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An Iterative Choice Approach to Valuing Clean Lakes, Rivers, and Streams*

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Abstract

This article introduces an iterative choice procedure for valuing inland water quality. This approach breaks up the valuation into a series of component tasks. The water quality ladder approach is not valid empirically. Consequently, respondents in Colorado and North Carolina assessed the value of making water quality rated "good" by EPA, which has a value of $22.40 per additional percent improvement. Nonuse and probabilistic use are highly valued. The results also indicate how water quality valuations differ for aquatic environment, edible fish, and swimming, as well as for water that is cloudy, smelly, or polluted by toxics. Minorities are particularly likely to rely upon monitorable water quality attributes.

Key words: Water quality, environmental benefits, nonuse values, toxic chemicals

JEL Classification: H40, K32, Q25, Q26

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1. Introduction

While water is undeniably one of our most fundamental and highly valued natural resources, it has been difficult to assign a value to improvements in water quality. This imbalance between the importance of water quality and our knowledge of the economic benefits of water quality improvement is surprising given the volume of benefit-cost analyses undertaken for water-resource projects, particularly in the last 20 years.[1] Both the Army Corps of Engineers and the U.S. Department of the Interior have assessed water quality benefit values for decades, focusing primarily on its recreational value and establishing the value of diverting water of a given quality to other uses, such as irrigation. More recently, attention has focused on a particular expression of water quality known as the water quality ladder.[2] This model values changes in water quality by assuming a particular hierarchy of values. It requires, for example, that all water that is satisfactory for swimming is also satisfactory for fishing. As we will demonstrate below, this hierarchical simplification is not an accurate reflection of our current scientific knowledge of water quality.

While we might wish otherwise, valuation of water quality is a complex multi-dimensional task. It involves quality measured along several distinct but correlated dimensions—swimming, edible fish, and quality of the aquatic environment. It also entails assessing both use and nonuse values, as the quality of water in regions one may never visit or have a small probability of visiting could have an economic value. Other complications enter as well, making this a formidable valuation task. Even though our focus is restricted to lakes, rivers, and streams, the problems associated with evaluating benefits derived from inland water alone are quite extensive. The principal contribution of this paper is to develop an empirical methodology for breaking these complex tradeoff issues into a series of more comprehensible tasks that can be used to construct water quality benefit values.

Our goal is to produce an evaluation methodology that is actionable, meaningful, and policy relevant. The principal methodology used is a survey approach that we term the "iterative choice approach," which differs from standard contingent valuation techniques in a variety of ways.[3] The following paragraphs briefly summarize the approaches we use. The rest of the paper then details both the approach and the valuations found. To make the results actionable, we seek values for cleaner bodies of water generally, particularly those that do not depend on the technology links or on the idiosyncrasies of a specific proposal. We present a method that estimates for each surveyed individual the dollar value of changing the percent of lakes in a given region that are rated "good." This information can be used to estimate the value of a given policy or environmental proposal by assessing its impact on the percent of "good" water. Since our output is a valuation model conditioned on the characteristics of the respondent and the characteristics of the change in water quality, it is straightforward to adjust for sampling biases or to project expected valuation to any affected population.

For such a measurement process to be meaningful, it is critical to provide a task that allows respondents to correctly articulate their preferences. Using computer-based interviewing permits flexibility and effectiveness in this regard that would be infeasible with paper-and-pencil and impractical with face-to-face interviews. To keep the task manageable and meaningful, we limit respondent judgments to choices between pairs that differ only on two attributes, water quality and cost of living. We further try to limit status quo and reference biases by framing the judgment as a choice between hypothetical regions to which respondents might move. A key part of the method involves asking respondents to elaborate on the attributes to ensure that they understand how they would feel in the face of changes in these attributes. For example, in the critical trade off between cost of living and quality of water, we first ask respondents to think about how much a difference of $200 per year in cost of living affects their well-being. Then we cue the value of improvements in water quality by asking about their likely use of lakes, rivers, and streams for fishing, swimming, or just sightseeing. We are typically not concerned with the answers to these questions; their purpose is to encourage respondents to think more deeply about how the tradeoffs would affect their families' lives.

There are a number of consistency checks that help ensure that the respondent is on the right track. For example, a warm-up choice question pits an area that is better than its alternative on both cost of living and water quality. Those choosing the dominated alternative are informed of their decision and asked if they wish to change it. The interview terminates for those who persist in choosing the rationally dominated alternative. Additionally, following an iterative series of choices, we improve the undesirable aspect of the unchosen alternative until it is best on both dimensions. People who consistently reject this dominating alternative are subsequently removed from the analysis.

Using the evaluation of water quality as an example, the purpose of this paper is to illustrate a very general process for evaluating commodities. Section 2 elaborates on how we characterize of water quality for purposes of benefit valuation, while Section 3 summarizes the general survey approach and the sample characteristics. Section 4 examines the tradeoffs between cost of living and water quality based on pairwise comparisons, and Section 5 examines the sensitivity of the results to a referendum format. Section 6 explores other choice dimensions, such as whether the water is smelly or is contaminated by toxic chemicals. Section 7 concludes the analysis.

The policy-oriented nature of our analysis dictated much of the overall structure of the research approach. The overall objective was to develop benefit values that could be used in conjunction with the water quality data used by the U.S. Environmental Protection Agency (EPA) to assess the benefits of changes in water quality. For these results to be operational for benefits assessment purposes, the survey had to match the EPA water quality rating system.

2. The dimensions of water quality

2.1. The water quality ladder

Previous studies have used a water quality ladder as an index of different levels of water quality, largely because simplifies the analysis by converting water quality rankings into a single dimension. In their contingent valuation study of the quality of fresh water, Mitchell and Carson (1989) used water quality rankings on an ordinal scale from zero to ten. At the top of the scale is drinkable water that is safe to drink and is safe for all other uses listed below on the ladder. The components of the water quality hierarchy are: water that is swimmable, water that is fishable, water that is boatable, and water that is not safe for any of these uses. With this scale, water with the highest quality is assumed to be safe for drinking as well as other uses, while water with a lower quality is assumed to be safe for swimming but not drinking. Thus, water that is drinkable must be swimmable, fishable, and boatable, and water that is not fishable cannot be drinkable or swimmable. This water quality hierarchy captured the previous EPA scientific understanding of different levels of water quality.

At this juncture it is also worth noting that this water quality ladder formulation has attractive properties from a survey standpoint. By using a single ladder, gradations in water quality can be converted into a single dimension. The cognitive difficulties for respondents in terms of the thinking about water quality consequently will be less than if they have to consider a multi-dimensional good in which each of the attributes may change independently of one another. However, the ladder becomes a scientifically invalid characterization in contexts where the implied hierarchical ranking does not in fact hold. Put differently, the ladder cannot be used to assess the values of shifts in values that violate the hierarchy.

Table 1 shows that this hierarchical relationship does not hold based on actual data pertaining to the water quality ladder reference points using water quality information from the U.S. EPA's Water Quality Inventory.[4] These data pertain to the percent of water rated as being of "Good" quality for each particular use. The results shown are for the nation as a whole, and the statistics vary by state. If the water quality ladder is accurate, boatable water should have the highest percentage

Table 1. Water quality ratings compared to the water quality ladder

Water quality ladder dimension	Water quality ladder prediction (% with good water quality)	National value for lakes (% of lake acres with good water quality)	National value for rivers (% of river miles with good water quality)
Drinkable	Lower % of all water	85%	69%
Swimmable		79%	73%
Fishable		82%	95%
Boatable	Higher % of all water	86%	87%

of water bodies rated good, followed by fishable, swimmable, and drinkable water. Consider first the percentages for lakes. Overall, 85 percent of the water is drinkable but only 79 percent is swimmable, violating the ladder hierarchy. Similarly, 82 percent of the water is fishable, below the 85 percent that is drinkable. The hierarchy also fails to hold for rivers, for which 87 percent of the water is boatable but 95 percent is fishable.

The failure of the water quality rankings to adhere to the water quality ladder structure is even more pronounced when considering data from individual states. Of the 28 states with data on the percent of lakes that are good for both fishing and swimming, 18 of the states (or 64 percent) do not obey the hierarchy in the water quality ladder. Similarly, of the 29 states with river data for both fishing and swimming, 15 of them (or 52 percent) do not obey the water quality ladder. Adherence to the water quality ladder is consequently the exception rather than the rule.

2.2. Multi-dimensional water quality

In recognition of these and other deficiencies of the single dimensional ranking of water quality, EPA has developed several dimensions of water quality to reflect these different characteristics.[5]

1. Aquatic life support
   The water body supports many plants, fish, and other aquatic life.
2. Fish consumption
   Fish caught in the water body are safe to eat.
3. Primary contact recreation—swimming.
   Prolonged contact with the water will not cause illness.

