PAPER NO. 13*

THE BENEFITS OF IMPROVING RECREATION QUALITY AND QUANTITY

1. INTRODUCTION

Of all valuation areas in environmental economics, studies addressing the nonmarketed services of recreation (mostly fishing and mostly salt water-based) are by far the most prevalent, owing to the early insight on valuation methods offered by the Clawson travel cost model; the theoretical complexities, and thus the academic attractiveness of estimating benefits in this area; many government funders; and widely available data. To give some idea of the magnitude of work in this area, Smith and Kaoru (1990) performed a meta-analysis on 77 studies of recreation demand, and Walsh, Johnson, and McKean (1988) reviewed 120 studies of the value of various types of recreation-activity days. Most of these studies pertain to individual sites or clusters of sites in a region. Some seek estimates of national recreation benefits.

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The recreation literature may be split into two contexts: the value of adding or eliminating one or more recreation sites (quantity) and the value of changing quality characteristics (e.g., water quality or catch rates) at one or more sites (quality). Of course, these distinctions are more apparent than real. Consider the effects of a new hydroelectric plant. By damming a river, its character may be dramatically altered downstream; upstream, it becomes a lake. Recreation opportunities of a certain type are eliminated, while recreation activities of a different type are added. Does one label these changes "quality" changes or "quantity" changes? More straightforward is the treatment of pollution-related damages. In this case, quantity changes may conceptually be considered the logical extreme of quality changes, that is, when pollution is bad

*Based largely an a paper by Alan Krupnick and Rebecca Holmes.

enough, the site is effectively eliminated from use. To make matters more confusing, in the absence of data linking pollution to quality changes, some analysts make the upper-bound assumption that the recreation opportunity will be eliminated rather than degraded, that is, that there will be a quantity change (RCG/Hagler, Bailly, Inc. 1991).

The state of the literature in this area largely determines the organization of this paper. Surprisingly, while there are several comprehensive reviews of the quantity studies there are no recent reviews of the quality studies. Thus, we also split the literature review into quality and quantity studies. However, owing to the recent and voluminous work on recreation damages associated with acid rain — addressing both a quality change and a quantity change — we treat the acid deposition-recreation pathways together. Thus, the literature review has three parts: non-acidic-recreation quality, acid deposition-recreation, and non-acid-deposition recreation quantity. This paper does not yet contain a review of the last set of studies. Below is a discussion of measuring welfare changes when recreation quality changes.

2. VALUING CHANGES IN RECREATION QUALITY

2.1 THEORY

As a consequence of the research activity in this area, there are a variety of valuation approaches ranging from the very simple to the esoteric [consult Smith (1989) for a summary]. But, to obtain benefit estimates, all of these approaches need estimates from the physical sciences of a long chain of effects. For instance, to estimate the benefits of reducing SO_2 and NO_x emissions along the "acid deposition path," at a minimum one would need information on (i) the effect of these emissions on acid deposition by location and (ii) the effect of deposition on stream and lake quality. Some economic valuation models use these quality changes as a start point. Others, use changes in catch rate. For the latter models, additional scientific information includes (iii) the effect of the quality change on fish populations and (iv) the effect of changes in fish populations on catch rate. The ideal model would need to capture the effects of worse fishing at some sites on recreation choices at all sites and the effects (in the case of environmental improvements) on current nonparticipants that might be induced to participate. In the same model, consistent with welfare maximization, the value recreators place on these changes would also need to be captured.

The simplest valuation approach, called the "unit-day" value approach, is a two-step procedure. It requires, first, estimates of the effect of the change in recreation site characteristics (such as water quality) on recreation participation. Then, from numerous studies in the literature, "prices" for a day of recreation are multiplied by the change in recreational participation to obtain an estimate of benefits. Walsh, Johnson, and McKean (1988) offer a 20-year review of 102 studies using travel cost and contingent valuation (CV) approaches to produce unit values (per activity day) for camping, picnicking, swimming, hiking, boating, hunting, fishing of four types (cold, salt, warm, anadromous), nonconsumptive fishing and wildlife, and wilderness. Some of the values are available for the eastern and western United States.

As the affected sites may have unique characteristics, "average" unit values drawn from the literature may be inappropriate. In particular, the participation choice and valuation are really two sides of the same coin that cannot be neatly separated, as is implied by the unit-day value approach. More important, changes in utility to recreators who continue to participate are ignored by the unit value approach.

There are better approaches. Each of these approaches takes as its point of departure the insight that the WTP for improvements in recreation quality characteristics can be revealed by examining recreation choices across sites that have different levels of quality and that are located at different distances from recreators, that is, one can estimate the tradeoff between quality and quantity of recreation experience and the travel costs and time needed to obtain these experiences.

The three major approaches are (i) multiple site demand models, (ii) discrete choice models, and (iii) hedonic travel cost models [see Bockstael, Hanemann, and Kling (1987)]. The first, also called a varying parameters model, estimates a system of demand equations for all sites in the area, with travel costs, personal characteristics, and site characteristics as arguments (the last indirectly in a second stage). The consumer surplus associated with a change in site characteristics (the willingness to pay for this change) can then be computed. The drawbacks of this approach are that nonparticipation and substitution possibilities across sites are not handled very well.

The discrete choice approach addresses both of these drawbacks by seeking to explain recreator choices per occasion, that is, the allocation of participation across sites. It explicitly allows for an individual to participate at some sites but not at others. The drawback of this approach is that it takes total participation in the area as given. In practice, additional analyses are appended to explain overall participation, using results of the site allocation model as input to the appended analysis. A recent study of swimming visits at 30 Boston beaches is a successful application of this approach that yields benefits in terms of water quality characteristics (Bockstael, Hanemann, and Kling 1987). This approach is also useful in valuing changes in site availability — the quantity issue.

The final approach, the hedonic travel cost model (Brown and Mendelsohn 1984) assumes that each individual can choose among sites with many different bundles of attributes and can trade off some of one attribute for more of another. By observing the sites individuals choose, the price and, ultimately, the demand for each attribute can be recovered. The basic assumptions of this model, like the others, have been criticized. For instance, Bockstael, Hanemann, and Kling (1987) note that there is no market for providing alternative attributes of sites the way there is for houses (an application of hedonic techniques that is theoretically more satisfying), and thus it is questionable how much meaning one should attach to estimates of such prices as estimates of marginal valuation of an attribute. Indeed, values of desirable attributes estimated by this technique have frequently come up negative. Smith, Palmquist, and Jackus (1990) have made a series of modifications to this approach that improve its theoretical and empirical performance, however. They estimate benefits per trip for a 60% increase in catch rate of boat fishing parties in Albermarle-Pamlico Estuary in North Carolina of about $1, in the range found by others for sportfishing in Florida using a discrete choice model (Bockstael, McConnell, and Strand 1989).

The importance of using models that account for substitution between different recreation sites can be seen in the results of Morey, Rowe, and Watson (1991) for salmon fishing in Maine. They found that a single site model estimated WTP per angler per year to avoid elimination of this fishery in the Penobscot River that was three times greater ($2124 versus $764) than an estimate obtained from a discrete choice.

There is also a relatively small literature using contingent valuation approaches to obtain use values for water quality improvements or increases in catch at recreation sites. Some of these studies use a water quality ladder to convey improvements in a river (Smith and Desvousges 1986) and nationally (Carson and Mitchell 1988).

In spite of the vitality of research on recreation benefits, a convincing case has not been made that recreation choice is highly sensitive to changes in site quality or characteristics and, therefore, that changes in quality are highly valued. For instance, a highly competent study of the recreation benefits of pollution reductions at 30 Boston beaches (Bockstael, Hanemann, and Kling 1987) finds per recreator per season benefits from a 10 percent reduction in oil, chemical oxygen demand (COD), or fecal coliform ranging from $0.50 (fecal coliform) to $6.70 (COD) (1989 $s). As another example, a 20 percent increase in catch of striped bass in the Maryland portion of the Chesapeake Bay was estimated to result in annual benefits to bass fisherman of only $2.50 per person, while benefits to beach users of a 20 percent reduction in nutrients in the Maryland portion of the Bay results in benefits of $17 per trip. Contrast these estimates with acute health benefits of $140 per person for a 50-60 percent reduction in ambient ozone concentrations in Los Angeles (NERA 1990).

