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ESTIMATING THE VALUE OF IMPROVED WATER QUALITY IN AN URBAN RIVER SYSTEM

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ABSTRACT

Improved water quality in the rivers of the metropolitan area is one of the benefits that can be derived from controlling combined sewer overflow in older large cities. This article estimates the value that cleaner rivers would have to Chicago citizens, and thus measures an important component of value to which the Chicago Deep Tunnel project can be expected to contribute. In a contingent value survey, average annual household values ranging from about $30 to $50 were observed for various degrees of improvement. An important result is that from two-thirds to nine-tenths of these reflect the intrinsic value of the rivers—nonuse values related to the existence of clean rivers or the option to use them in the future. A comparison with similar published studies confirms the credibility of the results.

OVERVIEW

Water quality in the streams and rivers of many older cities with combined stormwater-wastewater sewer systems is adversely affected by combined sewer overflows. The combined sewers fill to capacity with storm water and sanitary sewerage during heavy rains. As a means of preventing flooding in homes and surrounding areas, the effluents from these combined sewers are discharged directly to waterways in the area.

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A number of proposals have been considered to reduce or eliminate the adverse effects of combined sewer overflows on water quality. One of the most ambitious is the Deep Tunnel project in Chicago. The project would involve the construction of an extensive network of underground reservoir to catch rainwater until it can be treated. The Chicago project is an example of the large expenditures and potential benefits involved in the control of the environmental problems of combined sewer overflow.

USE AND INTRINSIC VALUES AND ENVIRONMENTAL RESOURCES

The value of an amenity like an urban river system resides in two different groups in the community: those who use the amenity, and those nonusers who desire its preservation or restoration for possible future use or simply for the satisfaction they derive from knowledge of its existence. The purpose of the study described here is to estimate the benefits to the Chicago area population of improved water quality in the metropolitan area river system. Three categories of water quality benefits were considered:

1. benefits related to personally using the rivers for outing, boating and fishing (use value);
2. benefits related to having the option of using the rivers for recreation in the future even though one may not presently be using the rivers (option value);
3. benefits related to knowing others in the community are able to use the rivers for recreation even though there is no intention ever to use the rivers personally (existence value).

The first category, use value, has been the traditional focus of studies of resource value. Categories 2 and 3 constitute nonuse or intrinsic values, and have been recognized in recent years as rivalling use value in importance. Measuring the benefits of public investment in the environment requires that both sources of satisfaction be taken into account.

Theoretical work has made similar advances in the basic understanding of nonuse or intrinsic sources of utility. Krutilla provides an important early discussion of nonuse values [1]. Desvousges et al. give a recent theoretical discussion of some contemporary issues involving nonuse values [2].

The rational for intrinsic values is normally linked to the preservation of irreplaceable environmental assets like the Redwood Forest of California or the tall-grass Nature Preserves in the Middle West. The basis of option value for a water recreational site is that uncertainty exists in people's minds regarding either the continued availability of the site or uncertainty regarding whether they may wish to use the site for recreation in the future. In either case the individual is willing to pay some premium in order to assure that present water recreational opportunities will exist in the future. Individuals who are willing to pay for the preservation of water resources, even though they never intend to use them, have an existence value for these opportunities. They may value these opportunities for their own sake, for the sake of future generations (bequest value), or for present use by others.

While a number of studies have estimated user-related benefits of water quality improvements, relatively few empirical studies have been carried out to determine option and existence values. One such study, by Walsh et al., measured use and preservation values of water quality in a survey of residents of South Platte River Basin of Colorado [3]. A second survey, by Mitchell and Carson, estimated willingness to pay to clean up all the rivers and lakes in the country [4]. A water quality ladder was used to represent water quality to respondents, in terms of the recreational activities that could be carried out under increasingly improved conditions. A third study, by Desvousges et al., investigated use, option and existence values for water quality improvement on Monongahela River by means of surveys and other analytic methods [2].

CONTINGENT VALUATION OF AN URBAN RIVER SYSTEM

The present study contributes to the newly developing literature on the use and preservation value of natural resources by estimating the recreation value of an urban river system. Like the studies just cited it employs the survey method known as contingent valuation. Contingent valuation entails the formulation of a hypothetical market in water quality that offers respondents several levels of water quality improvement. The object is to determine the maximum amount respondents would be willing to pay for each level of improvement if they could be purchased in real markets. The strength of contingent valuation is that it provides marketlike data where actual markets don't exist and where indirect inferences from other data sources are difficult or impossible.

SURVEY DESIGN

A clearly stated, plausible water quality market that respondents would respond to without bias was the essential requirement of the survey design. At the same time the programs had to be well defined quantitatively to be useful for policy purposes. This section describes the sample, the contingent market product and the nature of its value to users and nonusers, and the iterative bidding process used to obtain values. The survey was conducted for the Chicago District Corps of Engineers [5].