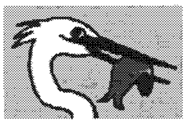
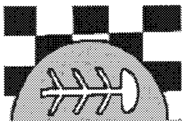
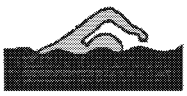
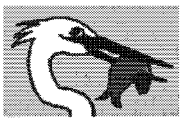
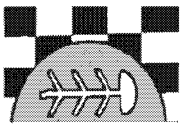
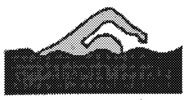
Within these three categories, each state's water has a particular score that reflects the percentage of water that meets the water quality standards. Thus, the quality of the water with respect to fish consumption, aquatic life support, and swimming receive independent rankings with respect to each of these dimensions rather than forcing them to be combined into a composite index of overall water quality.

The EPA ratings are based on the percent of miles for rivers or acres of lakes that meet the following levels of water quality: good-fully supporting the use, good but threatened, fair and partially supporting the use, poor and not supporting the use, and poor with the use not attainable. For our analysis we collapse these categories into those that are good, reflecting the first two categories, and those that are not good, reflecting the three lower categories.

Table 2 illustrates water quality inventory data for California. EPA has similar information for other states that can be used in projecting benefit levels associated with changes in the water quality index values with respect to each of the quality dimensions. It is noteworthy that because the rating of each dimension is with

Table 2. California water quality from water quality inventory

Percent of Water Meeting Each Level of Water Quality

Designated Use		**Good** Fully Supporting	**Good** Threatened	**Fair** Partially Supporting	**Poor** Not Supporting	**Poor** Not Attainable
Rivers and Streams (Total Miles = 211,513)	Miles Assessed					
 **Aquatic Environment**	12,567	30	2	66	2	0
 **Edible Fish**	4,253	63	6	27	4	0
 **Swimming**	5,449	52	5	41	2	0
Lakes (Total Acres = 1,672,684)	Acres Assessed					
 **Aquatic Environment**	489,982	31	0	68	0	0
 **Edible Fish**	239,194	38	0	62	0	0
 **Swimming**	328,517	35	0	65	0	0

respect to the percent of water that meets certain quality levels, the scores do in fact have quantitative and pragmatic significance and are not simply qualitative rankings. The valuation task requires, however, that a metric be constructed to establish tradeoffs between each dimension of water quality and money. Within this goal, we restrict the scope of our evaluations in two ways. First, we do not include drinkability as a criterion because it is not clear how drinkability should be evaluated given the appropriateness of water treatment before citizens would be encouraged to drink water from lakes, rivers or streams. Second, we only evaluate with changes from "good" to "not good," so that the current study is mute on the value of a change that only shifted from "threatened" to "fully supportive." The break point between "good" and "not good" in our coding is between "Good" and "Fair" in the EPA ratings in Table 2. It might not be feasible to assess valuations with a different break point, but to try to include different breakpoints in the same study would certainly make the task even more difficult for respondents.

Even with these simplifications, the cognitive task that will be posed in our survey will be much more complex than would be encountered using a single water quality metric. The advantage of this more complex structure is that it is related both to our current understanding of the scientific structure of the problem and to policy evaluation.

3. General survey approach

As in contingent valuation studies, the survey approach that we use involves individual interviews regarding hypothetical choices among economic and environmental commodities. However, the overall structure we utilize is more abstract than in traditional contingent valuation. Under the standard approach, the respondent considers a detailed characterization of a specific environmental good for which the respondent is asked to pay some amount to improve its quality. Our approach instead is to determine individual preferences based on the valuation of underlying attributes.[6] The survey structure establishes a valuation of each of the component attributes of water quality, determines these tradeoff values, and also assesses the overall conversion of the water quality component improvements into a dollar valuation of water quality more generally. Although this analysis begins with an assumption that a given improvement in percent good does not depend on the start point, say whether the base is 25% or 75% good, we test this assumption in a variety of ways.

A second key component of the valuation method is that respondents will consider moves to a *hypothetical* location for which different components of the choice will be varied. This method contrasts with the need for elaborate detail required in a conventional contingent valuation approach, but brings a benefit of providing estimates that can be applied generally.

A third critical component of this method is that it is based on *iterative choices*. Respondents first make a choice between moving to two hypothetical locations that differ in terms of water quality dimensions and cost of living. The computer then frames subsequent choices until the respondent reaches the point of indifference. This approach establishes tradeoff rates across water quality dimensions as well as a tradeoff rate between improved water quality and money.

We have used an iterative-paired approach in a number of previous studies. An early effort introduced the use of conjoint analysis into the environmental economics literature,[7] and a series of subsequent papers used the tradeoff values from paired comparisons both in valuation efforts for benefits as well as trade-offs among risky options after receiving different types of information.[8] While the paired comparison aspect is not novel, what is distinctive is that we are using this approach as part of a broader valuation task in which the commodity is being analyzed as a series of component attributes from which we will construct the overall evaluation.

3.1. Scope of the task

Our survey design considered three dimensions of water quality described in the National Water Quality Inventory. These dimensions are the ones most commonly reported in the water quality inventory state data. Because of the different aspects addressed by these attributes, respondents are led to understand that EPA can influence water quality in different ways by considering each of these dimensions in turn. The three dimensions of water quality included were aquatic life support, fish consumption, and recreational swimming, while the excluded water quality category was drinking water supply.

Our survey design uses the National Water Quality Inventory data only as it pertains to lakes and rivers. In the first parts of the survey, we combine these water quality ratings by presenting lakes and rivers as having the same level of water quality in the survey questions. Later, we include a separate set of questions within the structure of the survey instrument to differentiate an individual's preferences between lake and river water quality.

3.2. Focal trade-off choice questions

Ideally, a survey should elicit values of some standardized water quality improvement. This change in water quality should not be specific to the individual respondent in a way that cannot be generalized to obtain national water quality benefit values. In some respects, this approach is similar to placing all respondents within the context of John Rawls' (1971) original position. Each respondent will be moving to a hypothetical[9] new region without the specific water quality and availability attributes of the person's current residence. Moving to another region prevents undue focus on individual local water bodies and permits respondents to consider improvements for a large, well-defined area rather than for their own specific neighborhood alone. Respondents may, of course, differ in terms of their valuation of water quality, and this valuation may also depend on their current availability of water. As a result, the survey instructs respondents that they will move to an area that has the same volume of lakes and rivers as where they live now. Thus, the valuations that are elicited should be reflective of any regional influences to the extent that they are consequential, but they will do so in a manner that is highly structured. Notice it also should not elicit responses that relate to a personal circumstance—for example, whether they currently live right next to a lake or a river.

The survey also defines a region as an area within two hours' drive of the respondent's home. To better envision what a region entails, and the extent of local lakes and rivers, each respondent receives a map showing their state, the lakes and rivers in the state, with a circle defining the two-hour region. Figure 1 shows the regional specification for one of our survey locations located in Colorado.

In first tradeoff question, respondents choose between two possible regions to which they could move, one of which is characterized by a higher annual cost of living and a greater percent of lake acres and river miles in that region with good

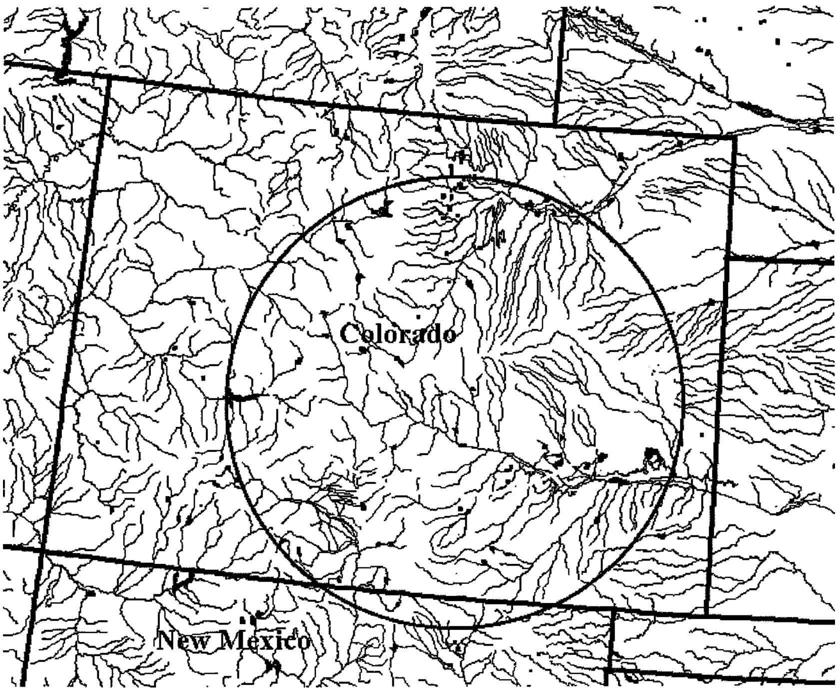


Figure 1. Map of Colorado.

water quality. Based on their first choice, respondents then consider a series of such paired choices until they reach a point of indifference.[10]

The result of this exercise is that it establishes a value of water quality for each respondent in terms of the dollar increase in cost of living that they are willing to incur for a one-percent improvement in water quality. The value can be derived using a straightforward calculation based on two equilibrating regions, each of which has an associated cost of living and percent of lake acres and river miles with good water quality. For example, suppose that respondents are indifferent between two regions, where one region imposes an additional $150 in living costs for a 15 percent improvement in water quality. Then each one-percent improvement in water quality has a value of $10. Notice that the method does not provide exact measures of each respondent's value for improvements in water quality. However, it does provide bounds whose medians can be easily aggregated across respondents.

