of a site. In this case, the presence of substitute facilities can be expected to mitigate the loss. Thus, the generalized travel cost model (which ignores the role of substitute sites) may overestimate the consumer surplus associated with the loss of the use of the Monongahela River for boating recreation.

The second comparison that can be made is between the contingent valuation and contingent ranking estimates of the option price. Regardless of the technique used to estimate the random utility function, the contingent ranking approximation of option price consistently exceeds the contingent valuation estimates. Because both methods focus on the same benefit concept, the explanations for it must arise from the assumptions of each approach. The approximations used to derive the contingent ranking benefit estimates may be especially important to such an explanation.* However, in the final analysis, there is little additional information that can be gleaned from a comparison of means.

The most interesting comparisons of contingent valuation and travel cost estimates are based on the subsample of users; the most interesting comparisons of contingent valuation and contingent ranking are based on the subsample of respondents with complete information on the ranking of water quality and payment alternatives. Both sets of comparisons use individual benefit estimates.

The comparison of contingent valuation and travel cost estimates of user values is presented in Table 8-4. The objective of this comparison is to judge how the benefit measures derived using the two approaches compared across individuals. Accordingly, a common set of procedures was used to evaluate the accuracy of a set of forecasts (see Theil [1961], pp. 31-33, for discussion of this type of application). In this comparison, the contingent valuation measure of user value was regressed on the travel cost estimate. Because this comparison may be affected by the question format used with the contingent valuation approach, qualitative variables for three of the four modes were also included as determinants of the level of the contingent valuation estimates.

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*This benefit measure is described as approximate because of its definition as an increment to the payment required to hold an individual's utility constant in the presence of a water quality improvement and because of the theoretical inconsistency in the functional form used for the indirect utility function (see Chapter 6 for details).

Table 8-4. A Comparison of Contingent Valuation and Generalized Travel Cost Benefit Estimates[a]

	ΔWQ = Loss of area		ΔWQ = Boatable to fishable		ΔWQ = Boatable to swimmable	
	Model	Test[b]	Model	Test[b]	Model	Test[b]
Independent variable						
Intercept	21.862 (1.371)	-	33.985 (1.900)	-	59.574 (2.017)	-
Travel cost benefit estimate	.328 (1.169)	-4.357	-3.670 (-1.204)	-1.712	-2.713 (-1.141)	-1.793
Qualitative variables						
Payment card	-32.640 (-2.551)	-	51.757 (2.639)	-	77.010 (2.359)	-
Direct question	-14.602 (-1.270)	-	12.957 (0.748)	-	21.001 (0.729)	-
Iterative bid ($25)	-31.817 (-2.549)	-	-11.244 (-0.595)	-	-21.819 (-0.693)	-
R^2	.099		.120		.107	
n	93		93		93	
F	2.42 (0.05)[c]		3.00 (0.02)[c]		2.62 (0.04)[c]	

[a]The numbers in parentheses below the estimated coefficients are t-ratios for the null hypothesis of no association.

[b]This column reports the t-ratio for the hypothesis that the coefficient for the travel cost variable was 1.55. The travel cost model measures consumer surplus in 1977 dollars. The contingent valuation experiments were conducted in 1981. Using the consumer price index to adjust the travel cost benefit estimates to 1981 dollars would require multiplying each estimate by 1.55. Since the estimated regression coefficients (and standard errors) will correspondingly adjust to reflect this scale change, a test of the null hypothesis that the coefficient of travel cost was equal to unity is equivalent to a test that is equal to 1.55 when the travel cost benefit estimates are measured in 1977 dollars and user values estimates (the dependent variable) are in 1981 dollars.

[c]This number in parentheses below the reported F-statistic is the level of significance for rejection of the null hypothesis of no association between the dependent and independent variables.

The analysis was considered for each of three water quality changes:

- Deterioration in water quality leading to the loss of the areas
- Improvement in water quality from its present state (boatable conditions) to fishable conditions
- Improvement from boatable to swimmable conditions.

The results generally reinforce the earlier judgments from comparing the estimated mean user values from each method. Theory suggests contingent valuation estimates would be less than the ordinary consumer surplus estimates from the travel cost model for water quality improvements, but these differences should be rather small. This a priori expectation can be evaluated by testing the null hypothesis that the intercept for the model is zero. Equally important, if the two methods provide comparable estimates of user values that closely

approximate each individual's willingness to pay, the slope parameter for the travel cost consumer surplus would be expected to be insignificantly different from unity. Finally, if the question mode does not influence the responses derived with contingent valuation surveys, the dummy variables for question mode would likely not be significantly different from zero.

More formally, it has been maintained that the contingent valuation estimates of an individual's willingness to pay for water quality changes "a", CV_a, will be approximately a homogeneous function of the conditional expectation for the Marshallian consumer surplus, MS_a (i.e., the predicted consumer surplus from the generalized travel cost model for water quality change "a"). This function will exhibit a slope of unity. This model is to be distinguished from an errors-in-variables framework in which it would be maintained that neither benefit measure describes what it is purported to measure. Under this study's interpretation, the travel cost estimates of consumer surplus play the same role as the estimates of the conditional expectation of endogenous variables in a deterministic simulation of an econometric model (see Howrey and Kelejian [1969] and Aigner [1972]). Hence, large sample evaluations of the parameters in the model--testing the hypotheses of zero intercept and unitary slope--do provide some guidance as to the relationship between methods.

The results provide some interesting insights for each of these issues. Considering the relationship between the level of the contingent valuation estimates and those of the travel cost model, there is some evidence for a difference between the levels of the two approaches for improvements in water quality that contradicts a priori expectations. The intercepts for the equations associated with both levels of water quality increments (i.e., from boatable to fishable and from boatable to swimmable) are positive and statistically significant at the 90-percent significance level. However, there are at least two reasons for interpreting these results cautiously. The generalized travel cost model does not permit the effect of the intercept to be distinguished from at least one of the questioning formats. In the models reported in Table 8-4, the intercept reflects the effects of the iterative bidding format with a $125 starting point. Testing whether the sum of the intercept and any one of the coefficients for other models was nonzero would simply change the format included. Ignoring the effects of question format by eliminating these variables from the models simply reinforces the conclusion that the intercept for these cases is positive and significantly different from zero.

Thus, there is some evidence to support the conclusion that contingent valuation methods may overstate willingness to pay for water quality improvements. It is not unambiguous evidence, because the tests are based on large sample behavior and have been applied using the conventional t-distributions. These findings are not necessarily at variance with the Brookshire et al. [1982] conclusions. Their evaluation concluded that contingent valuation estimates fall within the bounds which can be established by theory. It does not indicate how close the estimates fall to the "true" value of individual willingness to pay. An appraisal suggests that, for increments (improvements) to water quality, contingent valuation estimates may well overstate the user benefits.

The conclusion for reductions in water quality that would be associated with the loss of the area is less clearcut. In this case, the contingent valuation estimates are less than ordinary consumer surplus, as theory would imply. However, they are substantially less, and the reasons may be associated with the travel cost model and not the survey approach to benefit estimation. Based on the association between estimates across individuals, there is support for the conclusion that the travel cost model overstates the benefits associated with avoiding the loss of the area. The slope coefficient is significantly different from theoretical expectations. Since the travel cost benefits are measured in 1977 dollars, the correct null hypothesis for the slope coefficient when 1977 dollars are not converted to 1981 is that the coefficient equals the adjustment factor (in this case, 1.55).* For improvements in water quality, the coefficients are numerically large and have an incorrect sign, but they are not significantly different from 1.55.

Thus, for changes in water quality, the models do seem to move together (with the contingent valuation potentially exhibiting a positive bias in estimating willingness to pay). The performance of the contingent valuation method does appear to depend on the mode of questioning used--with the clearest distinctions found between the payment card and iterative bid with a $125 starting point. While the explanatory power of the model is not high, reflecting the variability in the contingent valuation responses for user values, the null hypothesis of no association between these measures of user values (along with the qualitative variables) is clearly rejected at high levels of significance based on the F-statistics, reported at the bottom of the table.

The second individual level comparison involves estimates of the option price using contingent valuation and contingent ranking methods. Table 8-5 reports a comparable set of regression models comparing these estimates. However, two further distinctions are possible in this comparison. Given the functional form specified for the indirect utility function, the contingent ranking estimate of option price will depend on the level of the payment suggested to the individual. Consequently, the benefits were calculated at all three levels and the regressions were replicated for each of them. In addition, two econometric estimators were used with the contingent ranking models so that each was also considered. Table 8-5 reports all of the comparisons for two increments in water quality--improvements from boatable to fishable and from boatable to swimmable.

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*Scaling all the values of an independent variable by k will scale the ordinary least-squares estimate of the parameter for this variable (in a linear model) and its estimated standard error by $\frac{1}{k}$. Thus, to test the null hypothesis of unity for such a parameter would imply using

$$\frac{\frac{\hat{b}}{k} - 1}{\frac{s_{\hat{b}}}{k}} \text{ or } \frac{\hat{b} - k}{s_{\hat{b}}} .$$

Table 8-5. A Comparison of Contingent Valuation and Contingent Ranking Benefit Estimates

Independent variable	ΔWQ = Boatable to fishable						ΔWQ = Boatable to swimmable					
	Payment = $50		Payment = $100		Payment = $175		Payment = $50		Payment = $100		Payment = $175	
	Model	Test	Model	Test	Model	Test	Model	Test	Model	Test	Model	Test
ORDERED LOGIT												
Intercept	-20.141 (-1.095)	-	-23.647 (-1.223)	-	-23.927 (-1.227)	-	-25.661 (-0.795)	-	-30.734 (-0.905)	-	-31.032 (-0.906)	-
Δ Payment	1.209 (4.279)	0.741	1.315 (4.237)	1.016	1.330 (4.214)	1.048	1.081 (3.925)	0.293	1.170 (3.867)	0.561	1.183 (3.841)	0.594
Qualitative variables												
Payment card	-22.486 (-2.424)	-	-22.070 (-2.380)	-	-21.960 (-2.367)	-	-46.842 (-2.877)	-	-46.145 (-2.834)	-	-45.961 (-2.822)	-
Direct question	-35.267 (-3.751)	-	-34.595 (-3.683)	-	-34.425 (-3.665)	-	-55.327 (-3.353)	-	-54.215 (-3.288)	-	-53.935 (-3.270)	-
Iterative bidding ($25)	-38.045 (-4.067)	-	-37.562 (-4.015)	-	-37.446 (-4.001)	-	-68.611 (-4.178)	-	-67.817 (-4.128)	-	-67.626 (-4.115)	-
R^2	.165		.164		.163		.153		.151		.150	
n	184		184		184		184		184		184	
F	8.87 (0.0001)		8.77 (0.0001)		8.72 (0.0001)		8.06 (0.0001)		7.94 (0.0001)		7.88 (0.0001)	
ORDERED NORMAL												
Intercept	-13.467 (-0.839)	-	-15.565 (-0.940)	-	-15.832 (-0.951)	-	-15.153 (-0.537)	-	-18.212 (-0.626)	-	-18.559 (-0.634)	-
Δ Payment	1.073 (4.554)	0.309	1.140 (4.528)	0.554	1.151 (4.516)	0.592	.962 (4.182)	-0.165	1.018 (4.146)	0.073	1.028 (4.131)	0.113
Qualitative variables												
Payment card	-22.642 (-2.457)	-	-22.357 (-2.426)	-	-22.286 (-2.418)	-	-47.108 (-2.910)	-	-46.630 (-2.880)	-	-46.510 (-2.872)	-
Direct question	-34.934 (-3.745)	-	-34.458 (-3.696)	-	-34.344 (-3.683)	-	-54.808 (-3.345)	-	-54.020 (-3.298)	-	-53.832 (-3.286)	-
Iterative bidding ($25)	-37.541 (-4.014)	-	-37.196 (-4.004)	-	-37.116 (-3.994)	-	-67.808 (-4.156)	-	-67.242 (-4.120)	-	-67.112 (-4.111)	-
R^2	.176		.175		.174		.162		.160		.160	
n	184[b]		184[b]		184[b]		184[b]		184[b]		184[b]	
F	9.53 (0.0001)[b]		9.47 (0.0001)		9.43 (0.0001)		8.63 (0.0001)		8.54 (0.0001)		8.51 (0.0001)	

[a]These estimates are for the combined sample including users and nonusers. It excludes protest bids and outliers detected using the Kuh-Welsch regression diagnostics.

[b]These estimates are for the sample of respondents with usable ranks and reported family income.

The interpretation of these results is somewhat different from the earlier comparison with travel cost estimates. In this case, both methods seek to estimate the same benefit concept. However, they are not independent. Each survey respondent was asked to engage in both activities--one of four types of contingent valuation experiment and a contingent ranking. Thus, these results reflect the consistency in individuals' responses and the potential effects of how the valuation exercise is undertaken (i.e., requests for bids or ranks). Despite the fairly substantial differences in the means for the two approaches as reported in Table 8-3, these results exhibit remarkable consistency. Once again, the relevant hypotheses are for zero intercept and unitary slope coefficients. Both hypotheses cannot be rejected across all possible variants of the contingent ranking and changes in water quality. Indeed, the numerical estimates of the slope coefficient exhibit rather considerable agreement between the direction of the movements in the two estimates of option price. The estimated coefficients for the question format used are especially interesting. They indicate that the association between the two approaches depends quite importantly on the question format, with the iterative bidding format with a $125 starting point providing larger estimates than any of the other three formats.

Overall, these findings suggest that even though the models used to derive benefit estimates from the contingent ranking models were somewhat arbitrary (and in some cases inconsistent with a strict interpretation of the relevant theory), the results move closely with the contingent valuation estimates. Indeed, one of the primary sources of divergence between the two arises in the format used with the contingent valuation questions.

8.4 IMPLICATIONS

This chapter has developed comparisons of three methods for estimating the benefits from water quality improvements. Each method has involved a fairly detailed set of assumptions and, in some cases, a complex model. Overall, the results are remarkably consistent across methods for comparable changes in water quality. While this discussion has been devoted to the types of discrepancies between each method's estimates, the consistency in these estimates should be interpreted as offering strong support for the feasibility of performing benefit analyses for water quality changes. The range of variation in estimates across methods is generally less than the variation expected in models seeking to translate the effects of effluent in a water body into the corresponding measures of water quality parameters.

Nonetheless, this conclusion does not imply that there is not room for improvement in benefit estimation methods. In most cases, the indirect methods for benefit measurement, such as the travel cost framework, have been limited by the data availability. While this study's analysis was greatly enhanced by the existence of the Federal Estate Survey, the form of the data nonetheless imposed limitations on the character of the travel cost demand models that could be formulated. Survey approaches do not face the same types of limitations. However, this study's findings do suggest that the question format used is an important factor in the benefit estimates derived from the survey. They also suggest that greater attention to the nature and form

of the information provided to survey respondents will be needed if this approach is to seek to develop detailed measures of the components of benefits. The analysis performed for this study had the advantage of a well-defined valuation problem that was easily explained and, according to interviewer feedback after the survey, readily understood by the survey respondents. Many of the most complex environmental valuation problems do not share this characteristic and therefore may not have the same successes reported here.

The specific findings of the comparison indicated that contingent valuation methods may overstate the willingness to pay for water quality improvements. Theory would suggest that ordinary consumer surplus should provide an upper bound for these estimates and this study's findings indicate it does not. Nonethless, these differences are not substantial and fall within the range of variation of the contingent valuation estimates across the question formats. For the case of the loss of the use of the area, the association adheres to theoretical anticipations. Indeed, there are reasons to believe that the travel cost estimates overstate the benefits provided by the area.

Comparison between the contingent ranking and contingent valuation estimates indicate a remarkable degree of consistency. While the mean benefit estimates derived from the contingent ranking framework appear larger than the contingent valuation estimates, there is not a statistically significant displacement between the two. Moreover, the benefit estimates move in close agreement across individuals.

CHAPTER 9

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APPENDIX A

SAMPLE DESIGN

This appendix provides a justification for the sampling sizes and the sampling protocol employed in the project.

A.1 SAMPLE SIZE JUSTIFICATION

One approach for using the survey information requires that many of the parameters to be estimated in this study be treated as proportions--for example, the proportion of adults who participate in water-related recreation activities. Accordingly, the proposed sample sizes were determined by computing the sample size required to estimate proportions of the underlying population (i.e., households in the Monongahela River basin).

The required sample size depends upon the desired precision of the proportion estimates. The sample size required to produce an estimate, $\hat{p}$, within δ units of the true population proportion, p, with α percent certainty depends upon δ, p, and α. Obviously, it is desirable to make δ small and α large. However, decreasing δ and increasing α each requires an increase in the required sample size. Additionally, a δ value considered precise for large p values is not necessarily precise for small p values. For example, let δ = 0.10, $\hat{p}_1$ = 0.85, and $\hat{p}_2$ = 0.05. Then, $\hat{p}_1 \pm \delta$ is equal to 0.85 ± 0.10, which is relatively precise. However, $\hat{p}_2 \pm \delta$, which is equal to 0.05 ± 0.10, is not very precise.

Table A-1 shows the sample sizes needed to detect a specific difference with power 1 - β. The crucial specific differences for this project were those in estimated values for the willingness to pay for different levels of water quality and differences in estimates of option and existence values for the Monongahela River.

An example using estimated coefficients of variation (which are equal to the standard error of the estimate divided by the mean estimate, or simply a method of comparing the variation in the measured benefits) from related studies, shown in Table A-2, will explain Table A-1. If the coefficient of variation is equal to 0.2 (as was the case in the Walsh et al. [1978] South Platte River Basin Study for Denver residents' willingness to pay for existence values), a sample size of 68 is necessary to detect a 10 percent difference in the mean value with 95 percent confidence that the difference is different from zero and a 10-percent chance of not rejecting the null hypothesis (Δ = 0) when it is false. If there is little or no variation in the estimates, small differences can be detected with minimal sample size. However, considerable variation in estimated values will mean that the sample size at 384 may not be able to detect small differences in the estimates. Thus, when proportions are estimated,

Table A-1. Sample Sizes Needed to Detect a Specified Difference With Power 1 - β

Detection level (Δ)	CV = coefficient of variation $(\sigma_e/\mu_c)^a$				
	0.1	0.2	0.3	0.4	0.5
	(a) α = Type I error = 0.05, β = Type II error = 0.1				
0.06 μ_c	48	190	428	760	1,189
0.08 μ_c	27	107	241	428	669
0.10 μ_c	17	68	154	274	428
0.15 μ_c	8	30	68	122	190
0.20 μ_c	4	17	39	68	107
0.25 μ_c	3	11	25	44	68
	(b) α = 0.05, β = 0.25				
0.06 μ_c	30	120	269	478	748
0.08 μ_c	17	67	151	269	421
0.10 μ_c	11	43	97	192	269
0.15 μ_c	5	19	43	77	120
0.20 μ_c	3	11	24	43	67
0.25 μ_c	2	7	16	28	43

[a] σ_e is the common standard deviation for both the treatment and control responses under the model, and μ_c is the mean response (usage level) for the control. The sample size is calculated as $n = 2(CV/\Delta)^2(a^z_{1-\alpha} + a^z_{1-\beta})^2$, where z is the standard normal variate.

relative precision is often considered as the most appropriate basis for determining sample size. This is accomplished by requiring that $\hat{p}$ lie within $p\delta$ units of the true p value with α percent certainty for smallest proportion of interest. In the above example, the estimate of the small p value would change from 0.05 ± 0.10 to 0.05 ± 0.005, which is a much more precise estimate. Obviously, this method significantly increases the required sample sizes for small p values.

Table A-3 contains minimum sample sizes for $\hat{p}$ to be within $p\delta$ units of p with 95 percent certainty (in the sense of repeated sampling) for various values of p and δ, assuming simple random sampling. The p values to be estimated in the study are unknown and will probably vary considerably from one activity to another. Therefore, it is impossible to determine exactly the appropriate sample size. Based on past work it is reasonable to assume that

Table A-2. Coefficients of Variation for Selected Benefits Estimates

Study 1[a]			Study 2[b]			Study 3[c]		
Measured benefit	CV	η	Measured benefit	CV	η	Measured benefit	CV	η
Boatable water quality	0.05	748	Existence value (user)	0.20	88	Aesthetic and health	0.38	10
Fishable water quality	0.05	748	Existence value (user)	0.33	88	Aesthetic and health	0.34	10
Swimmable water quality	0.05	748	Existence value (nonuser)	0.63	15	Aesthetic and health	0.43	9
			Bequest value (nonuser)	0.93	15	Aesthetic and health	0.05	7
						Aesthetic and health	0.61	8

[a]See Mitchell and Carson [1981].
[b]See Walsh et al. [1978].
[c]See Brookshire et al. [1979].

