United States Environmental Protection Agency

Office of Health and Ecological Effects
Washington DC 20460

EPA-600/5-78-010
June 1978

Research and Development

EPA

The Recreation Benefits of Water Quality Improvements

Analysis of Day Trips in an Urban Setting

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the SOCIOECONOMIC ENVIRONMENTAL STUDIES series. This series includes research on environmental management, economic analysis, ecological impacts, comprehensive planning and forecasting, and analysis methodologies included are tools for determining varying impacts of alternative policies, analyses of environmental planning techniques at the regional, state, and local levels; and approaches to measuring environmental quality perceptions, as well as analysis of ecological and economic impacts of environmental protection measures. Such topics as urban form, industrial mix, growth policies, control, and organizational structure are discussed in terms of optimal environmental performance. These interdisciplinary studies and systems analyses are presented in forms varying from quantitative relational analyses to management and policy-oriented reports.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

DISCLAIMER

This report has been reviewed by the Office of Health and Ecological Effects, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. This report is available for purchase from the National Technical Information Service, P. O. Box 1553, Springfield, Virginia 22161. The order number is PB257719.

ABSTRACT

Considerable past work has attempted to estimate the recreational benefits which might accrue from water quality improvements. The theoretical underpinnings of this work, however, are becoming increasingly suspect. This report explores demand models, new to recreation analysis, which are based on site characteristics and individual preferences to estimate benefit measured by consumer's surplus.

The empirical findings of this study are based on a structured survey of 467 representative households in the Boston SMSA. Our focus was specifically day trips to a system of Boston area beaches, but considerable additional data on willingness-to-pay, substitution between sites and activities, water quality perception and general recreation behavior was developed as well. The reader will find an extensive review of the post-war literature on recreation economics and water quality benefits.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

EPA-600/5-78-010

June, 1978

THE RECREATION BENEFITS OF WATER QUALITY IMPROVEMENT: ANALYSIS OF DAY TRIPS IN AN URBAN SETTING

by

Clark S. Binkley and W. Michael Hanemann

EPA Contract No. 68-01-2282

Project Officer
Dr. Dennis Tihansky

OFFICE OF HEALTH AND ECOLOGICAL EFFECTS
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

I. INTRODUCTION AND SUMMARY

Recent years have seen a substantial increase in water-based recreation at the same time the nation's rivers and lakes are becoming seriously degraded. In response to the increasing water pollution, Public Law 92-500, the 1972 Amendments to the Federal Water Pollution Control Act was enacted. This law established as a national goal "water quality which provides for the protection and propogation of fish, shellfish and wildlife, and provides for recreation in and on the water..." To help meet this objective, $18 billion has been appropriated for municipal treatment works, and consumer price increases from 1-5% are expected to support the required industrial treatment. The Act represents one of the largest public works programs ever instituted in the United States.

Objectives

This study is an inquiry into how water quality affects the recreation objectives of the Act. While national estimates of the recreation benefits stemming from water quality improvement could help evaluate and administer the nation's water pollution control program, such estimates were not the objective of this project.*

Our purpose is more limited. The principal objective was to advance the methodology for estimating the recreation benefits of water quality enhancement. To further this objective, data on the recreation habits of.a sample of 467 Boston area households was collected in the course of the project.

---

*One author [1] suggests over three-quarters of all water quality benefits lie in recreation.

NOTE: Throughout this report references are cited by number corresponding to alphabetical chapter bibliographies. A general bibliography is presented in Appendix IV.

The research also explores some of the fringes of recreation economics as well. We examine the importance of factors such as setting, facilities and maintenance in site choice. The distinction between benefits from water quality as a merit good are drawn and to a lesser extent quantified. Recreationists' perception of water quality is compared with objective measures of water quality and we investigate the potential for reducing the many dimensions which define "water quality" to a smaller number of composite measures.

Methods in Brief

Three general phases complete the study. The first concentrated on reviewing the recreation literature, and developing the theory of multi-site demand models. Based on the models selected for testing, a survey instrument was prepared, pre-tested and revised. A set of fresh and salt water sites within a one day visit from the Boston SMSA (about 50 miles) was delimited at this point in the project. The sites were chosen to represent most of the daily recreation trips, and to be close substitutes in terms of the activities available.

Data collection comprised the second phase. First, beach and water quality characteristics for the system of sites were compiled. From on-site visits, a beach quality catalog was completed by the research team and water samples were taken and analyzed. During December, the questionnaire was administered to a representative sample of 467 Boston SMSA households.* Nonresponse was eliminated by random replacement (Section IV. 3 details this procedure). Some respondents choose not to answer certain questions, so the "no answer" response was analysed separately for each questionnaire item.

---

*Originally the survey was to be conducted the first week in September, immediately after the Labor Gay closing of the outdoor recreation "season." Clearance by OMB of the survey instrument took much longer than expected, which necessitated the late starting date. Details of the sample design, and a discussion of the biases which may have been introduced by the delay are contained in Chapter IV.

The last phase of the project involved extensive statistical analysis of the survey data. First, the household characteristics were tabulated to check for possible, obvious biases in the sample--none were found. Then direct questions, concerning response to water quality changes were analyzed. Next, simple tabulations of visits, activities, and willingness-to-pay were made. At the same time, a factor analysis of water quality parameters was performed to examine the grouping of the variables across sites and develop composite water quality indices. These in hand, we examined the correlation between perceived water quality and actual water quality. The third step in the analysis involved estimating (via multiple regression) the determinants of willingness-to-pay and recreation behavior. Finally, two multi-site models were specified and estimated.

Outline of the Report

Seven more chapters complete the main body of this report. The next chapter deals with some important background issues--the definition and measurement of recreation activities and recreation benefits. Five measures of recreation benefits are reviewed and four are rejected. We choose to focus on a benefit measure based on consumer surplus and demand analysis and its correlary in survey research, willingness-to-pay. The chapter reviews the major post-war literature on demand analysis applied to recreation research, and codifies this research into a consistent theoretical framework.

Chapter III presents the theory of multiple site models and describes the problems of empirically estimating these models and retrieving consumer surplus measures from their parameters. It also reviews two previous multiple site models found in the economics literature.

Chapter IV focuses on the mechanics of the study. It describes how the network of sites was constructed, and reviews the characteristics of the system. The water quality parameters used in the study are described and justified, and a factor analysis reduction of the water quality variables is explored. This part of the report closes with a discussion of the household survey and a comparison of the sample with Boston SMSA population.

The principle empirical findings of the study are presented in Chapters V, VI and VII. Chapter V first analyzes the response to the direct questions concerning the determinants of recreation behavior and finds that water quality is not among the most important determinants of either site choice or demand. Chapter V continues to examine the accuracy of subjective ratings of water quality: to a large degree, public perceptions of water quality do not match the objective measurements.

Chapter VI considers willingness-to-pay: its magnitude, variation across subgroups of the sample and determinants. Despite the finding of Chapter V that recreationists neither seem to consider water quality in site choice, nor are able to perceive objective water quality, respondents of all income groups, races and educational levels are willing to pay between $20 and $26 per family per year for water quality maintenance and improvements. For the Boston SMSA, this may represent from $17 to $28 million per year.

Empirical estimation of multiple site recreation demand models is the subject of Chapter VII. After reviewing the data and aggregate determinants of recreation behavior, an "abstract site" model is estimated. Water quality seems to affect site choice but not the number of visits once a site is chosen. Because this model is not directly grounded in utility theory, retrieving consumer measures from its parameters is not possible. A second multiple site model which has this property is specified, but attempts to estimate it were constrained by the project budget.

Four appendices complete the report:

Appendix I: Site Facility Inventory Form
Appendix II: Water Quality Sampling
Appendix III: The Survey Instrument
Appendix IV: General Bibliography.

CITED REFERENCES

1. Department of the Interior, Federal Water Pollution Control Administration, "Delaware Estuary Comprehensive Study: Preliminary Report and Findings," July 1966, Chapter 6.

II. RECREATION AND MEASURES OF ITS BENEFITS

"The greatest gift is the power to estimate correctly the value of things."

Francois de la Rochefaucauld
Maxims, No. 224. Cited in
Resources [28].

The problem of "estimating correctly" the value of recreation benefits, probably unknown to Rochefoucauld when he penned this statement, requires three distinct steps:

(1) an exact definition of "recreation;"

(2) a metric for quantifying the recreation activities; and

(3) a transformation of the quantity of recreation into dollar terms.

Each of these steps must further be relevant to the particular problems of estimating benefits from water quality enhancement.

This chapter clarifies each of these three parts of benefit quantification to form a suitable background for the methodological and empirical chapters which follow. The first section below delimits the recreation experience, and discusses the recreation activities relevant to water quality improvements. The second section develops measures to help quantify the recreation experience. The last section reviews the metrics available for transforming recreation experience into benefit measures.

1. The Recreation Experience

Recreation benefits can be delimited in the context of Jordening's [16] taxonomy of water pollution abatement benefits. He lists four categories:

(1) human health;

(2) production;

(3) aesthetic; and

(4) ecological.

Our interest lies in the third category. According to the taxonomy, this category includes water-based and water-oriented recreation, property values and general aesthetic appreciation of water. Our focus is limited to water-based and water-oriented activities.*

Specific activity and duration define the types of recreation to be considered under this research. Outdoor recreational activities can be divided into three types:

(1) those which depend on the existence of water (water-based);

(2) those which may be enhanced by proximity to water (water-enhanced); and

(3) all others.

Our concern is with the first two. Table II-1 presents a participation analysis for these types of activities. Because of the importance of water quality characteristics to water-based recreation, these were the primary focus of the research. However, gross levels of water pollution may affect the enjoyment of water-enhanced activities, so picnicking, walking for pleasure and bicycling were included in the analysis. Camping and hunting were eliminated because, as explained below, their duration is typically longer than these other activities.

This list of activities does not complete the specification of recreation under study. The duration of the recreation experience must be addressed. Clawson and Knetsch [7] divide the recreation experience into five parts: (1) anticipation; (2) travel to the site; (3) on-site experiences; (4) travel from the site; and (5) recollection.

---

*Property value changes are often used as a measure of benefits, but then direct recreation and aesthetics are confused, and possibly double counted. Section II.3, below, considers other empirica1 and theoretic shortcomings of the property value approach.