The questions then iterate based on the respondent's initial response to either an increase or decrease in the level of tradeoff between money and water quality. This iteration continues until the respondent's answers provide both and upper and lower bounds on an estimate of water quality or until the answer reaches an extreme high or low value. In all, depending on the iterative choices made, 21 different estimates of willingness to pay are possible. The decision tree generating these estimates is shown in bold in Table 3. The tables gives the various choices and the resulting estimates of the dollar value of a one-percent increase in lakes and rivers with good water quality. Table 3 has the following structure. Respondents' first choice is between Region 1 with a cost of living increase of $100 and percent good water quality of 50 percent and Region 2 with a cost of living increase of $250 and 65 percent good water quality. Respondents picking Region 1 value water quality at less that $10 per percent change in water quality then consider the same Region 2 option as initially but a new Region 1 choice of $150 increase in cost of living for a 50 percent increase in water quality. Choice of Region 1 implies a value of water quality of under $6.67 per percentage change. The other entries in Table 3 have a similar interpretation.

These estimates are exact when the respondent indicated indifference between regions. In other cases the respondent's choice pattern enabled us to put bounds on the value of water quality, and we took as our estimate the mid-point between these logical bounds. When either region receives all choices, the value is undefined. If region 2 is chosen every time then the estimate of the value of water is infinite. We took as a conservative estimate twice the value of indifference at that step, or $300. However only 7 percent of our respondents were in that category, so it has a relatively small impact on our means. A different outcome results for the 2 percent of respondents who chose region 1 every time. In that case, the value of improving water is negative. Given that we had trained respondents to avoid such dominated choices, we interpret this response as a sign that they are not paying attention or are tired with the process. We therefore excluded them from the analysis. A separate analysis is provided characterizing those excluded respondents and showing the regression results with the full sample.

Table 3. Survey decision tree and outcomes for cost of living—water quality

	1. Region 1	2. Region 2	3. No Preference Between Regions
Cost of Living Increase	$100	$250	
% Good Water Quality	50%	65%	
Implied Tradeoff $ per 1% Increase in Good Water Quality	Less Than $10 per 1%	More Than $10 per 1%	Equal to $10 per 1%

If Region 1

1	2	3
$150	$250	
50%	65%	
< $6.67	> $6.67	$6.67

If Region 1

1	2	3
$200	$250	
50%	65%	
< $3.33	$5	$3.33

If Region 1

1	2	3
$225	$250	
50%	65%	
< $1.67	$2.50	$1.67

If Region 1

1	2	3
$250	$250	
50%	65%	
< $0	$0.83	$0

If Region 2

1	2	3
$125	$250	
50%	65%	
$7.50	$9.17	$8.33

If Region 2

1	2	3
$100	$250	
50%	*60%*	
< $15	> $15	$15

If Region 1

1	2	3
$100	$250	
50%	*62%*	
$11.25	$13.64	$12.50

If Region 2

1	2	3
$100	$250	
50%	*55%*	
$22.50	> $30	$30

If Region 2

1	2	3
$100	$250	
50%	*50%*	
$60	Infinite	$150

Parallel logic enables us to estimate tradeoffs among components of water quality in the rest of the survey. Respondents always make choices that are restricted to two different dimensions. For example, the study considers changes in cost of living, water quality for lakes and rivers, water quality for each of the three different uses, variations in water quality depending on whether the water is cloudy, smelly, or the result of toxic pollutants, as well as the role of nonuse value. In each case, to prevent the task from exceeding their cognitive limitations, the survey approach asks for choices among pairs that differ on just two dimensions.

To further help respondents cope with these choices, respondents do not consider new domains of choice without extensive preparation. The survey defines new concepts with which the respondents may be unfamiliar. These training questions continue throughout the survey instrument to ensure that respondents understand the concepts being utilized.[11]

3.3. Survey contents

The cost of living—good water quality tradeoff is only one example of the larger survey task. The survey consists of ten different sections. By subdividing the survey task into different substantive units, respondents were engaged in a particular valuation task and their responses focused on a specific tradeoff, avoiding the complicating influences of multiple dimensions that otherwise might be at stake. These ten sections are given in the order seen by respondents.

1. **Lake/river usage**. This section of the survey ascertains whether the respondent has used lakes, rivers, and streams recently and also obtains information regarding the character of the use. For example, has the respondent engaged in fishing or swimming? If yes, how often? The primary purpose of these questions is to encourage the respondent to think about the value of these activities in such a way that helps clarify the implications of the later choices.
2. **Question format explanation**. This section of the survey introduces the format of most survey questions that follow. Thus, the intent of this section is to provide a general introduction to the character of the tradeoffs that will be faced, but will not include specific questions to ascertain the cost of living-water quality tradeoff values.
3. **Cost of living versus water quality**. This is the key section of the survey that is designed to ascertain the rate of tradeoff between increases in cost of living and water quality improvements. The structure of this section utilizes a sequence of paired comparisons, where the first preferred option worsens until a point of indifference has been achieved.
4. **Lake quality versus river quality**. This section of the survey determines the individual's rate of tradeoff between lake and river water quality improvement. As in the case of the cost-of-living water quality tradeoffs, this section of the survey as well as subsequent sections utilize a series of paired comparisons

until a point of indifference has been achieved. The first tradeoff in this question set determines whether respondents prefer lake or river improvements by presenting a region with higher lake quality and another with higher river quality. Iterations adjust the quality of the preferred water bodies in the region until indifference is reached. Using these results it will be possible to ascertain the relative benefit assessment for water quality improvements for these two different classes of water bodies.

5. **Water uses tradeoff**. In this section, the respondent determines relative tradeoffs for swimming, aquatic environment, and fishing in three paired comparisons, i.e., swimming versus aquatic environment, swimming versus fishing, and fishing versus aquatic environment. For example, one question set offers respondents a choice between a region that has higher water quality for swimming while the other has higher quality for swimming. As before, the preferred use is made less desirable and iterations adjust the level of the preferred use until indifference is reached.
6. **Source of pollution**. Respondents may not care simply about the overall level of water quality, but also about the nature of the pollution that causes the decrease in water quality. A pollution component of particular interest is industrial toxic wastes. Are people more fearful of the decreases in water quality caused by toxic waste as opposed to conventional pollutants? The section of the survey addresses this issue by assessing rates of tradeoff between pollution due to agricultural wastes and pollution due to industrial toxic wastes.
7. **Nonuse values and probabilistic use**. A major and controversial benefit component in environmental policy areas is the nonuse value that should be placed on environmental improvements.[12] If, for example, the respondent is never likely to visit a particular region in which a water quality improvement will occur, is there nevertheless an economic benefit to the individual from improving the water quality? To explore this issue this section examines the rate of tradeoff between water quality improvements in the person's own region versus water quality improvements in a region which the respondent will not visit. Moreover, this section also analyzes the potential for evaluation of water quality based on the probability that the respondent will visit another region, which can be viewed as a form of economic option value. Respondents are presented with a policy that improves water quality in the region where the respondent has moved and another that improves water quality to a lesser extent in a neighboring region that the respondent will not visit. The improvement associated with the chosen policy is adjusted until indifference is reached. Another question set follows which asks the same questions, except that respondents are told they will the probability that they will visit lakes or rivers in the neighboring region.
8. **Aesthetic properties, smelliness and cloudiness**. Even if water quality meets a particular level based on the EPA criteria, individuals may also be sensitive to other attributes. The two attributes considered were the smelliness and cloudi-

ness of water. These results also may be instructive with respect to identifying different demographic groups who place greater weight on these aspects of water quality that are not currently part of EPA's criteria.

9. **Cost of living versus water quality referendum**. All previous tradeoffs considered thus far are based on a series of choices among paired alternatives. Here we adopt a referendum approach to assessing the value of water quality. In particular, individuals are asked to determine whether they support a policy referendum in which there will be some associated cost as well as an associated water quality improvement. Asking the water quality valuation question in this alternative way provides a valuable consistency test on the results above for section three of this survey in which the cost of living versus water quality tradeoff has been elicited through paired comparisons.
10. **Demographics**. This section of the survey obtains detailed information regarding the demographic characteristics of the respondents. These characteristics are of interest for a variety of reasons. First, analyzing the demographic characteristics is useful in testing whether the respondent group is representative of the population in the same area. Second, analyzing the characteristics of the respondents also is helpful in analyzing how various responses to questions, such as the valuation of water quality, vary with demographic characteristics. Based on a regression analysis of these valuations in conjunction with information on demographic characteristics, one could project water quality valuation from a sampled population to a broader population.