Table A-3. Required Sample Size for Estimates of p to be Within pδ Units of p, Assuming Simple Random Sampling

p \ δ	0.05	0.10	0.15	0.20	0.25
0.01	152,127	38,032	16,903	9,508	6,085
0.05	29,196	7,299	3,244	1,825	1,168
0.10	13,830	3,457	1,537	864	553
0.25	4,610	1,152	512	288	184
0.35	2,854	713	317	178	114
0.40	2,305	576	256	144	92
0.50	1,537	384	171	96	61
0.75	512	129	57	33	21
0.95	81	21	9	6	4

most p values will be in the range of 0.35 to 0.40 or higher. Ditton and Goodale [1973] found that 69.2 percent of the residents in the Green Bay, Wisconsin, area had engaged in water-related outdoor recreation within the last year. The 1977 outdoor recreation survey conducted by the Department of the Interior determined that, with this assumption, a reasonably precise estimate can be formed by requiring that $\delta = 0.20$ (i.e., $p\delta = (0.35)(0.20) = 0.07$ or $p\delta = (0.40)(0.20) = 0.08$). These values of p and δ produce a required sample size in the range of 144 to 178. These estimates are based on simple random sampling and need to be increased because of the effects of a cluster sample design. That is, the area sampling design requires expansion of the recommended sample size. The recommended sample size also assumed a 20-percent nonresponse rate. It should be recognized that the proposed sample size will give less precise estimates for p values below the 0.35 to 0.40 range and more precise estimates for p values above the range. Since the coefficients of variations for p shown in Table A-1 are approximately one and one-half times larger than the coefficients of variations in Table A-2, the recommended sample size should yield adequate power for detecting differences in the willingness to pay and option and existence values.

A.2 SAMPLING PROTOCOL

Using 1970 census computer data tapes (more up-to-date data were not available at the time of the study since the 1980 census computer data tapes had not been released) for Enumeration Districts and Block Groups (ED/BGs), noncompact clusters of approximately seven households were constructed. The 1970 data were adjusted by county using preliminary 1980 census data to more accurately reflect the present. Additionally, the 1970 occupancy rate and the estimated response rate were taken into account in determining the cluster size.

The clusters were constructed into three groups once they were stratified. The groups are those households in (1) Pittsburgh, (2) a place other than Pittsburgh, and (3) not in a place. Fifty-one clusters were selected. The number of clusters selected from each stratum were proportional to the number of households in that stratum. For example, since 61 percent of the households in the five-county area are located in Pittsburgh, 51(0.61) = 31 clusters were selected from Pittsburgh. The clusters were selected with equal probabilities within each stratum. Because of the proportional allocation of the sample to the strata, the probabilities of selection for all clusters were nearly equal.

Because the clusters were contained in ED/BGs, the general physical location of the cluster is known. Interviewers were sent to the field to count and list all households in the ED/BGs that contain the selected clusters. The lists produced during the counting and listing exercise were used to identify the specific households in the selected cluster. If the number of households did not exceed a predetermined number, all households in the cluster were contacted. For those clusters that were too large, the list was used to determine a subsample of the cluster to be contacted.

Once the households to be contacted were identified, the interviewers conducted a preliminary visit and compiled a roster of all adults living in the household. One of the adults was randomly selected (with equal probabilities) for interview.

APPENDIX B

SURVEY FORMS AND PROCEDURES

PART 1

HOUSEHOLD CONTROL FORM

Part 1 of this appendix contains the household control form used by field interviewers to provide assignment and other background information.

Estimating Benefits of Water Quality
RTI Project No. 410-2222-2

OMB No. 2000-0381
Approval Expires: 9/30/82

HOUSEHOLD CONTROL FORM
Form No. 01

I. ASSIGNMENT INFORMATION

A. Study No. [2][2][2][2] [2] (1-5) B. PSU/Segment No. [ ] - [ ][ ][ ][ ][ ] (7-12) C. Housing Unit No. [ ][ ][ ] (14-16) D. Interviewer No. [ ][ ][ ][ ][ ][ ]

E. Address _____ (Number/Street/RFD) _____ (Apartment No.) _____ (City) _____ (State) [ ][ ][ ][ ][ ] (Zip)

II. RECORD OF CONTACTS - ENUMERATION AND SAMPLE INDIVIDUAL

Day of Week	Date	Time	Notes	Result Code	FI
		am / pm			
		am / pm			
		am / pm			
		am / pm			
		am / pm			
		am / pm			
		am / pm			
		am / pm			

III. CONTACT RESULT CODES (CIRCLE BELOW THE FINAL RESULT CODE FOR EACH TYPE OF CONTACT)

Household Enumeration Contact Codes

01 Enumeration Completed
02 No Enumeration Eligible at Home
03 Enumeration Respondent Breakoff; Partial Data
04 Enumeration Respondent Refused
05 Language Barrier
*06 Vacant Housing Unit
*07 Not a Housing Unit; e.g., Merged, Demolished, Group Quarters, Non-Residential
08 Other (EXPLAIN IN "COMMENTS")
(18-19)

Sample Individual Contact Codes

20 Interview Completed (CIRCLE VERSION ADMINISTERED IN SECTION VI.B)
21 Appointment Made
22 Interview Breakoff; Partial Data
23 Sample Individual not Home
24 Refusal
25 Language Barrier
26 Other (EXPLAIN IN "COMMENTS")
(21-22)

IV. *Source of Information for Result Codes 06, 07

Name _____

Number/Street/RFD _____

City/State/Zip _____

( ) _____
Telephone Number

V. COMMENTS

_____

VI. HOUSEHOLD ENUMERATION AND SAMPLE INDIVIDUAL SELECTION

Hello, I'm (NAME) with the Research Triangle Institute of North Carolina. We are doing a household survey for a government agency to study levels of water quality and some outdoor recreational activities people take part in both near and on ponds, lakes, streams, and rivers in the Pittsburgh area. Your household has been randomly selected along with others in this area to be interviewed. In order to determine who in your household should be interviewed, I would like to ask a few questions about the residents of your household. I am required to talk with a household member who is 16 years of age or older. (ASK IF NECESSARY, ARE YOU 16 YEARS OR OLDER?)

1. First, are there any occupied or vacant living quarters other than your own (FOR SINGLE UNIT STRUCTURE) in this structure or on this property? (FOR MULTI-UNIT STRUCTURES?) in this unit?

   (CIRCLE NUMBER BELOW FOR RESPONSE)

   1 YES (ADD TO LIST OF ADDED HOUSING UNITS IF REQUIRED BY MISSED HU RULES)

   2 NO

2. Now, I would like to ask some general questions about you and all of the other people who live in this household, including friends and roomers. Let's list the people who live here in order of age, beginning with the oldest first. (ENTER AGES IN DESCENDING AGE ORDER IN COLUMN B.) I have listed ages for persons who are (READ AGES). Is there anyone else living here now? (IF YES, ENTER AGE(S) AND CORRECT AGE ORDER IN COLUMN B, IF NECESSARY.)

3. ASK THE SEX FOR EACH PERSON LISTED AND CIRCLE THE CORRECT CATEGORY IN COLUMN C.

4. Which person is the head of the household? (WRITE THE WORD "HEAD" IN COLUMN D FOR THE LINE NUMBER OF THE PERSON CONSIDERED THE HEAD OF HOUSEHOLD.)

5. FOR OTHER PERSONS LISTED ASK THEIR RELATIONSHIP TO THE HEAD OF HOUSEHOLD AND ENTER IN COLUMN D.

6. SELECT THE HOUSEHOLD MEMBER TO BE INTERVIEWED FROM AMONG ONLY THOSE PERSONS 18 YEARS OR OLDER (ELIGIBLE HOUSEHOLD MEMBERS). REFERRING TO THE AGES LISTED IN THE ROSTER, DETERMINE THE NUMBER OF PERSONS WHO ARE 18 YEARS OR OLDER AND DRAW A LINE ACROSS THE ROSTER TO SEPARATE THOSE PERSONS FROM THOSE 17 OR YOUNGER. LOCATE ON THE TABLE BELOW THE ROSTER THE NUMBER OF ELIGIBLE HOUSEHOLD MEMBERS. DIRECTLY BELOW THE NUMBER OF HOUSEHOLD MEMBERS, FIND THE ROSTER LINE NUMBER SELECTED. CIRCLE THE SELECTED LINE NUMBER ON THE ROSTER.

7. (You have/PERSON has) been selected as the person to be interviewed. (ASK FOR THE NAME OF THE PERSON SELECTED AND ENTER HERE)_____.

   PRINT NAME OF SELECTED INDIVIDUAL

   IF ENUMERATION RESPONDENT HAS BEEN SELECTED, ATTEMPT TO COMPLETE INTERVIEW. IF ANOTHER PERSON, DETERMINE IF HE/SHE IS AVAILABLE OR WHEN HE/SHE WILL BE.

8. QUESTIONNAIRE VERSION ADMINISTERED (CIRCLE VERSION) A B C D
   (24 CAR[illegible])

HOUSEHOLD ROSTER

A	B	C		D	CARD 2 1-16 DUP FROM CARD 1 COL. 80 = 2
		SEX			
		M	F		
	AGE	1	2	HOUSEHOLD HEAD/RELATIONSHIP	
01		1	2		(19-23)
02		1	2		(24-28)
03		1	2		(29-33)
04		1	2		(34-38)
05		1	2		(39-43)
06		1	2		(44-48)
07		1	2		(49-53)
08		1	2		(54-58)
09		1	2		(59-63)
10		1	2		(64-68)
11		1	2		(69-73)

(26-27)

CARD 1.
COL. 80 = 1

HOUSEHOLD SIZE:
1 2 3 4 5 6 7 8 9 10 11

1 1 1 4 4 3 4 5 8 10 9
RESPONDENT NO.:

PART 2

COUNTING AND LISTING EXAMPLES

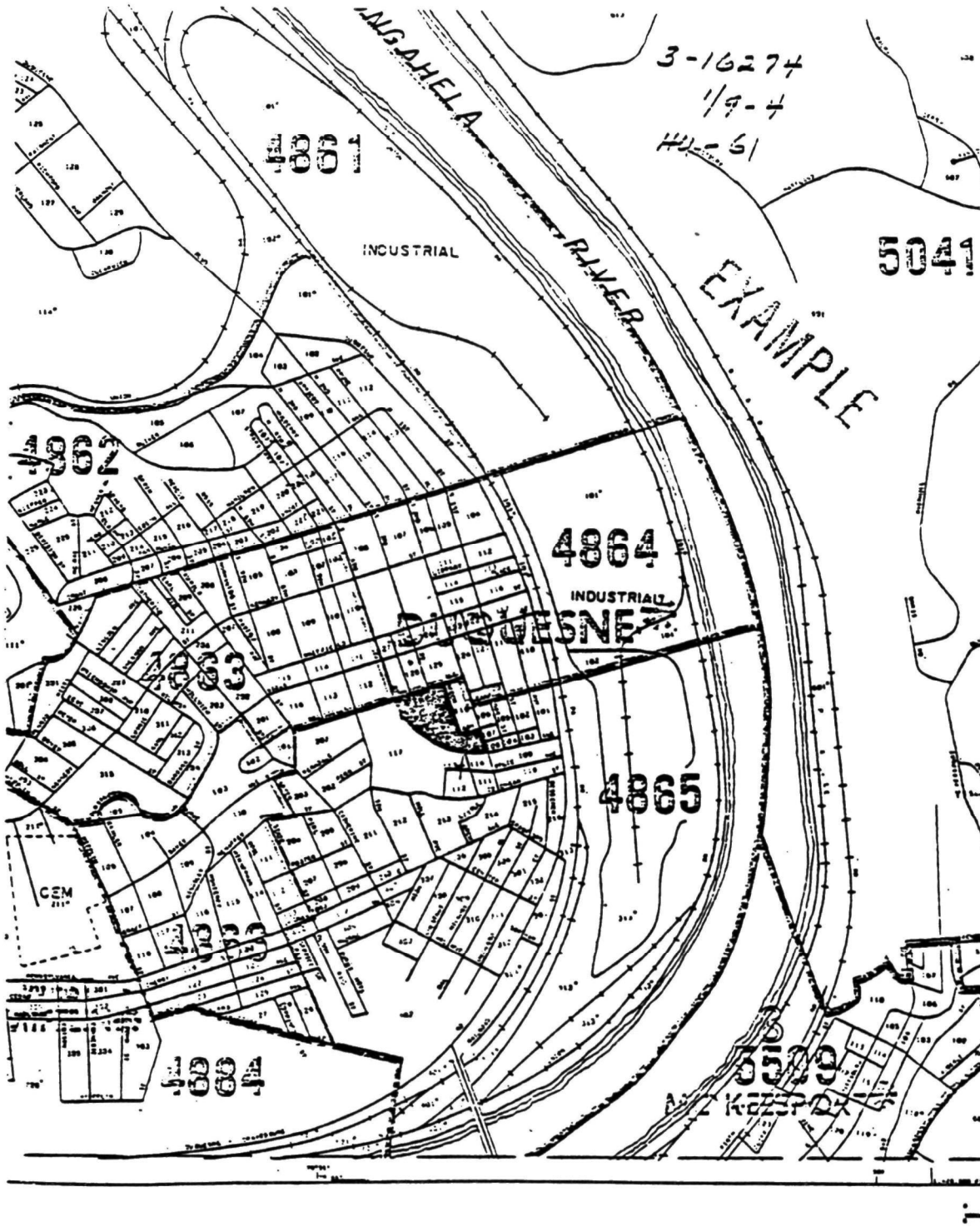

Figure B-1. Sample segment map.

SEGMENT ID 3-16274 PLACE DUQUESNE, PA

PREPARED BY N. EPPLER DATE 10/26/91

REVIEWED BY _____ DATE _____

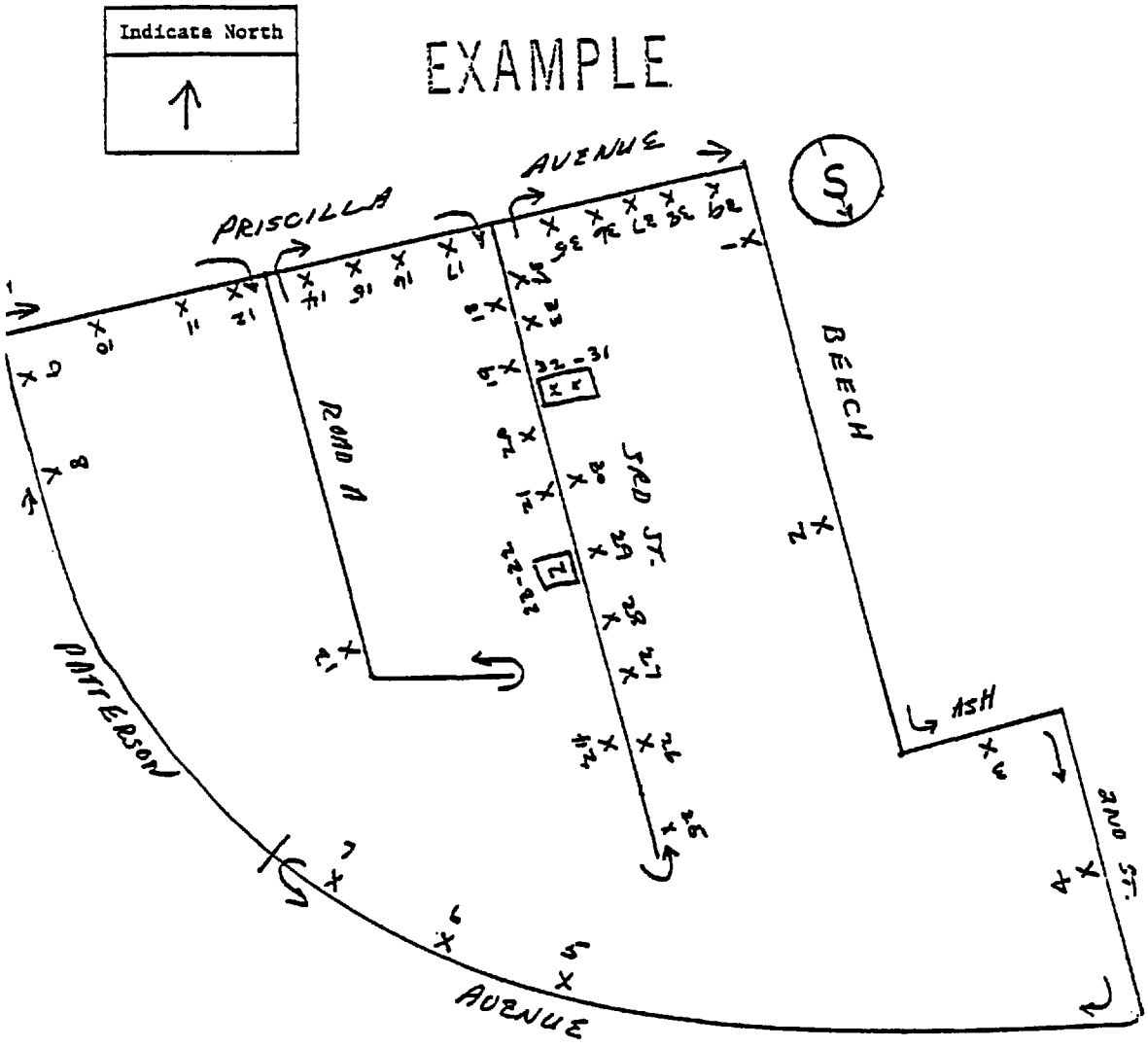

Figure B-2. List unit sketch.

EXAMPLE

Page 1 of 2

LIST OF HOUSING UNITS

Listed By N EPPLER / L. SORRELL

Date Listed 10 / 26 / 81 (Month) (Day) (Year)

ID No. 320267

Segment No. 3-1627 Part No. _____

1 HU No.	2 St. No.	3 Street Name	4 Apt. No.	5 Housing Unit Description	6 Apt. Location
1	407	BEECH ALLEY			
2	417	" "			
3		ASH		GREY SIDING - WH. TRIM	
4	438	2ND ST			
5	210	PATTERSON AVE			
6		"		GREY SIDING - WH SHUTTERS	
7	220			GREY INSUL BRICK GR. TRIM	
8		4th ST		GREY INSUL BRICK BL. PILLARS	
9	409	"			
10		PRISCILLA		ABOVE SLOVAK CIVIC FED	
11	315	↓			
12	313	↓			
13	307	ROAD A		NEWBY	
14		PRISCILLA		YELLOW ½ PAINTED FRAME	
15	309	↓			
16	307	↓			
17	400	↓		INSUL BRICK - REAR ENTRANCE	
18	402	3RD ST			
19	406	↓			
20	410	↓			

Post Office DUQUESNE PA (City) (State) Zip Code 15110 HU 1 - 39

Post Office _____ (City) (State) Zip Code _____ HU ___ - ___

Post Office _____ (City) (State) Zip Code _____ HU ___ - ___

Checked By _____

Figure B-3. List of housing units.

PART 3

DEBRIEFING AGENDA

Part 3 of this appendix contains the agenda used during the December 1981 interviewer debriefing session.

Estimating Recreation and Related Benefits of Water Quality
RTI Project 2222-2

DEBRIEFING AGENDA

Thursday, December 10, 1981

Welcome and Introductions

Evaluation of Training

- Effectiveness of home study materials
- Effectiveness of classroom sessions
- Adequacy of training time
- Areas encountered in interviewing that should have been covered in training
- Usefulness of specifications and manual
- Deficiencies in specifications and manual

Evaluation of Assignment Materials and Procedures

- Content and layout of Household Control Form
- Accuracy of sample member assignment data (names, addresses, etc.)
- Tracing/locating activities required
- Deficiencies in materials and procedures

Obtaining Respondent Cooperation

- Gaining access to sample members
- Explaining purposes of the survey
- Obtaining permission to complete enumeration
- Obtaining permission to complete the interview
- Intervention by other household/family members
- Effectiveness of "Dear Resident" and other informational material
- Characteristics of nonrespondents and reasons for nonresponse
- Procedures for converting refusing sample members

Conducting the Interviews

- Household enumeration procedures and problems
- Usefulness of handout materials
- Deficiencies of handout materials
- Section-by-section review of all questionnaires
  (1) What questions usually worked well and were understood by all respondents?
  (2) What questions frequently were difficult to administer or were misunderstood by respondents?
  (3) What questions appeared to elicit reliable responses with minimal probing?
  (4) What questions frequently yielded "Don't Know" responses?
  (5) What questions were respondents reluctant to answer? What reasons, if any, were stated?
  (6) What category of respondents (i.e., disabled, widowed, older men, etc.) had the most difficulty in responding to the questions?
  (7) What category of respondents were most reluctant to answer certain questions?
- Problems with layout or design of each instrument
- Problems in the interview setting
- Problems with interview length
- Questions or concerns expressed by respondents

Administrative Procedures

- Status reporting
- Communications with supervisor/central office
- Resolution of field problems
- Evaluation of callback requirements

Recommendations for Future Similar Surveys

- Respondent informational material
- Assignment materials and procedures
- Contacting, locating, and securing cooperation
- Instruments and handouts
- Administrative materials and procedures

PART 4

QUALITY CONTROL PROCEDURES

The quality control procedures used during and after administration of the survey questionnaire, including both field editing and validation procedures, are described below:

FIELD EDITING

Field interviewers were responsible for conducting a thorough field edit of each completed survey instrument. Interviewers were provided with an edit instruction for the instruments to insure that significant edit checks were made. The importance of the field editing process and procedures to be followed were emphasized in the interviewer's manual and received attention as part of interviewer training.

Field editing by interviewers involved two steps. First, each completed instrument was scanned for completeness at the conclusion of each interview while the interviewer was still in the respondent's presence. If any incomplete or omitted items were detected, the missing data were obtained. Second, interviewers thoroughly edited each completed instrument before submitting their work. Any omissions or problems noted during this edit were resolved by a telephone call or, if necessary, a return visit to the respondent by the interviewer. These field edit procedures were especially important as an aid to insure that high quality and complete data were received from the field.

To insure quality control of the interviewing process, each interviewer's completed interviews were edited at the Research Triangle Institute (RTI) during the fieldwork period. The editor used edit specifications that focus on the key elements of each document, and interviewers received ongoing assessments of the quality of their work by telephone. In addition, where graphic instruction to an interviewer was helpful to explain the nature of an error, photocopies were made of questionnaire pages to show interviewers exactly what the problem was.