Table II-1

Water-Related Outdoor Recreation Activities

Activity[1]	1970 % Population Participating[2]	Number of Recreation Days x 10^6	(% of total)[2]
Water-Based			
Swimming	46	1722	(14.2)
Fishing (fresh & salt water)	29	562	(4.5)
Boating (including canoeing, sailing. waterskiing)	24	422	(3.5)
Subtotal	--	2706	(22.3)
Water-Enhanced			
Picnicking	49	542	(4.5)
Walking for pleasure (including hiking, nature walks)	48	2235	(18.4)
Bicycling			
Camping	21	397	(3.3)
Hunting	12	217	(1.8)
Subtotal	--	3391	(28.0)
Total Water-Related	--	6097	(50.3)
Total All Outdoor Recreation	--	12,126	(100.0)

SOURCE: (1) Following N.L. Nemerow, H. Sumitano, & R.C. Faro, [24].

(2) Bureau of Outdoor Recreation, [5].

The experience itself (Phases 2-4) is taken to be as the recreation activity. This approach is consistent with past studies which include the cost of travel as part of the price of recreation.

The content of the on-site portion of the recreation activity constitutes the major component of the recreation activity. In order to derive appropriate benefit measures, it is important to understand clearly the content of this phase, as many previous studies confuse the purpose of the on-site recreational activity. Fishing provides a good example of this confusion. The utility of fishing is not necessarily related to the number of fish caught. Benefit measures based on the market value of fish or increased angling success may not reflect the qualities sought in a fishing experience.* A noted outdoor writer, Ernest Schwiebert [29] describes the experience:

> "Many satisfying things are to be found along trout water, and on hard pressed streams they help compensate for lack of fish . . . (the angler) remembers not only the fish taken or lost but also the little things along the stream. I remember the scores of ducks and geese on a Yellowstone pond, the intense blue of the Wyoming sky on those crisp September mornings and the doe and fawn that crossed a Boardman riffle at twilight in Michigan... A scoreless evening in the Catskills was saved by the balmy pine scented wind that swept down the Valley just at dusk. All of these things mean as much as the fishing itself."

---

*Studies using these and other benefit measures are reviewed in Section II.3, below.

2. Quantifying the Recreation Experience

Traditional metrics for quantifying the magnitude of a recreation experience are the user-day* or visit.** Theoretically at least, the number of days per visit and the number of visits must be ascertained simultaneously to derive user-days. Travel costs represent a fixed cost of the activity, and must be amortized over a sufficiently large number of days of the activity for the marginal value of the activity to exceed its cost.

The anticipation phase of the recreation experience offers a method for separating the interactions between the number of visits and the duration of the visit. Essentially three broad classes of recreational activities exist: day trips, weekend trips (two day or three with Monday holidays), and longer vacation trips. These differ in terms of the associated anticipation required, and hence may be considered as essentially distinct although possibly similar, classes of recreation. Then the unit of recreational activity is defined separately for each class of recreation. For day trips the unit is, equivalently, the number of trips or the number of days. For weekend trips the appropriate unit is the number of trips. For longer, vacation-related, recreation activities, the number of user-days should be examined.

---

*Defined by D.E. Hawkins & B.S. Tindall, [15], as (page 2), "The presence of one or more persons on lands or.waters, generally recognized as providing outdoor recreation, for continuous, intermittent or simultaneous periods of time totalling twelve hours."

**Defined by Bureau of Outdoor Recreation [6], as (pages 1-4), "A visit by one individual to a recreation development or area for recreation purposes during a reasonable portion or all of a 24-hour period. It is assumed that the average person participates in 2.5 activities during an average visit to a recreational area. Therefore, 2.5 activity occasions equal one recreation day."

We chose to focus on one day trips. This focus eliminates the theoretic quandary and empirical difficulties of estimating simultaneously the number and duration of visits. The possible travel distance for one-day trips conveniently establishes a universe of sites for sampling and survey. These low anticipation level recreation activities will tend to eliminate any cultural differences in the desire or ability to plan. Day trips from the Boston Area offer suitable variability in water quality and site characteristics to assess the recreational benefits of water quality enhancement. This limitation permits careful analysis of urban water quality problems where the recreation benefits of water pollution abatement appear to be greatest.

The major liability in this approach is the elimination of certain wilderness settings where the sensitivity of demand to water quality may be large. This limitation of the study necessitated dropping camping and hunting, together comprising about 5% of total recreation days, from the research.

Our empirical analysis, therefore, relies on visits as the principal measure of the amount of recreation. The specific definition of "visits" used in this analysis is discussed in Section IV.4 below.

3. The Monetary Value of the Recreation Experience

The post-war literature on recreation benefit measures offers six alternative approaches for transforming the recreation demand into dollar values:

(1) gross expenditure;
(2) market value of fishing;
(3) income multiplier;
(4) property values;
(5) willingness-to-pay interview; and
(6) demand function (consumer surplus).

This section of the report reviews these methods and concludes by arguing that consumer surplus estimates derived from demand functions are the most appropriate measure for estimating recreation benefits. The chapters below use this measure, and its survey research equivalent--willingness-to-pay--to estimate recreation benefits of water quality improvements.

The Gross Expenditure Method

Much of the early literature, particularly, favored this approach, whereby the benefits of recreation activity are measures by the total costs incurred per recreationist, including travel and on-site costs. The justification for this approach is that these costs must represent at least a lower bound to the value which the recreationist places on the activity for otherwise, if it was worth less than these costs to him, he would not undertake it. This argument is valid as far as it goes, but it does not go far enough. By ignoring consumers' surplus, the gross expenditure method underestimates the value to the recreationist of his activities. The understatement of benefits is serious because, when it comes to calculating the net benefits of providing recreation facilities, the only net benefits are the transfer payment component of costs, which may be zero even for projects which yield positive net benefits when the latter are correctly measured. The gross expenditure approach also leads to the well-known paradoxes that, when the elasticity of demand is equal to or less than unity, an increase in the quantity of recreation activity leads to a reduction in benefit as measured by gross expenditure, which is contrary to economic intuition. Note also that the use of the gross expenditure approach begs the question of how to predict recreation activity at a site.

Market Value of Fish

Crutchfield [8] argues the value of a sport fishery equals to the market value of the fish it produced. This work incited of a plethora of studies in agricultural and forestry experimental stations throughout the country to estimate the market value trout, salmon, bass, pickerel, pike, walleyes and so on. The principal shortcomings of this method is that it excludes the benefits of the recreation experience which are not related to filled keels. The most obvious demonstration of this omission is the extra money and time the angler expends beyond that required to obtain the fish from the market.

A related methodology, explored principally by Stevens [30 & 31] and Stovener [32], relates the benefits of water quality enhancement to angler success. This procedure relaxes the assumption that the value of the experience equals the market value of the fish caught, but still insists that the value is proportional to the number of fish caught. Where water quality improvements lead to step changes in the type of fishing, the number of fish caught of the preferred type may be significant. But this is an effect of shifting the demand curves, not moving along it. The most important step changes occur where water quality improvements lead to: (1) establishment of sport fisheries where previously no fishing existed, (2) replacement of carp and other coarse fish by bass and other warmwater species, and (3) introduction of salmonoid habitat.

The Income Multiplier Method

In some studies it is quite common to find an estimate of the increase in local income and production induced by an expansion in recreation activity, usually calculated via a local input-output matrix. (Recent examples are Reiling [28] , and Stoevener [32]). However, these estimates can be misleading. The existence of indirect benefits depends largely on local conditions. The method also assumes that there are locally underutilized resources (i.e., the shadow price of the activity or commodity is zero). If the resources used as inputs to the increased local production would otherwise have been fully employed, there is no net gain in the flow of goods and services available to society, merely a transfer from one location to another. These estimates of induced local income growth are valid only insofar as the regional distribution of income is a separate component of the objective function, and long run federal policies designed to encourage regional development are at least arguable.

The Property Value Method

This technique is widely used although, in our opinion, it suffers from certain fundamental conceptual flaws. The pioneering studies were done by Knetsch [17], also David [10 & 11], Berger [21], Darling [9], and Dornbusch [14]. Almost all of these studies apply the "cross-section" model of land value-benefit assessment; however, the Dornbusch study applies a "time series" model. The analytical issue can be seen most clearly by considering the cross-section model, which we discuss first.

The central concept in this approach is the "rent-gradient function" which expresses rent or property value at each location as a function of its distance from a central feature, in this case a water body. It is a well-documented empirical fact that, at least within a certain radius, this function has a negative slope i.e., land values are higher nearer to the water's edge. But what inference can be drawn from these data?

First, we mention some well-known objections to the land value method: it omits the benefits accruing to residents outside the area, and there may be some double-counting if estimates of recreation benefits obtained by this technique are added to estimates obtained by some other technique, such as willingness-to-pay interviews, a common practice (Berger, [21], Darling [9], Dornbusch [14]). However, the objection which we emphasize is that the land value method represents an illegitimate application of partial equilibrium analysis.

Our argument is in two steps:

(i) As usually conducted, the land value method of analysis is not an accurate measure of the change in land values because it ignores the impact on rents outside the vicinity of the area. The conventional analysis proceeds as follows (for the case of *ex post facto* analysis of a change in water quality). One observes that land values in the vicinity of the water body are higher than those at some distance from it, and that they decline with the distance. One calculates the aggregate differential in land values within some (often arbitrary) radius of the water body, over the level of land values outside that radius, and uses this differential as a measure of the benefits from the change in water quality. This would be a reasonable procedure on the assumption that (a) land values in the vicinity of the water body were at approximately the same level prior to the change as the level of rents observed outside the vicinity of the water-body after the change, and (b) land values outside the vicinity of the water-body were approximately the same before the change as after the change. It is very plausible that the second assumption is false. (Berger [21] for example, recognizes this, but proceeds to ignore it.)

Intuitively, one would expect land outside the vicinity of the water-body to become relatively less attractive after the change in water quality and, therefore, to fall in price. This assumes a fixed population of residents in the overall area. In practice, this assumption might be violated because of population increase. If the population of the overall urban area grew exogenously (i.e., from natural causes) the growth in the demand for housing might keep rents outside the vicinity of the water-body at their pre-quality change level. But clearly, this is an irrelevant phenomenon and the appropriate datum for measuring the benefits of the quality change is the pattern of rents which would have occurred in the absence of the population increase. If the population increase is endogenous (i.e., it is due solely to the water quality change which causes a flow of immigrants to the urban area), then it may be that rents outside the vicinity of the water body are stabilized at their pre-quality change levels and the total rent differential measured in the manner described above is an accurate index of the change in land values _within a general equilibrium setting_. However, we doubt whether the hypothesis of endogenous population growth is applicable to most of the pollution abatement situations studied-in the literature.