3.4. Recruiting and survey format

The survey was executed in two different ways. The first execution of the survey brought respondents to a central location in Research Triangle Park, North Carolina (RTP) following telephone recruiting. The central location approach resulted in strong oversampling of highly educated people, older people, and non-minorities, which is not surprising given the concentration of high tech firms in and around RTP. The second execution of the survey a series of mall intercepts in Cary, North Carolina and in Denver and Colorado Springs. This is a lower-cost method of recruiting respondents than paying respondents to come to a central location but one, which, as it turned out, also yielded a much more representative sample and more reliable responses.

The screening for participating in this study required that the respondent at least 18 years old and have a high school diploma. There seem to be no major difficulties with respect to educational group in terms of the ability to take the survey.

The RTP interviews from August 13, 1997 to August 29, 1997 brought 106 respondents to a central location where they received $15 for the interview. The mall intercepts in Cary, North Carolina (49 interviews), Charlotte, North Carolina (53 interviews), Denver, Colorado (100 interviews), and Colorado Springs, Colorado

(101 interviews) took place from January 27, 1998 to February 6, 1998. The incentive provided to respondents was $10.

3.5. Sample characteristics

The demographic breakdowns for the full sample appear in Table 4. The average age is 37, and the sample is evenly divided between men and women. Blacks and other minorities comprise just under one-third of the sample. About 10 percent belong to an environmental organization. An unusual characteristic of the sample is that two-fifths of the sample have a college diploma, which is largely attributable to the particular demographics of the RTP site.

The water evaluations discussed below reflect results from those who passed consistency checks. A subject could fail a consistency check by choosing a dominated choice at the extreme tail of a decision tree, or by choosing *no preference* for that dominated choice. This response indicated that the subject was not paying attention to the survey task or did not understand the survey question. Sixty-two of 410 subjects, or 15% of subjects failed at least one of several consistency checks throughout the survey. As shown in Table 4's comparison of the full sample to the consistent sample, inconsistent subjects were more likely to be retired, students, non-white. Including inconsistent respondents in the analysis below makes relatively little difference in the results except coefficients that include inconsistent respondents tend to be attenuated and their statistical significance is less strong. Further, imposing this consistency test on the survey results represents a more stringent rationality test than is typically found in environmental valuation surveys.

4. Cost of living versus water quality tradeoffs

The main focus of the survey was to obtain an estimate of each individual's tradeoff between money and improvements in water quality. Although later questions are directed at nuances in this valuation, such as differences in the valuation of water quality improvements that affect swimming as opposed to fishing, the first overall tradeoff of concern—and the one that will drive any overall benefit assessment for policy—will be how respondents value water quality generally. The next sections detail how this valuation is achieved.

Table 5 presents the text of the initial cost of living survey question. The survey defines *cost of living* and encourages respondent to think about its importance within the context of their overall household expenditures. After establishing this framework, the survey then confronts the respondent with an easy regional choice, where both regions are alike except for a difference in their cost of living. If the respondent does choose the area with the lower cost of living, the explanation included in Table 5 is provided, and the dominated question is repeated. The survey then shifts the focus from defining what we mean by cost of living to

Table 4. Sample characteristics

	Mean Values	
	Full sample	Consistent sample
Age	37.2	37.3
Female (0–1)	50.9	52.6
White (0–1)	68.9	70.4
Black (0–1)	14.4	12.6
Nonwhite, nonblack (0–1)	16.6	17.0
High school diploma (0–1)	92.6	94.8
College diploma (0–1)	41.3	44.2
Years of education	14.5	14.7
Employed (0–1)	75.3	74.4
Employed full time (0–1)	61.1	61.2
Retired (0–1)	12.0	11.2
Full time student (0–1)	6.6	6.3
Full time homemaker (0–1)	15.2	15.5
Household family income	$38,700	$40,400
Married	46.2	47.1
Household size (number)	2.6	2.6
Member of an environmental organization	9.8	10.9
Visited lake or river in last 12 months	12.0	10.6
Urban area	56.0	55.5
Suburban area	35.9	37.1
Rural area	8.1	7.5
Resident of state of survey site	98.0	98.9
Time to complete survey, in minutes (mean)	27.3	27.5
N	409	348

defining water quality. The survey indicates that water quality may differ across regions and that water quality may either be "*Good*" or "*Not Good*," where the survey defines what it means for water quality to be *Good* or *Not Good*. This section of the survey also clarifies that drinking water is specifically excluded and defines what is meant by the size of the region and the percent change in water quality. The respondent then considers a simple regional choice question where the regions differ only in terms of water quality. Once again, the first choice is deliberately a dominated choice, and individuals failing to choose correctly will be given the explanation that corrects their error and then repeats the question. Table 6 shows the question in which respondents now have to trade off cost of living and water quality. In this sample question there is a clear cut dominant choice, as Region 2 is less expensive in terms of the increased cost of living and has a higher percentage of water that is of *Good* quality. Individuals who answer incorrectly by failing to recognize the dominated choice are again put in a loop that explains the error in their answers. These dominated questions serve both to give the respondents confidence through easy questions, and to give extra training to those who do not understand.

Having been through the easy dominated choices, the respondent is then ready to respond to the first tradeoff question, shown at the bottom of Table 6. Depending on the respondent's answer to that question, the subsequent tradeoffs considered follows the iterative process described earlier.

Table 5. Cost of living task text

These are the questions that explain Cost of Living in the survey

Cost of Living

For purposes of this survey, the cost of living is defined as the amount of money that your family spends each year for things like food, clothing, and rent or mortgage.

When we say that a region has a higher cost of living, we mean that each year you would have to spend more for these items overall.

How concerned would you be if your family's cost of living suddenly went up $200 per year? (This would mean that items like food, clothing, and rent or mortgage would cost a total of $200 more each year than they do now.) This might mean an increase of $2 per week for food (or $104 per year) and $8 per month more for housing (or another $96 per year).

1. Not at all concerned
2. A little concerned
3. Somewhat concerned
4. Very concerned

Try answering this sample question to make sure we explained Cost of Living clearly.

Imagine that you must move to another region of the country. You have narrowed your choices down to two. Both regions have a higher cost of living than where you live now, but are alike in all other ways.

Which region would you prefer?

	1. Region 1	2. Region 2	3. No Preference Between Regions
Increase In Annual Cost of Living	$100 More Expensive	$250 More Expensive	

If the answer given is **2. Region 2**, then the following question is asked.

The question was not clear.

You chose to move to the region with a higher cost of living.
You could have chosen a region with a lower cost of living that is alike in all other ways.

To change your answer, press any key and we will ask the question again.

Otherwise, please tell the interviewer you do not want to change your answer.

Table 5. (Continued)

If the answer given is: **3. No Preference Between Regions**, then the following question is asked.
You indicated that you have no preference between two regions whose only difference is that it is more expensive to live in one of them. Are you sure that you don't care whether you would move to a region where it is more expensive to live? After all, you could move to a region with a lower cost of living that is alike in all other ways. 1. Yes, I'm sure that I have no preference. 2. No, I'm not sure. Ask the cost of living question again.
If the answer given is: **1. Region 1**, then the following question is asked.
The Region you chose, Region 1 has a lower annual cost of living than Region 2.

For all the samples as a group, respondents were willing to pay an additional $22.40 for a one-percent increase in the level of water quality. These amounts ranged from a low value of $20.10 for Colorado Springs to a higher of $28.50 for Charlotte. The median responses were much more tightly clustered and lower than the values of the means. With the exception of Cary and Charlotte, the median values ranged from $11.30 to $13.60 for each one-percent increase. The fact that the mean values are roughly twice as high as the medians suggests that the distribution of the valuation of water quality is skewed by a few respondents who have extremely high values for water quality.

5. Referendum version of the cost of living-water quality tradeoff

Before eliciting the demographic information, the survey included a referendum version of the cost of living-water quality tradeoff. Referendum approaches are believed to elicit more honest valuations, but they may be more difficult to process. We use the referendum approach as a sensitivity test to our basic paired comparison approach. The referendum question followed about five minutes of questions that elaborated on the value of components of water quality. The purpose of separating the referendum from the paired comparison regional choice was to decrease the chance that respondents would attempt to simply mimic their answers to their earlier questions when answering the referendum version.

Table 7 presents the initial referendum policy choice. In the referendum question, the respondent first moves to another region and is informed of the region's level of water quality. The respondent must then face a choice of whether a government policy will increase the quality of water by a certain amount, where this policy improvement would be paid for by additional taxes. The respondent then indicates whether he or she is in favor of this water quality improvement policy. If the answer is "Yes (No)," then the respondent considers subsequent pairwise comparisons that increase (decrease) the relative dollar value of water quality improvement. Thus, one can view this approach as an iterative referendum that differs from the traditional one-shot referendum format and incorporates elements of our iterative choice approach.