VALIDATION

A major quality control procedure involved validation of a random sample of 10 percent of the interviews conducted. This procedure was accomplished through telephone contacts with participating sample members. The validation contact was designed to determine whether the interview actually took place on or about the date reported; whether the interviewer secured a complete, current household roster; whether appropriate sample member selection procedures were followed; and whether the entire interview schedule was completed. Also, key items were asked and responses compared with original responses reported by the interviewer. In addition, the contact elicited other information concerning the interviewer's performance.

APPENDIX C

SURVEY ANALYSIS: SUPPORTING TABLES

This appendix provides supporting statistical analysis for the option price, user value, and option value results presented in Chapters 4 and 5. The tables in general focus on three issues: (1) estimates with outliers excluded; (2) estimates with protest bids excluded; and (3) t-tests for differences from zero.

In addition, Table C-16 supports the analysis in Chapter 6. This table shows benefit estimates from an alternative contingent-ranking specification.

Table C-1. Student t-Statistics of Characteristics for $H_o : \bar{X}_1 = \bar{X}_2$[a]

Characteristic	User vs. nonuser	Zero vs. nonzero bids
Ownership or use of a boat	2.471[b]	-1.589
Participation in any outdoor recreation in the last year	10.746[b]	-4.818[b]
Numerical rating of the Monongahela	0.365	-1.369
Rating for a particular site	5.988[b]	-3.205[b]
Length of residence	0.242	0.167
Education	1.655	-2.031[b]
Race	-0.804	1.699
Income	1.124	-1.713
Age	-5.995[b]	4.942[b]
Sex	-1.338	-0.347

[a]t-statistics are derived from the results reported in Chapter 4.

[b]Denotes significance at the 0.05 level.

Table C-2. Estimated Option Price for Changes in Water Quality: Effects of Instrument and Type of Respondent--All Respondents[a]

Change in water quality	Type of respondent: User $\bar{X}$	User s	User n	Nonuser $\bar{X}$	Nonuser s	Nonuser n	Combined $\bar{X}$	Combined s	Combined n
1. Iterative bidding framework--starting point = $25 (Version C)									
D to E (avoid)	21.7	18.6	24	23.7	32.9	54	23.1	29.2	78
D to C	15.0	16.4	24	11.9	15.6	54	12.9	15.8	78
C to B	9.4	13.7	24	5.7	10.7	54	6.9	11.7	78
D to B[b]	25.4	27.5	24	41.4	51.5	54	20.1	25.3	78
Combined: all levels	47.1	41.8	24	17.7	24.1	54	43.1	48.5	78
2. Iterative bidding framework--starting point = $125 (Version D)									
D to E (avoid)	89.5	70.3	22	44.6	84.1	50	58.3	82.4	72
D to C	63.9	53.5	22	29.7	56.0	50	40.1	57.1	72
C to B	41.8	54.2	22	19.9	51.1	50	26.6	52.6	72
D to B[b]	111.8	94.4	22	51.3	102.1	50	69.8	103.1	72
Combined: all levels	201.4	149.8	22	95.9	177.6	50	128.1	175.5	72
3. Direct question framework (Version B)									
D to E (avoid)	42.6	67.8	23	13.5	35.2	51	22.5	49.2	74
D to C	27.9	42.7	23	9.3	22.3	51	15.1	31.1	74
C to B	24.0	49.5	23	7.7	22.5	51	12.8	33.8	74
D to B[b]	53.0	84.6	23	17.7	43.5	51	28.7	61.0	74
Combined: all levels	95.7	130.7	23	31.2	77.0	51	51.2	100.6	74
4. Direct question framework: payment card (Version A)									
D to E (avoid)	57.1	92.8	24	38.9	68.8	51	44.7	77.1	75
D to C	46.0	71.1	24	15.9	30.3	51	25.5	48.9	75
C to B	22.5	45.3	24	5.6	17.3	51	11.0	30.1	75
D to B[b]	70.6	112.5	24	21.7	42.5	51	37.3	75.4	75
Combined: all levels	127.7	159.4	24	60.6	96.1	51	82.1	123.0	75

[a]The two respondents who did not complete the questionnaire are excluded.

[b]D to B includes respondents who were willing to give an amount only for fishable or swimmable water and respondents who were willing to pay some amount to avoid the decrease in water quality in addition to the improvements in water quality.

Table C-3. Estimated Option Price for Changes in Water Quality: Effects of Instrument and Type of Respondent--Protest Bids Excluded

Change in water quality	Type of respondent: User $\bar{X}$	User s	User n	Nonuser $\bar{X}$	Nonuser s	Nonuser n	Combined $\bar{X}$	Combined s	Combined n
1. Iterative bidding framework--starting point = $25 (Version C)									
D to E (avoid)	27.4	16.7	19	28.4	34.2	45	28.1	29.9	64
D to C	18.9	16.3	19	14.3	16.1	45	15.7	16.2	64
C to B	11.8	14.5	19	6.9	11.3	45	8.4	12.4	64
D to B[a]	32.1	27.1	19	21.2	25.0	45	24.5	25.9	64
Combined: all levels	59.5	38.1	19	49.7	52.7	45	52.6	48.7	64
2. Iterative bidding framework--starting point = $125 (Version D)									
D to E (avoid)	93.8	69.0	21	54.4	90.2	41	67.7	85.1	62
D to C	66.9	52.8	21	36.2	60.0	41	46.6	59.1	62
C to B	43.8	54.7	21	24.3	55.5	41	30.9	55.6	62
D to B[a]	117.1	93.3	21	62.6	109.8	41	81.0	107.0	62
Combined: all levels	210.0	146.4	21	117.0	190.1	41	148.8	180.9	62
3. Direct question framework (Version B)									
D to E (avoid)	51.6	71.7	19	18.6	40.3	37	29.8	54.7	56
D to C	33.8	44.9	19	12.8	25.4	37	19.9	34.4	56
C to B	29.1	53.3	19	10.6	25.9	37	16.9	38.0	56
D to B[a]	64.2	89.4	19	24.4	49.7	37	37.9	67.7	56
Combined: all levels	115.8	135.7	19	43.0	87.8	37	67.7	110.8	56
4. Direct question framework: payment card (Version A)									
D to E (avoid)	65.2	96.7	21	49.6	74.3	40	55.0	82.2	61
D to C	52.6	73.8	21	20.3	33.0	40	31.4	52.6	61
C to B	25.7	47.7	21	7.1	19.3	40	13.5	32.9	61
D to B[a]	80.7	117.1	21	27.6	46.3	40	45.9	81.3	61
Combined: all levels	146.0	162.6	21	77.3	102.6	40	100.9	129.3	61

[a]D to B includes respondents who were willing to give an amount only for fishable or swimmable water and respondents who were willing to pay some amount to avoid the decrease in water quality in addition to the improvements in water quality.

Table C-4. Estimated User Values for Changes in Water Quality: Effects of Instrument and Type of Respondent--All Respondents[a]

Change in water quality	Type of respondent: User $\bar{X}$	User s	User n	Combined $\bar{X}$	Combined s	Combined n
1. Iterative bidding framework--starting point = $25 (Version C)						
D to E (avoid)	5.2	11.5	24	1.6	6.7	78
D to C	3.3	7.0	24	1.0	4.1	78
C to B[b]	4.0	7.4	24	1.2	4.4	78
D to B[b]	8.3	13.5	24	2.6	8.3	78
Combined: all levels	13.5	23.3	24	4.2	14.2	78
2. Iterative bidding framework--starting point = $125 (Version D)						
D to E (avoid)	38.0	58.9	22	11.6	36.5	72
D to C	31.1	50.0	22	9.5	30.8	72
C to B[b]	32.0	52.9	22	9.8	32.4	72
D to B[b]	69.3	102.1	22	21.2	64.1	72
Combined: all levels	107.3	147.3	22	32.8	94.3	72
3. Direct question framework (Version B)						
D to E (avoid)	19.1	37.6	23	5.9	22.5	74
D to C	18.0	37.7	23	5.6	22.3	74
C to B[b]	11.9	31.6	23	3.7	18.2	74
D to B[b]	29.9	62.3	23	9.3	36.9	74
Combined: all levels	49.0	81.9	23	15.2	50.4	74
4. Direct question framework: payment card (Version A)						
D to E (avoid)	20.2	35.0	24	6.5	21.7	75
D to C	30.2	73.2	24	9.7	43.2	75
C to B[b]	16.0	42.7	24	5.1	25.0	75
D to B[b]	46.7	113.5	24	14.9	67.0	75
Combined: all levels	66.9	121.3	24	21.4	74.6	75

[a]The two respondents who did not complete the questionnaire are excluded.

[b]D to B includes respondents who were willing to give an amount only for fishable or swimmable water and respondents who were willing to pay some amount to avoid the decrease in water quality in addition to the improvements in water quality.

Table C-5. Estimated User Values for Changes in Water Quality: Effects of Instrument and Type of Respondent--Protest Bids Excluded

Change in water quality	Type of respondent: User $\bar{X}$	User s	User n	Combined $\bar{X}$	Combined s	Combined n
1. Iterative bidding framework--starting point = $25 (Version C)						
D to E (avoid)	6.6	12.6	19	2.0	7.4	64
D to C	4.2	7.7	19	1.3	4.5	64
C to B	5.0	8.0	19	1.5	4.9	64
D to B[a]	10.5	14.4	19	3.1	9.1	64
Combined: all levels	17.1	25.1	19	5.1	15.6	64
2. Iterative bidding framework--starting point = $125 (Version D)						
D to E (avoid)	39.8	59.7	21	13.5	39.1	62
D to C	32.6	50.7	21	11.0	32.9	62
C to B	33.6	53.7	21	11.4	34.7	62
D to B[a]	72.6	103.4	21	24.6	68.6	62
Combined: all levels	112.4	148.9	21	38.1	100.7	62
3. Direct question framework (Version B)						
D to E (avoid)	23.1	40.4	19	7.8	25.6	56
D to C	21.8	40.6	19	7.4	25.4	56
C to B	14.4	34.4	19	4.9	20.9	56
D to B[a]	36.2	67.1	19	12.3	42.1	56
Combined: all levels	59.3	86.9	19	20.1	57.2	56
4. Direct question framework: payment card (Version A)						
D to E (avoid)	23.1	36.6	21	8.0	23.8	61
D to C	34.5	77.5	21	11.9	47.7	61
C to B	18.3	45.3	21	6.3	27.6	61
D to B[a]	53.3	120.2	21	18.4	73.9	61
Combined: all levels	76.4	127.1	21	26.3	82.0	61

[a]D to B includes respondents who were willing to give an amount only for fishable or swimmable water and respondents who were willing to pay some amount to avoid the decrease in water quality in addition to the improvements in water quality.

Table C-6. Estimated Option Values for Changes in Water Quality: Effects of Instrument and Type of Respondent--All Respondents[a]

Change in water quality	Type of respondent: User $\bar{X}$	User s	User n	Nonuser $\bar{X}$	Nonuser s	Nonuser n	Combined $\bar{X}$	Combined s	Combined n
1. Iterative bidding framework--starting point = $25 (Version C)									
D to E (avoid)	16.5	17.0	24	23.7	32.9	54	21.5	29.1	78
D to C	11.7	13.8	24	11.9	15.6	54	11.9	15.0	78
C to B	5.4	9.9	24	5.7	10.7	54	5.6	10.4	78
D to B[b]	17.1	21.5	24	41.4	51.5	54	17.5	23.2	78
Combined: all levels	33.5	33.2	24	17.7	24.1	54	39.0	46.6	78
2. Iterative bidding framework--starting point = $125 (Version D)									
D to E (avoid)	51.6	69.9	22	44.6	84.1	50	46.7	79.6	72
D to C	32.7	48.2	22	29.7	56.0	50	30.6	53.4	72
C to B	9.8	28.2	22	19.9	51.1	50	16.8	45.3	72
D to B[b]	42.5	66.5	22	51.3	102.1	50	48.6	92.3	72
Combined: all levels	94.1	119.8	22	95.9	177.6	50	95.3	161.3	72
3. Direct question framework (Version B)									
D to E (avoid)	23.5	41.6	23	13.5	35.2	51	16.6	37.3	74
D to C	9.9	22.9	23	9.3	22.3	51	9.5	22.4	74
C to B	12.1	28.6	23	7.7	22.5	51	9.1	24.4	74
D to B[b]	23.1	50.5	23	17.7	43.5	51	19.4	45.5	74
Combined: all levels	46.7	84.5	23	31.2	77.0	51	36.0	79.1	74
4. Direct question framework: payment card (Version A)									
D to E (avoid)	36.9	73.9	24	38.9	68.8	51	38.3	70.0	75
D to C	15.8	25.4	24	15.9	30.3	51	15.9	28.7	75
C to B	6.5	21.1	24	5.6	17.3	51	5.9	18.5	75
D to B[b]	24.0	43.6	24	21.7	42.5	51	22.4	42.6	75
Combined: all levels	60.8	115.2	24	60.6	96.1	51	60.7	101.8	75

[a]The two respondents who did not complete the questionnaire are excluded.

[b]D to B includes respondents who were willing to give an amount only for fishable or swimmable water and respondents who were willing to pay some amount to avoid the decrease in water quality in addition to the improvements in water quality.

Table C-7. Estimated Option Values for Changes in Water Quality: Effects of Instrument and Type of Respondent--Protest Bids Excluded

Change in water quality	Type of respondent: User $\bar{X}$	User s	User n	Nonuser $\bar{X}$	Nonuser s	Nonuser n	Combined $\bar{X}$	Combined s	Combined n
1. Iterative bidding framework--starting point = $25 (Version C)									
D to E (avoid)	20.8	16.6	19	28.4	34.2	45	26.2	30.1	64
D to C	14.7	14.0	19	14.3	16.1	45	14.5	15.4	64
C to B	6.8	10.7	19	6.9	11.3	45	6.9	11.1	64
D to B[a]	21.6	22.1	19	21.2	25.0	45	21.3	24.0	64
Combined: all levels	42.4	31.9	19	49.7	52.7	45	47.5	47.3	64
2. Iterative bidding framework--starting point = $125 (Version D)									
D to E (avoid)	54.0	70.7	21	54.4	90.2	41	54.3	83.5	62
D to C	34.3	48.8	21	36.2	60.0	41	35.6	56.1	62
C to B	10.2	28.8	21	24.3	55.5	41	19.5	48.4	62
D to B[a]	44.5	67.4	21	62.6	109.8	41	56.5	97.3	62
Combined: all levels	98.6	120.9	21	117.0	190.1	41	110.7	169.0	62
3. Direct question framework (Version B)									
D to E (avoid)	28.5	44.4	19	18.6	40.3	37	21.9	41.6	56
D to C	12.0	24.8	19	12.8	25.4	37	12.6	25.0	56
C to B	14.7	31.0	19	10.6	25.9	37	12.0	27.5	56
D to B[a]	28.0	54.5	19	24.4	49.7	37	25.6	50.9	56
Combined: all levels	56.5	90.2	19	43.0	87.8	37	47.6	88.0	56
4. Direct question framework: payment card (Version A)									
D to E (avoid)	42.1	77.7	21	49.6	74.3	40	47.0	75.0	61
D to C	18.1	26.5	21	20.3	33.0	40	19.5	30.7	61
C to B	7.4	22.5	21	7.1	19.3	40	7.2	20.3	61
D to B[a]	27.4	45.7	21	27.6	46.4	40	27.5	45.8	61
Combined: all levels	69.5	121.0	21	77.3	102.6	40	74.6	108.3	61

[a]D to B includes respondents who were willing to give an amount only for fishable or swimmable water and respondents who were willing to pay some amount to avoid the decrease in water quality in addition to the improvements in water quality.

Table C-8. Option Price Student t-Statistics for $H_o : \bar{X} = 0$
With Outliers and Protest Bids Excluded[a]

	User	Nonuser	Total sample
Payment card			
Level D to E	4.56	4.22	5.59
Level D to C	2.62	3.94	4.36
Level C to B	-	2.34	2.85
Total D to B	2.49	3.82	4.04
Total E to B	4.15	4.81	6.34
Direct question			
Level D to E	2.86	3.05	3.86
Level D to C	2.92	2.93	3.93
Level C to B	2.34	2.26	3.22
Level D to B	3.01	2.86	4.03
Total E to B	3.91	3.03	4.67
Iterative Bidding $25			
Level D to E	7.14	5.20	7.20
Level D to C	5.07	5.97	7.81
Level C to B	3.57	3.86	5.23
Total D to B	5.15	5.63	7.54
Total E to B	6.80	6.05	8.48
Iterative bidding $125			
Level D to E	5.73	4.27	6.42
Level D to C	4.48	3.27	5.16
Level C to B	2.74	-	3.28
Total D to B	4.54	3.32	5.21
Total E to B	5.70	4.37	6.46

[a]Only those values that are significant at the 0.05 level are reported.

Table C-9. User Value Student t-Statistics for $H_o : \bar{X} = 0$ With Outliers and Protest Bids Excluded[a]

	User	Total sample
Payment card		
Level D to E	2.37	2.17
Level D to C	-	-
Level C to B	-	-
Total D to B	-	-
Total E to B	2.29	2.11
Direct question		
Level D to E	2.15	2.01
Level D to C	-	-
Level C to B	-	-
Total D to B	-	-
Total E to B	2.71	2.42
Iterative bidding $25		
Level D to E	2.28	2.12
Level D to C	2.39	2.21
Level C to B	2.73	2.46
Total D to B	3.18	2.76
Total E to D	2.97	2.62
Iterative bidding $125		
Level D to E	2.46	2.23
Level D to C	-	-
Level C to B	-	-
Total D to B	2.22	2.05
Total E to B	2.46	2.23

[a]Only those values that are significant at the 0.05 level are reported.

Table C-10. Option Value Student t-Statistics for Differences in Means Between Bidding Methods--Outliers and Protest Bids Excluded[a]

	User	Total sample
Iterative bidding $25 vs. iterative bidding $125		
Level D to E	-2.14	-1.97
Total E to B	-2.11	-

[a]Only those values that are significant at the 0.05 level are reported.

Table C-11. Regression Results for Option Price Estimates of Water Quality Changes--Protest Bids Excluded

Independent variables	Water quality change[a]				
	D to E (avoid)	D to C	C to B	Total all levels	Total: improvement only
Intercept	-22.132 (-0.510)	-18.171 (-0.627)	4.690 (0.177)	-25.618 (-0.308)	-3.486 (-0.069)
Sex (1 male)	23.756 (2.104)	5.268 (0.698)	3.989 (0.577)	33.597 (1.555)	9.840 (0.744)
Age	-0.314 (-0.983)	-0.283 (-1.328)	-0.239 (-1.221)	-0.869 (-1.423)	-0.555 (-1.485)
Education	3.826 (1.244)	1.968 (0.956)	0.306 (-0.162)	5.020 (0.853)	1.194 (0.331)
Income	0.0006 (1.299)	0.0002 (0.587)	0.0002 (0.892)	0.001 (1.178)	0.0004 (0.815)
Direct question	-31.506 (-2.208)	-13.203 (-1.384)	0.777 (0.089)	-44.026 (-1.613)	-12.520 (-0.749)
Iterative bidding game ($25)	-22.986 (-1.671)	-13.455 (-1.462)	-5.338 (-0.634)	-41.798 (-1.588)	-18.813 (-1.168)
Iterative bidding game ($125)	28.606 (2.028)	21.775 (2.308)	19.461 (2.252)	74.029 (2.743)	45.423 (2.749)
User (1 if user)	12.896 (1.097)	10.799 (1.374)	10.288 1.430	35.420 1.575	22.523 (1.636)
Willing to pay cost of water pollution (1 if very much or somewhat)	18.719 (1.601)	23.848 (3.050)	9.538 1.332	53.944 (2.411)	35.225 (2.572)
Interviewer 1	30.857 (1.325)	13.435 (0.862)	15.658 (1.097)	54.693 (1.227)	23.836 (0.874)
Interviewer 2	7.754 (0.355)	15.931 (1.091)	16.379 (1.224)	34.788 (0.832)	27.034 (1.057)
Interviewer 3	-24.009 (-1.32)	21.959 (1.547)	8.755 (0.674)	1.571 (0.039)	25.580 (1.029)
Interviewer 4	19.348 (0.501)	20.235 (0.783)	32.428 (1.370)	66.575 (0.900)	47.227 (1.043)
Interviewer 5	6.982 (0.316)	3.354 (0.227)	-4.095 (-0.302)	4.168 (0.099)	-2.814 (-0.109)
Interviewer 6	36.351 (0.716)	50.645 (1.490)	27.450 (0.882)	108.924 (1.121)	72.572 (1.220)
Interviewer 7	42.280 (1.815)	6.505 (0.418)	7.411 (0.520)	58.627 (1.315)	16.347 (0.599)
Interviewer 8	11.136 (0.510)	25.584 (1.750)	14.498 (1.083)	46.024 (1.101)	34.888 (1.363)
Interviewer 9	49.806 (1.385)	30.573 (1.271)	29.078 (1.320)	101.538 (1.476)	51.732 (1.228)
R^2	0.281	0.248	0.148	0.276	0.229
F	3.61	2.99	1.61	3.51	2.74
Degrees of freedom	166	166	166	166	166

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

Table C-12. Regression Results for User Value Estimates of Water Quality Changes--Protest Bids Excluded

Independent variables	Water quality change[a]				
	D to E (avoid)	D to C	C to B	Total all levels	Total: improvement only
Intercept	26.618 (1.408)	9.513 (0.422)	9.497 (0.546)	24.423 (0.630)	51.041 (1.023)
Sex	-0.567 (-0.115)	-7.465 (-1.273)	-5.447 (-1.204)	-11.303 (-1.122)	-11.870 (-0.915)
Age	-0.328 (-2.512)	-0.231 (-1.485)	-0.172 (-1.431)	-0.455 (-1.698)	-0.783 (-2.270)
Education	0.140 (0.104)	0.212 (0.132)	0.253 (0.204)	-0.041 (-0.015)	0.098 (0.028)
Income	0.000002 (0.010)	0.0001 (0.594)	0.0001 (0.452)	0.0003 (0.667)	0.0003 (0.522)
Direct question	-1.694 (-0.271)	-5.944 (-0.796)	-1.312 (-0.228)	-8.307 (-0.647)	-10.001 (-0.605)
Iterative bidding ($25)	-5.195 (-0.860)	-11.770 (-1.635)	-4.114 (-0.740)	-15.345 (-1.240)	-20.541 (-1.289)
Iterative bidding ($125)	6.214 (1.006)	-2.406 (-0.327)	5.525 (0.972)	6.233 (0.492)	12.447 (0.763)
Willing to pay cost	4.790 (0.950)	9.560 (1.591)	4.808 (1.037)	14.834 (1.436)	19.624 (1.475)
Interviewer 1	-10.977 (-1.075)	-3.649 (-0.300)	-7.453 (-0.793)	-9.504 (-0.454)	-20.481 (-0.760)
Interviewer 2	-5.433 (-0.567)	4.711 (0.412)	-1.321 (-0.150)	4.240 (0.216)	-1.193 (-0.047)
Interviewer 3	-9.462 (-1.039)	23.386 (2.153)	8.302 (0.990)	32.793 (1.756)	23.331 (0.970)
Interviewer 4	-11.818 (-0.697)	1.810 (0.090)	-3.542 (-0.227)	-0.471 (-0.014)	-12.289 (-0.275)
Interviewer 5	-12.842 (-1.322)	-5.401 (-0.466)	-9.620 (-1.076)	-12.998 (-0.653)	-25.840 (-1.008)
Interviewer 6	-10.835 (-0.486)	9.970 (0.375)	-1.871 (-0.091)	7.909 (0.173)	-2.926 (-0.050)
Interviewer 7	4.895 (0.482)	6.735 (0.557)	1.162 (0.124)	15.612 (0.750)	20.507 (0.765)
Interviewer 8	-10.016 (-1.044)	6.084 (0.532)	-4.086 (-0.463)	2.539 (0.129)	-7.478 (-0.295)
Interviewer 9	-2.618 (-0.166)	-0.119 (-0.006)	7.050 (0.485)	6.722 (0.208)	4.105 (0.099)
R^2	0.11	0.12	0.09	0.11	0.12
F	1.26	1.32	0.99	1.26	1.39
Degrees of freedom	167	167	167	167	167

[a]Numbers in parentheses are symptotic t-ratios for the null hypothesis of no association.

