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MEASURING THE BENEFITS OF FRESHWATER QUALITY CHANGES: TECHNIQUES AND EMPIRICAL FINDINGS

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ABSTRACT

This chapter gives an overview of the techniques used to value the nonmarket benefits of water-related public goods and of the major empirical studies in this area. Travel cost, hedonic pricing, and contingent valuation are described; special emphasis is placed on the problems and limitations of implementing these methods to value changes in the quality and quantity of water-related amenities. Major empirical efforts to value National and regional water quality improvements, water-based recreation, ecosystem preservation, instream flows, ground-water protection, and water supply reliability are discussed.

INTRODUCTION

Water is the quintessential multiattribute good. It supports fish and birds. Humans drink it, cleanse with it, grow food with it, recreate on it, maintain landscaping with it, and generate electricity from its flow. Policy decisions have been made from the time of recorded history about how water should appear, when it should appear, and how it should be used. This chapter deals with valuing policy changes which would result in changing some attribute of water; in particular, this chapter focuses on placing a dollar value on attributes of water which are not directly priced by the marketplace.

Much of modern benefit-cost analysis has roots in the valuation of water projects (Krutilla and Eckstein, 1958). Some of the services provided by these water projects, such as electricity, had readily available market prices. Other benefits, for example, flood control, were also presumed to be measured by market prices although major problems with this presumption were immediately apparent. Water-based recreation, another class of benefits, had no readily available, even if imperfect, market price. Valuing water-based recreation was the initial focus of nonmarket valuation and has remained one of its mainstays.

Water-based recreation takes many forms. The building of a reservoir creates new boating and fishing opportunities and, in some instances, new swimming, picnicking, and camping opportunities. The building of dams alters riverflows, which in turn influences rafting opportunities. In some instances, a water project indirectly affects recreation. For example, draining a wetland may create valuable commercial real estate but may at the same time destroy nesting grounds for ducks prized by hunters or birds sought by birdwatchers.

Enhancing recreation was a key component of the Clean Water Act of 1972, which set its objectives in terms of achieving fishable, swimmable quality water. In order to determine the benefits of upgrading sewer treatment plants, installing industrial pollution control equipment, and reducing agricultural runoff, dollar values must be assigned to improved recreational opportunities at National, regional, and local levels.

The environmental legislation of the 1970's and 1980's introduced the issue of nonuse values, such as the stewardship of resources and the desire to bequest resources to future generations. Nonuse values have received increased attention as policymakers have confronted drinking water contamination, groundwater contamination, oil spills, and toxic chemicals in rivers and streams -- all problems which cannot be readily remedied. Finally, the increased demand for water from all sectors of the economy has created the potential for water shortages, particularly in the Western States, prompting researchers to address the question: What is the value of a reliable water supply?

Table 1 is a list of the aspects of water currently being valued and cites representative studies valuing each aspect. In later sections an illustrative study is discussed from each category.

THEORETICAL BASIS OF BENEFITS

For goods which are readily bought and sold on the open market, price serves as a satisfactory indicator of value. For nonmarket goods, an alternative measure of value must be used. The preferred measure for benefits is usually the willingness to pay (WTP) Hicksian consumer surplus. This measure is the maximum amount of money that the consumer would be willing to pay for a good and have utility remain at some specified level. Less frequently the willingness to accept (WTA) Hicksian consumer surplus measure is used. Both WTP and WTA are derived from the Hicksian compensated demand curve. WTP is referred to as compensating variation and WTA as equivalent variation. These two Hicksian welfare measures differ in their assumptions about the consumers' property rights with respect to the good in question, the WTP measure assuming the agent does not have the right to the good and must therefore buy it, the WTA measure assuming the agent has the right to the good and can sell it. The ordinary (Marshallian) consumer surplus, which is the area below the demand curve and above the price paid by the consumer, falls between the two Hicksian measures and is often used as an approximation of those measures.[1]

Table 1. Representative water valuation studies[a].