SAMPLING AREA AND SIZE

The study area for the survey was the 352 square mile combined sanitary/storm sewer area in Cook County. This area includes the entire city of Chicago and the surrounding suburban communities. A sample of 350 households were surveyed by telephone.

DEFINITION OF WATER QUALITY

In the majority of empirical studies, water quality has been defined for the respondent indirectly by reference to recreational activities which a given level of water quality would support. In the Mitchell and Carson study four levels of water quality were defined: 1) water quality that was so low that it would support no recreational activity; 2) water quality that would allow boating; 3) a higher level of quality in which the lakes and rivers would support fishing; and finally, 4) water quality high enough to allow swimming. Desvousges et al. utilized a similar water quality ladder.

The water quality ladder approach was employed in the present study, with the important addition of a new category of water quality activity–outings. The willingness-to-pay questions pertained to hypothetical levels of water quality improvement:

1. a level allowing outings along the shores of the rivers, i.e., pollution control efforts aimed at removing odors and debris from the river;
2. a level allowing outings and boating on the river;
3. a water quality level allowing outings, boating, and fishing.

This modification is based on the actual use of the rivers in the Chicago area and the present perception of the rivers as an environmental asset. The actual use of the rivers in and around Chicago for recreation at the present time is quite limited because of extensive pollution. Water recreational opportunities in the Chicago area are dominated by Lake Michigan, which has benefited from extensive preservation efforts and is a very valuable recreational asset to the area.

To the extent that Chicago area rivers are used for recreation, activities are more likely to be focused on outings, such as picnicking, hiking, and photography rather than activities such as boating, fishing, and swimming. The aesthetic aspects of the river's water quality may thus be perceived to be more important than quality related to sport uses. Unlike past studies which have concentrated on active uses of water, this study gives explicit consideration to the value of cleaning urban rivers for aesthetic reasons.

DEFINITION OF BASELINE WATER QUALITY

In defining the commodity to be purchased, the questionnaire takes into account that it is the *improvement* in water quality levels (as measured by the incremental changes in allowable activities), that is being purchased. Thus, the perception of what the present water quality is affects the willingness to pay for improvements in water quality. For example, if individuals already believe that rivers are clean enough for boating, their willingness to pay an additional amount to improve the river water quality to this level should be zero. If the perceived water quality level is below that required to allow an activity then they may wish to pay to improve water quality to a higher activity.

In past studies, baseline quality was defined by the interviewer. Arbitrarily defining river quality throughout the region had, however, the potential to introduce a hypothetical bias into the study, i.e., an error introduced by posing hypothetical conditions which may not seem realistic to the respondent so that responses may not be representative of the actions an individual might take in a real market situation. In this study *the respondents* defined baseline water quality. Questions were first asked regarding perceived water quality as defined by the water quality ladder for both the rivers in the Chicago area and Lake Michigan. If the respondents subsequently answered that they would not pay anything for improving river water quality to a certain level they were then asked if their reason for not paying was based on the perception that water quality was already at this level.

This question was asked in order to assure that the respondents perceived that their willingness to pay for improved water quality was linked to the attainment of a higher quality level than existed at present. Thus, in this study the respondents' own views of present water quality were integrated into the estimate of their willingness to pay for improved water quality.

MEASUREMENT OF USE AND NONUSE VALUES

In order to understand the importance of the amenity to the community it is essential to estimate the size of the user and nonuser groups and the values that each places on the amenity. The present survey questioned respondents on the frequency of river use and the types of activities engaged in. Willingness-to-pay responses for the two groups were obtained and compared, and their relative importance in the overall population estimated by their representation in the sample.

ELICITATION OF WILLINGNESS-TO-PAY EXPRESSIONS

A bidding game approach was employed to elicit willingness-to-pay responses. The bidding game requires selecting a starting bid and asking respondents whether they would pay an additional amount over and above what they already pay for water pollution control to obtain a given water quality improvement. If the respondent answers "yes," a higher bid is presented; if "no," a lower bid is offered until the respondent makes a final decision.

SURVEY RESULTS

Willingness-to-Pay Estimates

The annual mean willingness to pay of the respondents to improve water quality to support outing, boating and fishing on the rivers is shown in Table 1.

The values of the contingent market goods correspond to a realistic progression of policy programs, as in a water quality ladder. They represent the demand side of the ladder, which relates dollar values to contingent market activities. Different steps of the ladder relate 1) water quality parameters such as dissolved oxygen to water quality levels, and 2) water quality levels to minimum input requirements for engaging in the contingent market activities. Table 1 makes it clear that improvements such as increased dissolved oxygen cause benefits to increase at an uneven rate depending on the activities that become available on the rivers. Properly defined contingent market activities are thus the pivotal point that relate the demand and supply sides in a benefit-cost analysis of river water quality. The mean annual household value for a river system with outing-quality water is $33. About $4 per year in recreational value is added by raising water quality to support boating. The next increment in value, achieved by permitting the rivers to support fishing, is about $8.