Table C-13. Regression Results for Option Value Estimates of Water Quality Changes--Protest Bids Excluded

Independent variables	Water quality change[a]			
	D to E (avoid)	D to C	C to B	Total: improvement only
Intercept	-3.931 (-0.105)	1.879 (0.091)	23.017 (1.205)	24.897 (0.684)
Sex	18.033 (1.745)	7.528 (1.324)	5.259 (1.002)	12.096 (1.209)
Age	-0.341 (-1.172)	-0.302 (-1.885)	-0.232 (-1.568)	-0.544 (-1.928)
Education	3.202 (1.143)	1.595 (1.035)	-0.810 (-0.569)	0.888 (0.328)
Income	0.0003 (0.830)	-0.0001 (-0.477)	-.0000 (-0.013)	-0.0001 (-0.324)
Direct question	-25.304 (-1.872)	-5.552 (-0.747)	4.980 (0.725)	-0.257 (-0.020)
Iterative bidding ($25)	-15.199 (-1.164)	0.690 (0.096)	0.970 (0.146)	0.775 (0.061)
Iterative bidding ($125)	25.841 (1.936)	27.909 (3.802)	17.004 (2.508)	45.796 (3.544)
Willing to pay cost	27.643 (2.655)	21.039 3.673	10.588 (2.001)	33.146 (3.287)
User	-18.682 (-1.770)	-14.078 (-2.424)	-9.307 (-1.735)	-24.071 (-2.355)
R^2	0.179	0.217	0.090	0.177
F	4.22	5.39	1.92	4.18
Degrees of freedom	175	175	175	175

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

Table C-14. Regression Results for Option Value Estimates of Water Quality Changes--Protest Bids and Outliers Excluded

Independent variables	Water quality change[a]			
	D to E (avoid)	D to C	C to B	Total: improvement only
Intercept	-35.228 (-1.019)	-24.058 (-1.185)	0.683 (0.043)	-17.021 (-0.547)
Sex	5.779 (8.986)	-0.172 (-0.033)	-2.209 (-0.531)	-4.046 (-0.500)
Age	-0.277 (-1.066)	-0.182 (-1.188)	-0.155 (-1.286)	-0.326 (-1.390)
Education	5.306 (2.131)	2.890 (1.975)	0.148 (0.128)	3.088 (1.378)
Income	0.0006 (1.532)	0.0001 (0.564)	0.0002 (1.39)	0.0003 (0.863)
Direct question	-29.503 (-2.596)	-8.629 (-1.292)	0.786 (0.149)	-6.927 (-0.676)
Iterative bidding ($25)	-14.040 (-1.294)	-0.575 (-0.090)	0.160 (0.032)	-1.138 (-0.116)
Iterative bidding ($125)	13.018 (1.084)	16.697 (2.366)	4.633 (0.833)	23.315 (2.153)
User	14.515 (-1.549)	-8.312 (-1.510)	-2.763 (-0.637)	-11.371 (-1.346)
Willing to pay cost	11.346 (1.224)	14.134 (2.595)	3.666 (0.854)	19.901 (2.382)
Interviewer 1	20.321 (1.100)	6.246 (0.578)	10.166 (1.189)	9.072 (0.545)
Interviewer 2	-1.272 (-0.075)	-0.279 (-0.028)	6.402 (0.818)	-0.745 (-0.049)
Interviewer 3	-9.319 (-0.563)	0.349 (0.036)	2.596 (0.339)	-3.135 (-0.210)
Interviewer 4	-20.891 (-0.656)	-5.726 (-0.306)	16.615 (1.123)	2.848 (0.099)
Interviewer 5	13.911 (0.832)	4.466 (0.454)	2.793 (0.361)	2.562 (0.170)
Interviewer 6	54.899 (1.063)	76.817 (2.530)	55.478 (2.318)	125.627 (2.698)
Interviewer 7	20.251 (1.070)	1.467 (0.132)	5.098 (0.582)	2.024 0.119
Interviewer 8	19.014 (1.115)	18.181 (1.814)	15.698 (1.987)	27.557 (1.792)
Interviewer 9	38.062 (0.992)	43.784 (1.942)	-3.945 (-0.222)	30.263 (0.875)
R^2	0.269	0.294	0.129	0.253
F	2.78	3.14	1.12	2.55
Degrees of freedom	136	136	136	136

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

Table C-15. Regression Results for Option Value Estimates of Water Quality Changes--Protest Bids Excluded

Independent variables	Water quality change[a]			
	D to E (avoid)	D to C	C to B	Total: improvement only
Intercept	-36.611 (-0.890)	-17.778 (-0.770)	2.781 (0.132)	-9.546 (-0.235)
Sex	20.914 (1.953)	9.950 (1.655)	7.304 (1.329)	15.986 (1.514)
Age	-0.257 (-0.849)	-0.274 (-1.611)	-0.236 (-1.521)	-0.511 (-1.711)
Education	4.067 (1.394)	2.067 (1.262)	-0.321 (-0.214)	1.811 (0.630)
Income	0.0005 (1.252)	-0.0000 (-0.010)	0.0001 (0.610)	0.0001 (0.206)
Direct question	-30.187 (-2.230)	-7.565 (-0.996)	1.854 (0.267)	-4.781 (-0.358)
Iterative bidding ($25)	-16.969 (-1.300)	-1.014 (-0.138)	-0.711 (-0.106)	-2.224 (-0.173)
Iterative bidding ($125)	24.667 (1.843)	26.037 (3.467)	15.358 (2.237)	42.630 (3.231)
User	-14.859 (-1.333)	-11.852 (-1.894)	-7.063 (-1.235)	-19.465 (-1.771)
Willing to pay cost	19.183 (1.730)	18.577 (2.984)	8.014 (1.409)	28.340 (2.592)
Interviewer 1	45.060 (2.039)	19.717 (1.590)	25.128 (2.216)	38.220 (1.754)
Interviewer 2	13.174 (0.636)	11.210 (0.964)	17.693 (1.665)	22.775 (1.115)
Interviewer 3	-4.031 (-0.200)	7.156 (0.633)	7.027 (0.681)	8.697 (0.438)
Interviewer 4	28.659 (0.782)	16.378 (0.796)	34.403 (1.829)	43.904 (1.215)
Interviewer 5	19.815 (0.944)	8.747 (0.743)	5.520 (0.513)	10.171 (0.492)
Interviewer 6	46.018 (0.955)	39.722 (1.469)	28.591 (1.156)	62.895 (1.324)
Interviewer 7	44.117 (1.997)	5.264 (0.425)	10.457 (0.923)	10.920 (0.501)
Interviewer 8	19.804 (0.955)	18.400 (1.581)	17.741 (1.668)	30.310 (1.483)
Interviewer 9	50.923 (1.493)	29.468 1.539	21.089 (1.205)	42.740 (1.271)
R^2	0.241	0.247	0.143	0.212
F	2.93	3.03	1.54	2.48
Degrees of freedom	166	166	166	166

[a]Numbers in parentheses are asymptotic t-ratios for the null hypothesis of no association.

Table C-16. Benefit Estimates from Contingent Ranking Models

Model/estimator	Average	Range
	Payment = 5 Water quality change: boatable to fishable	
Final Model (specification I)		
Ordered logit	-8.77	-73.77 to 115.82
Ordered normal	-9.90	-157.02 to 287.88
II	Payment = 50 Water quality change: boatable to fishable	
Ordered logit	51.40	48.51 to 55.41
Ordered normal	72.45	49.06 to 97.79
III	Payment = 100 Water quality change: boatable to fishable	
Ordered logit	49.56	48.31 to 51.70
Ordered normal	69.39	48.90 to 85.94
IV	Payment = 175 Water quality change: boatable to fishable	
Ordered logit	49.17	48.26 to 50.94
Ordered normal	68.75	48.86 to 83.67
V	Payment = 5 Water quality change: boatable to swimmable	
Ordered logit	-15.78	-132.78 to 208.48
Ordered normal	-17.82	-282.64 to 518.18
VI	Payment = 50 Water quality change: boatable to swimmable	
Ordered logit	92.52	87.31 to 99.74
Ordered normal	130.40	88.30 to 176.02
VII	Payment = 100 Water quality change: boatable to swimmable	
Ordered logit	89.21	86.95 to 93.05
Ordered normal	124.90	88.01 to 154.70
VIII	Payment = 175 Water quality change: boatable to swimmable	
Ordered logit	88.51	86.87 to 91.69
Ordered normal	123.75	87.95 to 150.60

Table C-17. Estimated Option Values for Water Quality Change: Effects of Instrument and Type of Respondent-- Protest Bids and Outliers Excluded

Change in water quality	Type of respondent: User[a] $\bar{X}$	User[a] s	User[a] n	Nonuser $\bar{X}$	Nonuser s	Nonuser n
1. Iterative Bidding Framework, Starting Point = $25						
D to E (avoid)	21.43	16.81	14	28.52	34.16	44
D to C	14.64	12.32	14	14.55	15.47	44
C to B	8.93	11.80	14	6.48	11.13	44
D to B[b]	23.57	22.65	14	21.02	23.61	44
2. Iterative Bidding Framework, Starting Point = $125						
D to E (avoid)	62.33	67.03	15	37.58	50.96	33
D to C	40.33	49.77	15	25.45	44.90	33
C to B	14.00	33.60	15	11.21	32.60	33
D to B[b]	54.33	72.60	15	39.24	68.30	33
3. Direct Question Framework						
D to E (avoid)	18.21	31.29	14	17.89	34.42	37
D to C	10.50	26.94	14	10.62	20.74	37
C to B	9.86	27.14	14	8.73	20.97	37
D to B[b]	22.14	53.73	14	20.30	39.75	37
4. Payment Card						
D to E (avoid)	27.73	30.03	11	49.19	72.69	43
D to C	15.91	21.19	11	20.47	32.27	43
C to B	5.00	10.00	11	6.63	18.70	43
D to B[b]	20.91	27.46	11	28.26	44.87	43

[a]These results are based on the narrow definition of users.

[b]D to B represents the sum of bids for the improvements in water quality and for some individuals the payment to move from Level D to Level B directly.

Table C-18. A Comparison of Contingent Valuation and Travel Cost Benefit Estimates--Protest Bids and Outliers Excluded[a]

	ΔWQ = Loss of area		ΔWQ = Boatable to fishable		ΔWQ = Boatable to swimmable	
	Model	Test[b]	Model	Test[b]	Model	Test[b]
Independent variable						
Intercept	17.482 (1.022)	-	35.422 (1.672)	-	58.359 (1.669)	-
Travel cost benefit estimate	.450 (1.475)	3.608	-4.923 (-1.299)	-1.708	-3.186 (-1.076)	-1.600
Qualitative variables						
Payment card	-34.502 (-2.335)	-	69.510 (2.883)	-	109.632 (2.734)	-
Direct question	-27.039 (-2.062)	-	17.831 (0.850)	-	17.421 (0.499)	-
Iterative bid ($25)	-28.803 (-1.993)	-	-4.740 (-0.201)	-	-11.500 (-0.293)	-
R^2	.117		.158		.146	
n	68		68		68	
F	2.09 (0.09)[c]		2.96 (0.03)[c]		2.68 (0.04)[c]	

[a]The numbers in parentheses below the estimated coefficients are t-ratios for the null hypothesis of no association.

[b]This column reports the t-ratio for the hypothesis that the coefficient for the travel cost variable was 1.55. The travel cost model measures consumer surplus in 1977 dollars. The contingent valuation experiments were conducted in 1981. Using the consumer price index to adjust the travel cost benefit estimates to 1981 dollars would require multiplying each estimate by 1.55. Since the estimated regression coefficients (and standard errors) will correspondingly adjust to reflect this scale change, a test of the null hypothesis that the coefficient of travel cost was equal to unity is equivalent to a test that is equal to 1.55 when the travel cost benefit estimates are measured in 1977 dollars and user values estimates (the dependent variable) are in 1981 dollars.

[c]This number in parentheses below the reported F-statistic is the level of significance for rejection of the null hypothesis of no association between the dependent and independent variables.

APPENDIX D

SURVEY QUESTIONNAIRES

This appendix contains two parts. Part 1 contains the survey questionnaires as administered during the survey of the Monongahela River basin. Part 2 contains a brief summary of suggestions for improving the questionnaire for future use in similar surveys.

PART 1

SURVEY QUESTIONNAIRE AS ADMINISTERED DURING THE MONONGAHELA RIVER BASIN SURVEY

OMB # 2000-0381
Approval Expires: 9/20/82

ESTIMATING BENEFITS OF WATER QUALITY
QUESTIONNAIRE

Form No. 02
(1)

I. IDENTIFICATION INFORMATION

A. Study No. [ ][ ][ ][ ] - [ ] *(2-6)*

B. PSU/Segment No. [ ] - [ ][ ][ ][ ][ ] *(8-13)*

C. Housing Unit No. [ ][ ][ ] *(15-17)*

D. Interviewer ID No. [ ][ ][ ][ ][ ][ ] *(Skip)*

E. Sample Individual Roster Line No. [ ][ ] *(19-20)*

F. Questionnaire Version **A** *(22)*

II. INTRODUCTION

IF THE ENUMERATION RESPONDENT IS ALSO THE SELECTED SAMPLE INDIVIDUAL, CONTINUE YOUR INTRODUCTION TO THE STUDY BY READING THE SECOND PARAGRAPH BELOW. IF THE SAMPLE INDIVIDUAL IS SOMEONE OTHER THAN THE ENUMERATION RESPONDENT, READ THE ENTIRE INTRODUCTION BELOW.

Hello, I'm (NAME) from the Research Triangle Institute in North Carolina. We are doing a study for a government agency to study levels of water quality and some outdoor recreational activities people take part in both near and on ponds, lakes, streams and rivers in the Monongahela River Basin. You have been randomly selected to participate in the study.

Your participation is entirely voluntary and you may refuse to answer any questions. Because only a small number of people are being selected for the study, the participation of each person selected is extremely important. Most of the questions have to do with your attitudes and opinions and there are no right or wrong answers. The information which you provide will be kept strictly confidential and will be used only for overall statistical results. If you would like, we will send you a summary of the results of the study.

CHECK APPROPRIATE BOX BELOW AND IF "YES" PRINT RESPONDENT'S MAILING ADDRESS.

RESULTS REQUESTED: YES [ ] NO [ ]

Mailing Address

_____ Number/Street/RFD Apt. No.

_____ City/State [ ][ ][ ][ ][ ] ZIP

INTERVIEW START TIME: _____ AM / PM

A-3 LEAVE CARD 1 IN FRONT OF RESPONDENT. GIVE RESPONDENT CARD 2, "LIST OF SITES." Here is a list of recreational sites in the area. GIVE RESPONDENT CARD 3, "PICTORIAL MAP." And here is a pictorial map showing the location of these sites. ALLOW RESPONDENT TIME TO LOOK AT BOTH CARDS. THESE THREE CARDS SHOULD REMAIN IN FRONT OF THE RESPONDENT THROUGHOUT THE INTERVIEW.

How many times within the past twelve months did you visit any of the sites listed on this card or any other recreational site near water?

AS SITES ARE MENTIONED, RECORD SITE CODE AND NUMBER OF TIMES THE SITE WAS VISITED. THEN ASK: Which activities listed on Card 1 did you participate in at that site during the last 12 months?

CIRCLE THE ACTIVITY NUMBER(S) IN THE COLUMN ACROSS FROM THE SITE(S) MENTIONED.

IF UNLISTED SITES ARE MENTIONED, ENTER SITE NAME ON LINE AND RECORD NUMBER(S) OF VISITS AND ACTIVITIES.

Site Names Not Listed	Site Codes	No. of Visits	CANOEING, KAYAKING, ETC.	OTHER BOATING	SAILING	WATER SKIING	FISHING	SWIMMING, SUNBATHING	CAMPING	PICNICKING	BIRD/WILDLIFE OBSERV/PHOTO	OTHER WALKING/JOGGING	BICYCLING	HORSEBACK RIDING	HUNTING	HIKING OR BACKPACKING	ATTEND SPORTS EVENTS	OTHER OUTDOOR SPORTS	OFF-ROAD DRIVING/RIDING	PLEASURE DRIVING	SIGHTSEEING
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19

A. RECREATIONAL ACTIVITIES

A-1 a. First, do you own or have the use of any kind of boat? CIRCLE NUMBER.

YES . . . . . 01 (GO TO A-1.b.) *(23)*

NO . . . . . 02 (GO TO A-2)

b. Which of the following describes the boat you use most often? READ ANSWER CHOICES AND CIRCLE NUMBER.

SAILBOAT . . . . . 01 *(24)*

INBOARD 02

OUTBOARD 03

CANOE 04

OTHER (SPECIFY) 05

_____

A-2 The next few questions we would like to ask deal with outdoor recreational activities which people take part in near lakes and rivers in this area; that is, the activities shown on this card. GIVE RESPONDENT CARD 1, "ACTIVITY CARD". Please look carefully over the list of activities, keeping in mind that all the activities listed refer to activities near lakes or rivers. ALLOW RESPONDENT TIME TO LOOK AT THE LIST.

Within the past 12 months, that is since last November, did you take part in any of the activities listed? CIRCLE NUMBER.

YES . . . . . 01 (GO TO A-3) *(25)*

NO . . . . . 02 (GO TO B-1)

B. BENEFITS MEASURES

B-1 The next group of questions is about the quality of water in the Monongahela River. Congress passed water pollution control laws in 1972 and in 1977 to improve the nation's water quality. The states of Pennsylvania and West Virginia have also been involved in water quality improvement programs of their own. These programs have resulted in cleaner rivers that are better places for fishing, boating, and other outdoor activities which people take part in near water. We all pay for these water quality improvement programs both as taxpayers and as consumers.

In this study we are concerned with the water quality of only the Monongahela River. Keep in mind that people take part in all of the activities on Card 1 both on and near the water.

Generally, the better the water quality, the better suited the water is for recreational activities and the more likely people will take part in outdoor recreational activities on or near the water. Here is a picture of a ladder that shows various levels of water quality. GIVE RESPONDENT CARD 4, "WATER QUALITY LADDER".

The top of the ladder stands for the best possible quality of water. The bottom of the ladder stands for the worst possible water quality. On the ladder you can see the different levels of the quality of the water. For example: (POINT TO EACH LEVEL -- E, D, C, B, A -- AS YOU READ THE STATEMENTS BELOW.)