In the context of cross-section studies, the rent-equation is misleading for analogous reasons; rents may fall in areas outside of the environmentally improved region and, in consequence, rise less in that region than the regression equation predicts. The circumstances in which this will happen can be described more rigorously in the context of a theoretical model of location and rent determination which is outside the scope of this study.

The Dornbusch methodology is slightly different, but it suffers from analogous defects. In that study the change in property values in areas where water quality has improved is regressed on distance from the site and it is shown that the increase is greater close to the site. But, in order for this finding to be meaningful, it would have to be shown that the increase in land values would not have occurred anyway even without the improvement in site quality, say, because of an exogenous change in population or income. In other words, the Dornbusch study does not show how much of the increase is due to the change in water quality. (One way to do this would be to undertake a similar study of the change in property values at sites whose water quality had not changed and to use these as a control group.) Moreover, the Dornbusch study does not consider whether property values have fallen, or grown less rapidly than would otherwise have happened, at sites outside the vicinity of the water body.

This first argument is quite widely recognized. Our second point is more often overlooked

(ii) Even assuming that one could accurately measure the change in equilibrium rent gradients of all points in the area occasioned by the change in water quality, this still would provide no basis for measuring the social value of the improvement in environmental quality. This can best be seen by considering the following hypothetical, but not unreasonable, example. Consider a community of 100 persons living in a town which contains, at one end, a polluted lake, and, at the other, a flat plain. There is space for 100 homes both on the lakeshore and on the plain but, since the lake is polluted, everyone prefers to live on the plain. Land rents on the plain are $100 per acre (or per dwelling--it makes no difference); on the lakeshore rents are only $10 per acre, since no one likes to live there. Now the quality of water in the lake is drastically improved and everybody wishes to live on the lakeshore. Everybody moves to the lakeshore, nobody lives on the plain and it so happend (there is no reason why this could not happen) that rents are now $100 per acre on the lakeshore and only $10 per acre on the plain.

The end result is that after the quality change there is no net change in total rent payments. Yet we would certainly wish to argue that there has been an increase in social welfare. (This can be proved by revealed preference arguments: people would not have moved home if they were not thereby better off.) Thus, it is seen that the change in aggregate rent payments, even when full allowance is made for rent changes outside the environmentally improved area, provide no indication of the change in social welfare. The reason why this is so is identical to the reason why gross expenditure does not provide an adequate measure of the social value of consumption (i.e., willingness-to-pay). In both contexts the omission of consumers' surplus understates benefits. Furthermore, in the present context, where there are shifts in the demand curve, as well as in the supply curve, the change in expenditure bears <u>absolutely no relation to</u> the change in the area under the demand curve. Without knowing the demand curve explicitly one can infer nothing from data on the change in equilibrium price and quantity.

Strotz [33] has recommended measuring the social benefit from environmental quality improvements by summing the <u>absolute</u> values of changes in rents at each point. However, it can be shown that this result derives from the peculiar assumption of his model and has no general validity. Also Lindsay [20] has recently attempted to prove that the aggregate change in land values is an adequate measure of social benefit of environmental quality changes, using a linear programming assignment model. However, the proof is based on certain quite limited assumptions and is not generally valid.

The Willingness-to-Pay Interview Method

This technique was first applied by Davis [12], and subsequently, by Knetsch and Davis [19], Berger [21], Dornbusch [14], and Brown and Hammack [3], and others. In principal, this technique is conceptually sound; however, its empirical value depends entirely on the method of application and the degree of confidence that one can have in the veracity (and accuracy) of interviewer responses. Knetsch and David [24] cite reasons for believing that respondents may both overstate and understate their true willingness-to-pay.

Since the method offers a correlate to consumer surplus derived from demand function, willingness-to-pay questions were implemented and analyzed from the survey research effort.

The Demand Function Approach

Hotelling [23] first suggested this approach in 1949 in a now famous letter to A.E. Demeray, then Associate Director to the National Park Service. During the post-war bidding for chunks of an expanding federal budget, the park service decided a "monetary evaluation" of park service facilities might both assist their management and expand their budget. The park service asked ten of the nation's leading social scientists and economists to comment on the feasibility of such a study. The reviews were mixed and mostly forgotten, but Hotelling drew on the work of Jules Dupuit, an 18th century French engineer, who derived formulae for estimating the public benefits of bridges, roads and canals, to suggest:

"Let concentric zones be defined around each park so that the cost of travel to the park from all points in one of these zones is approximately constant. The persons entering the park in a year, or a suitably chosen sample of them, are to be listed according to the zone from which they come. The fact that they come means that the service of the park is at least worth the cost, and this cost can probably be estimated with fair accuracy. If we assume that the benefits are the same no matter what the distance, we have, for those living near the park, a consumers' surplus consisting of the differences in transportation costs. The comparison of the cost of coming from a zone with the number of people who do come from it, together with a count of the population of the zone, enables us to plot one point for each zone on a demand curve for the service of the park. By a judicious process of fitting it should be possible to get a good enough approximation to this demand curve to provide, through integration, a measure of the consumers' surplus resulting from the availability of the park. It is this consumers' surplus (calculated by the above process with deduction for the cost of operating the park) which measures the benefits to the public in the particular year. This, of course, might be capitalized to give a capital value for the park, or the annual measure of benefit might be compared directly with the estimated annual benefits on the hypothesis that the park area was used for some alternate purpose."

The demand function approach has since been implemented somewhat inaccurately by Trice and Wood [34], and authoratively by Clawson and Knetsch [7]. Subsequently, it has been employed by Lerner [19], Ullman and Volk [35], Pankey and Johnston [25], Dearinger [13], and Brown [4], and extended by Merewitz [22], Stevens [30 & 31], Boyet and Tolley [2]. All of these formulations have been in the context of the demand for a single site. This approach may be summarized in the following equation:

$$V_i = F(P_i, Y_i) \qquad \ldots (1)$$

where V_i is the number of visits made to a recreation site by individual i (or by the inhabitants of county i), P_i is the cost of reaching the site (including travel cost) for individual i (or for a representative resident of county i) and Y_i is a scalar or vector of socioeconomic variables describing individual i (or describing the residents of county i including, usually, the county's population). In some early versions of the model, price was not entered as a variable but instead distance was used as a surrogate. Stevens [30 & 31] extended this model by adding an index of site quality to the explanatory variables. The particular index which he chose, angling success per day, is, as shown above, oddly an indirect measure of site quality.

Generally, demand is estimated for a single site without consideration for other sites, or all sites visited by the sample population are combined, and a single equation is estimated. The latter approach is essentially a "participation study" and is beyond the scope of this report. The former approach suffers from a significant short-coming, namely the so-called price dominance criteria.

The conventional procedure is to allocate recreation demand among some new site and the existing alternative sites according to a price dominance. Let P_i by the cost to residents of county i of visiting the old sites, and P_i'' the cost of the new site. The implicit criterion is that (i) if $P_i'' > P_i'$, nobody from location i attends the new site while (ii) if $P_i'' < P_i'$ everybody from that place visits the new site, the total volume of attendance being $V_i'' = F(P_i'', Y_i)$. In case (i), there is the same volume of recreation as before the.change, namely $V_i' = F(P_i', Y)$, and it is concentrated exclusively at the old sites. There is no economic gain from the quality change for the residents of the county. In case

(ii) nobody attends the old sites and the economic gain consists of the change in expenditures plus the change in consumers' surplus associated with the change in prices from P_i' to P_i''

This analysis can be justified in two ways: (1) if the new site and the old sites offer exactly the same bundle of characteristics and are identical in every way except for price/distance, then the price dominance criterion should be valid; and (2) if the new site offers a somewhat different bundle of characteristics from those offered by the old sites, in other ways besides price/distance, then the use of the price dominance criterion involves an assumption that recreationists choices are made only on the basis of price and are independent of other site characteristics.

This empirical hypothesis was not substantiated. It was tested by estimating appropriate demand functions for individual sites with other site characteristics besides price included among the explanatory variables. Once these models have been estimated, the hypothesis becomes a null hypothesis that non-price related coefficients are zero. As seen in Chapter 5, this is not the case.

One way around these difficulties is to estimate simultaneously demand functions for a system of competing sites which form the universe of sites visited by the sample population. Substitutions between sites are then explicitly estimated. Although certain conceptual and empirical difficulties arise with these models this is essentially the approach taken here. The handful of recreation studies which employ this technique, and a theoretical development of an improved multi-site model are contained in Chapter III, below.

Having the demand equation, three procedures have been used to estimate benefits, and two of these are incorrect. The most simple is the dollar value of a user day. This is used by the federal government in water resource project evaluation but omits the consumer surplus enjoyed by some users.

The second way of estimating benefits calculates the revenue which could be gained by a non-discriminating monopolist. But, of course, only a discriminating monopolist can price away all of the "willingness-to-pay" for a good, so the result is inaccurate in a manner similar to the first approach.

Consumer surplus measures the total willingness-to-pay for the recreation activity. If the prevailing price is $5 per unit, and a certain individual is just indifferent to consumption at a price of $15, he enjoys a consumer surplus of $10. Ignoring income effects, consumers' surplus equals the revenue which could be obtained by a discriminating monopolist. In 1949, Hotelling pointed out this fact, but it has not been considered by most recreation economists. Consumer surplus is the theoretically correct measure of benefit, and is the one used in this study.

One further note on benefit measurement from demand equations is appropriate. Total benefit can be measured as the area under the demand curve up to the prevailing price. If the good in question was traded in a competitive market, the costs (producer revenue) could be subtracted to estimate net benefits. However, recreation is not such a good and the public sectors' market share position depresses the private market and prices. Hence the costs are not the appropriate ones to consider. Basically, the problem comes down to determining the costs, both institutional and economic, required to achieve both adequate water quality for recreation, and increased recreation itself. (As seen below, the costs of additional facilities needed for recreation may be large.) These costs could then be weighed against the benefits to select the appropriate public policy. However, these costs, as are the benefits, are highly sensitive to local conditions. Therefore, neither net benefit calculations, nor nationwide benefit calculations are appropriate for the research at hand. Instead, this study focuses on total benefit measured by consumer surplus, and ignores the costs of providing that recreation.