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Given these small values, the major benefits of reducing pollution of recreation assets may well be in nonuse values, not because such values may be large per capita but because so many people may have them. A companion CV study of user and nonuser benefits to improving water quality in the Chesapeake Bay finds use values per household three times nonuse values ($94 per household per year versus $33) for those living in the Bay border States. If nonuse values extend to people living in other States, total nonuse values could easily exceed total use values. Of course, the Bay is a unique environmental asset. One would be surprised to find high existence values for common types of assets. In what is probably an amazing coincidence, a study asking for use and nonuse values for improving Minnesota lakes (Welle 1985) found the same result: the average user's WTP was about three times the WTP of the average nonuser. As all Minnesota lakes are included in the scenario, this group of assets may be viewed as unique in a similar way to that of the Chesapeake Bay.

An important complication for valuing recreational benefits of environmental improvements concerns the appropriate means of accounting for baseline conditions. Valuation studies of damages to lakes from acid rain assume that the historical baseline is appropriate rather than the current baseline — that damages already observed and related to a certain amount of deposition are a reasonable estimate of the benefits to be gained by reducing deposition (or slowing its increase) by the same amount. Far more useful to environmental costing would be to estimate the value of avoiding further deposition to lakes.[1]

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[1]If our project were considering the benefits from reducing emissions below the current baseline, then the concept of irreversibilities would also be important to incorporate in the analysis.

3. LITERATURE ON NONACIDIC RECREATION QUALITY

No studies in the literature specifically survey studies valuing quality change, but they often provide sufficient information to distinguish such studies. The surveys we used included Bockstael, McConnell, and Strand (1989); Desvousges and Skahen (1987); Feenberg and Mills (1980); Fletcher, Adamowicz, and Graham-Tomasi (1990); Mitchell and Carson (1989); Smith (1989); Smith and Kaoru (1990); Walsh, Johnson and McKean (1988); Ward and Loomis (1986); and Yardas, Peskin, Krupnick, and Harrington (1984).

In addition to these sources, we contacted recreation demand researchers for studies and reviews and the EPA for a database of nonmarket valuation literature. We searched the bibliographies of recent recreation demand studies and a social science database at the Library of Congress for travel cost and recreation valuation. We reviewed the Subject Index of Articles of the *Journal of Economic Literature* from September 1989 to the present. Our objective in each case was to find recreation demand studies valuing environmental quality change. The result was a preliminary bibliography of about 150 such studies. Where the information was available, we recorded each study's method, the study location, the recreational activity, and the environmental quality measure, in addition to bibliographic information.

Because of the large number of studies available, we were able to discriminate among them and analyze only a subset. We focused first on the methodologically superior studies, those using the discrete choice or Random Utility Model (RUM). According to Parsons and Kealy (1990), "Random Utility Models appear to have emerged as the model of choice for recreation decisions."[2] After analyzing the RUM studies, we narrowed down the remainder by looking at studies valuing assets relevant to the reference environments. For instance, we excluded the many marine recreation analyses and focused on those valuing rivers, lakes, streams, etc. We also analyzed those works most frequently cited in reviews. Twenty-one studies were included in our literature tables — Tables 1 and 2.

The following information is included in the tables, chosen with an eye for assessing the quality of the study and its usefulness in a benefit transfer. There are two types of tables, general features and valuation features. In the general feature studies, the study characteristics are author/year, location/asset type, recreational activity, method (model), sample population/sample

[2] Parsons, G.R. and M.J. Kealy, "Measuring Water Quality Benefits Using A Random Utility Model of Lake Recreation in Wisconsin," report to the EPA.

Table 1. Key general features of recreation studies

Author(s) and Year	Location/Asset Type	Recreational Activity	Method	Sample Population/Sample Size Number of Sites: Geographical Extent
McConnell, Strand and Blake-Hedges (1991)	Maryland, Atlantic shore	Shore fishing: small gamefish	TCM (Discrete choice, simple)	Atlantic anglers living in Maryland/38 anglers taking 258 trips total 7 sites: Maryland counties or groups of counties
Bockstael, Hanemann and Kling (1987)	Boston-Cape Cod area, beaches	Swimming	TCM (Discrete choice, nested)	Random households in Boston SMSA/Sample size not reported (1975) 30 sites: Boston and Cape Cod
Bockstael, McConnell and Strand (1989)	East Coast of Florida, Atlantic Ocean	Fishing: big game, small game, bottomfish	TCM (Discrete choice, nested)	Subjects intercepted at sites on East Coast of Florida (Nov/Dec 1987)/158 people, 161 trips) 9 sites: Florida counties or groups of counties
McCarthy, Tay and Fletcher (1991)	Indiana, U. S. freshwater sites visited by Indiana anglers	Freshwater fishing	TCM (Discrete choice, simple, with portfolios of recreation trips as choice alternatives)	Indiana residents/573 observations 368 sites (five considered for each respondent): U.S. regions or zones
Parsons (1991)	Wisconsin, lakes larger than 100 acres, Michigan and Superior excluded	Boating, angling, swimming, viewing	TCM (Discrete choice, nested)	Wisconsin residents/nearly 1200, 1133 sites, sample of 24 considered for each respondent: lake in Wisconsin
Parsons and Kealy (1990)	Wisconsin, lakes larger than 100 acres, Michigan and Superior excluded	Boating, angling, swimming, viewing	TCM (Discrete choice, nested)	Wisconsin residents/over 1200 1133 sites, sample of 12 considered for each respondent: lakes in Wisconsin
Parsons and Kealy (1988)	Wisconsin, lakes larger than 100 acres, Michigan and Superior excluded	General (boating, fishing, swimming, picnicking: not valued separately)	TCM (Discrete choice, simple)	Wisconsin residents/105 for site choice model (~2600 trips); 330 for participation model 1100 sites (of these, lakes visited define choice set for individual): lakes in Wisconsin

Table 1. Key general features of recreation studies

Author(s) and Year	Location/Asset Type	Recreational Activity	Method	Sample Population/Sample Size Number of Sites: Geographical Extent
Morey, Rowe and Watson (1991)	Penobscot River, Maine	Salmon fishing	TCM (Discrete choice, repeated)	Maine residents holding Maine Atlantic salmon fishing licenses in 1988/168 8 sites: Maine rivers and groups of rivers, New Brunswick rivers, Nova Scotia rivers, Quebec rivers
Kaoru and Smith (1990)	North Carolina, Albemarle-Pamlico Estuary, Atlantic Ocean: tidal fresh and mixed fresh-saltwater sites	Sport fishing	TCM (Discrete choice, simple)	Fishing party leaders or boat owners fishing at the estuary/612 observations Scenario (a) 35 sites: estuary launch points Scenario (b) (Pamlico-Tar river subset of estuary sites) 9 sites: estuary launch points
Morey, Shaw and Rowe (1991)	Oregon, coastal waters	Marine recreational fishing	TCM (Discrete choice, repeated. Authors' modification of standard model)	Oregon resident anglers/5855 7 sites: coastal counties
Rowe, Michelson and Morey (1989) (Chapter 5, TCM model)	Penobscot River, Maine	Atlantic salmon fishing	TCM (Discrete choice, repeated)	Atlantic salmon fishing license holders in Maine/421 8 sites: Maine rivers and groups of rivers, New Brunswick rivers, Nova Scotia rivers, Quebec rivers
Caulkins, Bishop and Bouwes (1986)	Wisconsin lakes	General lake recreation. Type not specified in model due to data limitations.	TCM (Discrete choice, nested)	Lake users residing in northern Wisconsin/45 Number and definition of sites not reported
Milon (1988)	Dade County, Florida/Artificial marine habitat	Near shore and offshore sportfishing: not broken down by species	TCM (Discrete choice, nested)	Dade County boat registrants/887 respondents 13 sites: known "fishing spots", natural reefs, artificial reefs
Smith, Desvousges and McGivney (1983)	Monongahela River, Pennsylvania	Boating, fishing, swimming	TCM (Varying parameters)	Households in five Pennsylvania counties/69 respondents taking 94 trips 13 sites along the Monongahela River