Table 6. Water quality task test

Water Quality
Some questions will ask you to choose between regions that differ in terms of the quality of the water in either lakes or rivers in the regions. The government rates water quality as either * Good or * Not Good. Water quality is Good if the water in a lake or river is safe for all uses. Water quality is Not Good if a lake or river is polluted or unsafe to use.
More specifically, Water quality is Good if the lake or river * Is a safe place to swim, * Has fish that are safe to eat, and * Supports many plants, fish, and other aquatic life. Water quality is Not Good if the lake or river * Is an unsafe place to swim due to pollution * Has fish that are unsafe to eat, and * Supports only a small number of plants, fish and other aquatic life.
This survey will not ask you about drinking water. Drinking water is treated by water treatment plants to ensure safety. Water treatment cannot be done for the dimensions described on the previous screen, since these dimensions involve visiting a lake or river instead of treating a limited amount of water taken from the lake or river.
We will talk about water quality for more than one lake or river. The questions will include all the lakes or rivers in the region. This means all lakes and rivers within a 2-hour drive or so of your home, in other words, within 125 miles.
We define the quality of the water in the lakes and rivers of a region by the percent of the total acres of lakes or miles of rivers in the region which have good water quality. For example, let's say a region has several rivers, running a total of 100 miles in the region. If pollution causes 50 of those miles to have a water quality that is not good, leaving 50 miles with good water quality, then we would call the water quality for rivers in that region 50% good.

Table 6. (Continued)

Water Quality

Try this sample question about water quality.
Imagine again that you must move to another region of the country.
You have narrowed your choices down to two regions. They differ in only one way, the quality of the water in the regions. They even have the same number of acres of lakes and miles of rivers within 2 hours or so of where you would live. Which region would you prefer?

	1. Region 1	2. Region 2	3. No Preference Between Regions
Percent of Lake Acres and River Miles With Good Water Quality	50%	65%	

The question was not clear.

You chose to move to the region with worse water quality.

You could have chosen a region with better water quality that is alike in all other ways.

To change your answer, press any key and we will ask the question again.

Otherwise, please tell the interviewer that you do not want to change your answer.

The Region you chose, Region 2, has better water quality than Region 1.

Next will be a sample question that combines water quality and cost of living.

You indicated that you have no preference between two regions whose only difference is that one has better water quality than the other.

Are you sure that you don't care whether you would move to a region where a lower proportion of lakes and rivers are safe and clean when you could move to a region with more rivers that are safe and clean that is alike in all other ways?

1. Yes, I'm sure that I have no preference
2. No, I'm not sure, ask the water quality question again

The results of the referendum approach in many respects are quite similar to those found with the pairwise regional choice questions, though not identical. The mean referendum value is per 1% improvement in water quality, and the mean value is $18.60. The mean referendum response has a low value of $13 per unit increase in water quality for the RTP site, but otherwise is closely clustered in the $20.50 per unit to $27 per unit range across all sites. For the median responses, the RTP group once again tends to be an outlier, with a value of $12.00. As in the earlier results, the distribution of the valuation of water quality is somewhat

Table 7. Sample referendum water quality task

Imagine again that you have recently moved to another region of the country, where water quality is 50% Good.
Imagine that the government is considering a policy that would increase water quality in your region from 50% Good to 65% Good.
This policy, through additional taxes, would increase your cost of living by $150 per year.
Would you be in favor of this policy? 1. Yes 2. No.

skewed, with some respondents having particularly high values for water quality, leading the mean value to exceed the median in the case of every survey location.

6. Regression analyses of regional and policy choices

The regression results analyzing the determinants of the valuations of cost-of-living and water quality appear in Tables 8a and 8b. The dependent variable is the total dollars of cost of living increase that the respondent is willing to incur in return for a one-percent increase in the percent of lake-acres or river-miles with good water quality. Table 8a reflects the iterative choice between new regions, and Table 8b reflects the referendum choice applied to a specific region. Each table includes four sets of estimates. Column 1 is the basic ordinary least squares (OLS) estimate. Because the responses to the iterative survey questions sometimes hit corner values in the iterative program, the water quality values in some cases could be beyond the reported levels. The tobit estimates in column 2 account for such influences. Another complication is that our focus on the consistent sample potentially imparts a bias to the estimated results when trying to assess the likely behavior of the population at large. Column 4 is the selection equation used in constructing the selectivity-corrected estimates in column 3. It is noteworthy that the coefficients of interest are fairly stable across all three sets of estimates.

Overall, the results appear to be stronger for the region choice estimates than for the referendum estimates. Indeed, for the selectivity corrected estimates for policy choice in Table 8b none of the substantive variables of interest is statistically significant. This result is consistent with our hypothesis that the region choice approach is better understood by respondents.

One aspect of the results pertinent to generalizing the findings is that there is no strong variation in the responses based on region. This result suggests that there may not be stark differences across regions in the valuation of water quality other than those that are reflected in the demographic variables included in the equation. The only significant regional difference is that reflected by RTP, which may

Table 8a. Regression estimates for cost of living value for water quality, region choice results

Dependent variable: Cost of living vs. water quality level
(Units are $ per 1% improvement in water quality. Higher value means willing to pay more for water quality improvement.)

	Estimated coefficient (standard error)			
	Region choice water value (OLS)	Region choice water value (tobit)	Region choice water value (selection corrected)	Selection equation for region choice model
Age	0.470 (0.114)**	0.433 (0.102)**	0.466 (0.132)**	−0.013 (0.009)
Age squared	−0.015 (0.006)*	−0.014 (0.005)**	−0.015 (0.007)*	0.001 (0.000)
Black	−4.373 (3.633)	−3.615 (3.224)	−4.532 (4.286)	−0.374 (0.244)
Race-other	−7.696 (3.219)*	−7.229 (2.857)*	−7.657 (3.436)*	0.124 (0.258)
Female	3.904 (2.412)	3.647 (2.143)	4.004 (2.780)	0.283 (0.189)
Household size	−0.492 (0.907)	−0.489 (0.805)	−0.484 (0.998)	0.013 (0.064)
Employment: full time	0.315 (2.583)	0.235 (2.295)	0.369 (2.777)	−0.018 (0.210)
Member of an environmental organization	−3.100 (3.742)	−2.815 (3.326)	−3.032 (3.849)	0.425 (0.465)
Household family income × 10,000	0.585 (0.516)	0.644 (0.459)	0.594 (0.559)	0.014 (0.041)
Income data missing	−4.226 (5.696)	−4.911 (5.067)	−4.275 (6.188)	−0.153 (0.444)
Visited lake or river in last 12 months	9.176 (3.846)*	8.821 (3.413)*	9.236 (4.350)*	0.114 (0.240)
Water quality lower bound %	−0.077 (0.067)	−0.079 (0.060)	−0.077 (0.074)	0.001 (0.004)
Survey location: Research Triangle Park	−4.458 (3.673)	−6.972 (3.266)*	−3.872 (7.971)	6.415 (0.000)
Survey location: Denver	1.273 (3.541)	0.917 (3.142)	1.467 (4.719)	0.425 (0.222)
Survey location: Charlotte	5.476 (4.151)	5.486 (3.683)	5.717 (5.538)	0.454 (0.268)
Survey location: Cary	3.444 (4.263)	3.209 (3.783)	3.771 (6.011)	0.592 (0.312)
Lives in the suburbs	−2.749 (2.685)	−1.783 (2.387)	−2.825 (3.013)	−0.194 (0.210)
Lives in the country	12.295 (4.547)**	9.282 (4.068)*	12.138 (5.221)*	−0.346 (0.308)

Table 8a. (Continued)

Dependent variable: Cost of living vs. water quality level
(Units are $ per 1% improvement in water quality. Higher value means willing to pay more for water quality improvement.)

	Estimated coefficient (standard error)			
	Region choice water value (OLS)	Region choice water value (tobit)	Region choice water value (selection corrected)	Selection equation for region choice model
High school graduate				0.590 (.0311)
Some college				0.826 (0.316)**
College graduate				0.938 (0.375)*
Post-graduate education				0.635 (0.363)
Mills: lambda			1.250 (14.478)	
Constant	2.765 (7.041)	4.235 (6.252)	2.188 (9.811)	0.034 (0.530)
Observations	348	348	348	409
R-squared	0.17			

Notes: * Significant at .10 level, ** significant at .05 level, *** significant at .01 level; Exclusion of the dummies for education levels used in the selection equation (fourth column) from the linear model (first column) cannot be rejected at any usual significance levels. The F-test for the exclusion restriction is 0.71, where Prob > F(4,325) = 0.5863.

reflect the differences in the character of the sample as well as minor differences in the structure of the survey administered at that site. Controlling for other factors, RTP respondents are willing to spend roughly $4–$7 less per unit change in water quality than the omitted survey location, Colorado Springs. The other areas do not exhibit any such significant differences.

