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Abstract

We estimate the economic benefits of water quality improvements for recreational users of lakes, rivers and coastlines in six northeastern states. The benefits are measured using separate travel cost random utility maximization models for fishing, boating, swimming, and viewing. All models are for day-trip recreation. The models are estimated using data from the 1994 National Survey of Recreation and the Environment and from water quality modeling simulations of the National Water Pollution Control Assessment Model. We consider several scenarios for water quality improvements and estimate annual benefits in the region due the Clean Water Act to be near $100 million per year.

Key Words: Water quality, recreation, economic value

1. Introduction

The purpose of this paper is to measure the economic benefits to recreation from improved water quality in Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. All lakes, rivers, and coasts (oceans and bays) in the region are included in the analysis. The benefits are measured using separate random utility maximization (RUM) models for fishing, boating, swimming, and viewing. All models are for day-trip recreation which accounts for approximately 77% of all water based recreation trips in the region. The models are estimated using data from the 1994 National Survey of Recreation and the Environment (NSRE94) and from water quality modeling simulations based on the National Water Pollution Control Assessment Model, Version 1.1 (NWPCAM1.1) (RTI, 2000).

We consider three welfare scenarios in our analysis. The first two are hypothetical. They assume that all water bodies in the region attain some minimum level of quality. We consider a moderate and then a high level of quality defined by levels of biological oxygen demand, dissolved oxygen, total suspended solids, and fecal coliforms. The third scenario considers a simulation of the actual improvement realized under the Clean Water Act through 1994.

Our approach follows a long line of research on measuring the economic benefits of water quality improvements. Various approaches have been used including contingent valuation, travel cost, and hedonic price methods. See Freeman (2003) or Champ, Boyle, and Brown (2003) for more on these methods. Some of the earlier efforts to measure water quality benefits using the travel cost approach, which we use here, include Vaughn and Russell (1982), Smith and Desvousges (1985, 1986), and Sutherland (1982). More recently, and using the travel cost random utility model are Bockstael, Haneman and Strand (1986), Parsons and Kealy (1992), and von Haefen (2003). Perhaps the most widely cited work is Carson and Mitchell's (1993) contingent valuation study which is one the few that estimate benefits nationwide. There are a handful of hedonic price studies and these are all quite localized. See for example Boyle et. al. (1999). For a good assessment of the efforts to estimate the benefits of water quality improvements over the last 25 years see Cropper (2000).

Our paper is organized into 4 sections. Section 2 lays out the RUM models. Section 3 discusses our application and the data. Section 4 presents the parameter estimates and welfare results.

2. The Model

We estimate separate models for fishing, boating, swimming, and viewing. Each is estimated in two stages: participation and site choice. The participation model considers the total number of trips a person makes over the season. Site choice considers the site chosen for the last trip taken. A site is a lake, segment of a river, or segment of a coastline. The two models are linked using an approach suggested by Bockstael, Hanemann, and Kling (1987) and latter adapted by Hausman, Leonard, and McFadden (1995).

It is easiest to describe the model beginning with site choice. An individual is assumed to visit one of S possible recreation sites on a given day. Let $i = 1,...,S$ denote a site. Each site i gives a person utility U_i. This *site utility* depends on the cost of reaching the site and the characteristics of the site

(1) $$U_i = tc_i \beta_{tc} + x_i \beta_x + \varepsilon_i$$

where tc_i is the trip cost of reaching site i, x_i is a vector of characteristics of site i, and ε_i is a random term. The βs are parameters to be estimated. The vector x_i includes characteristics of the sites that matter to individuals when making site choice – water quality, access and so forth.