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Author(s) and Year	Location/Asset Type	Recreational Activity	Method	Sample Population/Sample Size Number of Sites: Geographical Extent
Brown and Mendelsohn (1984)	Washington state streams	Steelhead fishing	TCM (Hedonic)	Washington licensed fishermen/5500 Over 140 Washington rivers
Gramlich (1977)	Charles River, Boston, Massachusetts	Swimming	CVM, combination of iterative bidding and open-ended	Households in the Boston metropolitan area/165
Johnson and Adams (1988)	Oregon/John Day River, a Columbia tributary	Steelhead trout sport fishing	CVM, open-ended valuation questions	John Day River anglers/62
Smith and Desvousges (1986): CVM	Monongahela River, western Pennsylvania	Boating, fishing, swimming	CVM, direct question, payment card and iterative bidding	Households in 5 counties in southwestern Pennsylvania/301 interviews completed (smaller sample size for each valuation method: 54 for payment card, excluding protests and outliers)
Smith and Desvousges (1986): TCM	Army Corps of Engineers flatwater recreation sites nationwide (include one in TN reported here as an example)	Fishing, sightseeing, picnicking, camping, boating, swimming	TCM (Varying parameters)	Site users/1891 22 sites: Flatwater sites in 9 states (lakes and reservoirs)
Brookshire, Eubanks and Rowe (1977)	Wildlife population levels (antelope, deer and elk) in Eastern Powder River Coal Basin, Wyoming	Hunting	Hedonic price equation derived from household production function	Wyoming hunters/Sample size not reported Number of sites not reported: Hunt areas in Wyoming
Bouwes and Schneider (1979)	Pike Lake, Wisconsin	Not specified	TCM, pooled	Wisconsin lake users/195 8 southeastern Wisconsin lakes

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues
McConnell, Strand and Blake-Hedges (1991)(a)	Mean of catch from 1980-1988	Five percent increase in historic catch	Historic catch rate: mean catch per day of small game for period 1980-1988 at site	$10.36 (angler's mean WTP per trip)	Catch/hour; travel cost; travel time	Subjects were anglers surveyed by phone who agreed to participate in study. (1988) Aggregated sites: counties or groups of counties
Bockstael, Hanemann and Kling (1987) (b)	1975 water quality? Study not explicit	(a) 10% reduction in parameters at all sites (b) 30% all sites (c) 30% downtown Boston beaches	Water quality parameters: Oil, Chemical Oxygen Demand (COD), Fecal Coliform, Turbidity	(a) Oil: $ 2.54 COD: $ 7.02 Coliform: $ 0.50 (b) Oil: $12.35 COD: $18.95 Coliform: $ 7.55 All + turbidity: $31.91 (Benefits per household per season)	Stage I est: oil; fecal coliform; temperature; COD; turbidity; noise; public transportation; beach ethnicity; trip cost Stage II: price; household size; % children; swimming pool access Participation: cost and quality of rec. opportunities; HH size; % children; sports equipment	Random survey of Boston households: participants and non-participants (1975) No site aggregation: all 30 used separately
Bockstael, McConnell and Strand (1989) (c)	Mean of catch and success rates from 1980-86	20% increase in catch and success rates for three species categories	Proxies for expected catch: catch rate--mean # of fish caught in Nov/Dec form 1980-86 (small and bottomfish) success rate--mean of proportion of anglers catching at least one fish in Nov/Dec from 1980-86 (big)	Small: $0.38 Bottom: $1.46 Big: $1.79 (Benefit per person per trip)	Fishing mode (shore, boat); species group; travel cost; travel time; boat ownership	Subjects were anglers surveyed by phone who agreed to participate in study. (1988) Aggregated sites: counties or groups of counties

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues
McCarthy, Tay and Fletcher (1991) (d)	1985 estimates of regional water quality indices	(a) 2% reduction in indices, assuming travel costs of 15 cents per mile (b) 2% reduction, 25 cents per mile	(see comments) Portfolio's water quality defined as sum of objective indices of each site's water quality, weighted by time consumer spends at site.	(a) TSS: $1,022,450 Phos: $1,560,900 Iron: $1,282,600 PCB: $747,780 FCB: $1,312,850 All: $5,953,200 (b) TSS: $1,704,890 Phos: $2,601,500 Iron: $2,601,500 PCB: $1,256,300 FCB: $2,187,680 All: $9,923,210 (Benefits of abatement to Indiana anglers: annual?)	Education; income; fish species; site type; coliform; TSS; iron; phosphorous; oxygen demand; travel distance	Uses 1985 survey of fishing, hunting, and wildlife-associated recreation, by the U.S. Census Bureau: sampling method unclear. Sites defined as 368 U.S. regions or zones: assume aggregated
Parsons (1991) (e)	1978 water quality	(a) High standard: high DO and clarity for all lakes (b) Low standard: no lakes have low DO	Dissolved oxygen (DO): high, moderate or low Clarity: high or low	(a) High standard: Boating: $8.44 Fishing: $1.88 Swimming: $11.64 Viewing: $11.06 (b) Low standard: Boating: $0.38 Fishing: $1.00 Swimming: $1.66 Viewing: $0.30	Travel cost; lake size; commercial facilities; remoteness; northern county; lake depth; boat ramp at lake; inlet in lake; dissolved oxygen; clarity	Random phone survey (1978) No site aggregation
Brookshire, Eubanks and Rowe (1977) (t)	Based on average of harvested animals for 3 year period 1971-73: Deer: pop. 16,800 Antelope: pop. 30,300 Elk: pop. 320	Uniform decline of deer and antelope populations across 9 antelope and 9 deer hunt areas in region by 1978: Deer: 5% decline Antelope: 9% decline Elimination of elk population	Deer, antelope and elk populations	$420 (Value per year for all hunters)	Hunting days per individual; stock of wildlife species; number of hunters in hunting group; density of all hunters at hunting site	

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues
Bouwes and Schneider (1979) (u)	LCI = 3	LCI = 10	LCI: Uttormark's Lack Condition Index for Wisconsin lakes. Index parameters are DO, Secchi depth, fish winterkill and macrophyte or algal growth. Index values range from 0 (best) to 23 (worst)	$0.50 (Benefit per year per recreator if damage is avoided)	Cost; perceived water quality (related to LCI: see comments); round trip time; income	Little information given on data
Parsons and Kealy (1990) (f)	1978 water quality	Scenarios 1 through 4, with increasing minimum water quality standards at all Wisconsin lakes	Water quality measures: Dissolved oxygen (DO); Secchi depth transparency; macrophytic algal growth	Scenario 1: $ 55.40 Scenario 2: $161.40 Scenario 3: $460.40 Scenario 4: $819.40 (Values per individual per season)	Site choice: lake size; public access; DO; clarity; winterkill; algal growth; price (incl. TC) Participation: lake property ownership; age; proximity to a Great Lake; importance of water quality to respondent; education; length of residence in Wisconsin	EPA random phone survey of Wisconsin residents (1978)

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues
Morey, Rowe and Watson (1991) (h)	1988 reported catch rate	(a) Doubling catch rate at Penobscot (b) Halving catch rate	Average catch per trip	(a) $719.40 (b) $336.60 (CV/angler/year, assuming 50 trips per year)	Income; fishing experience; membership in fishing club; age; trip costs; catch	Mail and telephone survey of Maine salmon license holders (1988) Aggregated sites: some are individual rivers, others groups of rivers, some including all rivers in a province. Authors state that catch varies less within groups than across groups. Source of catch data not reported: assume it is catch reported by surveyed anglers.
Kaoru and Smith (1990) (i)	1981-82 values of catch and water quality	(a) 1. Increase catch rate by one fish at all sites. 2. Increase catch rate 25% at all sites (b) Pamlico-Tar River Plan 1. 30% decline in N and Ph loadings, 30% increase in catch rates 2. 30% catch increase 3. 30% N/Ph decline	Catch rate: average over respondents of fish per person per fishing hour for each entry point Water quality: aggregates of discharges of nitrogen and phosphorus from point, nonpoint, upstream sources; discharges of BOD and TSS from plants within 10 miles upstream from sites	(a) 1. $6.79 2. $6.82 (b) 1. $11.26 2. $1.47 3. $5.89 (per person/per trip)	Travel cost; catch rate; type of boat ramp; area water classification (fresh, mixed); nitrogen loadings; phosphorous loadings	Intercept survey of estuary users Site aggregation: none in scenario reported