Because the effects tend to be fairly consistent across the results, we focus on equations for Table 8a, which are the estimates for the region choice, the first set of tradeoff questions. Overall, the non-white, non-black minorities tend to have lower valuations than did the other groups, even adjusting for income. Age is very influential, as the valuation of water quality has a peak in the teen years and decreases at an increasing rate with greater age. This result makes sense, as the ability to actively use lakes and rivers decreases with age. The variables intended to capture the environmental orientation of the respondent, such as environmental group membership, were not particularly influential once other demographics were included. An important variable that had an impact on desire for quality water was

Table 8b. Regression estimates for cost of living value for water quality, policy choice results

Dependent variable: Cost of living vs. water quality level
(Units are $ per 1% improvement in water quality. Higher value means willing to pay more for water quality improvement.)

	Estimated coefficient (standard error)			
	Region choice water value (OLS)	Region choice water value (tobit)	Region choice water value (selection corrected)	Selection equation for region choice model
Age	0.077	0.031	0.038	−0.013
	(0.094)	(0.055)	(0.114)	(0.009)
Age squared	−0.010	−0.007	−0.008	0.001
	(0.005)*	(0.003)*	(0.006)	(0.000)
Black	−0.924	−0.483	−2.274	−0.374
	(2.982)	(1.741)	(3.684)	(0.244)
Race-other	−3.964	−2.837	−3.632	0.124
	(2.642)	(1.538)	(2.951)	(0.258)
Female	0.072	0.171	0.924	0.283
	(1.980)	(1.154)	(2.390)	(0.189)
Household size	−1.572	−0.901	−1.503	0.013
	(0.744)*	(0.434)*	(0.856)	(0.064)
Employment: full time	0.348	0.040	0.809	−0.018
	(2.120)	(1.237)	(2.389)	(0.210)
Member of an environmental organization	1.079	0.855	1.662	0.425
	(3.071)	(1.790)	(3.319)	(0.465)
Household family income × 10,000	0.094	0.260	0.172	0.014
	(0.423)	(0.247)	(0.480)	(0.041)
Income data missing	−2.382	−1.450	−2.793	−0.153
	(4.675)	(2.728)	(5.309)	(0.444)
Visited lake or river in last 12 months	1.143	2.293	1.653	0.114
	(3.157)	(1.845)	(3.735)	(0.240)
Water quality lower bound %	0.012	0.003	0.009	0.001
	(0.055)	(0.032)	(0.063)	(0.004)
Survey location: Research Triangle park	−9.588	−6.950	−4.580	6.415
	(3.015)**	(1.755)**	(6.832)	(0.000)
Survey location: Denver	2.282	1.383	3.940	0.425
	(2.907)	(1.696)	(4.042)	(0.222)
Survey location: Charlotte	−0.116	−0.377	1.943	0.454
	(3.407)	(1.988)	(4.745)	(0.268)
Survey location: Cary	4.497	3.324	7.292	0.592
	(3.500)	(2.044)	(5.148)	(0.312)
Lives in the suburbs	−0.764	−0.891	−1.415	−0.194
	(2.204)	(1.285)	(2.587)	(0.210)
Lives in the country	5.820	1.140	4.473	−0.346
	(3.733)	(2.193)	(4.480)	(0.308)

Table 8b. (Continued)

Dependent variable: Cost of living vs. water quality level
(Units are $ per 1% improvement in water quality. Higher value means willing to pay more for water quality improvement.)

	Estimated coefficient (standard error)			
	Region choice water value (OLS)	Region choice water value (tobit)	Region choice water value (selection corrected)	Selection equation for region choice model
High school graduate				0.590 (0.311)
Some college				0.826 (0.316)**
College graduate				0.938 (0.375)*
Post-graduate education				0.635 (0.363)
Mills: lambda			10.676 (12.423)	
Constant	23.837 (5.779)**	19.499 (3.377)**	18.909 (8.417)*	0.034 (0.530)
Observations	348	348	348	409
R-squared	0.13			

Notes: * Significant at .10 level, ** significant at .05 level, *** significant at .01 level; Exclusion of the dummies for education levels used in the selection equation (fourth column) from the linear model (first column) cannot be rejected at any usual significance levels. The F-test for the exclusion restriction is 1.48, where Prob > F(4,325) = 0.2076.

whether the respondent had visited a lake or river in the last twelve months. Respondents who met this test valued improvements in water quality at $9.18 more per unit increase in the water quality level.

Analyzing the determinants of water quality valuation in terms of a value per unit of water quality may not be fully reflective of the character of individual preferences if these valuation differ depending on the level of water quality. If, for example, water quality has a higher value when it is very bad than do improvements in water quality when the value of water quality is quite higher, then we need to recognize this non-linearity when establishing benefit values. The survey can potentially incorporate such non-linearities into the analysis, though doing so would ultimately complicate any benefit assessment figures. To explicitly test for such a possibility, the regression analyses in Tables 8a and 8b include a variable indicating whether the lower bound of the water quality level considered by a respondent has a value of 25, 50, or 75, i.e. "water quality bound %." Thus, the coefficient examines if there is any difference in the value of 15% change in water quality base level improves. We had expected diminishing returns to improved water quality, but no significant effect was found in either regression. Since the coefficient was not statistically significant, there is little harm in valuations that begin from a common start point. However, to the extent that it is easy to include them in future studies, we advocate using different start points as insurance.

Table 7 presents an example of the policy referendum choice task, which is also iterative. The referendum regression results in Table 8b closely parallel those in Table 8a in terms of their substantive content, but the effects are usually weaker. Although the age variable is not significant, the squared value of age is, indicating that the value of water quality tends to diminish with age. Unlike the cost-of-living tradeoff questions, there is no significant effect of visiting a lake or river on the referendum response.

While the respondents' answers to the cost of living and referendum questions were not identical, they were nevertheless related. Table 9 presents different quartiles for the cost of living-water quality tradeoff valuation. For each tradeoff, information is included with respect to the mean level of the valuation implied by the referendum question. As is indicated, this value is a steadily increasing function of the pairwise regional choice valuation response. The referendum value for the lowest cost-of living regional choice quartile was $12.89 per unit increase in water quality, and this amount increases to a high of $26.73 for the fourth quartile.

7. Other choice dimensions

7.1. Water characteristics

The survey distinguished not only the valuation of overall water quality, but also sought to assess how these valuations depend on the character of the change and on the particular water body whose quality is affected. We analyzed four different aspects of water: lakes versus rivers, cloudy versus not cloudy, smelly versus not smelly, and toxic pollutants versus agricultural wastes. The survey also distinguished use and non-use values. These dimensions of choice should be distin-

Table 9. Comparison of cost of living tradeoff and referendum values

Cost of living vs. water quality level, policy choice question (units are $ per 1% improvement in water quality)	N	Policy choice mean	Std	Median
Cost of Living vs. Water Quality Level, 1st Quartile	87	12.89	1.13	11.7
Cost of Living vs. Water Quality Level, 2nd Quartile	87	20.08	1.99	18.6
Cost of Living vs. Water Quality Level, 3rd Quartile	87	22.24	1.64	22.5
Cost of Living vs. Water Quality Level, 4th Quartile	87	26.73	2.46	22.5

guished from valuations of specific water quality uses, e.g., swimming, which are separate dimensions of water quality that will be discussed below.

The comparisons between lakes and rivers involved iterative paired choices similar to those used for cost of living and water quality. Respondents first considered general questions designed to engage them in thinking about the water quality for lakes and rivers. They then considered a sample question dealing with lake and river quality in which one region was dominant. After completing this dominance question, they then considered a series of actual choices between regions, where the regions differed in their relative quality of lakes and rivers. For example, Region 1 might have a higher percentage of river miles with *Good* water quality, whereas Region 2 is lower on river-miles but has a higher percentage of lake acres with *Good* water quality. Respondents must choose the tradeoff rate between good water quality in both domains.

We also explored the relative value of altering water so that it is no longer smelly or cloudy. The questions introduced these concepts by asking respondents to consider the importance of these dimensions. We asked them to believe that these attributes are independent of the water quality ratings. For example, smelly water could be "Good" for swimming. Iterative choices then enable us to estimate the tradeoff people are willing to make between the percent of *Good* water quality which is smelly or cloudy and the percent of *Good* water quality without those attributes.

To assess whether the source of the pollution is consequential in affecting individuals' valuations, a series of questions explored whether respondents valued cleanup of pollution stemming from agricultural waste differently from that produced by industrial toxic wastes. The task for the respondent is to trade off the extent of good water against type of pollution. Once again, respondents faced a series of tradeoffs designed to ascertain their point of indifference between the two types of pollution. The initial tradeoff described two regions with equal water quality whose only difference was the source of pollution. Depending on the answer to the initial question and the version of the survey, the water quality in one of the regions either improved or worsened and the question was asked again. This continued until indifference was reached. The final difference in water quality between regions is the tradeoff for the less favored source of pollution.

The tradeoff results for the different aspects of water quality indicate that the various dimensions of choice regarding water quality improvements are often influential in determining the overall benefit value. Table 10 presents the overall valuation of lake water quality relative to river water quality. Although the median respondent viewed water quality improvements in lakes and rivers as being equivalent, the mean valuation was that lake water quality was roughly twice as valuable as improvements in river water quality, implying that far more people were willing to pay large amounts to improve lakes over rivers.