CITED REFERENCES

1. A.J. Blackburn, "A Non-linear Model of the Demand for Travel," Chapter 8 in, R.E.Quandt (Ed.) The Demand for Travel: Theory and Measurement, Lexington, Mass.: D.C. Heath, 1970.

2. W.E. Boyet & G.S. Tolley, "Recreation Projection Based on Demand Analysis," Journal of Farm Economics #48 (Nov.-Dec. 1966): 984-1001.

3. Gardner Mallard Brown, Jr. & Judd Hammack, "A Preliminary Investigation of the Economics of Migratory Waterfowl," in, Krutilla (ed.), Natural Environment Studies in Theoretical and Applied Analysis, Baltimore: Johns Hopkins University Press, 1972.

4. W.G. Brown, E.N. Castle, & A Singh, An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fisheries, Corvallis: Oregon Agriculture Experiment Station, 1964.

5. Bureau of Outdoor Recreation, Department of the Interior, The 1970 Survey of Outdoor Recreation Activities, Preliminary Report, Washington, D-C.: GPO, February 1972.

6. Bureau of Outdoor Recreation, Department of the Interior, Water-Oriented Outdoor Recreation in the Lake Ontario Basin, Ann Arbor, Michigan: BOR. 1967.

7. M. Clawson & J. Knetsch, Economics of Outdoor Recreation. Baltimore: Johns' Hopkins University Press, 1966.

8. J.A. Crutchfield, "Valuation of Fishery Resources," Land Economics Vo. 38, No. 1 (May 1962): 145-154.

9. A.H. Darling, "Measuring Benefits Generated by Urban Water Parks," Land Economics (February 1973).

10. Elizabeth David, "Lakeshore Property Values: A Guide to Public Investment in Recreation," Water Resources Research Vol. 4, No. 4 (August 1968): 697-707.

11. Elizabeth David, "The Exploding Demand for Recreational Property," Land Economics Vol. 45 (May 1969): 206-217.

12. R.K. Davis, The Recreation Value of Northern Maine Woods, unpublished Ph.D. Thesis, Department of Economics, Harvard University, 1963.

13. John A. Dearinger, Esthetic and Recreational Potential of Small Naturalistic Streams Near Urban Areas, Research Report #l3, Lexington, Kentucky: Water Resources Research Institute, University of Kentucky, 1968.

14. D.M. Dornbush & S.M. Barrager, Benefit of Water Pollution on Property Values, prepared for the U.S. Environmental Protection Agency, San Francisco: David M. Dornbusch & Company, Inc., August 1, 1973.

15. D.E. Hawkins & B.S. Tindall, Recreation and Park Yearbook 1966, Washington, D-C.: Recreation and Park Association, 1966.

16. David L. Jordening, "State-of-the-Art: Estimating Benefits of Water Quality Enhancement," Office of Research & Monitoring, U.S. Environmental Protection Agency, Contract #68-01-0744.

17. J.L. Knetsch, "The Influence of Reservoir Projects on Land Values," Journal of Farm Economics, Vol. 46: 520-538.

18. J.L. Knetsch & R.K. Davis, "Comparisons of Methods for Recreation," in A.V. Kneese & S.C. Smith (eds.) Water Research, Baltimore: Johns Hopkins Press.

19. Lionel J. Lerner, "Quantitative Indices of Recreational Values," Water Resources and Economic Development of the West: Economics in Outdoor Recreational Policy, Report #11, Conference Proceedings of the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, jointly with the Western Farm Economics Association, University of Nevada, Reno, 1962, pp. 50-80.

20. John L. Lindsay & Richard A. Ogle, "Socioeconomic Patterns of Outdoor Recreation Use Near Urban Areas," Journal of Leisure Research Vol. 4 (1972).

21. Louis Berger, Incorporated, Methodology to Evaluate Socioeconomic Benefits of Urban Water Resources, prepared for the Office of Water Resources Research, U.S. Department of the Interior, East Orange, N.J.: Louis Berger, Inc., July 1971.

22. Leonard Merewitz, "Recreational Benefits of Water Resources Development," Water Resources Research Vol. 2, No. 4 (Fourth Quarter, 1966): 625-639.

23. National Park Service, U.S. Department of Interior, "The Economics of Public Recreation: An Economic Study of the Monetary Evaluation of Recreation in the National Parks," Land and Recreational Planning Division, Washington, D.C., 1949.

24. Nelson L. Nemerow & Hisashi Sumitomo, "Benefits of Water Quality Enhancement (Onondago Lake)," Water Pollution Control Research Series, 16110 DAJ 12/70, Washington, D.C.: EPA, Water Quality Office.

25. V. S. Pankey & W.E. Johnston, Analysis of Recreation Use of Selected Reservoirs in California, Contract Report #1, Plan Formulation and Evaluation Studies--Recreation, Sacramento: U.S. Army Corps of Engineers District, May 1969.

26. S.D. Reiling, K.C. Gibbs, & H.H. Stoevener, Economic Benefits from an Improvement in Water Quality, Socioeconomic Environmental Studies Series, Environmental Protection Agency, Washington, D-C.: GPO, January 1973.

27. Resources for the Future, Resources, No. 1.

28. Resources for the Future, Resources, No. 46

29. Ernest Schiebert, Matching the Hatch, New York: MacMillan, 1955.

30. Joe B. Stevens, "Recreational Benefits from Water Pollution Control," Water Resources Research Vol. 2, No. 2 (Second Quarter, 1966): 167-182.

31. Joe B. Stevens, "Recreation Benefits from Water Pollution Control: A Further Note on Benefit Evaluation," Water Resources Research Vol. 1, No. 1 (First Quarter, 1967): 63-64.

32. Herbert H. Stoevener, et al., Multi-Disciplinary Study of Water Quality Relationships: A Case Study of Yaquina Bay, Oregon, Special Report 348, Corvallis: Oregon State University, February 1972.

33. R.H. Strotz, "The Use of Land Rent Changes to Measure Welfare Benefits of Land Improvements," in The New Economics of Regulated Industries: Bate-Making in a Dynamic Economy, Los Angeles: Economics Research Center, Occidental College, 1968: 174-186.

34. A.H. Trice & S.E. Wood, "Measurement of Recreation Benefits," Land Economics Vol. 34, No. 3 (Aug. 1958): 195-207).

35.. Edward L. Ullman & Donald J. Volk, "An Operational Model for Predicting Reservoir Attendance and Benefit: Implications of a Location Approach to Water Recreation," Papers of Michigan Academy of Science, Arts and Letters 47 (1962): 473-484.

III. MULTIPLE SITE MODELS FOR RECREATION DEMAND

Multiple site demand models offer one way to eliminate the shortcomings of the more common single equation models reviewed above. This chapter surveys the existing literature on systems of demand equations for recreation sites and sets down some principles for developing alternative demand models. Some of these alternative models have been applied to our data on recreation behavior in the Boston area, and the results are described in Chapter VII; others impose extremely heavy computational requirements and for this reason were not estimated.

The basic objective here is to model the demand for a set of alternative recreation sites in such a way as to (i) allow for the possibility of inter-site substitution, (ii) make explicit the relationship between environmental quality conditions and inter-site demands, and (iii) permit the explicit calculation of consumer's surplus measures of benefits-from changes in site costs or environmental conditions. As the next section shows, these objectives have not been achieved by the existing multi-site models in the literature. Section 2 sketches some non-stochastic models which do meet the objectives. Finally, Section 3 discusses some stochastic choice models which could be used for this purpose, and which explicitly allow for the phenomenon of zero visitation rates for many of the sites as well.

1. The Multiple Site Demand Models in the Literature

To the best of our knowledge there have been only a handful of recreation studies which attempt to estimate simultaneously the demand for a network of competing recreation sites. These studies may be divided into two groups. The first group may be called allocation simulation studies, and the second, system demand models.

The goal of the first type of model is to simulate the allocation of recreationists among a set of alternative sites using some reasonable criterion, but one not necessarily based on a statistically validated behavioral model of recreation choices. For example, in one version of the Tadros-Kalter [10,11] model recreationists are allocated among alternative sites on the basis of a travel distance minimization subject to constraints on site capacity, time and money expended on travel, and exogenous zonal recreation demands. The model is solved using conventional linear programming techniques. In another version of the Tadros-Kalter model, the same constraints are used but the allocation criterion becomes one of maximizing visitor day satisfaction, measured by the sum of attendance at each site from each origin zone weighted by an index of the attractiveness of the site to recreationists originating in each zone. The attractiveness index turns out to be the available recreation area at each site divided by its distance to each origin. Hence the attractiveness maximization criterion is similar to the travel distance minimization criterion of the first model.

The Ellis model [5 & 6] assigns recreationists to alternative sites through a combination of travel cost/distance minimization and site attractiveness. Total attendance at each site is proportional to an index of its attractiveness. Subject to this constraint on total attendance, site attendance by zone of origin is determined by cost minimization using network theory techniques. The site attractiveness index is a weighted sum of sub-indices of site capacity, the quality of water resources at the site, and the quality of the site's scenic setting. The weighting of these sub-indices is not based on empirical estimates of behavioral choices but appears to derive at least partly from calibration studies designed to assure that the model provides a reasonable facimile of observed recreation patterns.

It must be emphasized that neither the Tadros-Kalter models nor the Ellis model can claim to be grounded in observed recreation behavior. Both the cost minimization criteria and site attractiveness indices employed are assumptions which, although plausible, were not validated by acceptable statistical techniques.

Finally, there is a recent paper by Baron and Scheckler [1] which, though formally different from the Ellis study in its use of network analysis, is a similar combination of travel distance minimization plus an allowance for the differential attractiveness of alternative sites. As in the Ellis study, this differential attractiveness index derives from ad hoc calibration procedures rather than a verifiable model of recreationists' choice behavior. None of these models, therefore, is of direct interest to us since we wish to use formal statistical procedures to estimate the behavioral relationships. In addition, none of these models is based on utility theory and, therefore, the apparatus of consumers' surplus analysis cannot be applied to derive benefit estimates.