Level "E" (POINTING) is so polluted that it has oil, raw sewage and other things like trash in it; it has no plant or animal life and smells bad.

Water at level "D" is okay for boating but not fishing or swimming.

Level "C" shows where the water is clean enough so that game fish like bass can live in it.

Level "B" shows where the water is clean enough so that people can swim in it safely.

And at level "A", the quality of the water is so good that it would be possible to drink directly from it if you wanted to.

Card 5

a. Now, think about the water quality of the Monongahela River on the whole. In terms of this scale from zero to ten, how would you rate the water quality of the Monongahela River at the present time? POINT TO THE ZERO-TO-TEN SCALE ON THE LADDER AND CIRCLE NUMBER. *1-22 Dup.*

00 01 02 03 04 05 06 07 08 09 10 (GO TO B-1.b.) *(23-24)*

DON'T KNOW. . . . . 11 (GO TO B-2)

b. Is your rating for a particular site on the river? CIRCLE NUMBER.

YES . . . . . 01 (GO TO B-1.c.) *(25)*

NO . . . . . 02 (GO TO B-2)

c. On the map, please show me which river site your rating applies to.

Site Code: [ ][ ] *(26-27)*

IF NOT ON LIST OF RECREATIONAL SITES, SPECIFY:

_____

B-2 Another important purpose of this study is to learn how much the quality of water of the Monongahela River is worth to the people who live in the river basin. In answering this question, there are three ways of thinking about water quality that might influence your decision. GIVE RESPONDENT CARD 5, "VALUE CARD". The three ways are shown on this card.

a. One, you might think about how much water quality is worth to you because you use the river for recreation. POINT TO PART I OF VALUE CARD AND GIVE RESPONDENT TIME TO READ THAT PART.

How important a factor is your actual use of the river in making a decision about how much clean water is worth to you? CIRCLE NUMBER.

(28-29)

VERY IMPORTANT 01

SOMEWHAT IMPORTANT 02

NEITHER IMPORTANT NOR UNIMPORTANT 03

NOT VERY IMPORTANT 04

NOT IMPORTANT AT ALL . . . 05

b. Another way you might think about how much clean water is worth to you is that it is worth something to you to know that a clean water river is being maintained for your use if you should decide, in the future, that you want to use it. POINT TO PART II OF VALUE CARD AND GIVE RESPONDENT TIME TO READ THAT PART. For example, you might buy an advance ticket for the Steelers or Pirates just to be able to go to a home game if you later decide you want to go. Likewise, you might pay some amount each year to have a clean water river available to use if you should decide to use it.

In deciding how much clean water is worth to you, how important a factor is knowing that a clean water river is being maintained for your use, if you should decide to use it? CIRCLE NUMBER.

(30-31)

VERY IMPORTANT 01

SOMEWHAT IMPORTANT 02

NEITHER IMPORTANT NOR UNIMPORTANT 03

NOT VERY IMPORTANT 04

NOT IMPORTANT AT ALL . . . 05

c. A third thing you might think about in deciding how much clean water is worth to you is the satisfaction of knowing that a clean water river is there. POINT TO PART III OF VALUE CARD AND GIVE RESPONDENT TIME TO READ THAT PART. For example, you might be willing to pay something to maintain a public park even though you know you won't use it. The same thing could be true for clean water in the Monongahela; that is, you might pay something just for the satisfaction of knowing that it is clean and that others can use it.

In deciding how much clean water is worth to you, how important is knowing that a clean water river is being maintained? CIRCLE NUMBER.

(32-33)

VERY IMPORTANT 01

SOMEWHAT IMPORTANT 02

NEITHER IMPORTANT NOR UNIMPORTANT 03

NOT VERY IMPORTANT 04

NOT IMPORTANT AT ALL . . . 05

INTRODUCTION TO QUESTION B-3

Now, we would like for you to think about the relationship between improving the quality of water in the Monongahela River and what we all have to pay each year as taxpayers and as consumers. We all pay directly through our tax dollars each year for cleaning up all rivers. We also pay indirectly each year through higher prices for the products we buy because it costs companies money to clean up water they use in making their products. Thus, each year, we are paying directly and indirectly for improvements in the water quality of the Monongahela River.

I want to ask you a few questions about what amount of money you would be willing to pay each year for different levels of water quality in the Monongahela River. Please keep in mind that the amounts you would pay each year would be paid in the form of taxes or in the form of higher prices for the products that companies sell.

We are talking about different levels of water quality for only the Monongahela River, with water quality at other sites on Card 2 staying the same as it is now.

I also want you to keep in mind the recreational activities that you now do and that you might do in the future on the Monongahela River or at other sites. That is, keep in mind the first two parts of the value card. (POINT TO THE VALUE CARD, CARD 5.) Your actual use or possible use can involve activities in the water or near the water, or both, as we talked about earlier.

We know that for the Monongahela River as a whole the current water quality is at level "D", but that it may vary at different points along the river. At level "D" it is clean enough for boating, but not clean enough for catching game fish or for swimming.

HAVE REMINDER CARD READY. RECORD DOLLAR AMOUNTS GIVEN FOR EACH PART ASKED.

B-3 a. This payment card shows different yearly amounts people might be willing to pay for different levels of water quality. HAND RESPONDENT CARD 6, "PAYMENT CARD," AND ALLOW RESPONDENT TIME TO LOOK AT IT.

What is the most it is worth to you (and your family) on a yearly basis to keep the water quality in the Monongahela River from slipping back from level "D" to level "E", where it is not even clean enough for boating? Please pick any amount on the card, any amount in between, or any other amount you think is appropriate.

$_____ DOLLARS (IF ANY AMOUNT, GO TO B-3.b.; IF ZERO DOLLARS, ASK ↓) (34-36)

Would it be worth something to you (and your family) to raise the water quality level from level "D" to a higher level? CIRCLE NUMBER.

YES . . . . . 01 (GO TO B-3.b.)

NO . . . . . 02 (GO TO B-3.e.)

b. (In addition to the amount you just told me,) What is the most that you would be willing to pay each year in higher taxes and prices for products that companies sell to raise the water quality from level "D" to level "C", where game fish can live in it and it is improved for other activities?

$ _____ DOLLARS (IF ANY AMOUNT, GO TO B-3.c.; IF ZERO DOLLARS, GO TO B-3.d.) (37-39)

c. How much more than (READ AMOUNT FROM b.) would you be willing to pay each year in higher taxes and prices for products that companies sell to raise the water quality from level "C" to level "B", where it is clean enough for swimming and it is improved for other activities?

$ _____ DOLLARS (GO TO B-4) (40-42)

d. What is the most that you would be willing to pay each year in higher taxes and prices for products that companies sell to raise the water quality from level "D" to level "B", where it is clean enough for swimming and it is improved for other activities?

$ _____ DOLLARS (IF ANY AMOUNT IN a., GO TO B-4; IF ZERO DOLLARS IN a. AND: • ANY AMOUNT IN d., GO TO B-4.d.; • ZERO DOLLARS IN d., GO TO B-3.e.) *(43-45)*

e. We have found in studies of this type that people have a lot of different reasons for answering as they do. Some people felt they did not have enough information to give a dollar amount, some did not want to put dollar values on environmental quality, and some objected to the way the question was presented. Others gave a zero dollar amount because that was what it was worth to them.

Which of these reasons best describes why you answered the way you did? REPEAT REASONS IF NECESSARY AND CIRCLE NUMBER.

(46-47)

NOT ENOUGH INFORMATION . . 01
DID NOT WANT TO PLACE DOLLAR VALUE 02
OBJECTED TO WAY QUESTION WAS PRESENTED 03
THAT IS WHAT IT IS WORTH . 04
OTHER (SPECIFY) 05

(GO TO B-6)

_____

B-4 REFER TO REMINDER CARD. DO NOT ASK QUESTIONS CORRESPONDING TO ZERO AMOUNTS ON CARD.

a. In answering the next question(s), keep in mind your actual and possible future use of the Monongahela. You told me in the last section that it was worth $(AMOUNT) to keep the water quality from slipping from level "D" to level "E". How much of this amount was based on your actual use of the river?

$ _____ *(48-50)*

b. You (also) told me that you would be willing to pay $(AMOUNT) to raise the water quality from level "D" to level "C". POINT TO LEVELS "D" AND "C". How much of this amount was due to your actual use of the river?

$ _____ *(51-53)*

c. You (also) told me that you would be willing to pay $(AMOUNT) to raise the water quality from level "C" to level "B". POINT TO LEVELS "C" AND "B". How much of this amount was due to your actual use of the river?

$ _____ (GO TO B-5) *(54-56)*

d. You told me in the last question that you would be willing to pay $(AMOUNT) to raise the water quality from level "D" to level "B". POINT TO LEVELS "D" AND "B". How much of this amount was due to your actual use of the river.

$ _____ *(57-59)*

B-5 REFER TO REMINDER CARD. You have said that you would be willing to pay $(AMOUNT) to keep the level of water quality from slipping from level "D" to level "E" and you said that you would be willing to pay $(b. PLUS c., OR d.) to raise the level from level "D". This is a total of (READ TOTAL $ AMOUNT).

Let's think about another way that the quality of water in the Monongahela River could affect your recreation on or near water. I would like you to think about how the river being closed for certain activities for different periods of time would change the (READ TOTAL $ AMOUNT) you would be willing to pay per year. Suppose the government is considering relaxing the water pollution control laws, but not totally removing them. This would mean that the overall quality of the water in the Monongahela River would decrease to level "E" where it would be closed some weekends for activities on or in the water like boating, fishing and swimming and you would not know it was closed until the day you wanted to go. The area, however, would remain open all weekends for activities near the water, like jogging or hiking or picnicking.

a. If the water pollution laws were relaxed to the point that the water quality would decrease to level "E" and the area would be closed 1/4 of the weekends of the year for activities on or in the water but would remain open for activities near the water, how much would you change this (READ TOTAL $ AMOUNT) to keep the area open all weekends for all activities?

$_____ DOLLAR CHANGE (60-62)

b. If the area would be closed for activities on or in the water 1/2 of the weekends, how much would you change this (READ TOTAL $ AMOUNT) to keep the area open all weekends for all activities?

$_____ DOLLAR CHANGE (63-65)

c. If the area would be closed for activities on or in the water 3/4 of the weekends, how much would you change this (READ TOTAL $ AMOUNT) to keep the area open all weekends for all activities?

$_____ DOLLAR CHANGE (66-68)

B-6 a. If the water quality in the Monongahela River were improved from level "D" to level "B", where it is clean enough for swimming and it is improved for other activities, how would this affect your annual use or future use of sites along the river? CIRCLE NUMBER.

INCREASE USE BY MORE THAN 5 VISITS PER YEAR . . . 01 (69-70)
INCREASE USE BY 1 TO 5 VISITS PER YEAR. 02
NO CHANGE IN USE. 03
DECREASE USE ALONG THE MONONGAHELA RIVER. 04
DON'T KNOW. 05

b. How would this change from "D" to "B" in the Monongahela River affect your annual use or future use of other recreational sites near water, but not along the Monongahela River? CIRCLE NUMBER.

DECREASE USE BY MORE THAN 5 VISITS PER YEAR . . . 01 (71-72)
DECREASE USE BY 1 TO 5 VISITS PER YEAR. 02
NO CHANGE IN USE. 03
INCREASE USE. 04
DON'T KNOW. 05

B-7 Up to now we have talked about water quality based on your use and possible future use of the Monongahela River. Let's again think about the third part of the value card. That is, it is worth something just to know a river with clean water is there without actually using it or planning to use it. We want you to think only in terms of this satisfaction which excludes any use by you of the river. With this in mind, suppose the government were to remove the water pollution laws entirely. This would mean lower taxes and would allow companies to produce their products at lower prices. But, it would also mean that during most of the rest of your lifetime the Monongahela River would be at level "E" and would not be usable for recreational activities. The change could be reversed in your lifetime but it would cost a great deal of money.

a. What is the most that you (and your family) would be willing to pay each year in the form of higher taxes and prices for the goods you buy for keeping the river at level "D" where it is okay for boating, even if you would never use the river?

$ _____ (IF ANY AMOUNT, GO TO B-7.b.; IF ZERO DOLLARS, GO TO B-8) *(73-75)*

b. Suppose the change could not be reversed for an even longer period of time than your lifetime. How much more than (READ AMOUNT FROM a.) would you (and your family) be willing to pay per year to keep the river at level "D", even if you would never use the river?

$ _____ *(76-78)*

Col. 80 = 5

B-8 GIVE RESPONDENT THE FOUR CARDS FROM THE CARD SET 7. I would now like you to look at these cards which show different combinations of levels of water quality and amounts in higher taxes and prices it would cost every family each year to have the indicated water quality levels.

a. First, I would like you to rank the combinations of water quality levels and amounts you might be willing to pay to obtain those levels in order from the card, or combination, that you most prefer to the one you least prefer. I would like you to do this based only on your use and possible use in the future of the Monongahela River. That is, keeping in mind only Parts I and II of the value card. POINT TO VALUE CARD - PARTS I AND II. RECORD RANKING OF CARDS BY CIRCLED WATER QUALITY LEVELS AND DOLLAR AMOUNTS.

Card 6

1-22 Dup.

RANKING	WATER QUALITY LEVEL	$ AMOUNT	
Most Preferred	_____	$_____	*(24-27)*
2nd	_____	$_____	*(28-31)*
3rd	_____	$_____	*(32-35)*
Least Preferred	_____	$_____	*(36-39)*

b. Now, I would like you to repeat this procedure but assume this time that you will not use the river now or in the future. That is, think about only Part III of the value card. POINT TO VALUE CARD - PART III. RECORD RANKING OF CARDS BY CIRCLED WATER QUALITY LEVELS AND DOLLAR AMOUNTS.

RANKING	WATER QUALITY LEVEL	$ AMOUNT	
Most Preferred	_____	$_____	*(40-43)*
2nd	_____	$_____	*(44-47)*
3rd	_____	$_____	*(48-51)*
Least Preferred	_____	$_____	*(52-55)*

Col.
80 = 6

C. BACKGROUND DATA

I have a few more questions that will help our research staff analyze the results of the study properly.

Card 7

C-1 How long have you lived in the Monongahela River basin area? CIRCLE NUMBER. *1-22 Dup.*

LESS THAN 1 YEAR. . . . . 01 *(24-25)*

1 YEAR OR LONGER BUT LESS THAN 3 YEARS 02

3 YEARS OR LONGER BUT LESS THAN 5 YEARS 03

5 YEARS OR LONGER 04

C-2 Now I am going to read some phrases that describe different kinds of interests people have. As I read each one, please tell me how much the phrase is like you; that is, a lot like you, somewhat like you, a little like you, or not at all like you. CIRCLE ONE NUMBER ON EACH LINE. REPEAT ANSWER CHOICES AS NECESSARY.

	A LOT	SOME WHAT	A LITTLE	NOT AT ALL	NO OPINION	
a. AN OUTDOORS PERSON	01	02	03	04	05	*(26-27)*
b. AN ENVIRONMENTALIST	01	02	03	04	05	*(28-29)*
c. SOMEONE WHO IS AGAINST NUCLEAR POWER FOR ELECTRIC PLANTS	01	02	03	04	05	*(30-31)*
d. SOMEONE WHO IS CONCERNED ABOUT WATER POLLUTION	01	02	03	04	05	*(32-33)*
e. SOMEONE WHO IS WILLING TO PAY THE COST REQUIRED TO CONTROL WATER POLLUTION	01	02	03	04	05	*(34-35)*

C-3 Which of the following best describes your present status? READ CHOICES AS NECESSARY AND CIRCLE NUMBER. *(36-37)*

EMPLOYED FULL-TIME. 01
EMPLOYED PART-TIME. 02
RETIRED 03
(GO TO C-5)

NOT EMPLOYED. 04
A HOUSEWIFE 05
A STUDENT 06
OTHER (SPECIFY) 07
(GO TO C-4)

_____

C-4 Have you ever been employed? CIRCLE NUMBER. (38-39)

YES . . . . . 01 (GO TO C-5)

NO. . . . . 02 (GO TO C-6)

C-5 a. What kind of work (do/did) you do; that is, what (is/was) your job called? (40-42)

_____

_____

_____

b. What (do/did) you actually do in that job? What (are/were) some of your main duties and responsibilities? (43-45)

_____

_____

_____

c. What kind of an organization (do/did) you work for? (PROBE: What do they make, what do they do?) BE SURE TO NOTE IF RESPONDENT IS AN EMPLOYEE OF GOVERNMENT AT ANY LEVEL, INCLUDING THE SCHOOL SYSTEM. (46-48)

_____

_____

_____

d. How many hours (do/did) you work at your job in a usual week?

_____ NUMBER OF HOURS WORKED IN A WEEK (49-50)

C-6 What was the last grade of regular school that you completed -- not counting specialized schools like secretarial, art, or trade schools? CIRCLE NUMBER. (51-52)

NO SCHOOL 01

GRADE SCHOOL (1-8). 02

SOME HIGH SCHOOL (9-11) . . 03

HIGH SCHOOL GRADUATE (12) . 04

SOME COLLEGE (13-15). . . . 05

COLLEGE GRADUATE (16) . . . 06

POST GRADUATE (17+) 07

NO RESPONSE/REFUSED 08

C-7 ASK ONLY IF NOT OBVIOUS. How would you describe your racial or ethnic background? READ CHOICES AND CIRCLE NUMBER.

WHITE OR CAUCASIAN. . . . . 01 *(53-54)*

BLACK OR NEGRO. 02

OTHER (SPECFIY) 03

_____

C-8 Here is a list of income categories. HAND RESPONDENT CARD 8. Would you call off the code number of the category that best describes the combined income that you (and all other members of your family) received during 1980. Please be sure to include wages and salaries, or net income from your business, and pensions, dividends, interest, and any other income. CIRCLE NUMBER.

UNDER $5,000. . . . . 01 *(55-56)*

$5,000 - $9,999 02

$10,000 - $14,999 03

$15,000 - $19,999 04

$20,000 - $24,999 05

$25,000 - $29,999 06

$30,000 - $34,999 07

$35,000 - $39,999 08

$40,000 - $44,999 09

$45,000 - $49,999 10

$50,000 AND OVER. 11

NOT SURE/REFUSED. 12

Col. 80 = 7

C-9 There is a possibility that my supervisor would like to call you to verify your participation in this study. What is the telephone number where you can be reached?

TELEPHONE NUMBER: (_____) _____ - _____

Thank you for participating in this study.

INTERVIEW STOP TIME: _____ AM / PM

OMB # 2000-0381
Approval Expires: 9/20/82

ESTIMATING BENEFITS OF WATER QUALITY
QUESTIONNAIRE

Form No. 02
(1)

I. IDENTIFICATION INFORMATION

A. Study No. [ ][ ][ ][ ] - [ ] (2-6)

B. PSU/Segment No. [ ] - [ ][ ][ ][ ][ ] (8-13)

C. Housing Unit No. [ ][ ][ ] (15-17)

D. Interviewer ID No. [ ][ ][ ][ ][ ][ ] (Skip)

E. Sample Individual Roster Line No. [ ][ ] (19-20)

F. Questionnaire Version **B** (22)

II. INTRODUCTION

IF THE ENUMERATION RESPONDENT IS ALSO THE SELECTED SAMPLE INDIVIDUAL, CONTINUE YOUR INTRODUCTION TO THE STUDY BY READING THE SECOND PARAGRAPH BELOW. IF THE SAMPLE INDIVIDUAL IS SOMEONE OTHER THAN THE ENUMERATION RESPONDENT, READ THE ENTIRE INTRODUCTION BELOW.

Hello, I'm (NAME) from the Research Triangle Institute in North Carolina. We are doing a study for a government agency to study levels of water quality and some outdoor recreational activities people take part in both near and on ponds, lakes, streams and rivers in the Monongahela River Basin. You have been randomly selected to participate in the study.

Your participation is entirely voluntary and you may refuse to answer any questions. Because only a small number of people are being selected for the study, the participation of each person selected is extremely important. Most of the questions have to do with your attitudes and opinions and there are no right or wrong answers. The information which you provide will be kept strictly confidential and will be used only for overall statistical results. If you would like, we will send you a summary of the results of the study.

CHECK APPROPRIATE BOX BELOW AND IF "YES" PRINT RESPONDENT'S MAILING ADDRESS.

RESULTS REQUESTED: YES [ ] NO [ ]

Mailing Address

_____
Number/Street/RFD Apt. No.

_____ [ ][ ][ ][ ][ ]
City/State ZIP

INTERVIEW START TIME: _____ AM / PM

B-3 a. What is the most it is worth to you (and your family) on a yearly basis to keep the water quality in the Monongahela River from slipping back from level "D" to level "E", where it is not even clean enough for boating?

$_____ DOLLARS (IF ANY AMOUNT, GO TO B-3.b.; IF ZERO DOLLARS, ASK) (34-36)

Would it be worth something to you (and your family) to raise the water quality level from level "D" to a higher level? CIRCLE NUMBER.

YES . . . . . 01 (GO TO B-3.b.)

NO . . . . . 02 (GO TO B-3.e.)

b. (In addition to the amount you just told me,) What is the most that you would be willing to pay each year in higher taxes and prices for products that companies sell to raise the water quality from level "D" to level "C", where game fish can live in it and it is improved for other activities?

$ _____ DOLLARS (IF ANY AMOUNT, GO TO B-3.c.; IF ZERO DOLLARS, GO TO B-3.d.) (37-39)

c. How much more than (READ AMOUNT FROM b.) would you be willing to pay each year in higher taxes and prices for products that companies sell to raise the water quality from level "C" to level "B", where it is clean enough for swimming and it is improved for other activities?