A person is assumed to visit the site that gives the highest utility. That utility is called the person's *trip utility* and is defined as

(2) $$V = Max\{U_1, U_2, ..., U_S\}.$$

Substituting equation (1) into (2) gives

$$
(3) \qquad \begin{aligned} V = Max\{ & tc_1\beta_{tc} + x_1\beta_x + \varepsilon_1, \\ & tc_2\beta_{tc} + x_2\beta_x + \varepsilon_2, \\ & \ldots., \\ & tc_S\beta_{tc} + x_S\beta_x + \varepsilon_S\} \end{aligned}
$$

Now consider a change a water quality at one or more sites. Assume that x_i represents site characteristics at site i without an improvement in water quality and assume that x_i^* represents site characteristics at site i with an improvement. Only the element pertaining to water quality in x_i has changed between the two states of the world. For some sites there may be no change. Without the change in water quality a person's trip utility is V shown in equation (3). With the change in water quality and assuming the change only takes place at sites 1 and 2, trip utility is

$$
(4) \qquad \begin{aligned} V^* = Max\{ & tc_1\beta_{tc} + x_1^*\beta_x + \varepsilon_1, \\ & tc_2\beta_{tc} + x_2^*\beta_x + \varepsilon_2, \\ & tc_3\beta_{tc} + x_3\beta_x + \varepsilon_3 \;, \;. \\ & \ldots., \\ & tc_S\beta_{tc} + x_S\beta_x + \varepsilon_S\} \end{aligned}
$$

The change in utility due the water quality improvement is

$$
(5) \qquad \Delta w = V^* - V \;.
$$

If a person visits site k without the improvement in water quality, but chooses to visit site 1 now that it is cleaner, trip utility increases by $\Delta w = U_1^* - U_k$. If the person visited site 1 without the water improvement and continues to visit site 1 with the improvement, trip utility increases by $\Delta w = U_1^* - U_1$. The person makes the same trip but enjoys cleaner water. If the person visited site k without the improvement and continues to visit site k after the improvement there is no change in welfare. Perhaps sites 1 and 2 are located far from the person's home or have other features the person dislikes. Finally, if there is a relative change in water quality at sites 1 and 2, the person may shift from one site to the other and have a change in welfare. For example, a shift from site 1 to 2 would give an increase of $U_2^* - U_1$. All of these pathways to utility change are captured in equation (5) in Δw.

The change in trip utility is converted to money terms by dividing Δw by the negative of the coefficient on trip cost. In the RUM model $-\beta_{tc}$ is a measure of the marginal utility of income. It tells us how much an individual's site utility would increase if trip cost were to decline for that trip. The increase in welfare due to an improvement in water quality at sites 1 and 2 is

$$(6) \qquad cs = \Delta w / -\beta_{tc}.$$

In application, we use an expected value for Δw because its actual value is random and unknown to researchers. To see this substitute equations (3) and (4) into equation (5). Assume the parameters β are known or estimated. Since each site utility has a random component ε_i, Δw and cs must also be random. For this reason, the statistical expected values of V and V^* are used in application. The expected increase in welfare due to a water quality improvement is

$$(7) \qquad cs = \{E(V^*) - E(V)\} / -\beta_{tc}$$

where *E* denotes an expected value over the site utilities and will depend on the distribution of the errors terms in each site utility. Equation (7) gives a *per trip value* for the change in water quality.

The site choice model is estimated using a logit model. A person's probability of visiting site *k* on a given choice occasion in a logit model is

$$(8) \quad pr(k) = \frac{\exp(tc_k \beta_{tc} + x_k \beta_x)}{\sum_{i=1}^{S} \exp(tc_i \beta_{tc} + x_i \beta_x)}.$$

This form applies for any site and implies the following log-likelihood function

$$(9)\qquad \Lambda(\beta) = \prod_{j=1}^{N}\prod_{i}^{S} d_i^j \ln pr(i)$$

where $d_i^j = 1$ if individual *j* visited site *i* and $d_i^j = 0$ if not. The *pr(i)* in equation (9) takes the form shown in equation (8). This function gives the likelihood of observing the patterns of visits actually observed in the datat. The parameters β are chosen to maximize $\Lambda(\beta)$. Given the large number of sites in the choice set, we use a random draw of sites following McFadden (1978) to estimate β. We describe this in detail in the next section. The estimated parameters, in turn, may be used to estimate per trip welfare shown in equation (7). In the simple logit model expected trip utility takes the form

$$(10)\quad E(V) = \ln \sum_{i=1}^{S} \exp(tc_i\beta_{tc} + x_i\beta_x)\ .$$

This is sometimes called the 'inclusive value'. Although the parameters are estimated using a subset of full choice set, the inclusive value in equation (10) is calculated using the full choice set. The per trip value of a water quality improvement is

$$(11)\quad cs = \{\ln \sum_{i=1}^{S} \exp(tc_i\beta_{tc} + x_i^*\beta_x) - \ln \sum_{i=1}^{S} \exp(tc_i\beta_{tc} + x_i\beta_x)\} / -\beta_{tc}$$

where x_i^* is with the improvement and x_i is without.