Now consider two system demand models, both intended for statistical estimation and both at least tenuously related to utility maximization theory. These are the models of Burt and Brewer [3] and Cicchetti et al [4]. The two models are, in fact, virtually identical and differ only in the estimation techniques used to implement them. Both involve the estimation of a set of n equations (assuming n recreation sites):

$$\begin{aligned} x_{1t} &= f_1[P_{1t}, P_{2t} \ldots P_{nt}, Y_t] \\ &\vdots \\ x_{nt} &= f_n[P_{1t}, P_{2t} \ldots P_{nt}, Y_t] \end{aligned} \qquad \ldots \quad (1)$$

where x_{it} is the number of visits to site i by individual t, $(P_{1t} \ldots P_{nt})$ is a vector of the prices of the sites (travel costs, etc.) for this individual, and Y_t is a scalar or vector of such variables as his household income. The system (1) is a natural extension of the single site demand functions

$$\begin{aligned} x_{1t} &= f_1[P_{1t}, Y_t] \\ &\vdots \\ x_{nt} &= f_n[P_{nt}, Y_t] \end{aligned} \qquad \ldots \quad (2)$$

which were discussed in Chapter II.

The Burt-Brewer and Cicchetti et al implementations of (1) are somewhat unsatisfactory for the present study on two counts, one concerning the use of the model to obtain estimates of consumer's surplus and the other concerning the problem of how differing water quality conditions affect consumer's behavior. The first issue involves some technical aspects of the theory of consumer demand only summarized here. It is a fundamental theorem of consumer theory that if and only if a-set of demand functions such as (1) satisfy certain conditions on their first partial derivatives there exists a unique underlying utility function. Moreover, under these conditions, it is possible to define and calculate measures of consumers' surplus for price changes. The conditions to which we refer are that the cross-price derivatives of the compensated demand functions be equal. In terms of the ordinary demand functions--such as (1)--the conditions are that:

$$\frac{\partial x_i}{\partial P_j} + x_j \frac{\partial x_i}{\partial Y} = \frac{\partial x_j}{\partial P_i} + x_i \frac{\partial x_j}{\partial Y} \qquad \forall\ i,j. \qquad \ldots (3)$$

The conditions are sometimes, but mistakenly, taken to require that the cross-price derivatives of the ordinary function be equal--that is:

$$\frac{\partial x_i}{\partial P_j} = \frac{\partial x_j}{\partial P_i} \qquad \forall\ i,j \qquad \ldots (4)$$

This in fact is what Burt-Brewer and Cicchetti, et al both do although for different reasons. Burt-Brewer [3] require the cross price derivatives to be equal under the assumption that "income elasticities among the outdoor recreation commodities are relatively close in magnitude," an assumption they state but do not support or test (although it seems likely for their application). Note that these are the exact conditions when an unconstrained maximization problem is posed (Hotelling showed this in 1932). Hence if total expenditure on recreation is small relative to total income, then these may be good approximations to the exact conditions.

Cicchetti et al [4] analyze the integrability conditions in great detail. They find small income elasticities of demand for downhill skiing (a surprising result which they attribute to the use of income data aggregated to the county level), but that the cross price demand derivatives are not equal. They use a quasi-Bayesian approach to reconcile the two sets of price elasticities (prior information that the cross price terms were equal, sample information that they are not) and proceeds as though the integrability conditions were satisfied. Thus, they set out to estimate (1) as a set of linear functions in the variables $P_1 \ldots P_n$ and Y, and impose the constraint that the coefficient of P_j in the i^{th} equation be the same as the coefficient of P_i in the j^{th} equation.

Although it is erroneous, the condition (4) has a certain convenience in that it causes the integral of the area under the demand curves (1) between two price vectors to be path independent--in the same way that the condition (3) causes the integral of the area under the compensated demand curves to be path independent. However, this is of dubious value because the relevant area for measuring consumer's surplus is the area under the compensated demand function and not that under the ordinary demand curve. It is true that the latter area may be considered an approximation to the former but as we shall show in the next section, it is possible to adopt certain alternative specifications of (1) from which an exact measure of consumer's surplus can be obtained with relative ease.*

Note that when recreation demand is estimated separately from demand for all goods, the Y of equation (3) is total expenditures on recreation, not income. But neither Burt-Brewer nor Cicchetti et al estimate the cross elasticities of demand (between sites) with respect to total expenditures *or* recreation. Chapter VII returns to this point.

So far, the discussion has considered only exact measures of consumers' surplus. Willig [13] has shown that when the income (or in our case, recreation expenditure) is small, the errors in ignoring the cross elasticity term of (3) are also usually small. Rather than rely on this empirical serendipity, however, we choose to specify, in Chapter VI, a model where exact measures are possible.

---

*It would be possible to test this hypothesis using, for example, a likelihood ratio test, although neither Burt-Brewer nor Cicchetti et al bother to do this.

The second point concerning the Burt-Brewer and Cicchetti <u>et al</u> studies is less theoretical and is more directly concerned with the practical value for water quality analysis of the demand systems which they estimate. The equations in (1) do not contain environmental quality variables as explicit arguments. The fact that site conditions may differ and that this may influence recreationists' behavior is only acknowledged implicitly in these models. That is, if the sites do not differ, or if they differ but the differences have no influence on recreationists' behavior, then we would expect all the site demand functions to have the same own price coefficient and, presumably zero cross-price derivatives: in effect we are back to the single-equation general demand functions represented by equation (1) in Section II-3. Otherwise, if the coefficients of different equations are different, we may infer that this is because site conditions differ and that these differences affect recreationists' behavior, they are relatively unilluminating: they do not tell us which aspect of the site conditions has the most effect on recreation choices and whether this effect is large or small. They do not directly enable us to predict the consequences of changes in site conditions on recreation demand patterns, still less to measure the benefits of these changes in a theoretically rigorous manner. One way to achieve the first objective, if not the second, is to regress certain of the fitted coefficients--for example the own price conditions--on variables measuring site quality. Burt-Brewer and Cicchetti do not do this, but it is an eminently feasible procedure.* However, instead of doing this, we prefer to bring the environmental quality variables directly into the demand equations; in the next section we outline several methods for doing this.

---

*This procedure has been Followed in a different context by Parks & Barten [8] who were estimating a set of commodity demand equations separately for several countries. Parks & Barten wished to discover if consumer demand patterns were influences by demographic structure and they investigated this by regressing the coefficients of the fitted equations for each country on certain demographic variables.

2. System Demand Models--Nonstochastic Choice

We begin by elaborating on the remarks of the previous section that to obtain exact measures of consumers' surplus from the Burt-Brewer [3] or Cicchetti *et al* [4] type model a different specification of (1) which is more easily reconciled with the theory of consumer behavior must be adopted. It is true that there are relatively few analytical demand functions which automatically satisfy the conditions (3) and which, therefore, can be traced back to an underlying utility function. Nevertheless, there are some functions with this property and they have been used in studies of consumer behavior over the last decade with some success. Among the most convenient and widely used is the LINEAR EXPENDITURE SYSTEM, which actually was introduced by Stone [9] more than twenty years ago.

Before describing this model and showing how it can be used to model the demand for a set of recreation sites, it may be useful to review some basic elements of consumer demand theory. This will also enable us to clarify the distinction between the models discussed in this section and those to be discussed in the next section. Assume that the individual consumer has a utility function defined over his comsumptions of n commodities, $u(x_1 \ldots x_n)$ and that he arranges his purchases as though he were solving the constrained maximization problem:

$$\underset{x}{\text{maximize}} \quad u(x) \quad \text{subject to} \quad \Sigma P_i x_i = Y \qquad \ldots (5)$$
$$x_i \geq 0$$

The Kuhn-Tucker theory introduces the multiplier λ to derive the first-order conditions for the stationarily of (5) as

$$\partial u/\partial x_i - \lambda P_i \leq 0 \qquad i=1...n \qquad ... (6a)$$

$$\Sigma P_i x_i = Y \qquad ... (6b)$$

$$x_i \geq 0 \quad \lambda \geq 0 \qquad ... (6c)$$

$$x_i \cdot [\partial u/\partial x_i - \lambda P_i] = 0 \qquad i=1...n \qquad ... (6d)$$

The implication of (6d) is that if we knew that all n goods were always going to be consumed in some quantity the n demand functions could be obtained from the solution to the following equalities:

$$\partial u/\partial x_i - \lambda P_i = 0 \qquad i=1...n \qquad ... (7a)$$

$$\Sigma P_i x_i = Y \qquad ... (7b)$$

which are a subset of the equations in (6). Alternatively, if there were m>n goods, but we knew that the same (m-n) goods would never be consumed at any feasible prices and incomes, while the other n goods always would be consumed, then we could obtain the demand functions for the latter goods by solving (7); in effect we could ignore the prices of the (m-n) goods which are never consumed. In practice, as we shall see, neither of these assumptions is satisfied: by no means all of the sites are visited by each recreationist nor, on the other hand, it is not necessarily true to say that if a person is not visiting certain sites now then he would never visit them. However, since it is vastly simpler to derive a set of demand functions from (7) than from (6) we shall assume throughout this section that (7) is the relevant set of equations for deriving a system of demand functions from a specialized utility function. The next section presents some demand models which are explicitly based on (6).

Return to the linear expenditure system. If we take as the consumers' utility function the following specific formula

$$u(x) = \sum_{i=1}^{n} b_i \log(x_i - c_i) \qquad \ldots \; (8)$$

with $\Sigma b_i = 1$, and solve the equation corresponding to (7), we obtain the following demand functions

$$x_i = c_i - \frac{b_i}{P_i} Y - \sum_{1}^{n} c_j P_j \qquad i=1 \ldots n \qquad \ldots \; (9)$$

Direct differentiation of these equations will show that they satisfy condition (3). Moreover, an exact measure of the consumers' surplus when prices change from P_i^o to P_i' can easily be obtained from (8) and (9). It is given by:

$$C = \left[Y - \Sigma P_j^o c_j\right] \prod_{i=1}^{n} \left(\frac{P_i'}{P_i^o}\right)^{b_i} - \left[Y - \Sigma P_i' c_i\right] \qquad \ldots \; (10)$$

The utility function (8) is a simple translation of the Cobb-Douglas utility function.

$$u(x) = \Pi x_i^{b_i}, \quad \Sigma b_i = 1 \qquad \ldots \; (11)$$

The demand functions derived from the latter utility function are

$$x_i = \frac{b_i Y}{P_i} \qquad i=1 \ldots n \qquad \ldots \; (12)$$

Thus, (11) and (12) can be regarded as limiting forms of (8) and (9) when all the c_j's are zero. The effect of this restriction on the c_j's is that there are no cross-price terms in the demand functions for individual goods.