$ _____ DOLLARS (GO TO B-4) (40-42)

d. What is the most that you would be willing to pay each year in higher taxes and prices for products that companies sell to raise the water quality from level "D" to level "B", where it is clean enough for swimming and it is improved for other activities?

$ _____ DOLLARS (IF ANY AMOUNT IN a., GO TO B-4; IF ZERO DOLLARS IN a. AND: · ANY AMOUNT IN d., GO TO B-4.d.; · ZERO DOLLARS IN d., GO TO B-3.e.) *(43-45)*

e. We have found in studies of this type that people have a lot of different reasons for answering as they do. Some people felt they did not have enough information to give a dollar amount, some did not want to put dollar values on environmental quality, and some objected to the way the question was presented. Others gave a zero dollar amount because that was what it was worth to them.

Which of these reasons best describes why you answered the way you did? REPEAT REASONS IF NECESSARY AND CIRCLE NUMBER.

(46-47)

NOT ENOUGH INFORMATION . . 01
DID NOT WANT TO PLACE DOLLAR VALUE 02
OBJECTED TO WAY QUESTION WAS PRESENTED 03
THAT IS WHAT IT IS WORTH . 04
OTHER (SPECIFY) 05

(GO TO B-6)

_____

OMB # 2000-0381
Approval Expires: 9/20/82

ESTIMATING BENEFITS OF WATER QUALITY QUESTIONNAIRE

Form No. 02
(1)

I. IDENTIFICATION INFORMATION

A. Study No. [ ][ ][ ][ ] - [ ] *(2-6)*

B. PSU/Segment No. [ ] - [ ][ ][ ][ ][ ] *(8-13)*

C. Housing Unit No. [ ][ ][ ] *(15-17)*

D. Interviewer ID No. [ ][ ][ ][ ][ ][ ] *(Skip)*

E. Sample Individual Roster Line No. [ ][ ] *(19-20)*

F. Questionnaire Version **C** *(22)*

II. INTRODUCTION

IF THE ENUMERATION RESPONDENT IS ALSO THE SELECTED SAMPLE INDIVIDUAL, CONTINUE YOUR INTRODUCTION TO THE STUDY BY READING THE SECOND PARAGRAPH BELOW. IF THE SAMPLE INDIVIDUAL IS SOMEONE OTHER THAN THE ENUMERATION RESPONDENT, READ THE ENTIRE INTRODUCTION BELOW.

Hello, I'm (NAME) from the Research Triangle Institute in North Carolina. We are doing a study for a government agency to study levels of water quality and some outdoor recreational activities people take part in both near and on ponds, lakes, streams and rivers in the Monongahela River Basin. You have been randomly selected to participate in the study.

Your participation is entirely voluntary and you may refuse to answer any questions. Because only a small number of people are being selected for the study, the participation of each person selected is extremely important. Most of the questions have to do with your attitudes and opinions and there are no right or wrong answers. The information which you provide will be kept strictly confidential and will be used only for overall statistical results. If you would like, we will send you a summary of the results of the study.

CHECK APPROPRIATE BOX BELOW AND IF "YES" PRINT RESPONDENT'S MAILING ADDRESS.

RESULTS REQUESTED: YES [ ] NO [ ]

Mailing Address

_____ Number/Street/RFD Apt. No.

_____ City/State [ ][ ][ ][ ][ ] ZIP

INTERVIEW START TIME: _____ AM / PM

B-3 a. To you (and your family), would it be worth $25 each year in higher taxes and prices for products that companies sell to keep the water quality in the Monongahela River from slipping back from level "D" to level "E"? CIRCLE NUMBER.

YES 01

NO 02

IF YES, INCREASE THE DOLLAR AMOUNT IN $5 INCREMENTS UNTIL A "NO" ANSWER IS GIVEN. E.G., "Would it be worth $30 each year to keep water quality from slipping from level 'D' to level 'E'?" ETC. WHEN A "NO" ANSWER IS GIVEN, RECORD DOLLAR AMOUNT OF LAST "YES" ANSWER.

IF NO, DECREASE THE DOLLAR AMOUNT IN $5 INCREMENTS UNTIL A "YES" ANSWER IS GIVEN. E.G., "Would it be worth $20 each year to keep water quality from slipping from level 'D' to level 'E'?" ETC. WHEN A "YES" ANSWER IS GIVEN, RECORD DOLLAR AMOUNT.

$ _____ DOLLARS (IF ANY AMOUNT, GO TO B-3.b.; IF ZERO DOLLARS IS FINAL AMOUNT, ASK) *(34-36)*

Would it be worth something to you (and your family) to raise the water quality level from level "D" to a higher level? CIRCLE NUMBER.

YES . . . . . 01 (GO TO B-3.b.)

NO . . . . . 02 (GO TO B-3.e.)

b. Would you (and your family) be willing to pay (an additional) $25 each year in higher taxes and prices for products that companies sell to raise the water quality from level "D" to level "C", where game fish can live in it and it is improved for other activities? CIRCLE NUMBER.

YES 01

NO 02

IF YES, INCREASE THE DOLLAR AMOUNT IN $5 INCREMENTS UNTIL A "NO" ANSWER IS GIVEN. E.G., "Would you be willing to pay $30 (more) each year to raise the water quality from level 'D' to level 'C'?" ETC. WHEN A "NO" ANSWER IS GIVEN, RECORD DOLLAR AMOUNT OF LAST "YES" ANSWER.

IF NO, DECREASE THE DOLLAR AMOUNT IN $5 INCREMENTS UNTIL A "YES" ANSWER IS GIVEN. E.G., "Would you be willing to pay $20 (more) each year to raise the water quality from level 'D' to level 'C'?" ETC. WHEN A "YES" ANSWER IS GIVEN, RECORD DOLLAR AMOUNT.

$ _____ DOLLARS (IF ANY AMOUNT, GO TO B-3.c.; IF ZERO DOLLARS IS FINAL AMOUNT, GO TO B-3.d.) *(37-39)*

c. Would you (and your family) be willing to pay an additional $25 each year in higher taxes and prices for products that companies sell to raise the water quality from level "C" to level "B", where you can swim in it and it is improved for other activities? CIRCLE NUMBER.

YES 01

NO 02

IF YES, INCREASE THE DOLLAR AMOUNT IN $5 INCREMENTS UNTIL A "NO" ANSWER IS GIVEN. E.G., "Would you be willing to pay $30 more each year to raise the water quality from level 'C' to level 'B'?" ETC. WHEN A "NO" ANSWER IS GIVEN, RECORD DOLLAR AMOUNT OF LAST "YES" ANSWER.

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$ _____ DOLLARS (GO TO B-4) *(40-42)*

d. Would you (and your family) be willing to pay $25 each year in higher taxes and prices for products that companies sell to raise the water quality from level "D" to level "B", where you can swim in it and it is improved for other activities? CIRCLE NUMBER.

YES 01

NO 02

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$ _____ DOLLARS (IF ANY AMOUNT IN a., GO TO B-4; IF ZERO DOLLARS IN a. AND: · ANY AMOUNT IN d., GO TO B-4.d.; · ZERO DOLLARS IN d., GO TO B-3.e.) *(43-45)*

e. We have found in studies of this type that people have a lot of different reasons for answering as they do. Some people felt they did not have enough information to give a dollar amount, some did not want to put dollar values on environmental quality, and some objected to the way the question was presented. Others gave a zero dollar amount because that was what it was worth to them.

Which of these reasons best describes why you answered the way you did? REPEAT REASONS IF NECESSARY AND CIRCLE NUMBER.

(46-47)

NOT ENOUGH INFORMATION . . 01
DID NOT WANT TO PLACE DOLLAR VALUE 02
OBJECTED TO WAY QUESTION WAS PRESENTED 03
THAT IS WHAT IT IS WORTH . 04
OTHER (SPECIFY) 05

(GO TO B-6)

_____

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ESTIMATING BENEFITS OF WATER QUALITY
QUESTIONNAIRE

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(1)

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E. Sample Individual Roster Line No. [ ][ ] (19-20)

F. Questionnaire Version **D** (22)

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RESULTS REQUESTED: YES [ ] NO [ ]

Mailing Address

_____ Number/Street/RFD Apt. No.

_____ City/State [ ][ ][ ][ ][ ] ZIP

INTERVIEW START TIME: _____ AM / PM

B-3 a. To you (and your family), would it be worth $125 each year in higher taxes and prices for products that companies sell to keep the water quality in the Monongahela River from slipping back from level "D" to level "E"? CIRCLE NUMBER.

YES 01

NO 02

IF YES, INCREASE THE DOLLAR AMOUNT IN $10 INCREMENTS UNTIL A "NO" ANSWER IS GIVEN. E.G., "Would it be worth $135 each year to keep water quality from slipping from level 'D' to level 'E'?" ETC. WHEN A "NO" ANSWER IS GIVEN, RECORD DOLLAR AMOUNT OF LAST "YES" ANSWER.

IF NO, DECREASE THE DOLLAR AMOUNT IN $10 INCREMENTS UNTIL A "YES" ANSWER IS GIVEN. E.G., "Would it be worth $115 each year to keep water quality from slipping from level 'D' to level 'E'?" ETC. WHEN A "YES" ANSWER IS GIVEN, RECORD DOLLAR AMOUNT.

$ _____ DOLLARS (IF ANY AMOUNT, GO TO B-3.b.; IF ZERO DOLLARS IS FINAL AMOUNT, ASK .) *(34-36)*

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YES . . . . . 01 (GO TO B-3.b.)

NO . . . . . 02 (GO TO B-3.e.)

b. Would you (and your family) be willing to pay (an additional) $125 each year in higher taxes and prices for products that companies sell to raise the water quality from level "D" to level "C", where game fish can live in it and it is improved for other activities? CIRCLE NUMBER.

YES 01

NO 02

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YES 01

NO 02

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$ _____ DOLLARS (GO TO B-4) *(40-42)*

d. Would you (and your family) be willing to pay $125 each year in higher taxes and prices for products that companies sell to raise the water quality from level "D" to level "B", where you can swim in it and it is improved for other activities? CIRCLE NUMBER.

YES 01

NO 02

F YES, INCREASE THE DOLLAR AMOUNT IN 10 INCREMENTS UNTIL A "NO" ANSWER IS IVEN. E.G., "Would you be willing o pay $135 each year to raise the ater quality from level 'D' to level B'?" ETC. WHEN A "NO" ANSWER IS IVEN, RECORD DOLLAR AMOUNT OF LAST YES" ANSWER.

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NOT ENOUGH INFORMATION . . 01
DID NOT WANT TO PLACE DOLLAR VALUE 02
OBJECTED TO WAY QUESTION WAS PRESENTED 03
THAT IS WHAT IT IS WORTH . 04
OTHER (SPECIFY) 05

(GO TO B-6)

_____

PART 2

SUGGESTIONS FOR IMPROVING THE QUESTIONNAIRE FOR FUTURE USE

Any survey questionnaire can be improved based on the additional information learned in the execution of the survey. This questionnaire is not an exception. One of the most significant changes would amend the word "additional" to the introduction of Question B-7 to clarify that the bid amount is in addition to the amounts previously bid. It is also unclear whether the supply uncertainty dimension added in this question is effectively expressed. This could be improved with a couple of clarifying sentences.

The introduction to Question B-5 could be improved by better explaining how water quality might be worsened only for some weekends. For example, a sentence describing "the effect of higher water temperatures in the summer months could reduce water quality only in that part of the year" might clarify the supply uncertainty that is intended in this question.

The explanation and introduction to the contingent ranking format is too brief. While this may be minimized by the respondent's familiarity with water quality from the other contingent valuation questions, it would require expansion for an application as an independent format. This introduction could also explain in more detail the relation between water quality levels and the amounts paid.

There is a slight difference in wording between Versions A and B and C and D as a result of a word processing error. The phrase "where it is not even clean enough for boating" was inadvertently omitted from Question B-3a in Versions C and D. The water quality ladder would have shown that E was not suitable for boating, so the potential bias here is likely small but, nonetheless, could be avoided in future use.

Finally, some changes might be useful in the visual aids. The cards in the contingent ranking should be same size as the other aids to make them easier to handle. For consistency with the other aids, the value card could have been done in bolder print to make it stand out. There is some debate that a visual aid describing the payment vehicle might have made it clearer to people how they currently pay for water quality. On the other side of this argument is the thinking that this may actually increase the respondents' confusion.

In summary, the questionnaire performed well for most of the key questions, but some relatively minor changes might have made it even better. The question responses most affected by the change are the existence value responses in Question B-7.

APPENDIX E

TECHNICAL WATER QUALITY MEASURES: AN ECONOMIST'S PERSPECTIVE

E.1 INTRODUCTION

A discussion of water quality measurement should define the term water quality, including descriptions of the various attributes that determine quality. Although seldom together, several disciplines have repeatedly explored this issue, and a significant amount of literature is relevant to the questions that arise in benefit estimation. This appendix discusses several of these questions.

E.2 AN OVERVIEW OF TECHNICAL WATER QUALITY MEASURES

E.2.1 Introduction

The following sections briefly describe technical measures of water quality. Sections E.2.2 and E.2.3 discuss freshwater systems, focusing on their characteristics and their ability to assimilate effluents. Section E.2.4 discusses commonly used parameters, noting their importance in an ecosystem, their measurement, and the ability of individuals to perceive their changes.

E.2.2 Water Quality in Freshwater Systems

Freshwater areas are intricate systems differing in attributes and causal relationships. Freshwater system descriptions are complicated by climate, geography, land use, water management, and existing plants and animals. Because these particular characteristics are usually unknown, actual physical relationships cannot be determined. Descriptions are further complicated when scientific analysis cannot measure deleterious long-term or synergistic effects in a natural setting.

Freshwater systems are either lentic systems, which contain standing water such as lakes, or lotic systems, which contain running water such as streams and rivers. However, classifying a system as lentic or lotic can be difficult when natural impoundments, dams, and reservoirs occur in either. In addition, while the basic nutrient cycles are the same for both systems, life cycles and pollution effects differ considerably.

The scope of this project limits discussion only to lotic systems. Impoundments are considered due to their general dynamic nature. However, because the unique lentic system characteristics sometimes appear in natural and manmade impoundments, problems common to both system types are also discussed.

E.2.3 Assimilative Capacity

The ability of a lotic system to assimilate effluents determines actual pollution levels. Assimilative capacity is usually defined with respect to the absence of deleterious effects with a given level of discharge into a receiving water. However, any materials discharged into the water have an effect. The major problem is one of identifying and measuring these changes and of determining when they become deleterious. An effluent's effect on the environment is influenced by time period, amount of available oxygen, plant nutrients, and locational characteristics.

Daily and seasonal variation in the speed of nutrient cycling are major determinants of an effluent's effect on water quality. Lotic systems derive most of their nutrients from soil runoff, causing primary productivity to vary seasonally. As land nutrient and groundwater levels vary, so does the lotic environment's assimilative capacity. Available sunlight is the primary source of daily variation, with the peak rate of photosynthesis in the afternoon hours causing peak levels of dissolved oxygen.

Assimilative capacity is commonly measured by the availability of dissolved oxygen. Because all aquatic animal life depends on dissolved oxygen, low dissolved oxygen levels may cause a reduction in species diversity and number. Some effluents reduce dissolved oxygen because they change the rate of photosynthesis, the solubility of oxygen, and the diffusion of atmospheric oxygen or they increase aerobic bacteria activity.

Existing plant nutrients also determine the effect of effluents. Each ecosystem has a defined nitrogen-phosphorus ratio, and all organisms within the system can use nutrients only in this ratio. When an effluent increases nutrient levels, a natural growth limit is eliminated, resulting in excessive plant growth, which eventually decomposes and decreases dissolved oxygen.

Long-term changes in assimilative capacity occur due to an aging process. As erosion takes place, headwaters tend to migrate upstream, as will plant and animal communities. Erosion is also responsible for increases in suspended solids, which deteriorate and affect the composition of the river bottom over time.

E.2.4 Water Quality Parameters

The capacity of a water system to accommodate uses may be defined by a series of hydrological, physical, chemical, and biological parameters. These parameters are relevant in explaining the effects of an effluent on the equilibrium and existing conditions. Both relative and absolute measurements are important in evaluating parameters. No single parameter can be used as an adequate measure of water quality, yet in many cases focusing on one parameter is dictated by data limitations. Several types of parameters describe water quality, and a brief discussion of each follows.

Hydrological Parameters

Hydrological parameters determine the level of physical, chemical, and biological parameters. These parameters characterize the atmosphere and catchment area, and care is required in placing the analysis in a particular hydrological process. Consideration should therefore be given to climate, properties of air, precipitation, erosion, and vegetation.

Most studies that attempt to measure water quality do not explicitly consider hydrological parameters. Care is taken only to place measurements in a particular season. For example, flow is often described as important but not considered directly. This treatment can be explained by a lack of data on how often hydrological parameter changes occur and their synergistic effect on the level of other parameters. A possible methodology to include these parameters would be to use water quality modeling. This technique, however, requires large amounts of information and time.

Physical Parameters

Physical parameters are commonly used water quality measures. However, their values vary significantly due to seasonal and diurnal patterns and site-specific characteristics. Readings may not be applicable to wide areas due to these variations. These parameters include the following:

Turbidity is caused by the presence of suspended solids. These solids are usually a variety of substances influenced by man-made and natural occurrences. Increases in suspended solids will affect the level of photosynthesis as transparency is decreased. Also, as settling occurs, eggs and larva may be suffocated, affecting fish reproduction and species diversity. Water turbidity is usually measured by a Secchi disk. This disk is lowered into the water until it disappears, and the resulting depth is recorded. Alternatively, the Jackson Turbidity Unit can be used. Regardless of the measurement technique, individual perceptions of turbidity are thought to be generally correlated with measured levels, explaining its common use in water quality studies. Unfortunately, little is known of how sensitive individuals are to small turbidity changes and what importance this has in their decisionmaking.

Color is important in determining both transparency and aesthetics of water. Water may contain a variety of compounds that change the amount of sunlight allowed in a water column, resulting in a change in the photosynthesis rate. Color is usually determined by visual comparison to a group of standard colors. The use of this parameter in water quality studies is rare due to the lack of consistent measurement over time and among sites. The link between color and individual perceptions is also not well known.

Temperature is a major determinant of the level of biological and chemical activity because temperature changes also cause a change in the equilibrium of a water system. Lotic systems are greatly affected by

atmospheric temperature and usually do not contain any thermal stratification. For these reasons organisms are usually tolerant of large temperature changes. When impoundments occur in the lotic environment, temperature stratifications do occur, inhibiting the availability of dissolved oxygen at certain levels. Temperature readings are taken at various depths with a reversing thermometer or bathythermograph. Simple temperature readings are not a good indicator of water quality. A more appropriate measure would be deviation from the norm caused by man-made and natural infractions. A change in temperature is usually perceived through indirect changes such as algae growth, changes in fish population, and physiological disturbances in swimmers.

Odor and taste measure the presence of industrial discharges, microscopic organisms, and vegetation. These factors are usually the result of industrial discharge or aquatic decomposition. The measurement of odor is determined by concentration levels of various compounds in a sample. Effects of odor are difficult to measure because perceptions vary depending on the individual and distance to the water.

Chemical Parameters

Chemical parameters characterize natural and man-made components of a particular water sample. Reported results are often misleading because the parameters may not be measured from a desired area. The choice of parameters and sample sites usually is based on pollutants expected due to regional and man-made characteristics. Also, cause and effect relationships are not precisely known in the scientific community nor are changes well perceived by individuals. Thus, we cannot determine exact relationships between parameters and water quality. Usually only the direction of change in water quality is known. Common chemical parameters are as follows:

Dissolved oxygen measures the intensity of organic decomposition and the ability of self purification. Dissolved oxygen is necessary for respiration of plants and animals and aerobic decomposition. Concentrations of dissolved oxygen are increased with photosynthesis and atmospheric reaeration. Decreases are caused by nitrification, biological oxygen demand, and benthal oxygen demand. Many species are not tolerant of low levels of dissolved oxygen, and offensive odor may also occur as decomposition occurs without the presence of oxygen. Dissolved oxygen is expressed in terms of mg/liter or percent saturation. Extensive work has been completed on fish populations and levels of dissolved oxygen. These controlled experiments relate fish reproduction rates to minimum dissolved oxygen requirements for various species.

Total dissolved solids represent the concentration of nondegradable wastes in a water sample. These solids may be toxic to the surrounding food chain, but little is known about this relationship. Concentrations are usually in terms of mg/liter.

pH is an index of the acidic-basic relationship of various mineral and basic substances. Under natural conditions, pH ranges from 5.0 to 8.6 on a scale of 1 to 14. Heavily polluted water may cause a low pH (i.e., an increased concentration of acid). Existing plant and animal life may not be tolerant of severe pH changes. A pH change generally results in a smaller variety of organisms. Recreation use of water usually requires a pH in the range occurring in natural conditions. However, swimming may require a narrow range of 6.5 to 8.3. Individual perceptions of pH are sensitive only to large changes, though a change may be perceived through eye irritation or touch.

Nitrates are formed by the biochemical oxidation of ammonia. Some stratification occurs naturally, resulting in surface waters having higher concentrations. Increased concentration may indicate fecal pollution in the preceding period. The concentration of nitrates may also indicate the rate of self purification of a water system. Nitrates are usually reported as mg/liter.