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues
Morey, Shaw and Rowe (1991) (j)	Charter boat catch rate: 1.27 Private boat catch rate: 0.70	Increased catch: 2.27 charter 1.70 private Salmon enhancement program funded by $5 charter boat tax: WTP measured for increased catch and tax	Offshore salmon catch rates (average per-person, per-trip) in Clatsop County	(By county of origin) Clatsop: $1.51 Tillamook: $0.94 Lincoln: $0.53 Lane: $0.26 Douglass: $0.17 Curry: $0.09 Multnomah: $0.83 Deschutes: $0.19 (benefit per year per angler)	Price; salmon, perch, smelt/grunion, flatfish, rockfish/bottomfish catch rates	On-site surveys of anglers (1981): authors make correction for selection bias aggregated sites. Incomplete data on individuals' site selections; no data on income, boat ownership, species preference, age, sex, race, education
Rowe, Michelson and Morey (1989) (Chapter 5, TCM model) (k)	1988 catch rates	(a) Doubling catch rate at Penobscot (b) Halving catch rate at Penobscot	Salmon catch rates	(a) $688 (b) -$328 (value/angler/year)	Travel cost; catch rate; experience; fishing club membership age; income	Mail and phone survey of randomly selected license holders (1988) Aggregated sites: some are individual rivers, other groups of rivers, some including all rivers in a province
Caulkins, Bishop and Bouwes (1986) (l)	Not reported	One LCI unit improvement in water quality at Shadow Lake	Uttormark and Wall's Lake Classification Index (LCI)	Not calculated. Calculates change in trips from change in water quality.	Site choice: travel cost; LCI; urban shoreline; lake depth Participation: travel cost; LCI; urban shoreline; lake depth; age; recreation income of HH; number of people in individual's recreation group	Uses statewide water quality survey (as do Parsons and Kealy) for data on recreation

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues
Milon (1988) (m)	1985 catch	10% increase in catch within site group (near shore, offshore-natural, offshore-artificial)	Catch: weight of fish caught	Not calculated. Study reports change in site group choice probability resulting from change in catch.	Site choice: travel cost; travel time; catch weight; catch variability; age of site Habitat choice: boat equipment; opinion on productivity of artificial habitat; race; years boating in Dad Offshore vs. Near-shore: engine size; boat equipment; age; income	Mail survey, stratified sampling proportional by zip code
Smith, Desvousges and McGivney (n)	Current DO levels, adequate to support boating	(a) Increase DO to fishable levels (b) Increase DO to swimmable levels	Dissolved oxygen (DO), percent saturation	(a) $9.76 (b) $20.50 (benefits per household per season)	Not specified for Monongahela application. If same as for Army Corps sites application: Stage I: travel cost; income Stage II: total shore miles; recreational/developed access areas at site; water area/site area; mean DO; variance in DO	Stratified cluster survey of PA households, but only those who had taken at least one trip were used
Brown and Mendelsohn (1984) (o)	Gives "average" price for unit of catch	See baseline	Catch: number of fish caught per ten days	$4.80/trip (average price of catch per ten days) $110/season (per-trip price x average number of trips)	Stage I: fish density, scenery rating Stage II: (inverse demand) income; experience; scenery; lack of congestion; fish density; number of trips	Random sample of license holders

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues
Gramlich (1977) (p)	Charles River water quality in 1973	Increase in water quality throughout river to level "B", guaranteed by state and local government. Payment vehicle: tax increase	Water quality level "B": "clean enough for swimming, fish and wildlife but not necessarily good enough for use as a drinking water supply without further treatment."	$89.79 (value per household per year, using sample mean values of independent variables)	Income; high school education; proximity to Charles (dependent variable is WTP for specific quality change: quality not itself an argument)	Survey of both users and non-users
Johnson and Adams (1988) (q)	Expected catch rate with current fish populations 9.3 hrs/fish	(a) 7.1 hrs/fish (33% increase in population) (b) 5.0 (67%) (c) 2.9 (100%) Payment vehicle: fee in form of steelhead stamps	Changes in angler's mean expected catch rate with increases in fish population	(a) $10.21 (b) $13.22 (c) $16.17 (WTP/angler for increased population/catch)	Catch rate	On-site sampling Personal interviews
Smith and Desvousges (1986) CVM (r)	1981 water quality, represented as Level D	Four possible changes in water quality levels: (a) avoid decrease D->E (b) increase D->C (c) increase C->B (d) increase D->B Payment vehicle: increase in taxes and prices	RFF water quality ladder levels: A: Drinkable B: Swimmable C: Fishable D: Boatable E: No recreation use possible	(a) $8.93 (b) $14.00 (c) $8.93 (d) $23.20 (values per person per year)	Age; willingness to pay cost of water pollution	Stratified cluster sampling: HH's divided into clusters of ~7, entire clusters selected; face to face interviews; users and nonusers included
Smith and Desvousges (1986) TCM (s)	Boatable water quality	(a) water quality change from boatable to fishable (b) boatable to swimmable	RFF Water Quality Index levels: boatable, fishable, swimmable. Each associated with a particular DO level.	(for Cordell Hull Dam and Reservoir, Tennessee) (a) $30.69 (b) $68.08 (benefit per season per user)	Stage I: travel costs (income not significant) Stage II: size of water pool/size of site (income parameter only); DO (intercept only); variation in DO (intercept only); (shore miles, access areas not significant)	On-site interviews. Used maximum likelihood estimator in estimating demand curves to reflect truncation and censoring.

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues
Brookshire, Eubanks and Rowe (1977) (t)	Based on average of harvested animals for 3 year period 1971-73: Deer: pop. 16,800 Antelope: pop. 30,300 Elk: pop. 320	Uniform decline of deer and antelope populations across 9 antelope and 9 deer hunt areas in region by 1978: Deer: 5% decline Antelope: 9% decline Elimination of elk population	Deer. antelope and elk populations	$420 (value per year for all hunters)	Hunting days per individual; stock of wildlife species; number of hunters in hunting group; density of all hunters at hunting site	
Bouwes and Schneider (1979) (u)	LCI = 3	LCI = 10	LCI: Uttormark's Lake Condition Index for Wisconsin lakes. Index parameters are DO, Secchi depth, fish winterkill and macrophyte or algal growth. Index values range from 0 (best) to 23 (worst)	$0.50 (benefit per year per recreator if damage is avoided)	Cost; perceived water quality (related to LCI: see comments); round trip time; income	Little information given on data

Comments Code

Note: For conversion to 1990 dollars, I assume study gives values in dollars of the year the data is collected, unless otherwise specified.

(a) Method: Models catch as random variable (Poisson): function of historic catch rate, on-site time and skill; does not model change in participation due to quality change. Treatment of time: On-site: no cost imputed: brings only utility. Travel: explicit cost: for anglers with flexible work hours, travel time is valued at the wage rate; implicit cost: opportunity cost of discretionary time. Authors model by including travel time directly in utility function. Value: calculated using expected catch which varies across individuals. Authors also calculate benefits using mean angler characteristics to determine average expected catch: value is $9.00. Subjects: anglers' age varies form 18 to 80, with mean 39.4 and SD 14.55.

(b) Method: Authors also estimate hedonic travel cost equations, but results are counter-intuitive (many negative hedonic prices for quality) and they cannot estimate welfare changes. Models change in participation due to quality change; derivation of travel costs, including treatment of time, unclear. Value: Authors also calculate values per choice occasion.

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues

(c) Method: Uses data on fishing trips in Nov/Dec only. Does not model change in participation due to quality change. Treatment of time: Travel: 80% of wage for wage-earners who can vary time; travel time included directly for those who cannot vary time (refer to Bockstael, Strand and Hanemann, 1987).

(d) Method: Defines portfolio of recreation trips as choice alternatives. Assumes all recreation decisions made at beginning of period: destination, frequency and duration decided jointly. Appears to model change in participation due to quality change ("increases in the level of pollutants present in the water decrease the demand for recreational fishing," p. 15). Treatment of time: Estimates effect of distance on choice, then measures welfare by assuming two different per-mile costs of travel. No explicit treatment of the cost of time. Value: Authors also report benefits of 1% reductions, which are about 50% less. Used sampling procedures (of destination, frequency and total number of trips) to limit number of choices available to each consumer; corrected for bias introduced by sampling. Assumes utility derived from a day in a region depends linearly on water quality. Subjects: Heterogeneous income, age, sex, marital status, education, employment (Table 2 of study). Assumptions: *Utility of an n-day trip same as utility of n one-day trips.* Utility depends linearly on water quality.