Our participation decision models estimate the number of trips an individual takes during a year. The participation function takes the Poisson form

$$(12)\qquad \begin{aligned} pr(R_j = r_j) &= \frac{e^{-\lambda_j}\lambda_j^{r_j}}{y_j\,!} \\ \ln\lambda_{\mathrm{j}} &= \alpha_u(\hat{I}_j) + \alpha_z z_j \end{aligned}$$

where r_j is the number of trips taken by person *j* during the season. $\hat{I}_j = E(\hat{V}_j)/-\hat{\beta}_{tc}$ is a monetized utility index or consumer surplus for a recreation trip predicted using the parameter estimates from the site choice model. The vector z_j is a set of individual characteristics for person *j* believed to influence trip taking, like family size and age.

Equation (12) is Hausman, Leonard, and McFadden's (1995) formulation of the participation model. It is a simple adaptation of Bockstael, Hanemann, and Kling's (1987) model. The adaptation is the monetization of the expected utility. Since this is a linear transformation of a scalar, the models are the same. The transformation merely rescales the parameter estimate on the index. Neither model is strictly utility theoretic.

Using an estimated participation model in a Poisson form, Hausman, Leonard, and McFadden (1995) show that the annual change in welfare due an improvement in water quality like that discussed above is

$$(13) \qquad CS = (\hat{r}_j^* - \hat{r}_j)/\hat{\alpha}_u$$

where $\hat{r}_j^*$ and $\hat{r}_j$ are predicted values of trips for person *j* from the participation model with and without the change in water quality, and $\hat{\alpha}_u$ is the coefficient on $\hat{I}_j = E(\hat{V}_j)/-\hat{\beta}_{tc}$ in the same model. See Parsons, Jakus, and Tomasi (1999) for more detail on the participation function.

3. Application and Data

Our application covers six northeastern states: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island. All rivers, lakes, and coasts in the region are included in the analysis. The data are from two sources. The trip and respondent characteristic data are from the 1994 National Survey of Recreation and the Environment (NSRE94). The site characteristic data were developed using NWPCAM1.1, a national water quality simulation model that is built around the RF1 river/stream network database (EPA's Reach File 1).

In the NSRE94 individuals throughout the United States were contacted at random by phone and asked to report the total number of day and overnight trips taken separately for viewing, boating, fishing, and swimming at domestic water-based recreation sites over the past twelve months. See Appendix A for the survey questions defining recreation uses. Each person was also asked to report the site visited on the last trip for each type of recreation and to report the location of his or her hometown. Demographic data were also gathered for each respondent. This included income, age, job status, family size, and other characteristics. Our sample includes all individuals surveyed from the six northeastern states. The sample size is 632. Table 1 presents descriptive statistics over the sample population.

Our analysis is for day trips only. The participation rates and average number of trips for each type of recreation are

Recreation Use	Percent of the Sample Taking at Least One Day Trip to a Water-based Recreation Site Over the Past 12 Months (n = 632)	Average Number of Day Trips Taken by People Taking at Least One Trip During the Year
Viewing	25%	8.80
Boating	14	7.08
Fishing	12	10.06
Swimming	24	10.05

These rates are from the general population and exclude overnight trips. About 77% of all trips were day-trips. Our analysis ignores day trips taken by individuals outside the region but these account for less than 3% of the "last trips" in the NSRE94 to our six states. The average distances traveled on a day trip and the average distance to all sites in the choice set in our sample are

Recreation Use	Average Distance Traveled On Day Trips (miles)	Average Distance to all Sites in the Choice Set (miles)
Viewing	72	104
Boating	61	104
Fishing	50	104
Swimming	54	104

The maximum distance to a site in the choice set is 200 miles. Again, these are day trips only and ignore trips taken by persons outside the region.