Aspect of Water Valued	Author(s)
(1) Water Reliability	Carson (1989a)
(2) Water Flows	Daubert and Young (1981)
	Bishop, Brown, Welsh, and Boyle (1990)
(3) Water Quality	Gramlich (1977)
	Greenley, Walsh, and Young (1982)
	Sutherland and Walsh (1985)
	Smith and Desvousges (1986)
	Carson and Mitchell (1988)
(4) Water-Based Recreation (e.g., boating, fishing, swimming, beach activity)	McConnell (1977)
	Hanemann (1978)
	Bowes and Loomis (1980)
	Russell and Vaughan (1982)
	Sellar, Stoll, and Chavas (1985)
	Cameron and James (1987)
	Carson, Hanemann, and Wegge (1989)
(5) Ground Water	Edwards (1988)
	Mitchell and Carson (1989a)
(6) Ecosystem Preservation	Hammack and Brown (1974)
	Bishop and Boyle (1985)
	Walsh, Sanders, and Loomis (1985)
	Loomis (1987)
(7) Water-Enhanced Amenities	Brown and Pollakowski (1977)
	Blomquist (1983)
(8) Toxic Contamination	Freeman (1987)
	Hanemann, Kanninen, and Loomis (1990)

[a] A fairly comprehensive bibliography of travel cost and contingent valuation studies of outdoor recreation appears in Walsh, Johnson, and McKean (1988).

TYPOLOGY OF POSSIBLE BENEFITS

A comprehensive assessment of the benefits accruing from a change in the level of a public good should include consideration of all types of benefits which would result from that change. The typology in figure 1 illustrates how the possible types of benefits from a change in freshwater quality might be categorized. This typology, from Mitchell and Carson (1989), while certainly not the only way to categorize the different types of benefits, is reasonably exhaustive of the possible benefits of freshwater quality improvements.[2] As figure 1 indicates, the major division in this classification of benefits is that between use and nonuse or existence values. The classification of benefits to be valued into these two categories often dictates the appropriate technique by which these benefits should be measured. While throughout this chapter water quality is used as an illustrative water-related public good, the broader classification in figure 1 also applies to other public goods. Before examining the techniques typically used to measure the value of water-related public goods, the different types of benefits are introduced in more detail.

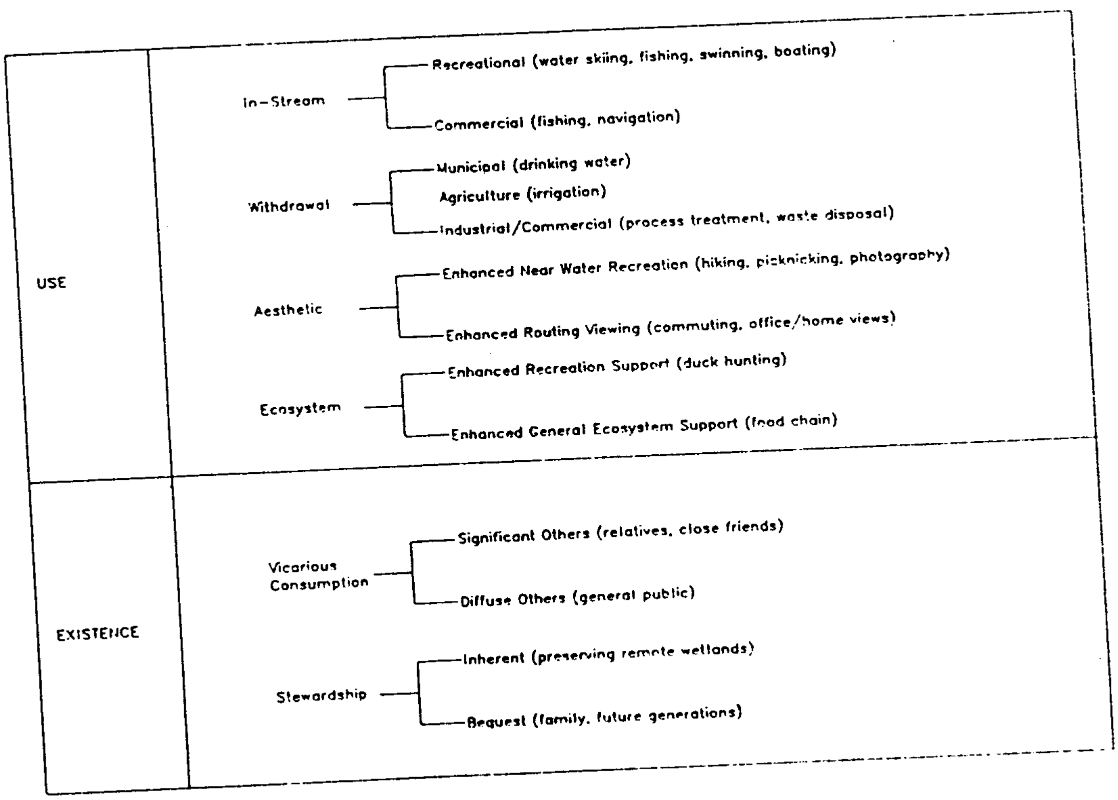

Figure 1. Typology of possible benefits.