The aesthetic characteristics of the water also influence its value, as is shown in the results in Table 10. A 1.0 percent increase in the percentage of water with *Good* quality that has no effect on smell is equivalent to a 3.6 percent improve-

Table 10. Lake quality versus river quality summary statistics

	N	Mean	Std. err.	Median
Lake vs. River Quality	346*	2.10	0.15	1.00
Smelly Water	348	3.66	0.17	2.14
Cloudy Water	348	2.79	0.16	1.67
Toxic vs. Agricultural	348	−17.00	1.12	−13.00

Lake Water Quality vs. River Water Quality.
(Units are % improvement in river quality necessary to forego 1% improvement in lake quality)
Smelly Water vs. Overall Water Quality Level.
(Units are % improvement in water quality for water that is smelly necessary to forego 1% improvement in water quality that is not smelly)
Cloudy Water vs. Overall Water Quality Level.
(Units are % improvement in water quality for water that is cloudy necessary to forego 1% improvement in water quality that is not cloudy)
Source of Water Pollution.
(Units are % difference in water quality at which respondents are indifferent between agricultural waste or industrial toxic waste as the source of pollution in their region.
A negative number indicates the respondent is willing to incur a decrease in overall water quality to have pollution caused by agricultural waste instead of industrial toxic waste.
A positive number indicates the respondent is willing to incur a decrease in overall water quality to have pollution caused by industrial toxic waste instead of agricultural waste.)
* Two respondents had a zero value for river quality (thus infinite ratio of lake to river). Those two observations were excluded here.

ment in water quality that is removes the smell. Similarly, respondents believe that a one-percent increase in the percentage of water with *Good* quality that already is not cloudy is equivalent to a 2.79 percent improvement in water quality that also removes the cloudiness. The source of the pollution is particularly influential. At the initial water quality levels faced by respondents, individuals in the sample are willing to have a water quality that is 17 percent lower if the pollution is caused by agricultural wastes rather than by industrial toxic wastes.

Although there is no strong theoretical basis for believing that any particular demographic factors exert a dominant influence on these preferences for water quality dimensions, some reasonable systematic effects are observed. Women and non-white, non-black minority respondents value lakes more highly, as do the older and more affluent respondents. Analysis of the desire to remove smell similarly indicates that the female and non-white, non-black minority respondents value cleaning smelly water quality more highly. It is noteworthy that members of environmental organizations are significantly less concerned about smelly water quality than good water quality overall. This result is consistent with their more fundamental focus on the overall quality of the environment rather than its more superficial aesthetic properties. Concern for industrial toxic wastes more likely to be held by black respondents and are more likely to be held by those who have visited lakes or rivers in the last twelve months. The main influences are that the two categories of minority respondents value reductions in the cloudiness of water more highly than improvements in water quality overall, which may indicate a distrust of scientific assessments of the water quality levels, compared with that which they can see.

7.2. Non-use benefit values

The benefits that individuals derive from improvements in water quality stem from the fact that water quality affects how they might use the water, for example, for recreational purposes such as fishing. There may also be a benefit that people derive from improvements in water quality even if they will not use the water. Non-use benefit values have been among the most controversial topics in the literature on contingent valuation and in legal debates, such as litigation surrounding damages for the Exxon Valdez oil spill. One of the fundamental difficulties in ascertaining the non-use benefit value is developing a survey structure that does in fact isolate true non-use, as and provides different values for alternatives that have different probabilities of use.

The policy choice question we use requires individuals to equilibrate a larger benefit for a region they will never or rarely visit against a smaller benefit for their own region. Subsequent questions alter the choice by permitting different probabilities of use. Thus, in one version of the survey, the respondents are told they would be making one out of every ten trips that might be taken to a lake or river using this water in the other region. Table 11 shows a question that half respondents saw specifying that the respondent will use this other region for one out of three visits. Thus, our results permit examination of respondents' valuation of water quality in other regions if the probability of visiting that region is 0, 1/10, or 1/3. To the extent that people overestimate small probabilities, one might expect a jump in values with a small probability of use. Note, however, that these are stated probabilities and that misperceptions may be different for low probability events for which probabilities are not stated.

Table 12 summarizes the valuation results. In the situations in which there is either no chance of visiting the other region or a small probability, such as 10 percent, respondents need a 0.50 or 0.51 percent improvement respectively in the water quality in their own region to be equivalent to a 1.0 percent improvement in the water quality in the other region. However, if the probability rises to a 33 percent chance of using the other region, then improvements in the water quality in the other region rise to 59 percent as valuable as improvements in their home region. Indeed, even in the extreme case in which there is no prospect of use of the water in the other region, respondents are willing to sacrifice substantial improve-

Table 11. Sample probabilistic use valuation task

Now imagine that, instead of having no chance of ever visiting a lake or river in the other region, imagine that for one of every ten trips you might take to a lake or river, you would visit a lake or river in the other region.

We would like to ask you the same types of questions as we did before, with this one difference.

Imagine that you have recently moved to another region of the country, and that the government is considering policies to improve water quality in your region or in another region. Which policy would you prefer?

	1. Policy 1	2. Policy 2	3. No Preference Between Policies
Change in Percent of Water With Good Quality:			
Your Region (9 of 10 Visits to Lakes and Rivers)	+ 10% Improvement	No Change	
Other Region (1 of 10 Visits to Lakes and Rivers)	No Change	+ 25% Improvement	

Now imagine that, instead of having no chance of ever visiting a lake or river in the other region, imagine that for one out of three trips you might take to a lake or river, you would visit a lake or river in the other region.

We would like to ask you the same types of questions as we did before, with this one difference.

Imagine that you have recently moved to another region of the country, and that the government is considering policies to improve water quality in your region or in another region. Which policy would you prefer?

	1. Policy 1	2. Policy 2	3. No Preference Between Policies
Change in Percent of Water With Good Quality:			
Your Region (2 of 3 Visits to Lakes and Rivers)	+ 10% Improvement	No Change	
Other Region (1 of 3 Visits to Lakes and Rivers)	No Change	+ 25% Improvement	

ments in the water quality in their home region to make the environment better elsewhere.

To put these results in perspective, respondents should find an improvement in water quality in another region equivalent to a 1.0 increase in the water quality in their home region of 100% of their visits are to the other region since it effectively is their home region. Unless there is some home regional bias, which there may well be, if valuations are proportional to the number of use visits, the valuation estimates in Table 12 should have been 0, 0.10, and 0.33. The complete non-use case with a zero probability of a visit is most out of line, the value for 10% visits is five times as great as expected, and the value for 33% of visits is one and a half times as great as expected. Thus, the premium commanded by non-use or probabilistic use relative to use value diminishes as the probability of use decreases. There is, however, a considerable non-use and probabilistic use value, the extent of which is potentially consequential for benefit valuation.

7.3. Uses-dimensions of water quality

The final aspect of the study is an exploration of the valuation of the different uses of the water quality—swimming, aquatic uses, and fishing. In this case the task was to establish relative values for each of these uses. For example, do respondents value improvements in the water quality index for fishing more highly than improvements in aquatic water quality measures?

The survey text informed the respondent of what we mean by these different categories. For example, water that is good for fishing is rated *Good* "if fish caught in the lake or river are safe to eat," whereas a *Good* aquatic environment implies that "the lake or river supports many plants, fish, and other aquatic life." The survey then introduces how each of these components of water quality is rated, which is in terms of its percent *Good* in the region. Since the respondents have already dealt with percent *Good* ratings in detail by the time they consider these tradeoffs, they should better be able to handle the additional dimensions of choice.

Table 12. Summary nonuse valuation summary statistics

Home region water quality vs. other region water quality
(units are % improvement in home region water quality necessary to forego 1% improvement in other region water quality)

	N	Mean	Std. Err.	Median
Never visit another region	348	0.50	0.025	0.40
10% of visits are to other	173	0.51	0.034	0.40
33% of visits are to other	121	0.59	0.045	0.45

The structure of the survey considers a sequence of pairwise comparisons in which respondents trade off swimming versus aquatic water quality improvements, swimming versus fishing water quality improvements, and aquatic versus fishing. Because of the nature in which the series of pairwise choices are chained, it is possible to determine whether respondents display the appropriate transitivity with respect to their water quality valuation responses. Overall, only 46 of the 348 respondents—or 13.2 percent—displayed inconsistent responses to the different sets of pairwise comparison valuations. If the respondents had been answering the survey randomly, one would have expected 52 percent of the respondents to be inconsistent for the three uses in some way.

To convey the implications of the relative valuations of water quality, a useful index is the percent of overall water quality improvement valuation that should be allocated to each of the three dimensions. These statistics indicate the relative quantitative importance of the water quality uses. As is shown in Table 13, swimmable water quality accounts for 35.3 percent of the overall benefit value, aquatic water quality is the second most highly valued at 31.8 percent, and fishable water quality has the lowest valuation—28.4 percent of total water quality value.