The site characteristic data were constructed using NWPCAM 1.1 and the EPA's RF1 database. There are 20,925 rivers, 2,975 lakes, and 1,231 coasts in the data set. A site on a river is defined as a stretch of river from one confluence to another without a major tributary, lake, or population center intervening. If a major tributary, lake, or population center is passed, a new site is defined. A coastal site is defined as the coastal line along a bay or ocean between the mouth of a major river or beginning of a new municipality and the mouth of another major river or beginning of a new municipality. The lake data set is all major lakes and ponds in the region. A single lake, no matter how large, is never divided into more than one site.

Site-specific water quality data were estimated using NWPCAM 1.1 (RTI, 2000). In this model, place-specific pollutant loadings from both point and nonpoint sources across the nation are linked and routed through the RF1 surface water network. The model incorporates a hydrodynamic and water quality modeling algorithm that allows it to estimate instream pollutant concentration throughout the network for dissolved oxygen (DO), biological oxygen demand (BOD), total suspended solids (TSS) and fecal coliform bacteria (FCB).

In our application we estimate separate models for each recreation type. Because of the large number of sites in each person's choice set, we estimate the model using a random draw of sites. Each person's choice set includes his or her actually chosen site plus 35 other randomly drawn sites. Each choice set for estimation is composed of 12 rivers, 12 lakes, and 12 coasts. See McFadden (1978) and Parsons and Kealy (1992) for more on estimation with randomly drawn choice sets.

Each model considers four basic attributes for site utility in equation (1): trip cost, resource type, choice set size, and water quality. Trip cost is the sum of travel and time cost

$$tc = (.35 \cdot rtdist) + (income / 2040) \cdot (rtdist / 40) \tag{14}$$

where *rtdist* is round trip distance and *income* is annual income. Round trip dist is the linear distance between each site and a person's hometown. Travel cost is assumed to be 35 cents per mile. The opportunity cost of an hour is approximated using annual income divided by 2040 which is the typical number of hours worked in a year. The average travel speed is assumed to be 40 miles per hour.

Resource type is a set of dummy variables distinguishing river, lake and coastal sites. Choice set size is a control variable to account for the fact that even though each person has the same number of alternatives in the choice set in estimation (36 sites), in reality some will have far more than others. Persons with larger choice sets, all else constant, are more likely to take a trip.

Water quality is defined as *low*, *medium*, or *high*. This is an index based on the levels of biological oxygen demand, total suspended solids, dissolved oxygen, and fecal coliform. The cut offs for *high* and *medium* are

	Biological Oxygen Demand (mg/L)	Total Suspended Solids (mg/L)	Dissolved Oxygen (% saturation)	Fecal Coliforms (MPN/100mL)
High Water Quality	< 1.5	< 10	> .83	< 200
Medium Water Quality	< 4	< 100	> .45	< 2,000

All four object measures must be below (or above in the case of dissolved oxygen) the cutoffs shown before the site is classified as having that quality level. If any single characteristic falls short of its cut off for *medium* quality, the site is classified as *low* quality. Sites with *low* water quality have no plant or animal life and often have visible signs of pollution (trash, oil). Site with *medium* water quality have some game fishing and usually few visible signs of pollution. Sites with *high* water quality are suitable for extensive human contact, have the highest natural aesthetic, and support high quality sport fisheries.

The water quality data are based on NPWCAM1.1 pollutant loading data and water quality modeling results (for mid-1990's conditions). Coastal water quality is based on the predicted water quality at the mouths of nearby rivers. In some instances, watershed averages are used when data at a site level were missing from the simulation results. The baseline distribution of water quality across sites is

	Percent of all Rivers	Percent of all Lakes	Percent of all Coasts
High Quality	49.9%	28.5%	30.8%
Medium Quality	36.4	59.9	37.7
Low Quality	13.7	11.6	31.5

Site utility then takes the following form in our application

$$(15) \quad U_i^m = \beta_{tc}^m tc_i + \beta_r^m riv_i + \beta_c^m cst_i + \beta_{hi}^m hwq_i + \beta_{mid}^m mwq_i + \ln(size) + \varepsilon_i^m$$

where *i* denotes a site and *m* denotes a recreation use (*m* = viewing, boating, fishing, or swimming). The choice set size variable is estimated with its coefficient set equal to one since it is entered as a weighting factor only. This gives us 20 parameters to estimate in the site choice model -- 5 parameters in each of the four models. More complex specifications which included site size, separate measures for each objective water quality measure in our index and an intermediate step in water quality between our *high* and *medium* gave rise to models that consistently failed to converge and in the isolated cases where convergence was achieved gave results that ran strongly against our priors.