(e) Method: Same basic study as Parsons and Kealy (1990). Uses randomly selected subset of all sites as individual's choice set, to limit choices without site aggregation bias. Model differs from Parsons and Kealy (1990) in that: authors estimate models with different numbers of selected sites in choice set: 3, 6, 12, and 24 (vs. 12 in P&K). Authors are more confident of estimates for larger choice sets. However, some parameter estimates are stable even for 3 site model, and benefit estimates are fairly stable for 6 and greater-site models. Authors do not model change in participation due to quality change. Also estimate a model using only sites visited by at least one respondent, and find parameter and benefit estimates robust. Time: 1/3 wage rate. Value: Study also reports values for 3, 6, and 12-site models, and model with visited sites only. Assumptions: Independence of Irrelevant Alternatives holds within any nest in model.

(f) Method: Authors use randomly selected subset of all sites as individual's choice set: limits choices without site aggregation bias. Treatment of time: time valued at one-third wage rate. On-site time assumed constant, equal to 4 hours. Models change in participation due to quality change. Value: Values presented are upper bounds, assuming the increase in number of trips predicted by participation equation: also present lower bounds, assuming no change in total trips. Also present values per choice occasion.

(g) Method: Study defines individual's choice set as lakes he/she actually visited. For nonparticipants, this means their choice set contains no sites, and it is assumed that they will always be nonusers. Models change in participation due to quality change. Treatment of time: time valued at one-third wage rate: wage rate defined as family income/average number of working hours in a year. Travel time calculated as distance/average speed of 35 mph. Value: Values per choice occasion also reported. Spread of values reported. Assumptions: Independence of irrelevant alternatives (IIA). No diminishing marginal utility to visiting a given site during a season.

(h) Method: Models participation decision by including "not fishing" as one of choices . Alternative models: authors also estimate: 1) repeated discrete choice model without income effects; 2) standard logit model without income effects or nonparticipation alternative; 3) share model of site choice; 4) single-site linear demand model and find their model preferable to all. Authors use estimated equations to predict visits to Penobscot under current conditions: estimate is 9.75 vs. and actual 11.85 visits. Some indication of predictive power of model. Treatment of time: travel and on-site time valued at one-third the wage rate. Value: Value reported is mean value: median values 20-33% less. Also reports EV; values nearly identical.

(i) Method: Study investigates effect of site aggregation on benefit measures by using three site definition scenarios with different degrees of aggregation: 1) 35 sites: estuary launch points; 2) 23 sites: groupings of proximate launch points; 3) 11 sites: coastal counties within estuary. Small effects on estimated parameters, but significant effect on benefit estimates. Study tests hypothesis that behaviorally relevant quality measure is a composite of "objective" quality measures. Quality definition found to affect benefit estimates (Scenario (b)). Treatment of time: travel time derived from distance by assuming average speed of 40 mph. Cost of time estimated as wage rate using a 1977 hedonic wage model and 1978 data scaled to survey year with the CPI. For students, unemployed and retired subjects, cost of time estimated as minimum wage. Does not model change in participation due to quality change. Value: Values reported are derived from least aggregated (35 and 9-site) models using nitrogen and phosphorus loadings as quality measure. Authors also report results from models with different aggregation levels and using BOD and TSS as quality measure. Coefficients of BOD and TSS were not significant in estimated equations.

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues

(j) Method: Authors develop a version of a repeated discrete choice model which allows estimation with incomplete trip data and corrects for oversampling of "avid" participants due to on-site survey. Models participation by including "not fishing" as one of choice alternatives. Treatment of time: model includes the "value of time" in travel costs, but study does not describe its derivation. Estimation equation: coefficients of expected sign, except for flatfish and rockfish/bottomfish, with negative coefficients. Authors cite possible multicollinearity. T-statistics not given. Subjects: All counties in Oregon represented. Assumptions: Constant marginal utility of income: no income effect.

(k) Method: Models participation by including "not fishing" as one of choice alternatives. Treatment of time: valued at one-third the wage rate. Assumes travel time = distance/40 mph. Value: Mean value reported. Authors also report median, which is lower, and range.

(l) Method: Study compares RUM to pooled model. Models participation as function of water quality. Treatment of time: Values travel time at 1/4 hourly wage rate. Entire travel cost expression (transportation costs + time costs + fees) deflated by opportunity cost of time. Same data set as used by Parsons and Kealy (1990) (P&K, p. 3).

(m) Method: Study measures travel costs as costs in traveling from launch site to fishing site, not costs from home to launch site. Nested discrete choice model: 1) Offshore or near shore; 2) If offshore, natural or artificial; and 3) Site choice. Does not model change in participation due to quality change; assumes total trips taken is exogenously determined. Authors use model primarily to estimate the value of new artificial reef sites. Could also, presumably, use to value change in catch.

(n) Method: Authors estimate model using data on Army Corps of Engineers sites first, reporting estimation equations, but do not calculate benefits from quality change. Then they calculate benefits form quality change using Monongahela River data, but do not report estimation equations. Treatment of time: Travel time valued at wage rate, using a hedonic wage model to calculate wage. On-site time not considered as a cost. Value: Not clear whether value given is for change in quality at one or all sites. Spread of values also reported. Assumptions of model: Single purpose trips only. SE characteristics besides income not included in specification.

(o) Method: Hedonic travel cost method: based on the idea that consumers will travel farther to higher quality sites, method estimates demand for site characteristics: Stage I: regress travel cost on site characteristics to determine implicit prices for characteristics. Stage II: regress prices on level of characteristics consumed (and other variables) to produce inverse demand functions for characteristics. Treatment of time: valued at 30% of wage rate. (Gave stablest parameters.) Value: Survey year not reported: unclear in what year's dollars values are measured. Demand functions for scenery and congestion also calculated. Assumptions: No user fees.

(p) Method: Bias: Measurement: author not confident of accuracy of income measurement. Strategic: author believes it was clear to respondents that results would not affect policy. Hypothetical: No real cost to answer: upward bias. Abstract/unfamiliar good: downward bias. Starting point: author acknowledges possibility of bias in using iterative bidding game, but notes that, with starting point of $10 and average WTP of ~$30, bias will be downward. Sequence: author asks for WTP for Charles immediately after asking for WTP for all U.S. rivers. Value: Author reports 95% confidence interval for mean WTP. Author also reports values for: WTP for Charles for various levels of income and education, assuming typical values for other variables. WTP to increase water quality to level "B" for all rivers in U.S. WTP to increase water quality to level "B" for all rivers in U.S. excluding the Charles.

(q) Method: Study values incremental streamflow changes by estimating: 1) Steelhead fishery productivity as function of streamflow and 2) value of change in fishing quality (using CVM). CVM method: 1) Gave anglers information on average success rates for each of past five years at the John Day River. 2) Asked to estimate own catch rate at the river in an average year. 3) Gave 3 scenarios: 33%, 67% and 100% increase in steelhead stock. Asked to estimate expected increase in catch rate. 4) Asked maximum fee would pay for improvements.

(r) Method: Four valuation methodologies employed: 1) Iterative bidding: $25 starting point; 2) Iterative bidding: $125 starting point; 3) Direct question; and 4) Direct question with payment card. Statistically significant differences between values derived form 1. and 2. for some scenarios. Respondents asked to include use and option values in bids, then what portion of total they allocate to use. Value: This value for subset of survey for which direct payment with payment card method was used. Also, report values for other methods. Also report values for option + use value as well as use value alone. Use values were statistically different from zero for some, but not all, scenarios and methodologies.

Subjects: Education - Mean 12.75 - Standard Deviation 1.73
Race (white=1) - Mean 0.90 - Standard Deviation 0.30
Income (1990$s) - Mean 28,135 - Standard Deviation 18,985
Age - Mean 47.82 - Standard Deviation 18.34

Table 2. Values from recreation studies

Author(s) and Year	Baseline	Scenario	Damage Measure (Startpoint)	Value of Quality Change (1990 $'s)	Significant Variables	Data Issues

(s) Method: Treatment of time: used hedonic wage model estimated form 1978 Current Population Survey. Used predicted wage as opportunity cost of time. Did not include substitute prices or characteristics in site demand estimation. Authors also use Corps sites model to estimate values for changes in water quality at Monongahela sites, but find the results implausibly high (>30X CVM measures). They attribute this to the physical differences between Corps and Monongahela sites. Value: Values given here are Marshallian welfare measures: Hicksian measures are $100.53 and $299.55, respectively. Values also reported for each of 20 other sites. Subjects: Variety of Characteristics: for example, average income ranges from $9,199 to $29,571 ($19,870 to $63,873, 1990 $s).) Assumptions: Constant on-site time.