The problem to be resolved is how to generalize the equations for the utility function such as (8) and (11) to deal with product quality as well as consumption quantities. The solution proposed is to make the parameters of the utility function themselves a function of commodity characteristics. This, in turn, has the effect of making the parameters of the demand curves a function of commodity characteristics. To see how this works introduce a set of variables Z_{ik}, i=1...n, k=1...m, representing the amount of characteristic k available at site i. Then, starting with the utility function (11), we postulate:

$$u(x,Z) = \Pi x_i^{b_i}$$
$$b_i = f_i[Z_{i1},...Z_{im}] \quad ...\ (13)$$

The resulting demand functions are, of course, the same as (12), with the functions $f_i(\cdot)$ substituted for the b_i's. However, this model is computationally inconvenient because we have to impose the restriction that $\Sigma f_i=1$. In view of this, it is actually simpler if we work with the more general utility function (2) and make the c_i's functions of the commodity characteristics:

$$u(x,Z) = \Sigma b_i \log(x_i-c_i)$$
$$c_i = f_i[Z_{i1},...Z_{im}] \quad ...\ (14)$$

There is no theoretical basis for choosing a specific form of $f_i(\cdot)$; for example, we could have

$$c_i = W_{io} + \sum_k W_{ik} Z_{ik} \quad ...\ (15a)$$

or

$$c_i = W_{io} + \sum_k W_{ik} \log(z_{ik}), \quad ...\ (15b)$$

where $(W_{io}...W_{im})$ are unknown coefficients to be estimated along with b_i. However, it simplifies the computations greatly if we assume that

$$W_{ik} = W_k, \qquad i=1...n,\ k=1...m.$$

This assumption implies that, other things being equal, the effect of a change in a given characteristic--say turbidity--is the same for all sites. This does not necessarily mean that all sites are equally attractive, because site characteristics are likely to be different. Moveover, we have also left open the possibility that the b_i's and W_{io}'s are different across sites, so that even if all sites had exactly the same characteristics and the same prices, their demands could differ. With this assumption, the site demand functions implied by (14) and (15a) for the case of two characteristics are:

$$x_i = W_{io}+W_1Z_{i1}+W_2Z_{i2}-b_i\frac{Y}{P_i} - \sum_{j=1}^{n} b_iW_{jo}\frac{P_j}{P_i} - \sum_{j=1}^{n} b_iW_1Z_{j1}\frac{P_j}{P_i} - \sum_{j=1}^{n} b_iW_2Z_{j2}\frac{P_i}{P_i} \ \ldots$$

$$i=1\ldots n \qquad \ldots (16)$$

A similar set of demand functions would result if we used (15b) instead of (15a). The estimation of these systems of equations is discussed in Chapter VI.

3. Stochastic System Demand Models

There are several stochastic choice models available in the literature which could be used. For example, the multinomial logit model assumes that the individual selects one of n alternatives--in this case recreation sites--so as to maximize an explicit utility function.* The observed output of this process is an nxl vector with (n-1) zero elements corresponding to the rejected alternative and one element containing the value "1" corresponding to the alternative which is chosen. Blackburn [2] independently developed a slightly more general model in which the output is an (nx1) vector containing (n-1) zeros as before and, in the row corresponding to the chosen alternative, the number of times the preferred alternative is actually chosen (consumed).

Both these models are restricted to situations in which only one alternative is chosen, and there is reason to believe that is not the case with the choice of recreation sites. It is, therefore, interesting to enquire whether a general stochastic choice model can be written in which an arbitrary number out of n alternatives is selected. Such a model could be based on the full set of Kuhn-Tucker conditions for utility maximization given the previous section. The method used makes some of the parameters of the utility function (and hence the demand function1 stochastic variables. First, ignore the question of commodity quality, since it can be incorporated relatively easily along the same lines as in equations (15) above.

In order to allow for the case of zero consumption, the utility function (8) must be slightly altered to ensure a bounded derivative at the zero consumption point. As an example, the

---

*See Theil [12] and McFadden [7].

utility function could be

$$u(x) = \sum_{i=1}^{n} \tilde{b}_i \ln(1+x_i) \qquad \ldots (17)$$

where the $\tilde{b}_i$ are random variables, depending partly on the site characteristic z_{ik}. Then (6) and (17) imply that the probability of an observed individual consumption pattern in which, say, the individual visits only the first m sites, the frequency of visitation being V_i, i=1...m, while V_i=0, i=m+1...n, is given by:

$$\Pr \left\{ \tilde{b}_i \frac{\sum_{j=1}^{m} \tilde{b}_j}{Y + \sum_{j=1}^{m} P_j} \quad \text{for all } i=m+1\ldots n \right.$$

$$\left. \text{AND} \quad \frac{\tilde{b}_i}{\sum_{j=1}^{m} \tilde{b}_j} = \frac{(1+V_i)P_j}{Y + \sum_{j=1}^{m} P_j} \quad \text{for all } i=1\ldots m \right\} \qquad \ldots (18)$$

If a suitable distribution can be assumed for the b_i's, we can write down the likelihood function based on (18) in closed form and apply maximum likelihood estimation techniques. However, it is clear that with (at least) 29 alternative sites the maximization of this likelihood function will be computationally infeasible. Therefore, the empirical work in Chapter VII relies on the non-stochastic system demand models described in the previous section.

---

*The model would be feasible only with about 3-5 alternatives.

CITED REFERENCES

1. Mira Baron & Mordechai Scheckler, "Simultaneous Determination of Visits to a System of Outdoor Recreation Parks with Capacity Limitations," Regional and Urban Economics Vol. 3, No. 4 (1973): 327-359.

2. A. Blackburn, "A Non-linear Model of the Demand for Travel," Chapter 8 of The Demand for Travel: Theory and Measurement, R.E. Quandt, Lexington, Mass.: D.C. Heath, 1970.

3. Oscar Burt & Durward Brewer, "Estimation of Net Social Benefit from Outdoor Recreation," Econometrica Vol. 39, No. 5 (September 1971): 813-827.

4. Charles J. Cicchetti, A.C. Fisher & V. Kerry Smith, "An Economic Evaluation of a Generalized Consumer Surplus: The Mineral King Controversy," unpublished paper, Natural Environments Program, Resources for the Future, 1975.

5. J.B. Ellis, "A System Model for Recreational Travel in Ontario: A Progress Report," Ontario Joint Highway Research Program, Report No. RR126, Ontario, Canada: Department of Highways, July 1967.

6. J.B. Ellis & C.S. Van Doren, "A Comparative Evaluation of Gravity and System Theory Models for Statewide Recreation Travel Flow," Journal of Regional Science Vol. VI, No. 2 (1966).

7. D. McFadden, "Conditional Logit Analysis of Qualitative Choice Behavior," in P. Zarembka (ed.) Frontiers in Econometrics, Academic Press, 1974.

8. R.W. Parks & A.P. Barten, "A Cross-Country Comparison of the Effects of Prices, Income & Population Composition on Consumption Patterns," Economic Journal (September 1973).

9. Stone, The Measurement of Consumer's Expenditure and Behavior in the UK, 1820-1938, Vol. 1, Cambridge University Press, 1953.

10. M. Tadros & R.J. Kalter, "A Spatial Allocation Model for Projected Outdoor Recreation Demand: A Case Study of the Central New York Region," College of Agricultural Experiment Station, "Search" Series No. 1, Department of Agricultural Economics, January 1971.

11. M. Tadros & R.J. Kalter, "Spatial Allocation Model for Projected Water Based Recreation Demand," Water Resources Research Vol. 7, No. 4 (August 1971): 798-811.

12. H. Theil, "A Multinomial Extension of the Linear Logit Model," International Economic Review (October 1969).

13. R.D. Willig, "Welfare Analysis of Policies Affecting Prices and Products," Memorandum #153, Center for Research in Economic Growth, Stamford University, 1973.

IV. SITE AND HOUSEHOLD SAMPLE, SURVEY AND CHARACTERISTICS

Chapters II and III outlined our methodological approach for estimating the recreation benefits of water quality enhancement. This chapter describes the data used to implement these methodologies.

The data needed for these approaches includes:

(1) a network of recreation sites which are potential substitutes;

(2) data on the characteristics of the sites; and

(3) data on the number of visits by a representative individual to each of the sites.

A number of recreation studies were reviewed to obtain the requisite information from secondary material. These sources included:

- National Park Service
- Forest Service
- Bureau of Outdoor Recreation
- Corps of Engineers
- Bureau of Sports Fisheries and Wildlife
- Massachusetts Department of Natural Resources
- Boston Metropolitan District Commission
- Boston Redevelopment Authority
- Metropolitan Area Planning Council (Boston's Area A-95 agency)

None possessed the three requirements outlined above, so a data collection effort was mounted. This included:

- establishing a network of water-based recreation sites available for a one-day trip from the Boston SMSA;

- assembling water quality, cost and beach characteristics data on these sites; and
- surveying a representative sample of Boston SMSA households.

This chapter describes, in five parts, the data collection effort. First, a system of sites is presented. Then the site characteristics and water quality variables and data are discussed. This section includes a factor analysis designed to reduce the water quality variables to an analytically more manageable number. Next, the rationale and design of the household survey is presented. Finally, to set the stage for the empirical results contained in Chapters VI and VII, this chapter concludes with a discussion of alternate measures of attendance.

1. The Network of Sites

Delimitation of the geographic extent of the study is the initial step in defining a system of recreation sites for analysis. Ideally, all possible sites available for one-day trips from the Boston inner city would be included. Due to the lack of data on the recreational habits of Bostonians, a surrogate to visitation--distance--was arbitrarily employed to delimit the one-day trip region. This region is roughly bounded by the New Hampshire border to the north, the Cape Cod Canal to the sourth, Massachusetts Bay and the Atlantic Ocean to the east, and Lake Cochituate to the west. It is enclosed by a major circumferential highway, I-495, and lies within 40 miles of the Massachusetts State House.