Four participation models, one for each recreation use, were also estimated separately in Poisson form and included the attributes shown in Table 1. The expected utility index ($\hat{I}_j / -\beta_{tc}$) in these regressions was constructed from the relevant site choice stage. All participants and nonparticipants were included in each regression. The results of the site choice and participation regressions are reported in the next section.

We consider three welfare scenarios using our model. The first two assume water quality at all sites attains some minimum level. The first assumes water quality attains at least a *medium* level as defined above at all sites in the region. Under this scenario 13.7% of all rivers, 11.6% of all lakes, and 31.5% of all coasts realize water quality improvements. The second assumes water quality attains a *high* level of quality at all sites. This is a significant improvement in water quality in the region affecting 50.1% of all rivers, 71.5% of all lakes, and 69.2% of all coasts over the six northeastern states.

The last scenario considers the water quality we are likely to have realized in 1994 in the absence of the Clean Water Act and assuming no state, local, or judicial controls were otherwise established. In this scenario we assume water quality improves from a hypothetical 'no-CWA' state of the world to current conditions. This is approximately the recreational benefits realized due to the existence of the Clean Water Act in 1994. The 'no-CWA' conditions were estimated using the same simulation model used to estimate current conditions. Pollutant loadings were adjusted in that model to reflect loads likely to have been attained in the absence of the Clean Water Act. To get an idea of how the CWA simulation is changing water quality in the model, consider the following table. The table reports the value of the ratio

$$\frac{\text{Number of sites at quality level } wq \text{ with the improvement}}{\text{Number of sites at quality level } wq \text{ without the improvement}}$$

where *wq* = *low, medium or high*. The table shows the degree of shift from lower to higher quality sites.

	River Ratio	Lake Ratio	Coast Ratio
High	1.25	1.44	1.10
Medium	1.01	.94	1.17
Low	.56	.07	.79

The next section presents the parameter estimates and welfare results for each of these scenarios.

4. Parameter Estimates and Welfare Results

The parameter estimates for the site choice model are shown in Table 2. For the most part, the signs are as expected. The coefficient on trip cost is negative and significant in all four models. Recall that this variable is used as the marginal utility of income and is important in converting measures of utility change into dollars. The coefficients on the resource type dummies suggest that coasts, all else constant, are the most important resource for recreation use. Lake is the excluded category so the resource type coefficients are interpreted relative to lakes. The parameter estimate on coast is highest for viewing and lowest for fishing. The coefficient on river suggests that river sites, all else constant, are the lowest valued among the three resource types except for boating. There are a number of large rivers in the region where boating is quite popular. This, no doubt, accounts for the result on boating. The negative river coefficient for swimming is largest capturing the infrequent use of rivers in this activity.

The coefficient on *middle WQ* is positive and significant in two of the four models – fishing and swimming. This implies that moving from *low* to *middle* level water quality imparts benefits mostly to fishing and swimming uses. Between these two recreation types the utility is increased most for fishing. Boating also has a positive but insignificant coefficient on *middle WQ*. Viewing has a negative and insignificant coefficient. Modest improvements in water quality appear to yield little or no increase in utility for these recreation uses.

The coefficient on *high WQ* is positive and significant in all four models as one would expect. The coefficients also show that *high* water quality gives higher utility than *middle* water quality. Again, going from *low* to *high* water quality, the utility increase is greatest for fishing and swimming. However, the coefficients on viewing and boating imply utility increases for these recreation uses as well. It is interesting to note that for fishing most of the increase in utility comes from moving from *low* to *middle* water quality. For viewing and boating almost all of the utility increase comes from moving from *middle* to *high* water quality.

The results of the Poisson models are shown in Table 3. The coefficient on the monetized utility index (expected utility or inclusive value from the site choice stage divided by the negative of the coefficient on trip cost) is positive in all four regressions. This coefficient gives us some idea of how responsive participation in each recreation use will be to improvements in water quality. Viewing and fishing participation are the most responsive to improvements. Swimming is somewhat less responsive and boating shows little if any responsiveness.