(t) Method: Basically a hedonic travel cost approach, except that time costs are not included in expenditure estimates. Characteristic demand functions do not include income as an argument, because of data limitations. Value: Authors reported PV of loss over 30 years at different discount rates (zero and 8%). I assumed value spread over 30 years beginning in 1978, determined annual benefit and converted to 1990$s assuming value originally in 1978$s. (If I assume instead that losses occur over 30 years starting from 1975, with no losses until 1978, and using 1975 as base year, the value is $566.) Assumptions: Authors use harvest of animals as proxy for populations in model, and assume that a given percentage change in population will cause an equal percentage change in harvest.

(u) Method: Authors estimate relation between perceived and objective water quality measures. In interviews at lakes, asked for respondents' perceptions of lake's water quality, using a scale of 0 to 23. They then regressed lakes' perceived water qualities on their LCI's to obtain an expression relating the two. Using this expression, they were able to measure the welfare change from a change in LCI using demand equations estimated using perceived water quality. Did not include cost of time in trip cost; instead, included time directly in demand equation. Value: I assumed values given were in 1977 dollars.

size/number of sites, and geographical extent. In the valuation features table, we include information on baseline, scenario, damage measure (start point), the valuation estimate, significant variables, and data issues.[3] Other comments are included in extensive endnotes on the table.

For the WTP estimates, we index all reported values to the same year and translate where possible into the same units; this allows us to see the range of values and whether they are consistent across studies. However, this may *not* always be possible. As noted above, inconsistent damage measures and baselines preclude comparison. Different scenarios do the same: if one study values a 10% increase in catch, and another a 50% increase, the values are not comparable.

The studies surveyed were primarily recent. Most were published (or written) after 1988; only three, before 1980. They valued a variety of assets, primarily freshwater lakes, rivers and streams. The majority studied fishing benefits, though some valued swimming, boating, viewing, picnicking, camping, or hunting. A few of the RUM studies were of marine recreation. Most of the studies used the RUM, with the rest divided between other travel cost and contingent valuation methods. Average sample size was 1014 (486 excluding the two highest and two lowest). Many of the travel cost studies included sites across a State, though some were less extensive (a river, several counties, a metropolitan area) and some more extensive (sites in nine States, several States and a province, etc.).

Damage measures were highly variable. Many valued catch rate for a fish species. Scenarios and methodologies differed greatly. For studies reporting values per person per trip, the average value was $7 for an increase in catch rate. Annual values ranged from $0.09/person to $719.40/person, with typical values in the hundreds. However, the scenarios valued vary so much that comparison is not very meaningful.

For studies reporting values per person per trip, the average value was $7 for an increase in catch rate.

The other predominant category of damage measures was objective water quality measures, most frequently dissolved oxygen. However, in these studies the scenarios are so variable that no comparison of the reported values is useful.

[3]A data issue specific to multiple site travel cost models is site aggregation. Because of computational requirements, the RUM studies are particularly likely to define sites as aggregates of sites; this may introduce bias if the aggregate sites are large and heterogeneous.

A particularly important study for our work is a recent study by Jones and Sung. Jones and Sung (1991) present results from a random utility travel cost model developed for the valuation of environmental quality at Michigan recreational fishing sites. Specifically, they calculate the damages to Michigan-licensed recreational anglers from fish kills caused by the operation of the largest pumped-storage plant in the United States, and they calculate the benefits of cleaning up PCB contamination in a river in Michigan. The strength of the study lies in the authors' improvements upon the methodology. The usefulness of the results is limited, however, by the imprecise quality of the data they use.

Jones and Sung note the strengths of the random utility model but point out that many issues need to be resolved concerning the correct specification of the model and the sensitivity of welfare estimation to specification errors.

Jones and Sung's improvements upon the standard methodology presented in the literature include the development of a consumer surplus measure that can accommodate changes in the predicted number of total trips resulting from policy changes. The standard methodology requires an assumption that the total trips made remain unchanged once the proposed policy is adopted. Jones and Sung also improve upon the treatment of the opportunity costs of time, which has been inadequate in previous studies.

Due to limited information on the frequency of participation, consisting only of the date of an individual's most recent trip and the survey return date, the authors had to develop a stochastic renewal model to infer the total trips made per season by all Michigan anglers. Although necessitated by their data limitation, the model allowed them to assess the dependency of a trip choice on the duration of the trip, which is lacking in many random utility model studies that restrict their analysis to day trips. Jones and Sung, by showing that two-thirds of the damages in their policy scenarios accrue to anglers taking trips of longer than one day, conclude that ignoring this relationship of trip choice on trip duration may lead to severe underestimation of damages.

...two-thirds of the damages...accrue to anglers taking trips of longer than one day...

Because the stochastic renewal model poorly matched the total trip days indicated by another less comprehensive survey, the authors issue a warning, stating that the total benefits or total damages they estimate "should not be treated literally." They do, however, say that the consumer welfare measures calculated on a per trip basis may be cited. The consumer welfare measures are reported for the first policy scenario, which is the termination of fish mortalities caused by the pump-storage power plant. For this scenario, which is expected to lead to a roughly 10% increase in all salmon catch rates, they calculate an average conditional compensating variation of $.12 per trip when considering all of Michigan. If restricted to those areas and anglers most affected by the power plant scenario, the compensating variation is $1.08 (1984 $) per trip. If the increase in catch rates were 20%, which is similar to the scenarios of other studies [Bockstael et al. (1988, 20%), Smith and Palmquist (1988, 25%)], the average compensating variation would be $2.92 per trip, which is of the same order of magnitude obtained in these and other studies. No similar comparison is made for the PCB cleanup scenario, although it appears that the compensating variations are roughly the same. Finally, the model can be manipulated to estimate the value of changing the fish populations over a given number of stream miles. Given a decrease in fish kills from the pump-storage facility that would increase fish populations over 100 stream miles, the average benefit is $0.04 per mile affected per trip.

4. ACID DEPOSITION-RECREATION PATHWAY STUDIES

We have examined six studies of this pathway. Two of the studies also examine nonuse values. Four apply to the Adirondacks [Englin et al. (1991) applies to all the Northeast], one applies to Minnesota, and another applies to Norway. The methods used span the full range. The scenarios are all for large changes in emissions or changes in a variety of impact measures or proxies (environmental quality index). Values per person (or angler) per year vary over a wide range.

Englin et al. (1991) is by far the most complete. Like most studies of acid rain damages to lakes, the Englin et al. report for NAPAP focuses on the Adirondacks. This region has the best documented evidence of damage. The study takes information on trips made by anglers from Maine, New Hampshire, Vermont, and New York and produces estimates of social welfare for a variety of scenarios. Anglers from New York City were excluded from the analysis.

Damages for eight scenarios were estimated: the standard NAPAP emission projections of S1 (no additional sulfur controls beyond those already legislated) and S4 (reduction of 10 million tons) in both 2010 and 2030, a 30% increase in deposition in the year 2030, no change by the year 2030, a 50% reduction in deposition, and current damages. By the year 2030, S1 and S4 will achieve just about the same level of control, with S1 retaining slightly higher levels of emissions.

The Englin et al. report makes all of the linkages back to deposition. Deposition is linked to an acidic stress index (ASI) for fish through calculations based on measured chemical characteristics of lakes, where possible, and through forecasts based on other observed characteristics of lakes where the chemical characteristics information is not available. The equation using the chemical characteristics was based on laboratory toxicity experiments on fish. Survival of fish fry is related to the pH, calcium concentration, and aluminum concentration of the lake. For lakes where this information was not available, a regressions was fit for characteristics of the lake that could be observed by the anglers. These nonchemical characteristics used to predict ASI were state, pond vs lake, percentage of watershed in leafy trees, percentage of watershed in pine trees, percentage of watershed in meadows, percentage of watershed that is agricultural land, subjective description of the weediness of the lake, visibility, and whether boating or swimming was included on the trip.

The Englin et al. report makes all of the linkages back to deposition.

Similarly, Englin used a regression to estimate the relationship between catch per hour and the biological response of fish to changes in water quality. Using actual average catch per hour as a base, the percentage change in ASI was used to calculate future catch per unit effort for each scenario.

Two methods were used to value the change in catch per unit effort: a hedonic travel cost model (HTC), and a random utility model (RUM). The effect of the change in catch per unit effort (CPUE) on participation in recreational fishing is also modelled. The participation model is somewhat problematic. It not only includes catch per unit effort for both bass and trout, but a range of demographic information as well. There is not enough information given in the report to isolate the effect of the acid rain from the changing population.