Once the geographic extent of our study was defined it was necessary to inventory the recreation sites available in that area. One of the problems inherent in deriving an exhaustive water recreation survey from the Boston Metropolitan Area is the multiplicity of sites. Besides the ocean frontage, Boston is the locus of several rivers and their watersheds, and many natural lakes and ponds. Our first attempt at a water site inventory began with several good maps of the metropolitan area. It became apparent that the number of small, unmarked sites was large, and that we should direct our efforts elsewhere.

The Department of Natural Resources of the State of Massachusetts had conducted a state-wide open space survey in 1970* from which we culled the water-recreation sites for the towns within the study area. This inventory was supplemented by lists of the State of Massachusetts Metropolitan District Commission (MDC) beaches, beaches from the Trustees of Reservations, state parks and forests, and streams and ponds stocked by the Massachusetts Division of Fisheries and Game. This inventory included over 200 swimming sites, nearly 200 fishing sites, and about 70 boating sites for the metropolitan region. Table IV-1 presents the breakdown between types of sites.

Table IV-1

Analysis of Available Recreation Sites

Area	Number of:		Number of Sites Offering:	
	Towns	Sites	Swimming & Fishing	Boating
Inside Route 128	38	143	111	28
Remainder of Study Area	77	201	91	43
TOTAL	115	344	202	71

*Massachusetts Department of Natural Resources [13].

Such a large inventory presents several major problems for our methodology, however. The difficulty of analysis increases more than geometrically with the number of substitutable sites. In addition, the survey would be unwieldly with so many locations. Many of the sites are small, and used only by a very local constituent population; further, it is difficult to collect data on facilities, characteristics, and water quality from such a large number of sites. Because of these difficulties, the focus of our site inventory turned to a sample of sites in the study area which could account for a large proportion of the area's recreation. However, the site-specific visitation data required to delimit numerically the major sites is sparse. One source* was used for this purpose, and a set of eighteen major sites was developed. Our experience, however, suggested a number of important sites were not represented. The initial list was supplemented by major sites from the Massachusetts Department of Natural Resources open space inventory. This composite list was presented for review to a number of individuals and agencies familiar with and knowledgeable about recreation in Eastern Massachusetts. Reviewing agencies included:

Metropolitan District Commission
Metropolitan Area Planning Council
Massachusetts Department of Natural Resources

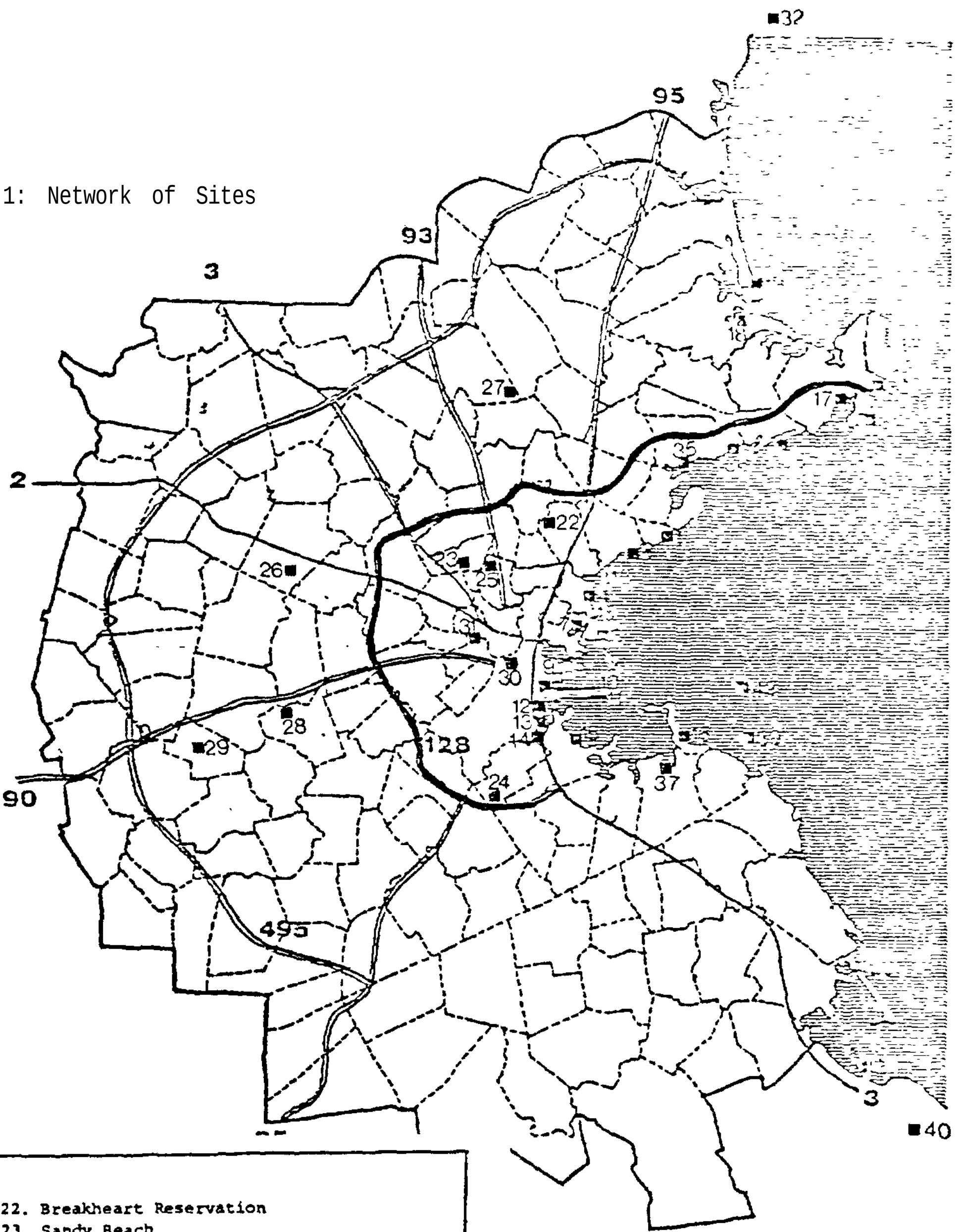
In addition, a private recreation planner with extensive experience in Eastern Massachusetts reviewed our list.

During the course of the survey, this list of 31 sites was supplemented by asking respondents what other sites they visited. Another 14 sites or generic places (i.e., Cape Cod Beaches, New Hampshire Lakes, etc.) were identified. The network of sites and the study area are depicted in Figure IV-1. These site numbers are used throughout the report to identify the sites.

---

*Metropolitan Area Planning Council [15]

Figure IV-1: Network of Sites



SCALE IN MILES

0 5 10 15 20

■ - recreation site

= - interstate highway

— - major US or Mass. highways

--- - town boundar

List of Sites

1. Kings Beach
2. Lynn Beach
3. Nahant Beach
4. Revere Beach
5. Short Beach
6. Winthrop Beach
7. Constitution Beach
8. Castle Island
9. Pleasure Bay
10. City Point
11. L & M Street Beaches
12. Carson Beach
13. Malibu Beach
14. Tenean Beach
15. Wollaston Beach
16. Nantasket Beach
17. Wingaersheek Beach
18. Crane's Beach
19. Plum Island
20. Duxbury Beach
21. White Horse Beach
22. Breakheart Reservation
23. Sandy Beach
24. Houghton's Pond
25. Wright's Pond
26. Walden Pond
27. Stearns Pond
28. Cochituate State Park
29. Hopkinton State Park
30. Esplanade/Storrow Lagoon
31. Charles River, between Weeks & Anderson Bridges
32. New Hampshire Beaches, Lakes & Parks
33. Good Harbor
34. Gloucester Beaches in General
35. Dane Street Beach
36. West Beach
37. Hingham Beach
38. Other North Shore Beaches
39. Other South Shore Beaches
40. Cape Cod Beaches
41. Lynch Park
42. Other Massachusetts Lakes & Ponds

The sites in this set are, with one exception (Crane's Beach, operated by the Trustees of Reservations and open to the public), public facilities. It is well-known by recreation management that the public provision of recreation facilities is subsidized, depresses the private market for recreation. For our analysis this is important only because the fees customarily paid are likely to be much lower than the marginal social benefits of the facility, and estimates of willingness-to-pay may, therefore, be biased downward. According to one study [13] of the 229,423 acres of recreation lands in Eastern Massachusetts, 46,551 acres, or 20.3%, are private. Private sites number 779 or 14.7% of the 5,318 sites in the region. Private ownership includes both profit and non-profit operations:

- private clubs
- Massachusetts Audubon Society
- Trustees of Reservations;
- Boy and Girl Scouts;
- YMCA and YWCA; and
- commercial recreation lands.

While there is significant incidence of private recreation in the area, not all of these operations are entirely supported from fees. Hence our estimates of willingness-to-pay may be understated.

2. Site Characteristic Variables

Site characteristics can be broadly divided into economic, beach quality related, and water quality related. Each of these groups are discussed separately below.

The site characteristics used in this study were culled out of the literature on recreation participation and demand. In particular, Myles [16], Aukerman [2], David [5], Holman & Bennet [10], and Gamble & Meglie [9], contributed to this effort. Throughout we have distinguished objective characteristics and perceived characteristics. Objective characteristics are those, like water temperature, which can be measured using known, accurate and reliable techniques. Perceived characteristics reflect how people believe the beach to be. The perception includes an assessment--possibly erroneous--of the objective characteristics, and a reaction to that assessment. No doubt, demand is more closely related to the perceived characteristics than the ones only a scientist can measure. And, in fact, the first step in our analysis tests whether or not perceived and objective characteristics mesh. Unless the two measures--objective and subjective--are collinear, inferences from the relationships between demand and objective water quality measures may be misleading.

The contrast between perceived and objective water quality has other interesting ramifications. Recall Clawson and Knetch's five phases of the recreation experience. Anticipation of a recreation experience sets the expectations for the site characteristics and activity content. Once on site, the perception of the site is matched against the anticipation, and this contrast forms the basis for recollection. In turn, that recollection, in large part, determines future anticipation of a similar experience and hence repeat demand. Equilibrium levels of demand should represent a reasonable matching of expectation and perception. Therefore, to the extent that only equilibrium demand is measured, inferences from objective measures to preferences will be valid.