Income has a positive effect on viewing, boating, and fishing participation and a negative affect on swimming. Urbanities have lower participation rates in all uses, all else constant, but the effect is insignificant in the viewing model. As one ages the probability of participating in all four recreation uses decreases. Retired folks have a higher probability of participating in boating and fishing and a lower probability in viewing and swimming. Men have higher probabilities of participating in boating and fishing, and women in viewing and swimming. Education level increases ones probability of participating in all uses except for fishing where it has a negative and significant affect on participation. Unemployment also increases the probability for all uses except fishing but the coefficient is insignificant. Being a student increases the likelihood that you will participate in viewing and swimming. Being a homemaker increases your likelihood for swimming only. Larger families have higher probabilities for viewing and boating. Having more leisure hours increases one’s probability of participating in all uses but fishing. And finally, owning a boating dramatically increases one’s probability of boating and fishing and to a lesser extent viewing. We excluded boat ownership from the swimming model.

Now we turn to the benefit estimates for water quality improvements. The annual average per person benefits over all resource types for our three scenarios are as follows

	Viewing	Boating	Fishing	Swimming
All sites improve to *middle WQ*	---	$.04	$3.14	$5.44
All sites improve to *high WQ*	$31.45	$8.25	$8.26	$70.47
Improvements due to Clean Water Act (CWA)	$.47	$.62	$2.40	$5.59

These averages include participants and nonparticipants and are computed using equation (13).[1] The first two scenarios use current conditions as the baseline. The CWA scenario uses pre-CWA water quality as the baseline. Table 5 shows the same results for each scenario by recreation use and separately for improvements to rivers only, lakes only, and coasts only.

For modest improvements in water quality (to *middle WQ*) almost all of the benefits go to fishing and swimming. The annual fishing benefit is about $3 per person. The annual swimming benefit is about $5. Again, this includes participants and nonparticipants. Table 5 shows a negative benefit for viewing due to the negative coefficient on *middle WQ* in the view model. In the table above, we have simply recorded no benefit for viewing. Table 5 also shows that most of the swimming benefit is coming from cleaning up the coast, and most of the fishing benefit is coming from the clean up of coasts and lakes.

For significant improvements in water quality (to *high WQ*), all four recreation uses realize benefits and these benefits are must larger. Swimming and viewing are the highest at $70 and $31 per person. Boating and fishing are about $8 per person. For fishing 38% of this benefit is realized in moving from *low* to *middle* quality, and 62% is realized in moving from *middle* to *high* quality. For swimming the same incremental benefits are 8% and 92%. And, as noted earlier for viewing and boating, nearly all of the benefit is realized in the second increment. Most of the benefits are coming through a clean up of the coastlines.

[1] Per trip values using equation (11) are also provided in Table 4. Since annual values are typically of more interest for policy we focus our discuss on these.

For improvements due the Clean Water Act, all recreation uses realize benefits. Swimming and fishing are the largest at $6 and $2 per person. Viewing and boating are positive but less than $1 per person. In this case the source of most of the benefits are the rivers and lakes where the CWA has had it largest effect.

Table 6 shows aggregate benefits for each scenario. These are calculated by multiplying the mean per person benefit for each state by its population in 1994 over the age of 16. All numbers are in 1994 dollars. Summarizing Table 6, we have

	All sites Attain *medium WQ*	All sites attain *high WQ*	Due to the Clean Water Act
Total Benefit in 1994 Dollars	$77 million	$1.295 billion	$99 million
Distribution of Total Benefits by recreation use:			
Viewing	0%	26%	5%
Boating	0%	7%	7%
Fishing	36%	7%	26%
Swimming	63%	60%	61%

The aggregate benefits to the region range from $ 77 million for improvements to *medium* water quality to $1.3 billion for improvements to *high* water quality. Again the benefits go mostly to swimming and fishing for a *medium* clean-up. The benefits go mostly to swimming and viewing for improvements to *high* water quality. The annual aggregate benefits due to the Clean Water Act in 1994 dollars are $99 million. These estimates assume the controls set by the Act are not in place and are not replaced by any state, local or judicial controls. This leads to some overstatement of the benefits attributed to the CWA. At the same time, the exclusion of overnight trips, non-recreation use, and nonuse values leads to some understatement of the benefits across all scenarios.