Use Values

The use class of benefits consists of all the current direct and indirect ways in which an agent makes physical use of water quality. Direct use benefits may arise as a result of recreational or commercial activities that occur on the water; or they may arise from withdrawal activities such as agricultural irrigation, cooling or washing operations in industrial processes, or drinking water. This class of use benefits also has an indirect dimension created when the water body's characteristics enhance nearby activities. Figure 1 lists two types of indirect use benefits: those occurring because water quality is a vital component of an ecosystem or habitat that supports certain types of recreation, such as, hunting or birdwatching, and those occurring because water quality provides an esthetically pleasing setting for activities like picnicking or gazing at the scenery.

Nonuse (Existence) Values

In contrast to use values, which exist because people are physically affected by an amenity, existence values, or more generally nonuse values, embody the notion that a person need not visit a physical site or use services from that site to gain utility from its maintenance or improvement.[3] The motives for existence values usually stem from vicarious consumption or stewardship concerns.

In the case of existence values induced by vicarious consumption, an individual's utility arises from the consumption of the good by others. These "others" may be generalized, or they may be particular individuals. The motivation behind vicarious consumption values may stem either from a sense of obligation to provide the good for use by others or from a sense of interdependent utility.

Stewardship values involve a desire to see public resources used in a responsible manner and conserved for future generations. Two types of stewardship values are distinguished here: bequest and inherent. Bequest values exist if the motivation lies in knowing that the preservation of an amenity will make that amenity available for others to use in the near or distant future, whether those users are family or others. The other kind of stewardship value, termed inherent, stems from the satisfaction that an amenity is preserved regardless of its eventual use.

BENEFIT MEASUREMENT TECHNIQUES

The challenge confronting economists for the past several decades has been that of measuring the public's WTP or WTA compensation for the changes in the level of provision of a public good. Economists have developed several techniques for measuring the potential benefits of water quality changes, including travel cost, hedonic pricing, and contingent valuation. These methods differ greatly in their data requirements and in their assumptions about economic agents and the physical environment. Travel cost and hedonic pricing rely on data from actual market choices by consumers, such as deciding on a trip or buying a house. These two benefit measurement techniques are known as observed indirect methods because they rely on observed behavior with respect to an activity which is related to the amenity change to be valued. In contingent valuation, a hypothetical direct method, agents are queried directly about their valuation of particular hypothetical changes in amenity quality or quantity. These three general techniques differ in the types of values they are able to measure. For example, the travel cost and hedonic pricing techniques cannot measure existence values.

Travel Cost

The travel cost method proposed by Hotelling in 1949 (Clawson and Knetsch, 1966) has been used extensively to value site-specific recreation benefits.[4] In the simplest type of travel cost model, concentric circles of different radii around a particular site are used in calculating the average number of per capita visits to the site by the residents in each distance zone, the area between two concentric circles. The travel information is obtained by survey interviews or site visitation records. These data are used to trace a site-specific, trips-per-capita demand curve as a function of distance. The per-capita demand curve is used to estimate price until the number of trips is driven to zero. If a monetary value is assigned to each mile from the site, consumer surplus is calculated by measuring the area below the demand curve.

One data set often discussed in the travel cost literature is that of 1977 river recreation permits on the Colorado River through Westwater Canyon in Utah. Some 211 trips were recorded and assigned into 28 zones of varying distance from Westwater Canyon. The trips per capita were calculated from the population for each respective zone. Bowes and Loomis (1980) were the first to publish results for this model; and Vaughan, Russell, and Hazilla (1982) later commented on the estimates reported by Bowes and Loomis. These papers point to the necessity of using the correct functional form to model the relationship between trips and travel costs. The following table combines information from both papers and shows the trips-per-capita demand curve estimates and the value of benefits resulting from each. The GLS functional form is the OLS regression weighted by the square root of N^i where N^i is the

Regression Type	Equation	Total Benefits
OLS	5.7192-.0218·cost	$78,000
GLS	1.0260-.0031·cost	$24,000
Box-Cox	2729-.0255·cost	$14,000

population of zone i; this method corrects the problem of heteroscedasticity. Vaughan et al. concluded the Box-Cox travel cost model with a heteroscedasticity correction was best supported by the data. Their results indicate that benefit estimates from even simple travel cost models can be very sensitive to the functional form by which they are specified.