The WTP per person per year is quite different according to the method used. For instance, with no reduction in deposition from 1989 levels, WTP is $1.54 using the hedonic travel cost approach, but only $0.30 using the random utility model. The relationship between results turns completely around for the scenario involving a reduction in deposition of 50%. In this case, the hedonic model reveals WTP of $0.24 while the RUM estimates WTP of $0.82.

Mullen and Menz (1985) use data from the 1976 New York State Anglers' Survey to estimate a relationship between an individual's fishing days and site availability, which is measured as the sum of acres of fishable water (for four different kinds of fishing), weighted by the travel cost from each site (or collection of sites) to the individual's residence. This is converted to a demand function by adding a price term to the weights and using the estimated relationship to determine changes in visitation as a function of the price. In the next step they remove from the available fishable waters all sites where pH has fallen below 5 in measurements made since 1976, according to surveys of Adirondack lakes made since 1976. A new demand curve is calculated, and the economic losses due to acidification are estimated by the area between the two curves.

This analysis is not very useful for making estimates of external costs, although in fairness to the authors it should be noted that this was not their purpose. The analysis of Mullen and Menz has been vigorously criticized by Shaw (1989), who argues that their demand curve is not consistently derived from economic theory and is not really a demand curve at all. However, we think this argument is of secondary importance in evaluating the use of Mullen and Menz for purposes of making external cost estimates. Far more important are the authors' failure to make a linkage back to emissions and their inattention to the sunk cost problem. (1) There is no observed connection between physical damages and recreation behavior. Mullen and Menz assume a decline in recreation visits is associated with acidification; they do not observe it. Of the lakes removed from the supply of fishable water, it does not appear from their article that they can assert that these lakes are not being fished today or that they were being fished prior to 1976. (2) Mullen and Menz value the damages that they believe have already occurred to Adirondack lakes. As explained above, a far more useful concept is the valuation of lakes that would not become acidic if emissions were reduced.

Violette (1985) applies two models, a travel cost model with site characteristics and a simpler participation model, to fishing sites in the Adirondack Mountains of New York. This method only considers use values, although Violette notes that the nonuse values may exceed the use values. Acid rain was assumed to affect both the number of sites available for fishing and the characteristics of the sites. Only lakes are included in the analysis. Sites were characterized by the number of lakes they contained with certain characteristics, for instance acres of cold water, and two-story or warm water lakes. Site characteristics were obtained from the Adirondack Lake and Pond Survey. The economic damages were calculated by changing the characteristics of the sites, for instance by changing the fishable acres of cold water lakes. The characteristics did not include catch rates. For the fishermen, Violette uses the same data set as Mullen and Menz, the New York Angler's Survey for 1976-77. The survey was mailed to a 3 percent sample of fishermen licensed in New York State. It asked questions on fishing activities, expenditures, preferences, attitudes and opinions, and participant background. Violette designed the model to yield an upper-bound estimate for damages. For instance, he did not take substitutability of fishing sites into account. The estimates of damages from the travel cost model ($0.8 to $11.6 million) and the participation model ($1.7 to $10.5 million) are about the same.

Like Mullen and Menz, Violette's work appears to us to be interesting and competently done. However it is not useful for estimation of external cost because it too does not link his estimates of economic damages either to acid deposition in the region or to emissions. In addition, the Lake and Pond Survey is not a very comprehensive or up-to-date data set. Not all lakes and ponds are surveyed each year or necessarily within the last 20 years. Data on pH existed for only 35% of measured surface area, and information on alkalinity was available for only 52%. This lack of information is a problem since what the Lake and Pond Survey records as the state of the lake may have no relationship to its actual state at the time anglers were making a recreation decision.

Morey and Shaw, using the 1976-77 New York Anglers Survey — the same data as Violette and Mullen and Menz — estimate a share model for seven lakes or sets of lakes in the Adirondacks and for eight varieties of sport fish. Each fisherman allocates a fixed recreational budget to alternative sites, and the model estimates the effect of site characteristics on shares. The site characteristics Morey and Shaw consider are fishable acreage and average catch rate for the individual's first and second most preferred species at the site. Morey and Shaw estimate the willingness to pay for a 25% increase in catch rate per season at $8.68 per fisherman; for a 50 percent increase, $15.61.

Morey and Shaw did not link acidity to fish populations or fish populations to catch rates, so the study is only useful as a demonstration of the sensitivity of benefit estimates to catch rates. Because there is no link between physical and economic damages, the study does not in and of itself produce useable results for environmental costing. Once such links are available, however, this study may become quite valuable despite its limitations. One such limitation is the assumption of a fixed recreation budget. This is bound to underestimate benefits of improvements, owing to substitution between fishing and other activities. However, the effect is not likely to be large. The approach also assumes an exogenous total number of recreation trips.

Welle (1985), calculates existence values and use values for the environmental quality of lakes in Minnesota, which may be affected by acid rain.[4] About 1,000 Minnesota residents were asked how much they would be willing to pay to prevent declines in the environmental quality of Minnesota lakes from acid rain. The changes in environmental quality were presented as

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[4]NAPAP, p. 6-34.

movements on an "environmental quality ladder." In addition, they were asked to characterize themselves as users or nonusers, and the bids of nonusers were characterized as existence values by Welle. When including protest bids of $0, the mean bids for nonusers ranged from $30 to $36 depending on the degree of damage, and for certain users the bids were $91 to $109. Excluding protest bids, the mean nonuser bid was $57 for both moderate and severe effects; the mean certain user bids were $102 for moderate effects, and $124 for severe effects.[5] The range of damages was unspecified in NAPAP's summary of the report. NAPAP described the study as limited in terms of the population and the scope of the effects of acid deposition to which they can be applied.[6] In addition, the questions asked in this study were only loosely tied to theory, so the existence values calculated may not be near the true existence values.

Navrud's (1989) study of willingness to pay of households in Norway for incremental improvements in freshwater fish populations calculated median nonuse values of $12 to $36 per fish per household per year. The author asked respondents to indicate the maximum amount of money they would pay for improvements from liming, and to divide their total bid into use, option, and existence and bequest values. The improvements were equal to the expected effects of 30%, 50%, and 70% reductions in sulphur emissions in Europe, although the empirical basis for this linkage is not discussed, nor are any literature citations provided. Median WTP for the 30%-equivalent reduction was 100 to 300 Kroner, depending on starting bid (i.e., the experiment suffered from mild starting-point bias). This translates into a range of $16 to $48 at the exchange rate in effect in April 1988, when the survey was conducted.[7] Respondents reported 12 percent of WTP to be recreational value, 12 percent option value, and 76 percent existence value.

Assuming Americans have the same preferences as Norwegians, it would seem that these results can be used in environmental costing applications in the United States. However, two vital pieces of information are still needed. First, we need to know how many people should be included in the population valuing the resource. Second, we still need the "transfer coefficient" relating changes in emissions to changes in water quality. The link between water quality improvements and the 30, 50, and 70 percent emission reductions assumed by Navrud are not justified in the paper, and even if they can be justified they relate only to European, not American, experience. Corresponding emission reductions in the U.S. are likely to be quite different.

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[5] Welle, p. 180.

[6] NAPAP, p. 6-34.

[7] Purchasing power parity would provide a more meaningful comparison but is not as readily available.

REFERENCES

Bockstael, N. E., K. E. McConnell, and I. Strand. *Measuring the Demand for Environmental Improvement,* Institute for Environmental Studies, Urbana, IL.

Bockstael, N. E., W. M. Hanemann, and C. L. Kling (1987). "Estimating the Value of Water Quality Improvements in a Recreational Demand Framework," *Water Resour. Res.* **23**(5), 951–960, (May).

Bockstael, N. E., K. E. McConnell, and I. E. Strand (1988). *Benefits from Improvements in Chesapeake Bay Water Quality,* Report for EPA under Cooperative Agreement CR-811043-01-0 with the University of Maryland, College Park, MD.

Bockstael, N. E., K. E. McConnell, and I. E. Strand (1989). "A Random Utility Model for Sportfishing: Some Preliminary Results for Florida," *Mar. Resour. Econ.* **6**(3), 245–260.

Bouwes, N. W., Sr., and R. Schneider (1979). "Procedures in Estimating Benefits of Water Quality Change," *Am. J. Agricu. Econ.* **61**(3) 535–539, (August).