It is probable that at relatively low levels of improvement, diminishing returns to the quality of the boating experience set in, with correspondingly low marginal willingness to pay for the improvements. Additional improvements, however, might permit fishing for desirable species of fish, with an attendant jump in marginal willingness to pay. Still greater improvements would increase the range of desirable species, and the picture would become even more complicated by the eventual suitability of the rivers for swimming. Careful empirical investigation of potential benefits of water quality improvement is, therefore, essential when making comparisons with costs for policy purposes.

Table 1. Aggregate Willingness to Pay for River Water Quality Improvements without Protest and Endowment Bids[a]

Improve water quality for	*Mean*	*Standard error*
outings (N = 296)	$33.49	1.95
outings, boating (N = 279)	$37.76	2.81
outings, boating, fishing (N = 280)	$46.05	3.55

[a]See section on protest and endowment bids, p. 11.

In interpreting these willingness-to-pay magnitudes, it is important to keep in mind that they are expressions of value for closely related goods. One cannot infer the value of each component from the values in the table; they tell only the value of the package as a whole. For example, we cannot divide the $46 price for the outing-boating-fishing package into $33 for outing, $4 for boating, $9 for fishing. If outing is a good substitute for boating, then people will offer much less for boating having already purchased outing. If boating is complimentary to fishing, then people will offer more for fishing after purchasing the boating opportunity. Thus it is only the value of the overall package that is measured by willingness to pay. If the components were offered in reverse order (ignoring the lack of realism in this case) the component values would change greatly, although the package as a whole would be expected to have the same value.

Table 2 breaks down aggregate willingness to pay by respondents who currently use the rivers and nonusers. Only about 10 percent of respondents were users. Once again the biggest jump in marginal value for both subgroups occurs with the introduction of fishing, although the effect is much more pronounced among users than nonusers.

The most important lesson of Table 2 is that nonusers value water quality improvements virtually as much as users. Nonusers' values range from three-quarters to nine-tenths of corresponding user values. Because nonuser willingness to pay is based solely on intrinsic values, whereas user willingness to pay embodies both use and intrinsic values, Table 2 strongly suggests that intrinsic values dominate the values of the water quality improvement programs.

Zero Bids

A common feature of contingent valuation studies is the occurrence of a number of zero bids. Close to 30 percent of responses were zero bids. Some of these are legitimate zero bids, some are protest bids, and in this study some zero bids reflect the respondents' matching of perceived water-quality endowment with the contingent market programs. In this survey all zero bids were probed to determine their nature. They are explained briefly below.

Table 2. River User and Nonuser Willingness to Pay for Water Quality Improvements Without Protest and Endowment Bids

Improve water quality for	*User mean (standard error)*	*Nonuser mean (standard error)*
outings	$43.21 ($N$ = 28) (9.54)	$32.48 ($N$ = 268) (1.91)
outings, boating	$43.88 ($N$ = 27) (10.89)	$37.11 ($N$ = 252) (2.89)
outings, boating, fishing	$49.63 ($N$ = 27) (12.49)	$45.76 ($N$ = 253) (3.70)

Legitimate zero bids – Legitimate zero bids reflect a zero valuation of program benefits by the respondent. They are retained in the data set.

Protest bids – Respondents who do not accept the contingent valuation exercise, or perhaps don't understand it, frequently express their feelings in a zero bid. For example, some respondents will reason that they did not contribute to pollution so they should not be expected to pay for it. The resulting zero bid has nothing to do with the value to them of a cleaner environment, and must consequently be removed from the data set.

Endowment zero bids – Some respondents believe that water quality is already as good or better than that offered in the contingent market program. The program is already part of their water-quality endowment. They are expected to bid zero for such programs. These zero bids were removed from the data set.

Table 3 presents the breakdown of reasons given for the zero bids for improvement of water quality to a level that permits outings.

Socio-economic Characteristics

Basic socio-economic information about respondents was obtained at the end of the survey, including income, age, education, size and structure of household, length of residence in Chicago, home ownership, and distance of resident from the Lake and rivers. The purpose was to determine the extent to which aggregate estimates of water quality value could be refined by taking household characteristics into account.

River usage, presently confined to a small portion of the population, does not give evidence of belonging strongly to any particular socio-economic group. Age appears to be unimportant. Larger households (four or more members) do appear to use the rivers somewhat more than smaller households. Among one-, two-, and three-person households in the sample, 8 percent were users. Among households of four or more, 12 percent were users. Education was a significant influence in the sample–respondents with at least some college education were more than twice as likely to be users as others. Willingness to pay for water-quality programs was even less related to demographic variables than usage.