Several other considerations make the simple travel cost model problematic for measuring the benefits of water quality changes. First, the model is a highly site-specific technique in which the substitutes are fixed; the model does not allow for varying the substitute sites available or for varying the characteristics of any particular site. Second, with only one site, the explicit incorporation of environmental quality into the travel cost model is not usually possible. People travel to a lake for a variety of reasons which relate in various tenuous ways to the lake's water quality. Some progress has been made in overcoming these two problems in recent generalized travel cost models which incorporate a first-stage participation estimation with water quality as an argument (Hanemann, 1978; Vaughan and Russell, 1982; Bockstael, Hanemann, and Strand, 1985; Caulkins, Bishop and Bowes, 1986; and Smith and Desvousges, 1986). The third problem with the travel cost method is the difficulty of handling the role of time: identifying the temporal elements to be interpreted as costs of recreation activity and assigning monetary values to those elements (Freeman, 1979). Although recent progress on this topic by Willman (1980) and, particularly, Bockstael, Strand, and Hanemann (1985) represents a substantial advance, this difficult question is far from resolved. The fourth and fifth problems are even less likely to yield solutions. Bockstael and McConnell (1980) have shown that benefit measures using the travel cost method are very sensitive to the functional forms used in the estimation.[5] Even more fundamentally problematic, for which no solution seems likely, is that travel cost models can only measure a limited range of benefit categories: the direct recreation benefits and some benefits in the esthetic and ecosystem-use categories (Hay and McConnell, 1979). No travel cost model can measure existence values.

Some of the problems with travel cost models discussed above have led researchers to consider a number of extensions to the simple one site travel cost model. The most straightforward of these was to generalize the basic travel cost model to multiple sites along the lines of Burt and Brewer (1971), Cicchetti, Fisher, and Smith (1976), and Vaughan and Russell (1982); the current state of the art is represented by Smith and Desvousges (1986).[6] Another direction explored was the estimation of gravity models, a concept taken from geographers and regional scientists, in which the attributes of sites attract potential recreationalists. How such models should be estimated and the set of conditions under which the gravity model is consistent with utility theory was pursued by Sutherland (1982). The hedonic travel cost model (Brown and Mendelsohn, 1984) was another attempt to overcome the difficulties of the single site travel cost model. A number of prominent resource economists have heavily criticized the gravity models and the hedonic travel cost models (Smith and Kaoru, 1986 and Bockstael, McConnell, and Strand, 1989).

The most popular direction for travel cost models appears to be the discrete choice, random utility models (RUM) proposed by McFadden (1974). These models allow the straightforward incorporation of multiple sites and of quality indicators for those sites. To a large degree the RUM models represent a switch from the aggregate data sets typically used by other types of travel cost models to data sets with observations on individual recreational trips. The earliest applications of this framework for valuing recreation are found in Hanemann (1978), which looks at Boston beaches, and Vaughan and Russell (1982), which looks at National fishing behavior. Both studies focused on the role of water quality in recreational behavior. These models have steadily increased in size and complexity as better microdata sets have become available.

The largest and most comprehensive discrete choice travel cost model was constructed by Carson, Hanemann, and Wegge (1989) in a study of recreational fishing behavior in Alaska. That study used a random utility model statistically implemented as a nested multinomial logit model with four different levels. In the first level, a fisherman chooses a particular species of fish, for example, king salmon, red salmon, silver salmon, or pink salmon, and, in the second, chooses among broader groupings, such as, salmon, freshwater, saltwater, and no target. The third level captures the number of times a fisherman wishes to fish in a given week; and, in the fourth level, a household decides whether or not to fish that season.

The model has 29 fishing areas and 13 types of fish. The quality of fishing varies each week at each area for each type of fish. In some weeks, certain types of fish, for instance, king salmon, are not available at some sites. The characteristics of sites may be changed in several ways, for example by adding cabins, reducing congestion, changing the quality of fishing for one or more types of fish, or closing down one or more sites to one or more types of fishing. The model can produce dollar estimates of the welfare effects of these types of changes. Tracing the effects of a single change, for example, closing the Kenai

River to king salmon on a particular week in July, helps explain how the model works.[7]

The first result of this closure is the redistribution of king salmon fishing that week to sites near the Kenai River with similar king salmon runs. The second effect is the reduction of the total number of king salmon trips that week, some of which are reallocated to other types of salmon. Some of the original Kenai king salmon fisherman switch from salmon to other types of fish, for instance, halibut, while others decide not to fish at all that week. The welfare economic effects put into play by closing the Kenai River to king salmon for that week was estimated by the model to be $482,000. This model is currently used by Alaska's Department of Fish and Game (DFG) to allocate the fixed fish stock between recreational and commercial fisherman and to ascertain the cost of closing down a particular site for biological management purposes.