Metals present in a lotic environment can be caused by soil drainage. Therefore, seasonal changes will affect the concentration of metals present. Industrial sources of metals include mine pit discharge, ore enriching factories, and iron and steel factories. The effects of several metals such as copper, lead, and mercury are commonly studied and well known. The effects of other metals such as chromium, cadmium, cobalt, and nickel are not as well known. Concentrations are usually reported as mg/liter. Severe concentrations may inhibit development if they are passed to higher members of the food chain.

Surface active agents represent a variety of man-made compounds. These agents or surfactants are usually found in detergents. Concentrations result in the normal breakdown of organic material. More noticeable effects are a bitter taste, a soapy and kerosene odor, and the presence of foam. Concentrations usually are measured in terms of mg/liter.

Pesticides are any substance designed to destroy plant or animal organisms. These compounds enter the water indirectly from runoff and drainage or by direct application. Agriculture is the dominant source of pesticide contamination. Many pesticides have a cumulative effect, causing increased concentrations at higher levels of the food chain. As concentrations increase, the natural development of organisms will be altered. Pesticides include a wide variety of compounds and are usually described in mg/liter. Even though their diversity usually precludes their use as a measure of water quality, pesticides are considered an important indicator of water quality.

Biological Parameters

Biological parameters reveal the quality, size, and type of animal and plant populations within a water system. Data readings vary significantly with the season and flow velocity, but these parameters may give a reliable picture of the average situation since organisms cannot rapidly adapt to change. Individuals do not directly perceive changes in these parameters but notice them through such effects as odor, algae, and resulting illness. These factors are most important to direct contact uses but also apply to secondary recreation. The two important biological parameters are as follows:

Biological oxygen demand measures the rate of oxygen consumption in a system due to organic decomposition. High levels of organic waste cause an increase in the biological oxygen demand and a resulting decrease in available dissolved oxygen. These rates will differ depending on the state of the matter being decomposed. Since temperature controls the rate of organic activity, it also greatly influences oxygen demand. Biological oxygen demand is generally measured as the amount of oxygen removed from a sample in a 5-day period and is an important part of most water quality determinations. However, sample readings may not be comparable due to changes in assimulative capacity. For example, a reading may have a large value and yet have little effect on water quality due to characteristics such as large available dissolved oxygen and strong flow.

Microbiological parameters determine the presence of waterborne disease. The parameters would include bacteria, viruses, and algae. Both bacteria and viruses may be excreted in the feces of infected animals. The most common parameter of fecal contamination is the test for coliform bacteria expressed as number of bacteria per liter. Limits are currently set on fecal coliform depending on the use of the river. The presence of bacteria and viruses does not affect the appearance of the water. Except at high levels, algae is not toxic but may indicate overfertilization of the system by man or other mammals. Algae may be considered a pollutant since it is readily noticed in water.

E.3 ISSUES IN DETERMINING WATER QUALITY

E.3.1 Introduction

Several issues arise in attempts to define water quality, the most important of which involve the uses of a water system as they affect quality and the selection of an appropriate site. A discussion of these two issues follows, including a brief description of how they relate to this study.

E.3.2 Water Quality and Use

Water quality is directly dependent on current and future uses of a site. Common use categories are drinking, swimming, fishing, boating, and industrial. This list is an obvious simplification as it does not recognize the attrib-

utes desirable for each use. The use of water for drinking, for example, may occur within a wide range of attributes given various levels of water treatment. The inability to define these attribute ranges causes oversimplification when water quality is measured over various uses.

Uses of a water system are related to each other in a spatial and temporal sense. As the level of one use changes, the benefits derived from competing uses will also change. This relationship is not well defined because it depends on several variables, including the particular uses considered, characteristics of the area, and the time frame considered. In some instances, the relationship may depend on differential preferences of the potential users (e.g., teenagers and young families may desire a crowded beach while honeymooners and older people may prefer an uncrowded beach), and, in extreme cases, uses may be completely independent or mutually exclusive.

To ensure the same uses at each site in the travel cost approach, this study used only U.S. Army Corps of Engineer areas. Using only these areas eliminates part of the problem of defining uses, but it does not account for competing uses. Ideally, more consideration should be given to variation in uses between sites and their relationship to each other.

E.3.3 Water Quality Within an Area

Water quality is related to the physical boundaries of the study area in two ways: boundaries determine both the physical attributes and the scientific parameters to consider. In turn, physical attributes determine the uses allowed and the interrelationship between uses. For example, the presence of a dam increases the damage caused by an industrial effluent on fish populations.

The determination of the appropriate scientific parameters is subject to the continuous nature of water quality. As these measurements vary between measuring sites, the problem becomes more complex. Quality of water to a user is determined by the immediate and surrounding area. How to incorporate these readings is not clear. Consideration should be given to uses involved, as well as the physical relationship between areas. This issue is clouded by incomplete data when water quality is actually measured.

Data availability ultimately constrains the determination of the study area. The locations of existing monitoring sites are based on a variety of concerns such as location of fisheries, effluents present, and convenience. Quite often the measurements obtained do not conform to the desirable study requirements. Hence, the use of these data may bias results depending on site proximity to the study area and the use being considered.

E.4 MEASUREMENT OF WATER QUALITY

E.4.1 Introduction

A useful measure of water quality would be a universal number or index that can compare uses and scientific parameters. Both individual perceptions

of parameters and scientific measures of parameters could be used individually or to compare to an index. However, assigning the appropriate weights to each measure is a difficult task. A brief discussion of advantages to various methods to describe water quality follows.

E.4.2 Human Perceptions and Water Quality Measurement

Individual perceptions play an important role in water quality determination, but consistent measurement of perceptions is a major problem. Studies have shown that perceptions usually vary with questionnaire design information provided and sample population. Binkley and Hanemann [1978] found that respondents base evaluations of water quality on incorrect information. Ditton and Goodale [1973] found that respondents tended to describe areas closest to their residence, which causes large variations in the water quality rating over the entire study area. Moreover, changes in other site attributes limit the ability to draw general conclusions as to the effects of changes in water quality alone. On the other hand, Bouwes and Schneider (1979) found reasonably good correlation between perceptions and the scientifically based lake condition index.

Some differences in perceptions have been attributed to characteristics of the respondents. Barker [1971] found that users of an area tend to rate water quality more favorably than nonusers. Ditton and Goodale [1973] determined that swimmers' perceptions of water quality differed from fishermen's, both in terms of their ratings of water quality and the relative importance of individual features.

E.4.3 Technical Water Quality Measurement

Scientifically measured parameters are usually good indicators of water quality changes. Unlike individual perceptions, the technical water quality tests are usually comparable over time and between sites. Determination of important parameters is difficult, however, since most scientific information is obtained only through controlled experiments. Changes in water quality caused by parameters are difficult to determine because particular site characteristics must be known to determine an expected change, even in the short run. In addition, long-term and synergistic effects also usually cannot be determined because of poor information.

E.4.4 Water Quality Indexes

An ideal water quality measure would combine scientifically measured parameters, individual perceptions, and alternative uses of an area. Unfortunately, these measures require considerable information, and their components may vary between sites. In lieu of complete information, many studies have used approaches that rely on individual parameters or indexes to determine water quality. While most studies have used one or more individual parameters without determining their relative importance, other studies have used the index approach to solve several of the problems noted above. Thus, while far from perfect, the index approach does represent a tractable method of relating water quality to users, perceptions, and scientific judgment.

E.4.4.1 The National Sanitation Foundation Index

The ideal measure of water quality would incorporate scientific parameters, public perception of the water, and potential uses of the water. As an attempt to incorporate these considerations, the National Sanitation Foundation (NSF) index is a constructive approach to several problems in water quality measurement. A composite of nine parameters, the NSF index was developed through several questionnaires given to individuals with water quality experience. Respondents first selected parameters they felt were important to water quality. Followup contacts were then made to give the previous group responses to the respondents and to allow them to change their initial responses. A rating of these parameters in terms of water quality and synergistic effects was then developed based on these responses. The final parameters chosen included dissolved oxygen, fecal coliform density, pH, 5-day biological oxygen demand, nitrates, phosphates, temperature, turbidity, and total solids.

The next step in developing the NSF index required the development of water quality curves for each parameter. These curves represent the expected result of parameter concentrations on water quality and must be combined with the relative weights derived from the respondents' rankings of each parameter. These quality curves and weights constitute the final components of the index. More details on this index can be found in EPA [1982].

Researchers have applied the NSF index in a number of studies. The U.S. Environmental Protection Agency (EPA) applied the NSF index to the Kansas River basin to determine its effectiveness, including an appraisal of sampling and computing difficulties. The Kansas River basin, a wide, shallow river of moderate velocity, has light industry and receives treated municipal wastes from over 40 cities and towns. EPA calculated two forms of the NSF index with almost 600 water samples from over 26 sites. Calculated index values were consistent with researchers' attitudes toward the various reaches of the river.

The index calculations were also used to examine several other concerns. For example, the correlations between several variables were measured to test the validity of substituting parameters when certain data do not exist. The study determined that suspended solids can be substituted for turbidity and total coliform for fecal coliform.

The NSF index provides a scientifically based method of linking changes in water quality to the effects of those changes. The index, however, does not provide a linkage to individual perceptions of water quality changes and cannot differentiate threshold values for specific uses like fishing or swimming.

E.4.4.2 Resources for the Future Water Quality Ladder

A significant problem with the NSF index is that it does not take into account potential uses for a particular body of water. At Resources for the Future (RFF), Vaughan in Mitchell and Carson [1981] used a variation of the NSF index to determine minimum levels of water quality for various uses. Specifically, Vaughan's index used five NSF index parameters chosen on the

Table E-1. Water Quality Classes by Parameter and Index Values

Water quality use designation	Measurable water quality characteristics					Ladder value
	Fecal coliform (#/100 mL)	Dissolved oxygen (mg/L)[a]	5-Day BOD (mg/L)	Turbidity (JTU)	pH	
Acceptable for drinking without treatment	0	7.0 (90)	0	5	7.25	9.5
Acceptable for swimming	200	6.5 (83)	1.5	10	7.25	7.0
Acceptable for game fishing	1,000	5.0 (64)	3.0	50	7.25	5.1
Acceptable for rough fishing	1,000	4.0 (51)	3.0	50	7.25	4.5
Acceptable for boating	2,000	3.5 (45)	4.0	100	4.25	2.5

[a]Numbers in parentheses are percent saturation at 85° F.

basis of judgment and data availability: fecal coliform, dissolved oxygen, biological oxygen demand, turbidity, and pH. As shown in Table E-1, Vaughan associated specific parameter levels with five use designations. He then used a truncated version of the NSF index to place each minimum use designation on an index value range from 0 to 10 with the final index values for each use classification shown in Table E-1.

The RFF index provides a valuable link between various parameters and use designations. Even though the parameter choice may be somewhat arbitrary, the parameters neatly map into desirable attributes for a particular use. However, the RFF index does not account for differing individual perceptions that may be easily incorporated with further research. The RFF ladder is used in this study, as shown in Figure 4-5.

E.5 SUMMARY

The questions involved in defining water quality are complex, and there are no clear answers. Water quality studies must jointly determine the parameters to be considered, the uses to be considered, and the definition of the site to be studied. In addition, each of these issues has many aspects, such as how to define the relationship between uses, and each is subject to the constraint of available data. To date, very little has been done to measure water quality between sites or over time. One exception would be the RFF and NSF indexes, which measure various aspects of water quality and weigh them using informed judgment. Further research in this direction could lead to an index that incorporates individual perceptions and unique characteristics of an area.

APPENDIX F

TRAVEL COST: SUPPORTING TABLES

This appendix contains tables displaying data that support the travel cost analysis presented in Chapter 7. Tables F-1 through F-4 provide additional data for the benefits calculations. Table F-5 shows the tailored models that were estimated for selected sites.

Table F-1. Distribution of Benefit Estimates (Consumer Surplus Loss Avoided) for Loss of Use of the Monongahela River by Income Levels for 33 Sites for Individual Users

Income (1981 dollars)	Benefit estimate (1977 dollars)[a]											
	0	0-10	10-20	20-30	30-40	40-50	50-60	60-100	100-150	150-200	200 and above	Total
0 - 5,000	0	1	0	0	0	0	2	0	1	0	0	4
5,000 - 10,000	1	1	3	1	1	0	1	0	1	0	0	9
10,000 - 15,000	1	0	1	1	0	0	0	0	2	1	0	6
15,000 - 20,000	2	2	0	1	3	0	1	0	2	0	1	12
20,000 - 25,000	1	1	1	1	1	0	0	1	0	0	0	6
25,000 - 30,000	2	1	2	0	0	1	2	0	0	0	1	9
30,000 - 35,000	1	0	0	0	0	0	0	0	3	0	0	4
35,000 - 40,000	0	0	0	1	0	0	2	1	1	0	0	5
40,000 - 45,000	0	0	0	0	0	0	0	1	0	0	0	1
45,000 - 50,000	0	0	1	1	0	0	2	0	0	0	0	4
50,000 and above	0	0	0	1	0	0	0	0	1	0	1	3
Total	8	6	8	7	5	1	10	3	11	1	3	63

[a]To convert to 1981 dollars, multiply the endpoints of the benefit scale by 1.55.

Table F-2. Distribution of Benefit Estimates (Consumer Surplus Loss Avoided) Due to Loss of Use of the Monongahela River by Survey User Income for 33 Sites--Includes Multiple Visits

Income (1981 dollars)	Benefit estimate (1977 dollars)[a]									
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	Total
0 - 5,000	0	0	0	1	2	0	4	3	4	10
5,000 - 10,000	0	0	0	0	0	0	2	5	4	11
10,000 - 15,000	0	0	0	0	0	0	0	5	3	8
15,000 - 20,000	0	0	1	1	2	0	2	7	5	18
20,000 - 25,000	1	0	1	1	0	1	0	2	0	6
25,000 - 30,000	1	0	1	1	1	4	4	8	2	22
30,000 - 35,000	0	0	0	1	2	0	1	2	1	7
35,000 - 40,000	0	0	0	0	0	0	1	1	1	3
40,000 - 45,000	0	0	0	1	0	0	1	0	1	3
45,000 - 50,000	0	0	0	0	0	0	0	4	0	4
50,000 and above	0	0	0	0	0	0	0	2	0	2
Total	2	0	3	6	7	5	15	39	17	94

[a]To convert to 1981 dollars, multiply the endpoints of the benefit scale by 1.55.

Table F-3. Distribution of Benefit Estimates (Consumer Surplus Increment) Due to Water Quality Improvement: Boatable to Fishable by Survey User Income for 33 Sites--Includes Multiple Visits

Income (1981 dollars)	Benefit estimate (1977 dollars)[a]				
	0-10	10-20	20-30	30-40	Total
0 - 5,000	0	1	7	2	10
5,000 - 10,000	0	0	11	0	11
10,000 - 15,000	0	0	8	0	8
15,000 - 20,000	1	5	12	0	18
20,000 - 25,000	3	3	0	0	6
25,000 - 30,000	5	17	0	0	22
30,000 - 35,000	7	0	0	0	7
35,000 - 40,000	3	0	0	0	3
40,000 - 45,000	3	0	0	0	3
45,000 - 50,000	4	0	0	0	4
50,000 and above	2	0	0	0	2
Total	28	26	38	2	94

[a]To convert to 1981 dollars, multiply the endpoints of the benefit scale by 1.55.

Table F-4. Distribution of Benefit Estimates (Consumer Surplus Increment) Due to Water Quality Improvement: Boatable to Swimmable by Survey User Income for 33 Sites--Includes Multiple Visits

Income (1981 dollars)	Benefit estimate (1977 dollars)[a]						
	0-10	10-20	20-30	30-40	40-50	50-60	Total
0 - 5,000	0	0	1	2	4	3	10
5,000 - 10,000	0	0	0	0	11	0	11
10,000 - 15,000	0	0	0	5	3	0	8
15,000 - 20,000	0	2	3	13	0	0	18
20,000 - 25,000	1	2	3	0	0	0	6
25,000 - 30,000	3	11	8	0	0	0	22
30,000 - 35,000	3	4	0	0	0	0	7
35,000 - 40,000	3	0	0	0	0	0	3
40,000 - 45,000	3	0	0	0	0	0	3
45,000 - 50,000	4	0	0	0	0	0	4
50,000 and above	2	0	0	0	0	0	2
Total	19	19	15	20	18	3	94

[a]To convert to 1981 dollars, multiply the endpoints of the benefit scale by 1.55.

Table F-5. Regression Results of Tailored Models for Selected Sites[a]

Site	Site number	Intercept	T+M cost	Income	Income squared	Age	Sex	RECIMP	Day	R^2	DF	F-ratio
Lock and Dam No. 2 (Arkansas River Navigation System), AR	302	2.63 (7.12)	-0.012 (-2.20)	8.7×10^{-5} (-1.37)	3.1×10^{-9} (1.12)					0.17	37	2.51
		2.39 (8.24)	-0.012 (-2.08)	-1.8×10^{-5} (-1.08)		-0.003 (-0.50)				0.15	37	2.12
		2.25 (8.06)	-0.013 (-2.29)	-1.6×10^{-5} (-0.86)			0.062 (.037)			0.14	37	2.07
		1.94 (6.02)	-0.013 (-2.46)	-1.5×10^{-5} (-0.88)				0.378 (1.62)		0.20	37	3.04
		2.25 (9.41)	-0.010 (-1.67)	-8.5×10^{-6} (-0.45)					-0.209 (-1.30)	0.18	37	2.67
Beaver Lake, AR	303	1.69 (9.09)	-0.007 (-12.46)	-1.2×10^{-5} (0.68)	1.9×10^{-9} (0.51)					0.43	222	57.02
		1.70 (11.98)	-0.007 (-12.10)	-3.8×10^{-6} (-0.84)		-0.003 (-0.92)				0.44	222	57.37
		1.48 (13.17)	-0.007 (-13.04)	-2.3×10^{-6} (-0.51)			0.212 (2.32)			0.45	222	60.05
		1.48 (12.03)	-0.007 (-12.85)	-4.0×10^{-6} (-0.91)				0.191 (1.82)		0.44	222	58.83
		1.74 (16.32)	-0.006 (-11.75)	-1.9×10^{-6} (-0.43)					-0.310 (-3.18)	0.46	222	62.83
Blakely Mt. Dam, Lake Ouachita, AR	307	1.58 (5.59)	-0.008 (-5.14)	6.6×10^{-6} (0.24)	-3.2×10^{-10} (-0.53)					0.24	87	9.13
		1.53 (5.87)	-0.008 (-5.18)	-6.3×10^{-6} (-0.79)		0.005 (0.84)				0.24	87	9.31
		1.69 (9.71)	-0.008 (-5.09)	-7.9×10^{-6} (-1.01)			0.048 (0.31)			0.24	87	9.05
		1.28 (5.95)	0.008 (-5.23)	-9.8×10^{-6} (-1.31)				0.555 (3.00)		0.31	87	12.93
		1.88 (9:22)	-0.007 (-4.89)	-7.0×10^{-6} (-0.92)					-0.275 (-1.56)	0.26	87	10.07

DF = Degrees of freedom.

[a]t-values of no association are shown in parentheses. RECIMP is a binary variable that is 1 if the respondent considers recreation to be important. Day is a binary variable that is 1 if the respondent stayed 1 or more days.

Table F-5. (continued)

Site	Site number	Intercept	T+M cost	Income	Income squared	Age	Sex	RECIMP	Day	R^2	DF	F-ratio
Cordell Hull Dam and Reservoir, TX	310	1.97 (8.96)	-0.014 (-5.94)	-1.4×10^{-5} (-0.63)	3.6×10^{-10} (0.67)					0.34	100	17.10
		1.58 (7.74)	-0.015 (-6.28)	2.8×10^{-6} (0.33)		0.007 (1.74)				0.36	100	18.40
		1.65 (10.41)	-0.014 (-6.33)	2.4×10^{-6} (0.29)			0.311 (2.29)			0.37	100	19.52
		1.87 (9.14)	-0.014 (-5.93)	5.6×10^{-8} (0.01)				-0.021 (-0.11)		0.34	100	16.88
		1.88 (14.25)	-0.013 (-5.63)	1.4×10^{-6} (0.17)					-0.208 (-1.35)	0.35	100	17.79
Dewey Lake, KY	312	0.26 (0.64)	-0.002 (-2.74)	3.6×10^{-5} (1.01)	-3.1×10^{-10} (-0.47)					0.18	42	3.16
		0.16 (0.55)	-0.003 (-3.19)	1.9×10^{-5} (1.91)		0.009 (1.24)				0.21	42	3.70
		0.08 (0.36)	-0.003 (-3.67)	2.5×10^{-5} (2.74)			0.498 (2.89)			0.31	42	6.46
		0.43 (2.17)	-0.002 (-2.91)	2.0×10^{-5} (1.99)				-0.018 (-0.10)		0.18	42	3.08
		0.54 (2.79)	-0.002 (-1.85)	1.9×10^{-5} (1.96)					-0.359 (-1.78)	0.24	42	4.37
Grapevine Lake, TN	314	1.54 (7.16)	-0.007 (-8.78)	3.5×10^{-5} (1.74)	-5.4×10^{-10} (-1.36)					0.48	88	26.94
		2.16 (13.76)	-0.006 (-7.89)	7.6×10^{-5} (1.59)		-0.013 (-3.14)				0.52	88	31.95
		1.74 (13.96)	-0.007 (-8.85)	8.0×10^{-6} (1.59)			0.109 (1.00)			0.47	88	26.41
		1.44 (8.05)	-0.007 (-9.26)	9.4×10^{-6} (1.92)				0.392 (2.47)		0.50	88	29.60
		1.80 (15.13)	-0.009 (-6.62)	9.2×10^{-6} (1.77)					-0.296 (-2.36)	0.44	88	22.88

DF = Degrees of freedom.