Some Comments for Future Research

Generally, we found the quality of the data from the National Survey quite good. The definition of sites, the measurement of the characteristics of the sites, and matching visited sites with actual sites however was quite time consuming and led to some unwanted compromises. Data limitations also prevented us from having greater detail on site characteristics. It would be beneficial to have data on site access, presence of amenities, parks, size, and so on. When large regions are studied, it is difficult to obtain consistent measures of site characteristics across the sites. This was even true for water quality. For many of the lakes aggregate (watershed level) measures of quality were used as a proxy and efforts to incorporate finer measures of quality failed. We believe this was due in large part to the lack of precision of the water quality measure across sites. We were able to characterize water quality "in a broad sense" – overall low, medium, or high – but not in great detail with consistency. Coastal sites relied on water quality measures at nearby river mouths. We would like to have had better measurement here. Future studies should concentrate on consistent, complete, and accurate measures of characteristics that matter to people -- water quality as well as other attributes.

At the same time, we consistently found a strong correlation between the sites visited and the quality of water at those sites. This gave us a plausible set of values and is encouraging for future applications of the 2nd National Survey of Recreation and the Environment which analysts are now beginning to consider.

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Table 1: Descriptive Statistics

	Description	Sample Mean
Income	Annual household income	$56,574
Urban	Urban dummy (=1 if live in an urban area)	.18
Age	Age	43
Retired	Retirement dummy (=1 if retired)	.18
Gender	Gender (=1 if male)	.41
Education	Level of education (scale 1 (no high school) – 5 (completed college))	4.38
Unemployed	Unemployment dummy (=1 if unemployed)	.13
Student	Student dummy (=1 if full time student)	.10
Homemaker	Homemaker dummy (=1 if homemaker)	.22
Family Size	Number of people in family at home	2.9
Leisure Hours	Leisure hours per week	21.8

Table 2: Random Utility Model of Site Choice (t-statistics in parenthesis)

	Viewing	Boating	Fishing	Swimming
Price	-.042	-.062	-.055	-.030
	(33.1)	(24.8)	(21.1)	(36.0)
River	-.090	.716	-.689	-5.489
	(5.6)	(3.9)	(4.4)	(7.7)
Coast	4.59	3.54	1.865	3.69
	(37.7)	(24.1)	(11.2)	(44.2)
High WQ	.421	.496	.912	.881
	(2.56)	(1.73)	(3.16)	(6.7)
Middle WQ	-.136	.016	.898	.325
	(1.4)	(0.1)	(4.94)	(3.6)
Log-Likelihood	-.335	-5.13	-4.91	-13.44

Table 3: Poisson Participation Model (uncorrected t-statistics in parenthesis)

	Viewing	Boating	Fishing	Swimming
$E(\hat{V})/\hat{\alpha}_u$	.0064 (13.5)	.0012 (1.2)	.0051 (5.8)	.0017 (5.0)
Income	.0098 (1.5)	.0031 (3.7)	.0077 (10.9)	-.0024 (3.9)
Urban	-.013 (0.2)	-.802 (6.3)	-.897 (8.3)	-.139 (2.3)
Age	-.013 (6.2)	-.023 (7.5)	-.021 (8.6)	-.015 (7.2)
Retired	-.502 (3.7)	1.135 (5.1)	.503 (3.6)	-.805 (6.6)
Gender	-.500 (9.9)	.190 (2.6)	1.266 (15.6)	-.232 (4.7)
Education	.131 (9.0)	.041 (1.8)	-.167 (9.0)	.225 (16.4)
Unemployed	-.640 (5.0)	-.690 (3.4)	.060 (0.5)	-.289 (2.6)
Student	.656 (10.4)	-.391 (3.2)	-.505 (4.6)	.285 (4.4)
Homemaker	-.610 (8.0)	-1.08 (6.1)	.031 (0.2)	.324 (5.6)
Family Size	-.041 (2.7)	-.119 (4.3)	.064 (3.5)	.124 (11.2)
Leisure Hours	.0081 (8.4)	.004 (3.4)	-.004 (2.3)	.008 (8.9)
Boat Own	.5422 (4.4)	2.78 (34.4)	1.78 (26.2)	-
Log-Like	-3708	-1176	-2228	-3878