HEDONIC PRICING

The other major, observed, indirect method is hedonic pricing (Adelman and Griliches, 1961; Ridker and Henning, 1967; and Rosen, 1974).[8] This method assumes that the price of a marketed good is a function of its different characteristics. Letting X represent a commodity class and P_i the price of some good i in commodity class X which has characteristics Q_j, results in

[1] $P_i = P(Q_1 ... Q_j ... Q_n)$.

The implicit price of a particular characteristic Q_j is found by differentiating P_i with respect to Q_j. In a second stage analysis, this relationship is combined with other restrictions on the demand and supply of the characteristic of interest, and a demand function for that characteristic is estimated. Consumer surplus is calculated using that demand function.

The most common use of the hedonic pricing technique is to access property values which include the value of some environmental good such as local shorelines or air quality (Brown and Pollakowski, 1977; Harrison and Rubinfeld, 1978; Freeman, 1979b; and Brookshire, Thayer, Schulze, and d'Arge, 1982). Most studies have focused on residential real estate; however, an increasing number of studies focus on the quality of land, particularly in agriculture (Miranowski and Hammes, 1984 and Palmquist and Daniels, 1989). The quality of the land varies with characteristics such as potential groundwater contamination and salinity content. The other major area of interest for researchers has been hedonic wage studies (Thaler and Rosen, 1976) in which different risk levels are thought to be incorporated into the wages for different jobs.

An illustrative study on water-enhanced amenities is the 1977 Brown and Pollakowski study. Brown and Pollakowski examined the value associated with shoreline development, specifically, the value associated with the demand for open space and the welfare gains and losses resulting from a change in the amount of water-related open space. They used market sales data obtained from 1969 to 1974 for houses in three relatively homogeneous neighborhoods in Seattle. The data set has a comprehensive set of structural attributes for each unit. A function was estimated by regressing the housing bundle attributes on the selling price to derive marginal implicit prices for each attribute, in particular for proximity to the water and water-related open space.[9] The results indicated both variables of interest were statistically significant and important in explaining variation in the dependent variable. As expected, the sample was willing to pay a premium for open space and proximity to the waterfront; the premium decreased as proximity to the waterfront decreased.

While the hedonic pricing technique can, in principle, value all of the use categories, in practice, it suffers from serious problems. First, the data requirements for a valid hedonic pricing study are unusually exacting. All relevant characteristics--structural, neighborhood, and environmental--must be subject to control; if many resources or unique resources are already in public hands, this control may be impossible. Second, sufficient market data for reliable estimations are often difficult to obtain. Housing turnover, for instance, is relatively slow; and locating genuinely comparable houses in relevant neighborhoods is not easy. Third, the functional forms of the true underlying hedonic pricing equations are unknown; and the researcher is confronted with a number of competing formulations with quite different implications (Freeman, 1979b and Halvorsen and Pollakowski, 1981). Fourth, people must be aware of the actual physical differences in the levels of characteristics being valued. For example, to assume such awareness may be unreasonable when dealing with risk levels posed by chemicals or with colorless or odorless air pollutants. Fifth, expectations about changes in the good being valued and its relevant characteristics are generally unobservable; but presumably such expectations affect the determination of prices. In particular, such expectations may affect the prices of property. For example, people may incorporate their assumptions concerning future water quality in a given location into their WTP or WTA a given purchase price. Sixth, to value simultaneous changes in substitute sites is difficult, if not impossible. Finally, perhaps the most serious problem, identified by Brown and Rosen (1982), is that the standard method (Rosen, 1974) of identifying systems of hedonic pricing, supply and demand equations, is tautological and incorrect except in special and unlikely cases. Separately identifying the equations has been the subject of much recent work (Epple, 1987; Bartik, 1987a and 1987b; and

Mendelsohn, 1985) as identification is crucial to the estimation of benefits (Palmquist, 1988).