[a]t-values of no association are shown in parentheses. RECIMP is a binary variable that is 1 if the respondent considers recreation to be important. Day is a binary variable that is 1 if the respondent stayed 1 or more days.

Table F-5. (continued)

Site	Site number	Intercept	T+M cost	Income	Income squared	Age	Sex	RECIMP	Day	R^2	DF	F-ratio
Greers Ferry Lake, AR	315	1.49 (8.04)	-0.006 (-8.91)	7.3×10^{-6} (0.35)	2.6×10^{-11} (0.05)					0.28	213	27.07
		1.61 (10.63)	-0.006 (-9.09)	9.6×10^{-6} (1.60)		-0.004 (-1.14)				0.28	213	27.66
		1.45 (12.25)	-0.006 (-8.97)	8.4×10^{-6} (1.42)			0.054 (0.53)			0.28	213	27.20
		1.15 (6.69)	-0.007 (-9.34)	9.0×10^{-6} (1.55)				0.372 (2.39)		0.29	213	29.70
		1.76 (15.29)	-0.006 (-8.90)	1.0×10^{-5} (1.92)					-0.494 (-4.89)	0.35	213	38.06
Grenada Lake, MS	316	1.91 (7.47)	-0.010 (-4.37)	2.1×10^{-5} (0.41)	-1.6×10^{-9} (-0.63)					0.22	72	6.76
		1.81 (7.07)	-0.009 (-4.31)	-5.0×10^{-6} (-0.32)		0.005 (1.13)				0.23	72	7.14
		2.06 (11.44)	-0.009 (-4.16)	-1.0×10^{-5} (-0.65)			-0.049 (-0.32)			0.22	72	7.36
		1.28 (4.31)	-0.010 (-4.62)	-9.6×10^{-6} (-0.67)				0.806 (2.98)		0.30	72	10.36
		2.03 (13.01)	-0.008 (-3.57)	-1.8×10^{-6} (-0.12)					-0.419 (-2.51)	0.28	72	9.26
Lake Washington Ship Canal, WA	320	2.69 (3.27)	-0.004 (-4.16)	-1.6×10^{-4} (-2.06)	4.3×10^{-9} (2.36)					0.35	39	6.95
		1.10 (2.20)	-0.003 (-2.98)	1.6×10^{-5} (0.73)		-0.005 (-0.52)				0.26	39	4.57
		0.81 (2.11)	-0.004 (-3.81)	1.9×10^{-5} (0.94)			0.234 (0.92)			0.27	39	4.83
		1.00 (2.01)	-0.004 (-3.64)	1.7×10^{-5} (0.81)				-0.079 (-0.24)		0.26	39	4.48
		EQUATION 5 IS NOT OF FULL RANK BECAUSE ALL VISITS WERE DAY VISITS.										
Melvern Lake, KS	322	1.87 (3.93)	-0.008 (-1.60)	-6.7×10^{-5} (-1.36)	1.6×10^{-9} (1.5)					0.11	41	1.69

DF = Degrees of freedom.

[a]t-values of no association are shown in parentheses. RECIMP is a binary variable that is 1 if the respondent considers recreation to be important. Day is a binary variable that is 1 if the respondent stayed 1 or more days.

Table F-5. (continued)

Site	Site number	Intercept	T+M cost	Income	Income squared	Age	Sex	RECIMP	Day	R^2	DF	F-ratio
Melvern Lake, KS (con.)	322	1.10 (2.39)	-0.009 (-1.72)	4.8×10^{-6} (0.36)		0.005 (0.57)				0.07	41	1.01
		1.36 (4.30)	-0.008 (-1.69)	5.9×10^{-6} (0.43)			-0.135 (-0.49)			0.07	41	0.98
		0.96 (2.38)	-0.007 (-1.46)	5.1×10^{-6} (0.39)				0.380 (1.21)		0.09	41	1.42
		1.47 (4.39)	-0.008 (-1.62)	7.0×10^{-6} (0.52)					-0.303 (-1.02)	0.08	41	1.26
Millwood Lake, AR	323	1.48 (4.82)	-0.008 (-3.96)	1.1×10^{-5} (0.39)	1.2×10^{-10} (0.20)					0.25	49	5.41
		0.83 (2.35)	-0.009 (-4.45)	2.1×10^{-5} (2.57)		0.013 (1.96)				0.30	49	7.10
		0.98 (4.68)	-0.009 (-4.59)	1.7×10^{-5} (2.29)			0.691 (3.41)			0.39	49	10.54
		1.30 (4.60)	-0.008 (-3.94)	1.7×10^{-5} (2.03)				0.166 (0.59)		0.25	49	5.55
		1.51 (8.13)	-0.007 (-3.47)	1.9×10^{-5} (2.34)					-0.333 (-1.50)	0.28	49	6.39
Mississippi River Pool No. 3, MN	324	2.12 (3.90)	-0.005 (-4.22)	-7.2×10^{-5} (-1.63)	1.4×10^{-9} (1.78)					0.38	45	9.20
		1.01 (1.89)	-0.006 (-4.53)	4.8×10^{-6} (0.55)		0.008 (0.74)				0.34	45	7.89
		1.40 (4.21)	-0.006 (-4.44)	4.4×10^{-6} (0.50)			-0.143 (-0.73)			0.34	45	7.88
		0.94 (2.41)	-0.006 (-4.97)	3.1×10^{-6} (0.37)				0.539 (1.69)		0.38	45	9.05
		1.32 (4.05)	-0.006 (-4.56)	4.5×10^{-6} (0.51)					0.036 (0.18)	0.34	45	7.63
Mississippi River Pool No. 6, MN	325	1.23 (3.16)	-0.007 (-4.31)	3.1×10^{-5} (0.88)	-3.5×10^{-10} (-0.51)					0.22	66	6.34
		1.24	-0.007	1.4×10^{-5}		0.005				0.23	66	6.46

DF = Degrees of freedom.

[a]t-values of no association are shown in parentheses. RECIMP is a binary variable that is 1 if the respondent considers recreation to be important. Day is a binary variable that is 1 if the respondent stayed 1 or more days.

Table F-5. (continued)

Site	Site number	Intercept	T+M cost	Income	Income squared	Age	Sex	RECIMP	Day	R^2	DF	F-ratio
Mississippi River Pool No. 6, MN (con.)	325	(4.19)	(-4.31)	(1.58)		(0.78)						
		1.45 (6.21)	-0.007 (-4.05)	1.3×10^{-5} (1.50)			-0.074 (-0.36)			0.22	66	6.29
		0.98 (3.43)	-0.007 (-3.88)	1.0×10^{-5} (1.20)				0.537 (2.08)		0.27	66	8.08
		1.42 (6.74)	-0.007 (-4.15)	1.4×10^{-5} (1.53)					-0.040 (-0.21)	0.22	66	6.25
Ozark Lake, AR	331	1.53 (5.06)	-0.005 (-4.45)	1.3×10^{-5} (0.32)	-6.2×10^{-10} (-0.58)					0.32	48	7.46
		1.64 (5.25)	-0.005 (-4.40)	-8.6×10^{-5} (-0.63)		0.001 (0.09)				0.31	48	7.30
		1.71 (7.57)	-0.004 (-4.19)	-1.0×10^{-4} (-0.73)			-0.96 (-0.47)			0.32	48	7.40
		1.42 (5.11)	-0.005 (-4.58)	-7.1×10^{-6} (-0.53)				0.285 (1.18)		0.33	48	7.98
		1.80 (9.04)	-0.003 (-3.15)	-2.0×10^{-5} (-1.15)					-0.541 (-2.15)	0.37	48	9.54
Philpott Lake, VA	333	1.61 (5.17)	-0.009 (-4.56)	4.2×10^{-5} (1.10)	-1.3×10^{-9} (-1.22)					0.39	34	7.28
		2.26 (6.85)	-0.009 (-4.39)	-8.6×10^{-7} (-0.006)		-0.011 (-1.41)				0.40	34	7.53
		2.01 (9.05)	-0.008 (-3.98)	-1.5×10^{-6} (-0.12)			-0.232 (-1.26)			0.39	34	7.33
		1.40 (3.61)	-0.009 (-4.64)	5.5×10^{-6} (0.40)				0.449 (1.48)		0.40	34	7.64
		1.92 (10.03)	-0.007 (-3.61)	3.4×10^{-6} (0.27)					-0.483 (-2.43)	0.46	34	9.60
Pine River, MN	334	0.19 (0.50)	-0.001 (-0.90)	5.0×10^{-5} (1.64)	1.1×10^{-9} (-1.90)					0.08	71	2.16
		0.69 (2.69)	-0.002 (-1.36)	-6.6×10^{-6} (-0.95)		0.004 (0.62)				0.04	71	1.04

DF = Degrees of freedom.

[a]t-values of no association are shown in parentheses. RECIMP is a binary variable that is 1 if the respondent considers recreation to be important. Day is a binary variable that is 1 if the respondent stayed 1 or more days.

Table F-5. (continued)

Site	Site number	Intercept	T+M cost	Income	Income squared	Age	Sex	RECIMP	Day	R^2	DF	F-ratio
Pine River, MN (cont.)	334	0.82 (4.51)	-0.002 (-1.06)	-6.5×10^{-6} (-0.92)			-0.092 (-0.20)			0.04	71	0.93
		0.53 (2.36)	-0.002 (-1.25)	-8.2×10^{-6} (-1.19)				0.363 (1.91)		0.08	71	2.17
		1.07 (3.42)	-0.002 (-1.31)	-5.3×10^{-6} (-0.75)					-0.291 (-0.99)	0.05	71	1.25
Proctor Lake, TX	337	2.13 (8.57)	-0.013 (-6.48)	-6.8×10^{-6} (-0.25)	1.5×10^{-10} (0.32)					0.54	48	18.61
		1.81 (6.57)	-0.013 (-7.50)	3.7×10^{-6} (0.53)		0.005 (1.11)				0.55	48	19.43
		1.99 (12.86)	-0.014 (-7.86)	-3.0×10^{-7} (-0.04)			0.273 (1.81)			0.57	48	20.89
		1.94 (7.54)	-0.013 (7.41)	1.3×10^{-6} (0.20)				0.139 (0.61)		0.54	48	18.61
		2.06 (11.79)	-0.013 (-7.09)	1.2×10^{-6} (0.17)					0.010 (0.05)	0.54	48	18.54
Sardis Lake, MS	340	2.07 (13.95)	-0.004 (-3.95)	-2.9×10^{-5} (-1.78)	8.6×10^{-10} (2.18)					0.07	201	5.13
		1.91 (13.52)	-0.003 (-3.07)	3.3×10^{-6} (0.57)		-0.003 (-0.97)				0.05	201	3.79
		1.84 (18.39)	-0.003 (-3.14)	4.5×10^{-6} (0.81)			-0.057 (-0.68)			0.05	201	3.63
		1.12 (7.57)	-0.003 (-3.93)	4.2×10^{-6} (0.80)				0.767 (5.58)		0.18	201	14.38
		1.88 (20.69)	-0.003 (-3.50)	7.5×10^{-6} (1.32)					-0.208 (-2.61)	0.08	201	5.84
Whitney Lake, TX	344	1.50 (8.68)	-0.003 (-1.70)	-7.7×10^{-6} (-0.45)	2.3×10^{-10} (0.67)					0.02	198	1.30
		1.40 (8.79)	-0.002 (-1.75)	3.3×10^{-6} (0.73)		0.0003 (0.09)				0.02	198	1.15
		1.34 (11.61)	-0.003 (-1.83)	2.9×10^{-6} (0.64)			0.160 (1.50)			0.03	198	1.91
		1.23 (9.22)	-0.003 (-1.74)	1.6×10^{-6} (0.35)				0.271 (2.19)		0.04	198	2.78
		1.83 (14.50)	-0.003 (-2.09)	3.4×10^{-6} (0.81)					-0.601 (-5.61)	0.15	198	11.81

DF = Degrees of freedom.

[a]t-values of no association are shown in parentheses. RECIMP is a binary variable that is 1 if the respondent considers recreation to be important. Day is a binary variable that is 1 if the respondent stayed 1 or more days.

APPENDIX G

ALTERNATIVE REGRESSION MODELS

This appendix provides a detailed listing of the alternative specifications of regression models. Listings are given for both the survey and travel cost models.

Table G-1. Independent variable combinations used in option price, user value, and option value regressions. Dependent variables are dollar bids given for changes in water quality.

Sex	Age	Education	Income	Dummy Variables to Denote Survey Version	Bidding vs. Non-Bidding Game Dummy	Length of Residence	Attitude Index[1]	Attitude towards Cost Dummy	User Dummy	Water Quality Rating Dummy[2]	Dummy variables to denote Interviewer	Dummy variables to denote Pro-fession	Dummy Variables to denote SIC Industry
X	X	X	X	X			X				X		
X	X	X	X	X			X		X		X		
X	X	X	X	X			X					X	
X	X	X	X	X			X					X	
X	X	X	X	X			X		X			X	
X	X	X	X	X			X		X	X		X	
X	X	X	X	X			X						X
X	X	X	X	X			X		X				X
X	X	X	X	X			X		X	X			X
X	X	X	X	X				X			X		
X	X	X	X	X				X	X		X		
X	X	X	X	X				X	X	X	X		
X	X	X	X	X				X				X	
X	X	X	X	X				X	X			X	
X	X	X	X	X				X	X	X		X	
X	X	X	X	X				X					X
X	X	X	X	X				X	X				X
X	X	X	X	X				X	X	X			X
X	X	X	X	X			X						
X	X	X	X	X									
X	X	X	X	X			X		X				
X	X	X	X	X		X							
X	X	X	X			X							
X	X	X	X	X		X			X				
X	X	X	X										
X	X	X	X		X						X		

(continued)

Table G-1 (continued)

Sex	Age	Education	Income	Dummy Variables to Denote Survey Version	Bidding vs. Non-Bidding Game Dummy	Length of Residence	Attitude Index[1]	Attitude towards Cost Dummy	User Dummy	Water Quality Rating Dummy[2]	Dummy variables to denote Interviewer	Dummy variables to denote Pro-fession	Dummy Variables to denote SIC Industry
X	X	X	X		X		X				X		
X	X	X	X		X			X			X		
X	X	X	X		X		X		X		X		
X	X	X	X		X			X	X		X		
X	X	X	X		X								

[1]This index was constructed by adding responses to various attitudinal questions.
[2]See question number B-1-b in the survey questionnaire.

Table G-2. Independent variable combinations used in all 43 outdoor recreation survey sites. Dependent variable LN (visits).

Travel Time Cost	Mile Cost	On-Site Cost	Travel and Mile Cost	1/3 Travel and Mile Cost	Site and Travel and Mile Cost	Site and 1/3 Travel and Mile Cost	Site and Travel Cost	Recreation-Importance Dummy	Income	Income Squared	Day Dummy[1]	Day Travel Cost Dummy[2]	Age	Sex	Hour Dummy[3]	Hour Site Cost Dummy[4]	Race Dummy[5]	Day Site Cost Slope Dummy[6]
X	X	X							X									
X	X	X							X				X					
X	X	X							X					X				
X	X	X						X	X									
X	X	X							X		X							X
X	X	X							X		X		X					X
X	X	X							X		X			X				X
X	X	X						X	X		X							X
X	X	X							X	X								
X	X	X							X	X			X					
X	X	X							X	X				X				
X	X	X						X	X	X								
X	X	X							X	X	X							X
X	X	X							X	X	X		X					X
X	X	X							X	X	X			X				X
X	X	X						X	X	X	X							
		X	X						X	X					X	X		
		X	X						X	X			X		X	X		
		X	X						X	X				X	X	X		
		X	X					X	X	X					X	X		
		X	X						X	X		X			X	X		X
		X	X						X	X		X	X					X
		X	X						X	X		X		X	X	X		X
		X	X					X	X	X		X			X	X		X
		X		X					X	X					X	X		
		X		X					X	X			X		X	X		
		X		X					X	X				X	X	X		

(continued)

Table G-2 (continued)

Travel Time Cost	Mile Cost	On-Site Cost	Travel and Mile Cost	1/3 Travel and Mile Cost	Site and Travel and Mile Cost	Site and 1/3 Travel and Mile Cost	Site and Travel Cost	Recreation-Importance Dummy	Income	Income Squared	Day Dummy[1]	Day Travel Cost Dummy[2]	Age	Sex	Hour Dummy[3]	Hour Site Cost Dummy[4]	Race Dummy[5]	Day Site Cost Slope Dummy[6]
		X		X				X	X	X					X	X		
		X		X					X	X		X			X	X		X
		X		X					X	X		X	X		X	X		X
		X		X					X	X		X		X	X	X		X
		X		X				X	X	X		X			X	X		X
X	X	X						X	X	X			X	X			X	
					X			X	X	X			X	X			X	
						X		X	X	X			X	X			X	
	X						X	X	X	X			X	X			X	
		X	X					X	X	X			X	X			X	
		X		X				X	X	X			X	X			X	
X	X	X						X	X	X			X				X	
					X			X	X	X			X				X	
						X		X	X	X			X				X	
	X						X	X	X	X			X				X	
		X	X					X	X	X			X				X	
		X		X				X	X	X			X				X	
X	X	X						X	X	X			X	X				
					X			X	X	X			X	X				
						X		X	X	X			X	X				
	X						X	X	X	X			X	X				
		X	X					X	X	X			X	X				
		X		X				X	X	X			X	X				
X	X	X						X	X	X				X				X
					X			X	X	X				X				X
						X		X	X	X				X				X
	X						X	X	X	X				X				X
		X	X					X	X	X				X				X
		X		X				X	X	X				X				X
X	X	X							X	X			X	X				X
					X				X	X			X	X				X
						X			X	X			X	X				X
	X						X		X	X			X	X				X
		X	X						X	X			X	X				X
		X		X					X	X			X	X				X
X	X								X	X								
									X	X								

(continued)

Table G-2 (continued)

Travel Time Cost	Mile Cost	On-Site Cost	Travel and Mile Cost	1/3 Travel and Mile Cost	Site and Travel and Mile Cost	Site and 1/3 Travel and Mile Cost	Site and Travel Cost	Recreation-Importance Dummy	Income	Income Squared	Day Dummy[1]	Day Travel Cost Dummy[2]	Age	Sex	Hour Dummy[3]	Hour Site Cost Dummy[4]	Race Dummy[5]	Day Site Cost Slope Dummy[6]
				X					X	X								
			X						X				X					
X	X								X				X					
				X					X				X					
			X						X					X				
X	X								X					X				
				X					X					X				
			X					X	X									
X	X							X	X									
				X				X	X									
			X						X		X							
X	X								X		X							
				X					X		X							

[1]Intercept dummy equal to one if the respondent stays one or more days and zero otherwise.
[2]Slope dummy calculated by multiplying day by travel cost.
[3]Intercept dummy equal to one if stayed less than one hour.
[4]Slope dummy calculated by multiplying hour by site cost.
[5]Intercept dummy equal to one if white and zero otherwise.
[6]Slope dummy calculated by multiplying day by onsite cost.

Table G-3, Independent variable combinations used as tailored models for a subsample of the 43 outdoor recreation survey sites. Dependent variable is LN (visits).

Travel Time Cost	Mile Cost	On Site Cost	Travel & Mile Cost	1/3 Travel & Mile Cost	Recreation Importance Dummy	Income	Income Squared	Day Dummy	Day Travel Time Plus Mile Cost Dummy[1]	Age	Sex	Camping Dummy
X	X					X						
X	X					X					X	
X	X					X		X			X	
X	X				X	X		X				
X	X				X	X						
X	X					X	X					
X	X					X	X			X		
X	X					X	X	X				
X	X											
			X			X			X		X	
		X	X						X		X	
			X						X		X	
			X			X					X	
			X			X				X	X	
			X			X		X			X	
			X		X	X			X			
		X	X		X	X					X	
			X		X				X	X		
			X						X			
		X	X			X			X			
		X	X		X	X			X			
			X		X				X			
			X		X	X		X		X		
			X			X				X		
			X			X						
			X		X	X		X				
			X									
			X			X	X					
		X	X			X	X					
			X				X					
		X	X			X						
			X			X	X	X				
			X			X				X		
		X	X			X	X		X			

(continued)

Table G-3 (continued)

Travel Time Cost	Mile Cost	On Site Cost	Travel & Mile Cost	1/3 Travel & Mile Cost	Recreation Importance Dummy	Income	Income Squared	Day Dummy	Day Travel Time Plus Mile Cost Dummy [1]	Age	Sex	Camping Dummy
			X			X	X		X			
		X	X			X		X				
			X			X			X			
			X				X		X			
			X			X	X			X		
				X		X					X	
				X		X		X			X	
				X	X	X						
				X	X	X		X				
				X	X	X		X			X	
				X	X	X				X		
				X		X	X					
				X		X	X	X				
				X		X						
				X		X		X		X		
				X		X		X		X		
			X			X			X	X	X	X
X	X				X	X		X		X		
X	X					X				X		
X	X					X		X				
X	X					X		X		X		
X	X							X				
X	X	X				X				X		
X	X	X				X		X				
		X	X			X				X		
			X						X	X		
X	X					X					X	

[1] Intercept dummy equal to one is respondent engaged in camping.