Brookshire, D. S., L. S. Eubanks, and R. D. Rowe (1977). "The Impact of Coal Development on Wildlife: An Economic Analysis," paper given at Fifth National Conference on Energy and the Environment in Cincinnati, OH, (November 3).

Brown, G., Jr., and R. Mendelsohn (1984). "The Hedonic Travel Cost Method," *Rev. Econ. Stat.* **66**(3), 427–433, (August).

Carson, R. T., and R. C. Mitchell (1988). "The Value of Clean Water: The Public's Willingness to Pay for Boatable, Fishable and Swimmable Quality Water," Discussion paper, Department of Economics, University of California, San Diego, (February).

Caulkins, P. P., R. C. Bishop, and N. W. Bouwes (1986). "The Travel Cost Model for Lake Recreation: A Comparison of Two Methods for Incorporating Site Quality and Substitution Effects," *Am. J. Agric. Econ.* **68**(2), 291–297.

Desvousages, W. H., and V. A. Skahen (1987). *Techniques to Measure Damages to Natural Resources,* Final Report to CERCLA 301 Task Force, U.S. Department of the Interior, (June).

Englin, J. E. et al. (1991). *Valuation of Damages to Recreational Trout Fishing in the Upper Northeast Due to Acidic Deposition,* Report Prepared for the National Acidic Precipitation Assessment Program under a Related Services Agreement with the U.S. Department of Energy, (January).

Feenberg, D., and E. S. Mills (1980). *Measuring the Benefits of Water Pollution Abatement,* Academic Press, New York.

Fletcher, J. J., W. L. Adamowicz, and T. Graham-Tomasi (1990). "The Travel Cost Model of Recreation Demand: Theoretical and Empirical Issues," *Leisure Sci.* **12,** 119–147.

Gramlich, F. W. (1977). "The Demand for Clean Water: The Case of the Charles River," *Natl. Tax J.,* **30,** 183–194, (June).

Johnson, N. S., and R. M. Adams (1988). "Benefits of Increased Streamflow: The Case of the John Day River Steelhead Fishery," *Water Resour. Res.* **24,** 1839–1845, (November).

Jones, C. A., and Y. D. Sung (1991). *Valuation of Environmental Quality at Michigan Recreational Fishing Sites: Methodological Issues and Policy Applications,* Draft Final Report #EPA Contract No. CR-816247-01-2, School of Natural Resources and Economics Department, University of Michigan, (July).

McCarthy, P. S., R. Tay, and J. J. Fletcher (1991). *Estimating the Value of Water Quality Improvements from a Fully Discrete Model of Recreational Fishing,* Report #1001, Institute for Research in the Behavioral, Economic, and Management Sciences, Krannert Graduate School of Management, Purdue University.

McConnell, K. E., I. E. Strand, and L. Blake-Hedges (1991). "Random Utility Models of Recreational Fishing: Catching Fish With a Poisson Process," paper given at European Association of Environmental and Resource Economists (EAERE) in Stockholm, (June).

Milon, J. W. (1988). "A Nested Demand Share Model of Artificial Marine Habitat Choice by Sport Anglers," *Mar. Resour. Econ.* (5) 191–214.

Mitchell, R. C., and R. T. Carson (1989). Using Surveys to Value Public Goods: The Contingent Valuation Method Resources for the Future, Washington, D.C.

Morey, E. R., R. D. Rowe, and M. Watson (1991). *An Extended Discrete-Choice Model of Atlantic Salmon Fishing: With Theoretical and Empirical Comparisons to Standard Travel-Cost Models,* Report #91-7, Department of Economics, University of Colorado, Boulder.

Morey, E. R., and W. D. Shaw (1988). "An Economic Model to Assess the Impact of Acid Rain: A Characteristic Approach to Estimating the Demand for and Benefits from Recreational Fishing," in *Advances in Applied Microeconomic Theory,* ed. V. K. Smith and A. D. Witte, JAI Press Inc., Greenwich, CT.

Morey, E. R., W. D. Shaw, and R. D. Rowe (1991). "A Discrete-Choice Model of Recreational Participation, Site Choice and Activity Valuation When Complete Trip Data Are Not Available," *J. Environ. Econ. Manage.* **20,** 181–201.

Mullen, J. K., and F. C. Menz (1985). "The Effect of Acidification Damages on the Economic Value of the Adirondack Fishery to New York Anglers," *Am. J. Agric. Econ.* **67**(1), 112–119, (February).

National Economic Research Associates, Inc. (1990). "Benefits of the 1989 Air Quality Management Plan for the South Coast Air Basin," prepared for the California Council of Environment and Economic Balance, (March).

Navrud, S. (1989). "Estimating Social Benefits of Environmental Improvements from Reduced Acid Depositions: A Contingent Valuation Survey," in *Valuation Methods and Policy Making in Environmental Economics,* ed. H. Folmer and E. van Ierland, Elsevier, Amsterdam.

Parsons, G. R. (1991). "The Participation Decision in a Random Utility Model of Recreation," paper given at European Association of Environmental and Resource Economists (EAERE) in Stockholm, (June 10–14).

Parsons, G., and M. J. Kealy (1988). "Measuring the Benefits of Water Quality Improvements: A Preliminary Report Using Wisconsin Survey Data," Report #E.P.A. Cooperative Agreement #CR-815427-01-0, Unpublished paper, (November 30).

Parsons, G. R., and M. J. Kealy (1990). "Measuring Water Quality Benefits Using a Random Utility Model of Lake Recreation in Wisconsin, " Report #EPA Cooperative Agreement CR-815427-01-0, Unpublished paper, (February).

RCG/Hagler, Bailly Inc. (1991). "Valuation of Other Externalities: Air Toxics, Water Consumption, Wastewater and Land Use," Final Report prepared for New England Power Service Company, (October).

Rowe, R. D., A. M. Michelsen, E. R. Morey (1989). "Fishing for Atlantic Salmon in Maine: An Investigation into Angler Activity and Management Options," RCG/Hagler, Bailly Inc., Final draft prepared for Mr. Fred Ayer, Bangor Hydro-Electric Company, Bangor, ME, (September).

Shaw, D. W. (1989). "Valuing the Effect of Acidification Damages on the Adirondack Fishery: Comment," *American Journal of Agricultural Economics*, pp. 217-220, (February).

Smith, V. K. (1989). "Taking Stock of Progress with Travel Cost Recreation Demand Methods: Theory Implementation," *Marine Resource Economics*, vol. 6, pp. 279-310.

Smith, V. K., W. H. Desvousges, and M. P. McGivney (1983). "Estimating Water Quality Benefits: An Econometric Analysis," *Southern Economic Journal*, vol. 50, no. 2, pp. 422-437, (October).

Smith, V. K., and W. H. Desvousges (1986). *Measuring Water Quality Benefits* (Boston: Kluwer-Nijhoff).

Smith, V. K., and Y. Kaoru (1990). "Signals or Noise: Explaining the Variation in Recreation Benefit Estimates," American Journal of Agricultural Economics, vol. 72, pp. 419-433, (May).

Smith, V. K., and R. B. Palmquist (1988).

Smith, V. K., R. B. Palmquist, and P. Jakus (1990). "Combining Farrell Frontier and Hedonic Travel Cost Models for Valuing Estuarine Quality," Working Paper Second revision, (November).

Violette, D. M. (1986). "A Model Estimating the Economic Impacts of Current Levels of Acidification on Recreational Fishing in the Adirondack Mountains," Report #EPA-230-12-86-021, Energy and Resource Consultants, Inc., Report prepared for the U.S. Environmental Protection Agency, (September).

Walsh, R. G., D. M. Johnson, and J. R. McKean (1988). "Review of Outdoor Recreation Economic Demand Studies with Nonmarket Benefit Estimates, 1968-1988," (June).

Ward, F. A., and J. B. Loomis (1986). "The Travel Cost Demand Model as an Environmental Policy Assessment Tool: A Review of Literature," *Western Journal of Agricultural Economics*, vol. 11, no. 2, pp. 164-178.

Welle, P. (1985). Potential Economic Impacts of Acid Rain in Minnesota: The Minnesota Acid Rain Survey (Department of Economics, Bemidji State University, Bemidji, Minnesota: unpublished manuscript).

Yardas, D. et al. (1984). Directory of Environmental Asset Data Bases and Valuation Studies (Washington, D.C.: Resources for the Future).