In terms of the demographic factors affecting these valuations, swimmable water quality is less highly valued by environmental group members and by people who have visited lakes and rivers in the last twelve months. However, large households tend to value swimming more highly, as one would expect for families with children. The aquatic and fishable water quality valuations were not strongly influenced by any of the demographic characteristics.

8. Conclusion

It is instructive to combine the implications of the previous results to value a change in water quality. Table 14 describes the effects of specific water quality measures on the overall benefit value for water quality improvements. The table uses as an example a 15% improvement in water quality, but the table could be replicated for any desired improvement level.

Table 13. Summary water quality use valuation results

Portion of water quality improvement that should improve:				
Water quality use	N	Mean	Std. err.	Median
Swimmable water quality	348	35.3%	0.011	33.3%
Quality of aquatic environment	348	31.8%	0.011	26.7%
Fishable water quality	348	28.4%	0.010	23.8%

To understand the structure of the program and its implications, it is useful to explain the calculations used to generate Table 14. Answers to the set of tasks dealing with cost of living traded off with water quality improvements indicated a mean value for a 1% improvement in water quality of $22.40. That value multiplied by the total amount of improvement in the first row yields the total value of the improvement, shown in the second row, which is $336.

Data from the set of tasks that traded off lake improvements with river improvements demonstrated that to lakes were 2.1 times more valuable to improve than rivers. The total value of the improvement is divided between lakes and rivers at that rate to yield the next two rows in the table, which are $227 for lakes and $108 for rivers.

The survey then asked respondents to trade off improvements in their home region versus improvements in another region that they would not visit. Answers to those tasks showed that improvements outside of a respondent's region were worth half what improvements in the home region would be. That result is multiplied by the overall improvement value, and the result is reflected in the fifth row.

Other task blocks focused on people's tradeoffs between individual use of lakes and rivers, specifically swimming, fishing, and a healthy aquatic environment. Data from these tasks showed that 35.3% of improvements should be designated to ensure lakes are safe for swimming, 28.4% to ensure lakes have fish that are safe to eat, and 31.8% to ensure a healthy environment for fish, birds, and other aquatic life. That apportionment between uses is multiplied by the overall use value, and the results are shown in rows six through eight.

The tradeoffs between different pollution sources revealed that respondents were indifferent between a 1.44% improvement in water quality in a region polluted by toxic waste pollution and a 1% improvement in water quality in a region polluted by agricultural wastes. The 1.44 ratio is applied to the overall improvement value. Doing so yields the result for the value if the improvement reduces toxic waste pollution, which is shown in the last row.

One can combine these calculations if the value of multiple features is desired. For instance, the value for only lakes of a 15% improvement that reduces toxic

Table 14. Overall benefit values for water quality improvements

	Value per household
1. Percent Improvement in Water Quality	15%
2. Value of Improvement	$336.00
3. Value if Improvement only to Lakes	$227.47
4. Value if Improvement only to Rivers	$108.53
5. Value to Non-Residents	$168.00
6. Value if Improvement only for Swimming	$113.23
7. Value if Improvement only to Aquatic Environment	$102.14
8. Value if Improvement only to Fishing	$91.06
9. Value if Improvement reduces Toxic Waste Pollution	$485.23

waste pollution is calculated by multiplying the 1% value ($22.40) by the amount of the reduction (15%). That result is multiplied by the portion of improvements that should be applied to lakes (67.7%). Finally, that value is multiplied by the relative importance attached to avoiding toxic waste pollution (1.44). Since all modifications are multiplicative, the order in which the features are calculated is not important, and further features can be calculated on top of any finished calculation.

This survey yielded diverse assessments of different components of water quality, some of which are summarized in Table 15. How do people feel about clean lakes

Table 15. Summary of findings from water quality survey

Respondents place the following values on water quality improvements.
$22.40 increase in cost of living per 1% improvement in water quality (cost of living vs. water quality in new region question).
$20.50 increase in cost of living per 1% investment in water quality (policy to improve water quality which leads to higher cost of living question).
Respondents do not value lake and river improvements equally.
River improvements are 2.1 times as valuable as lake improvements.
Respondents closely associate aesthetic properties with water quality.
Improving the quality of water that remains smelly is worth $5.60 per 1% improvement (policy choice format).
Improving the quality of water that remains cloudy is worth $7.35 per 1% improvement (policy choice format).
The source of pollution is important to respondents.
Respondents are willing to forego a 17% improvement in water quality to avoid a region polluted by industrial toxic waste (new region format).
Respondents showed a substantial non-use value for water quality improvements.
$10.25 increase in cost of living per 1% improvement in water quality for water in a region where the respondent will never visit a lake or river (policy choice format).
$10.46 increase in cost of living per 1% improvement in water quality for water in a region where the respondent will visit for 1 of 10 trips (policy choice format).
$12.10 increase in cost of living per 1% improvement in water quality for water in a region where the respondent will visit for 1 of 3 trips (policy choice format).
Individual dimensions of water quality have different levels of importance to respondents.
The share of water quality improvement value is 35.3% to ensure water is swimmable, 31.8% to ensure water has a healthy aquatic environment, and 28.4% to ensure water has fish that are safe to eat.

versus rivers, fishing versus swimming, and clean water versus cost of living? The iterative choice approach broke this complex valuation task into a series of tradeoffs so that the respondents could manage the survey demands.

Applying the survey results to policy contexts is facilitated by various linearity assumptions, but can accommodate non-linearities. Tests for salient linearities failed to suggest their influence except for probabilistic use. A subsequent national study will examine these and other issues in greater detail. People are willing to pay disproportionately high values for water quality improvements with low or zero probabilities of use. Whether such non-use values reflect cognitive limitations given the survey task or valid underlying preferences remains an open question.

The interactive choice survey instrument included numerous tests of rationality, consistency, and transitivity. Respondents performed quite well even with the imposition of demanding rationality requirements. The strong and consistent performance of respondents provides additional support for the benefits of constructing valuations of complex goods by exploring their multi-attribute structure.

Appendix

Table A. Full sample regression estimates for cost of living value for water quality

Dependent variable: Cost of living vs. water quality level.
(Units are $ per 1% improvement in water quality. Higher value means willing to pay more for water quality improvement.)

Variable	Region choice parameter estimate (standard error)
Age	0.25 (0.20)
Age squared	−0.019* (0.010)
Black	−4.23 (6.01)
Race-other	−12.84** (5.54)
Female	−0.44 (4.13)
Household size	1.50 (1.51)
Employment: full time	1.60 (4.47)
Member of an environmental organization	−2.63 (6.89)
Household family income × 10,000	−0.26 (0.86)

Table A. (Continued)

Dependent variable: Cost of living vs. water quality level.
(Units are $ per 1% improvement in water quality. Higher value means willing to pay more for water quality improvement.)

Variable	Region choice parameter estimate (standard error)
Income data missing	2.08 (9.71)
Visited lake or river in last 12 months	−1.33 (6.30)
Time to complete survey	0.040 (0.21)
Water quality lower bound %	−0.076 (0.11)
Survey location: Research Triangle Park	−19.01*** (6.08)
Survey location: Denver	−4.59 (5.81)
Survey location: Charlotte	−2.78 (6.88)
Survey location: Cary	−9.46 (7.22)
Intercept	36.51*** (12.41)
N	409
F value	1.512
R-square	0.0617

* Significant at .10 level, ** significant at .05 level, *** significant at .01 level.

Notes

1. See Berkman and Viscusi (1973) for a review and critique of these practices.
2. See, for example, the analysis by Mitchell and Carson (1989, 1993) and by Smith and Desvousges (1986).
3. Fischhoff and Furby (1988), Bishop and Heberlein (1990), and Schkade and Payne (1993) provide a superb discussion of the cognitive issues involving contingent valuation.
4. U.S. EPA (1994).
5. U.S. EPA (1994).
6. Keeney and Raiffa (1993) provide a formal basis for analyzing components of larger valuation tasks.
7. See Magat, Viscusi, and Huber (1988).
8. Much of this work appears in Viscusi and Magat (1987), Magat and Viscusi (1992), and Viscusi and Magat (1987).
9. While we are concerned with respondent's motivation to respond truthfully in the context of a hypothetical question, we are heartened by Smith and Mansfield (1998) who show that the percent of respondents willing to accept a future task is unaffected by whether the offer is real or hypothetical.
10. The region chosen in the first question is made less desirable and presented as a new choice replacing the chosen region. The declined alternative remains constant. In further iterations, the

only region that changes is the region that changed after the first question; it either improves or worsens depending on whether that region was chosen. Unless the subject expresses indifference, each subject is presented with at least three questions in each iteration tree, and more if the subject continues to choose the less and less desirable region.

11. Helping respondents to think about the attributes they are trading off is similar to the recommendation by Cameron and Englin (1997) to control for experience in referendum questions. They find that people with less fishing experience produce values with greater variation in valuation of trout stocking programs than those with experience. In the current study our efforts to have people think about their experiences with lakes and rivers is designed to increase the salience of their experience.
12. For antecedents in the literature on this difficult issue see Bishop and Welsh (1992).

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