Table 3. Reasons Given for Bids of $0 for Outings

	% response
Rivers already clean enough or cannot be made clean enough	28
Enough or too much is being spent on water pollution control	19
Cannot afford to pay	44
Other	9

Estimation of Use Values

Our comparison of user and nonuser willingness to pay is dominated by intrinsic values. Mitchell and Carson have suggested a method of estimating use values in isolation by separating the sample into users–who have both use and intrinsic values, and nonusers–who have only intrinsic values. The method entails subtracting mean nonuser values from mean user values in the sample to obtain an estimate of mean use value. It assumes that user and nonuser populations are identical in all relevant respects.

In Table 2 these subtractions result in mean use value estimates of $10.73 for outings; $6.77 for outings plus boating; and $3.87 for outings, boating and fishing. These results disconfirm the Mitchell and Carson approach in that they suggest that larger activity sets are worth less than smaller ones. Thus, the Mitchell and Carson method does not succeed in identifying use values in our sample. The reason appears to be that users and nonusers constitute distinct populations who react differently to the expanding opportunity set in the contingent market, even though we lack statistical evidence of different populations in our sample. A properly specified regression model that held population differences constant might be capable of isolating use values by the Mitchell and Carson method, but errors of estimation are likely to be large relative to estimated use values, rendering this approach impractical in most studies. However, more detailed knowledge about the user and nonuser populations would be a valuable contribution to the valuation of environmental resources.

Willingness to Pay in Related Studies

Several recent survey studies of willingness to pay for recreational use of water resources help the interpretation of the present survey results and provide general perspective on values, which will increase over time as additional studies are completed. Table 4 summarizes three of these studies in addition to the results of the present survey.

Mitchell and Carson estimated willingness to pay to make all rivers and lakes in the United States boatable, fishable, and swimmable. They assumed uniform water quality nationwide at the outable level. Their nationwide values are about four times those expressed by people in the Chicago sample for local rivers. This comparison gives some insight into how people value distant natural resources in relation to the nearby. Proximity accounts for a great deal of both use and nonuse value. It is likely that expressed values for the Chicago area river programs would be higher if the predominant natural resource, Lake Michigan, did not exist. This would strengthen the impression gleaned from the Mitchell and Carson comparison.

Walsh et al. [3, pp. 34-37] report total user values of $80 and total nonuser values of $42 annually for improvements in water quality in the lakes and

Table 4. Water Quality Values in Related Studies

	Resource	*Program*	*Values (dollars per year)*
Mitchell and Carson	Rivers and lakes of US	make b) boatable, c) fishable, d) swimmable	Average user: b) 150; c) 197; d) 230 Average nonuser: 45% of user.
Walsh et al.	Lakes and streams of South Platte River Basin	Prevent deterioration; improve to intermediate clean levels	User: use) 57; option) 23. Nonuser: existence) 25; bequest) 17.
Desvousges et al.	Monongahela River	Make c) fishable; d) swimmable	Average user: b) to c) 19; c) to d) $13. Average option: b) to c) 18.
Croke and Brenniman	River of Chicago Deep Tunnel Project Area		Average existence (user and nonuser): $50.
	River of Chicago Deep Tunnel Project Area	make a) outable, b) boatable, c) fishable	User: a) 44; b) 49; c) 53. Nonuser: a) 29; b) 38; c) 47.

streams of the South Platte River Basin, Colorado. These values are half again as large as for the Chicago area programs, although the programs are not strictly comparable. Nonuser values, on the other hand, are smaller in relation to user values. In both Walsh and Mitchell and Carson studies, nonuser values are about half of user values. In the Chicago-area study, the ratio ranged from three-fourths to nine-tenths.

Desvousges et al. derive incremental values moderately higher than those of the present study. Their boatable-to-fishable improvement value of $19 compares with an aggregate increment of about $9 for the Chicago-area rivers. Nonuser values are proportionately higher than in the Walsh and Mitchell and Carson studies.

In summary the Chicago study gives program values at the lower end of the range of studies reviewed here. There is, however, a good general agreement in the results, after making allowance for generally lower program targets and the fact that Lake Michigan dominates the Chicago area as a recreation resource. The importance of nonuser values is a result of major importance in all of these studies, amounting to half to considerable more than half of values expressed by users.

Introduction of the "outable" category into the water quality ladder is an innovation of the present study. Other studies that use activity-based water quality ladders usually place boatable water quality on the lowest rung. In the densely populated industrial setting of the present study, however, people generally understand that outable water quality represents a considerable improvement over current conditions. That approximately two-thirds of total program benefits are accounted for by outings (Table 1) is an important result for urban water resource planning. It suggests that even relatively modest improvements in urban water quality are capable of conferring large benefits on urban populations.

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