CONTINGENT VALUATION

The Contingent Valuation Method (CVM) uses survey questions to elicit preferences for public goods by discovering what respondents would be willing to pay for specified improvements in those goods.[10] The method elicits WTP in dollar amounts and circumvents the absence of markets for public goods by presenting consumers with hypothetical markets in which they may buy the good in question. The hypothetical market may be modeled after either a private goods market or a political goods market. Because the elicited WTP values are contingent upon the particular hypothetical market described to the respondent, this approach came to be called the CVM.

Respondents are presented with material which consists of three parts. First, a detailed description of the good being valued and the hypothetical circumstances under which it would be made available to the respondent is presented. The researcher constructs a model market, often in considerable detail, which is communicated to the respondent in the form of a scenario read by the interviewer during the course of the interview. The hypothetical market, designed as plausibly as possible, typically describes the good to be valued, the baseline level of provision, the structure under which the good is to be provided, the range of the available substitutes, and the method of payment. To trace the demand curve for the good, respondents are often asked to value several levels of the provision.

Second, questions which elicit the respondents' WTP for the good being valued are asked. These questions are designed to facilitate the valuation process without themselves biasing the respondent's WTP amounts.

Third, questions about respondents' demographics, their preferences relevant to the good being valued, and their use of the good are asked. This information, some of which is usually elicited preceding and some following the reading of the scenario, is used in regression equations to estimate a valuation function for the good. Successful estimation using variables which theory identifies as predictive of WTP provides evidence for the reliability and validity of the results.

If the survey is well designed and carefully pretested, the respondents' answers to the valuation questions should represent valid WTP responses.[11] These amounts are used to develop a benefit estimate. If the sample is meticulously selected through random sampling procedures, if the response rate is high enough, and if the appropriate adjustments are made to compensate for participants who fail to respond and for those who give "bad" quality data, such as "protest zeros," the results can be generalized with a known margin of error to the population from which the respondents were drawn. Generalization is a powerful feature of the sample survey method; a thousand people can be used to estimate the responses that would be given by everyone in a river basin, a state, or region, or even the entire country.

The following is presented as an illustrative contingent valuation study. The goals of the Clean Water Act support certain forms of water-based recreation. Mitchell and Carson (1988) attempted to measure the value of achieving boatable, fishable, and swimmable quality water on a National level. They asked a large National sample how much they would be willing to pay to move from a baseline level below boatable (which would occur without current levels of expenditure on sewage treatment and industrial/agricultural pollution control) to boatable, fishable, and swimmable water quality levels.

The key features of this study included: a water quality ladder which maps recreation levels onto physical quality levels, a payment vehicle which facilitates the elicitation of values, a test for whether air quality values were included in the WTP for water quality, a look at the reduction in benefits by obtaining a somewhat less than uniform National level of water quality, and a prediction of Smith and Desvousges' (1986) estimates for the Monongahela River Basin.

The suggested annual benefits of a uniform swimmable quality water level were in the $20 billion range, an amount sufficient to justify most of the water pollution control activities to date, but not enough to justify the cost of obtaining a uniform National level of swimmable water quality, and certainly not enough to justify the Clean Water Act's second goal of "zero discharge."

EMPIRICAL RESULTS OF REPRESENTATIVE STUDIES

The remaining studies discussed in this section employ the CVM to value regional water quality, ecosystem preservation, water flows, ground-water contamination, and water reliability.[12]

Regional Water Quality

Greenley, Walsh, and Young (1982) attempt to measure use values, option values, and other preservation values (bequest and existence) associated with preserving water quality in the South Platte River Basin in Colorado.[13] This particular river basin is subject to potential irreversible degradation in water quality due to mining activity. Greenley et al. used a bidding game with a random sample of 202 households in Denver and Fort Collins to measure WTP for incremental changes in water quality to enhance recreational enjoyment.

Two alternative payment vehicles were used, a general sales tax and a residential water sewer fee.[14]

Approximately 80 percent of the households interviewed in the sales tax version actually engaged in water-based recreational activities in the river basin; this portion of the sample was willing to pay an average of $57 per year for water quality to enhance enjoyment of recreational activities. In addition, these households were willing to pay an additional $23 per year for the option to engage in recreational activities in the future. Nonuser values totaled $42, $27 existence and $17 bequest, annually for the 20 percent of the sample who did not engage in recreational activities in the basin and $67, $34 existence and $33 bequest, for the remainder of the sample.[15] Total annual benefits aggregated over the approximately 576,000 households residing in the river basin were estimated to be $61 million.