Table 4: Mean Per Trip Benefits Per Person (1994 dollars)

	Viewing	Boating	Fishing	Swimming
Sites Attain middle WQ:				
All Sites	$-.48	$.03	$1.67	$1.48
Rivers Only	-.01	.003	.13	.0006
Lakes Only	-.05	.007	.87	.31
Coasts Only	-.41	.02	.70	1.19
Sites Attain high WQ:				
All Sites	9.75	5.99	3.87	19.4
Rivers Only	.82	1.82	.76	.03
Lakes Only	2.17	1.63	1.10	5.96
Coasts Only	7.41	3.07	2.19	15.3
Due to Clean Water Act:				
All Sites	.22	.49	1.45	1.69
Rivers Only	.10	.28	.45	.01
Lakes Only	.13	.12	.58	.72
Coasts Only	-.03	.07	.38	0.93

Table 5: Mean ***Annual*** *Benefits Per Person (1994 dollars)*

	Viewing	Boating	Fishing	Swimming
Sites Attain Middle Level WQ Improvement:				
All Sites	$-1.61	$.04	$3.14	$5.44
Rivers Only	-.02	.003	.54	.002
Lakes Only	-.15	.01	1.29	1.06
Coasts Only	-1.43	.03	1.34	4.41
Sites Attain High Level WQ Improvement:				
All Sites	31.45	8.25	8.26	70.47
Rivers Only	2.25	2.51	1.86	.11
Lakes Only	6.21	2.39	1.73	21.20
Coasts Only	24.67	4.01	4.39	55.50
Due to Clean Water Act:				
All Sites	.47	.62	2.40	5.59
Rivers Only	.21	.36	.72	.03
Lakes Only	.38	.17	.95	2.55
Coasts Only	-.13	.07	.65	3.04

Table 6 Annual Aggregate Benefits (millions of 1994 dollars)

	Viewing	Boating	Fishing	Swimming	*TOTAL*
Sites Attain* middle WQ *Improvement:					
All Sites	-17.614	.418	34.340	59.490	*76.634*
Rivers Only	-.242	.035	5.903	.019	*5.715*
Lakes Only	-1.650	.092	14.151	11.639	*24.233*
Coasts Only	-15.691	.290	14.688	48.220	*47.506*
Sites Attain* high WQ *Improvement:					
All Sites	344.015	90.268	90.318	770.725	*1295.326*
Rivers Only	24.558	27.499	20.312	1.152	*73.520*
Lakes Only	67.958	26.128	18.939	231.838	*344.863*
Coasts Only	269.766	43.815	48.028	606.958	*968.567*
Due to Clean Water Act:					
All Sites	$5.120	$6.830	$26.298	$61.085	*$99.333*
Rivers Only	2.336	3.990	7.921	.292	*14.539*
Lakes Only	4.198	1.850	10.431	28.271	*44.749*
Coasts Only	-1.410	.744	7.077	33.214	*39.625*

Appendix A
Survey Questions Defining Four Recreation Uses

Boating

Did you leave from your home to take any trips or outings where the primary purpose was to go boating in the last 12 months? Boating inludes trips to go motorboating, sailing, windsurfing, canoeing or kayaking, rowing, tubing or other floating. Please do not include trips taken for any other primary purpose such as swimming, fishing, or to just be near water.

Fishing

Did you leave from your home to take any trips or outings where the primary purpose was to go fishing in the last 12 months? Please do not include trips taken for any other primary purpose such as swimming, boating, or to just be near water.

Swimming

Did you leave from your home to take any trips or outings where the primary purpose was to go swimming outdoors in something other than a pool in the last 12 months? Please do not include trips taken for any other primary purpose such as fishing, boating, or to just be near water.

Viewing

Did you leave from your home to take any trips or outings where the primary purpose was to visit a beach or waterside in the last 12 months? Please do not include trips taken for any other primary purpose such as fishing, boating, or swimming. Please include trips for example, your picnics, nature study outings, and vacations, where you purposely chose to be by the water.