Ecosystem Preservation

Bishop and Boyle (1985) conducted a study in the early 1980's to measure the benefits, both use and nonuse, associated with preserving and maintaining the Illinois State Nature Preserve. Due to erosion of a ridge of sand dunes, there was concern that Lake Michigan would invade and flood the Nature Preserve unless a series of offshore breakwaters were built. Bishop and Boyle mailed their survey to a stratified random sample of 600 Illinois heads of households; the response rate was 63 percent. The elicitation technique chosen was dichotomous choice, that is, take-it-or-leave-it, and the payment vehicle was annual membership to a private foundation that would effect the necessary measures to maintain the Nature Preserve. The average Illinois head of household responding to the survey placed a value of approximately $28 per year on the Nature Preserve. Extrapolating this estimate to the State of Illinois yields an annual value of about $60 million.

Instream Flows

The value of instream flows to recreationists is often ignored in water allocation decisions, a disregard sometimes leading to suboptimal policy changes. Daubert and Young (1981) used the contingent valuation approach to estimate the value of instream flows for a sample of recreationalists on the Cache la Poudre River in Northern Colorado.[16] A total of 134 personal interviews of recreationists using the river (49 fisherman, 45 shoreline recreationists, and 40 whitewater enthusiasts) were conducted in the summer of 1978. The interviewers used color photographs of eight different instream flow rates at four different sites and presented corresponding physical stream characteristics. Each respondent was asked in a bidding game framework about his WTP for instream flows. The payment vehicles were either an increase in sales tax or an increase in a hypothetical entrance fee. The values from the sales tax version always exceeded the values from the entrance fee version. Benefit functions were estimated for three different activities: Trout fishing, whitewater boating, and streamside recreation (picnicking, camping, and hiking).

Instream flow quantity was identified as the key variable in determining WTP for fishing and whitewater boating, explaining over 40 percent of the variation in the regression equations. Waterflow was also significant in the shoreline benefit function, but to a lesser degree. In the entrance fee version, the maximum value per day for fishing was $30 (1978 dollars) for a flow of 500 cubic feet per second (ft^3/s) and the shoreline activity, $10 for a flow of 700 ft^3/s. The WTP estimates for whitewater recreation increased throughout the range of observations which varied from 100 to 900 ft^3/s. Daubert and Young concluded that during periods of low flows, the marginal value of instream flows was greater than the marginal value of water used for irrigation, suggesting a need for reexamination of allocation choices.

Ground-Water Protection

Edwards (1988) conducted a contingent valuation study of WTP to prevent possible future nitrate contamination of a potable supply of ground water in Cape Cod.[17] Option price was chosen as the appropriate measure of economic value because of demand and supply uncertainty and the uncertainty surrounding the probabilities of actual contamination. Edwards used 10 questionnaire versions varying year of expected future contamination, probability of nitrate contamination, and price of bottled water. After conducting a pilot study of 200 households, the discrete choice referendum format was adopted; bids ranged from $10 to $2,000. One thousand random households were sampled with a mail survey instrument. Three telephone followups led to a respectable response rate of 78 percent; however, only 58 percent were deemed by Edwards to be usable in the final analysis.

The study results indicated respondents with strong bequest motivations held dramatically higher option prices relative to those who did not. Edwards found that income displayed a very strong, positive effect on WTP for ground-water protection and that the respondents' perception of their own probability of future demand for the ground water was positively related to their WTP. The results also indicated the WTP bids varied with the level of uncertainty of future contamination; thus policymakers who only explore the worst-case scenario, that is, who assume contamination is certain when making aquifer management decisions, are potentially overestimating benefits.

Water Supply Reliability

The issue of water shortages in the West looms large. Carson (1989a) informed California voters of the likely prospect of water shortages in the coming years. Four different water shortage scenarios were valued with each respondent valuing two scenarios: One 10-15 percent shortage in a 5-year period, two 10-15 percent shortages in a 5-year period, one 30-35 percent shortage in a 5-year period, and one 30-35 percent shortage and one 10-15 percent shortage in a 5-year period. Respondents were told what changes in water consumption behavior the shortages of different magnitudes would likely entail.

Two thousand respondents were interviewed by telephone; random digit dialing was used. Each respondent was asked two binary discrete questions with randomly assigned dollar amounts for each of the two scenarios valued. An interval-censored survival analysis technique was used to evaluate the resulting data. Median annual household amounts ranged from $83 annually for the mildest shortage scenario to $258 for the most severe. Northern and southern California household responses were, for the most part, quite similar.

CONCLUDING REMARKS

Nonmarket valuation techniques have made large strides during the past decade and have now reached the point at which they can be used in many circumstances for serious policy analysis and decisions. The work of the past decade reflects three important lessons. First, the data requirements to successfully implement nonmarket valuation techniques are much more demanding and expensive than first believed. Travel cost analysis now typically requires large microdata sets with individual trips to an array of potential substitute sites and quality variables for each of these sites. Hedonic pricing requires detailed data on land prices and typically requires such data across time periods or markets. Contingent valuation requires extensive instrument development. Focus groups, pretests, and pilot studies are often needed to ensure that the desired good is being valued and that the scenario is well understood and accepted by respondents. Furthermore, contingent valuation in many cases may require expensive in-person surveys with well-trained interviewers. The econometric skills needed for correct implementation of any of the nonmarket techniques have increased substantially relative to the practices of even a few years ago.

The second lesson is that a significant learning curve frequently hampers nonmarket valuation when dealing with a new type of good. The implications of this lesson are many. Agency funding is needed to conduct exploratory research in such cases, which need not be used immediately for policy purposes. Multiple researchers need to attack the problem in order to determine the best solutions and the common features of different solutions. Interaction between economists, survey researchers, physical scientists, engineers, and policymakers is necessary to define the issues so that research results will be eventually useful to policymakers.

The third lesson is that economists tend to rely too heavily on existing data sources and tend to overlook the potential limitations those data sources may impose. Collecting new data is an expensive undertaking; but the cost of data collection often pales in comparison to the magnitude of costs involved in the pending policy decision. Trying to construct benefit estimates from bad or inappropriate data can only serve to discredit nonmarket benefit measurement techniques.

NOTES

[1]See Just, Hueth, and Schmitz (1982) for a comprehensive look at welfare economics. See Hanemann (forthcoming) for a discussion of the relationship between these welfare measures in the case of changes in the quantity or quality of a public good.

[2]This typology is widely, although not universally, accepted. Disagreements are usually over the terms used to describe nonuse values and whether and how to include different types of uncertainty (i.e., option and quasi-option values).

[3]A large portion of the millions of dollars in fees and voluntary contributions paid by members of environmental groups and the willingness of environmental activists to volunteer their time to lobby for such legislation as the Alaska Wilderness Bill can be cited as evidence for the reality of existence values for wilderness amenities. Referenda on environmental programs often receive very strong voter support even among voters whose communities are unaffected by the improvements.

[4]See Bockstael, McConnell, and Strand (1989) and Smith (1989) for recent reviews of the current state of the art of travel cost modeling.

[5]The work of Vaughan and Russell (1982) and Kling (1988) confirms this finding.

[6]See Kling (1988) for a critique of welfare estimates from these and other modern variants of the travel cost model.

[7]The Kenai River is perhaps the world's premiere king salmon fishery.

[8]See Palmquist (1989) for a review of the current state of the art of hedonic pricing models.

[9]Both the dimensions of the setback area (i.e., size of open space) and the distance to the waterfront appeared in log form in the equation as the relationship was expected to be a nonlinear one.

[10]Mitchell and Carson (1989b) provide an extensive discussion of most contingent valuation issues.

[11]The survey designer must take care to ensure that respondents are valuing the good intended to be valued. Focus groups are often used for this purpose.

[12]Hanemann, Kanninen, and Loomis (1990) recently conducted a study of toxic contamination in the San Joaquin/Sacramento Bay Estuary. A subsequent chapter in this book is devoted entirely to that study.

[13]See Smith and Desvousges (1986) or Gramlich (1977) for additional examples of contingent valuation studies on water quality in river basins.

[14]The results indicate WTP was quite sensitive to the payment vehicle used; WTP was about 75 percent less in the residential sewer fee version. This difference is not surprising as increasing the sewer fee only affects the residents whereas increasing the sales tax also affects tourists so the sales tax vehicle may have been perceived as more equitable. One consistent finding of the contingent valuation literature is that the public often has strong preferences over how they pay for a particular public good. Often policy dictates the payment vehicle which could actually be used.

[15]At present, whether WTP may be meaningful and uniquely divided into subcomponents is subject to considerable debate.

[16]A more recent study examining waterflows is Bishop, Brown, Welsh, and Boyle (1990).

[17]See Mitchell and Carson (1989a) for another example of a study examining potential contamination of ground-water supplies.

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