Furthermore, any demand analysis can only address "iso-anticipation" activities. In other words, exogenous considerations--leisure time, family income, time of year, etc.--determine tradeoffs between day trips, weekend trips, and vacation trips, but within the anticipation classes, endogenous site characteristics, including travel cost and price, prevail. Secondly, demand surveys must be conducted in equilibrium conditions. Ideally, then, only users with prior knowledge of the site should be surveyed, perhaps only repeat users. Similarly, sites where relative changes in water quality have occurred should be omitted from the analysis. A brief investigation indicated that none of the sites in the sample had undergone notable changes in water quality during the last few years.

2.1 Economic Variables

These variables describe the costs incurred by the recreationist prior to the on-site phase of the activity. They include the costs of travel and entrance. Four variables were identified:

- Entrance/parking fee
- Travel time
- Travel cost
- Distance.

The first three of these were determined from the survey.

Entrance Fee: When your party goes to a beach you might have some expenses just to get onto the beach, such as parking or entrance fees. For each site, about how much are these expenses?

---

*Throughout the report, the particular question being analyzed is repeated in the main text to aid the reader. A copy of the complete survey instrument is contained in Appendix III.

Travel Time and Cost:

A. For each site you mentioned in Question 2 (A & B) above, how did you or your group get there?

a. walking
b. bicycle
c. automobile
d. bus
e. subway/streetcar
f. taxi
b. other ________

B. About how long does it take to get there that way? (in minutes)

C. How much does it cost to get there? If by bus or subway or taxi, how much is the roundtrip fare? If by auto, what was the price of tolls? (the total cost for the visiting group)

Distance: Distance was calculated as a straightline Euclidean distance between the respondent's location and the site. This was computed by plotting all the sample points and all the sites on a large scale map. A quarter inch grid was overlaid and the coordinates recorded. The distance from respondent i to site j was computed from the formula:

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

where: $(x,y)_i$ = Cartesian coordinates of respondent i

$(x,y)_j$ = Cartesian coordinates of site j

and then scaled to miles.

Actual road milages are the best measure of distance, but because of the large number of respondent-site combinations in relation to the project budget, those computations were not possible. An alternative is to scale straightline distances according to the size of the road grid. It is easy to show that on a uniform grid the average distance equals about 20% more than the straight-line distances. One could hypothesize a larger grid size as the distance from the center city increases, and scale the distance variable accordingly. Instead we chose to use, in the model specifications, the straightline distance squared as a surrogate for this phenomenon.

Table IV-2 presents the summary statistics for these variables.

Table IV-2

Economic Variables

Variable	Mean	Std. Dev.	Skewness	Kurtosis
Entrance/Parking Fee ($)	1.04	3.77	6.040	35.83
Travel Time (Minutes)	32.87	22.25	1.447	1.993
Travel Cost ($)	.65	1.10	2.441	4.897
Distance* (miles)	17.77	9.12	.557	-1.293

*This distance is the average distance from the sample points to the sites. It is not the distance traveled averaged over all individuals.

2.2 Beach Characteristic Variables

Four dimensions of beach quality were defined:

- setting:
- facilities;
- quality; and
- crowding.

Data on these characteristics were collected two ways. First, the sites known at the time of the survey were catalogued using the form contained in Appendix I. To reduce bias introduced by the personal perception of the researcher who visited the site, only two people were assigned this job. They inventoried together several beaches to insure comparable interpretations. Second, respondents were asked to rate the beach they attended most often according to beach quality, beach facilities and crowding. Quality and setting were lumped together because it was thought the two would not be distinguished by respondents.

Setting:

Setting was determined from the questionnaire in the following categories, in descending order toward less natural settings:

A. Surrounding Land Use

1. Natural
2. Agricultural
3. Low Density Residential (1 & 2 family homes)
4. High Density Residential (includes multi-family buildings)
5. Commercial
6. Industrial

Table IV-3 shows the distribution of these settings across sites.

Table IV-3

Site Setting

Setting	# of Sites	Percent
Natural	12	27.3
Agricultural	0	0
Low-Density Residential	13	29.5
High-Density Residential	1	2.6
Commercial	3	6.8
Industrial	3	6.8
Not Surveyed	12	27.3

Facilities:

Facilities--bathhouses, picnic tables, etc.--related to all water-oriented activities were inventoried. Initially we suspected sites could be distinguished according to activities available, but the facilities provided proved to be remarkably homogeneous across sites, so the objective measures of facilities were omitted from further analysis.

Of special interest to this study is our finding that facilities seem to be rather important to recreationists. Of 467 respondents, 24.5% mentioned the presence of either changing rooms or lifeguards as the most important determinant of characteristics toward their choice of site. Hence, if water quality is enhanced, additional capital and operating investments will be needed to obtain the potential recreational benefits. This point is further amplified by response to littering, pointed out below. Chapter V analyzes the results in greater detail.

Quality:

Objective measures of beach quality are difficult to define. Three were attempted. The first related to the physical description of the beach--composition, slope, nature of water bottom, amount of water movement. The second included measures of annoyance--presence of litter, natural debris, and flies. The third was an indirect measure of quality--the frequency of maintenance.

Data collection difficulties rendered these three measures inadequate for analytic purposes. The necessarily subjective judgements concerning beach topography were found to be inconsistent. The inventory was made on different days of the week, so the judgements concerning littering (and crowding) were not consistent cross-sectionally. Data on maintenance frequency was difficult to obtain and largely incomplete. Because of these difficulties, the analysis relies on perceived rather than objective quality ratings.

When questioned about the most important characteristic in choosing a site, the absence of litter was ranked first by 31.1% of all respondents. This factor appears to be the single most important factor in determining site preferences. The implications of this finding are twofold. First, maintenance must be provided at any new beaches opened due to water quality improvements. Second, from the narrow standpoint of public recreation policy, money might be more efficiently spent on maintenance of existing beaches rather than improving water quality at any beach.

Crowding:

Crowding is a subjective assessment of the size and temporal and spatial distribution of attendance in relationship to the area of the site. Two approaches were tried to measure objectively this variable. First, during the inventory, crowding at the sites was rated by the project staff. Second, we sought secondary data on attendance, particularly peak day attendance, to estimate crowding. Total average and peak attendance data were consistently unavailable for the sites. By and large, the agencies responsible for these sites neither collected data nor kept records on attendance or crowding. Because no systematic information on crowding was available, we were forced to rely on the respondent's crowding ratings. Because crowding is inherently a perceived characteristic, this may offer better statistical fits, but it begs the question of "explaining" perception.

2.3 Water Quality Variables*

Three main properties of water affect its suitability for recreational use: hygenic factors, aesthetic factors and features which indirectly influence nuisances. (The basic references for this discussion are National Academy of Sciences [17], and Environmental Protection Agency [8].) Table IV-4 summarizes the variables considered in this study and Table IV-5 presents the data for the sites. Note that two parameters, Biological Oxygen Demand (BOD) and Suspended Solids, which are commonly considered in water quality analyses, were omitted from this study. BOD was not determined because of the theoretical and practical invalidity of cross-sectional comparisons between ecosystems. Suspended Solids, commonly thought to be related in a non-linear fashion to fish productivity, were partly accounted in our turbidity measures. Note further, that observations are available for only 29 sites. These are the sites selected prior to the household survey. Constructing a comparable data series for the sites developed in the survey would not have been possible.

This section continues to describe the parameters selected and explains the rationale for their includion. Appendix II details the procedures used to measure the selected parameters.

*We are indebted to Dr. J.C. Morris, Cordon McKay Professor of Sanitary Chemistry, Harvard University, for assisting in identifying those water quality characteristics pertinent for study. Further assistance in delimiting these parameters was provided by Dr. Fraser Walsh and Dr. Alfred Ajami of Eco Control, Inc., in Cambridge, Massachusetts. Under a subcontract to USR&E, water quality samples were taken under the direction of Eco Control and analyzed by that organization.

Table IV-4

Water Quality Variables

Variable	Acronym	Units	Effect on Water Quality**
Oil or grease	OIL	mg/1	
Turbidity	Text	Jackson Turbidity Units	-
Color	COLOR	APHA Platinum Cobalt Standard	-
Odor*	--	Threshold Odor Number	-
pH	PH	pH	-
Alkalinity	ALK	mg/1 as calcium carbonate	-
Total Phosphorus	TPOS	mg/1	-
Nitrate	NITR	mg/1	-
Ammonia	AMMO	mg/1	-
Chemical Oxygen Demand	COD	mg/1	-
Temperature	TEMP	Degrees F	?
Fecal Coliform Bacteria	COLI	#/100 ml	-
Total Bacteria	TBAC	#/100 ml	-

*Odor was dropped from the analysis because all sites with the exception of Hopkinton State Park (#29) had no detectable odor.

**"+" means higher values are associated with better water quality, "-" means the opposite.

Table IV-5

Water Quality Data

Site No.	OIL	JTU	COLOR	ODOR	pH	ALK	TPOS	NITR	AMMO	COD	COLI	TBAC	TEMP
01	06.0	4	5	-	8.0	112	.03	-	.6	87	100	250	65.0
2	04.6	2	5	-	8.0	111	.04	-	.3	29	250	7500	64.0
03	09.0	4	4	-	8.1	111	.04	-	.6	57	1500	7500	65.0
04	05.8	1	3	-	8.0	101	.05	-	.6	32	100	2500	66.0
05	08.8	0	5	-	7.9	103	.06	-	.3	41	7500	20000	66.0
06	07.2	2	5	-	7.9	123	.04	-	.2	46	100	750	66.0
07	08.0	3	8	-	7.9	103	.09	.02	.2	34	100	1000	66.0
08	18.0	6	10	-	8.0	112	.06	-	.3	36	100	100	67.0
09	16.8	4	8	-	8.1	106	.06	.01	.4	34	100	1500	66.0
10	33.0	8	21	-	7.9	106	.15	.17	.3	35	500	1500	70.0
11	08.1	10	20	-	7.9	108	.09	.08	.2	81	250	2500	69.0
12	06.8	6	15	-	8.0	110	.10	.01	.3	62	2000	20000	68.0
13	12.2	3	5	-	7.9	106	.06	.01	.3	50	250	2000	68.0
14	9.4	16	16	-	7.9	105	.08	.04	.4	43	9000	25000	67.0
15	7.2	14	15	-	7.9	106	.17	.01	.4	35	17500	40000	65.0
16	19.4	4	8	-	8.1	116	.04	-	.2	-	2000	7500	64.0
17	5.6	0	3	-	8.0	108	.04	-	.2	26	100	100	68.0
18	4.4	0	3	-	8.0	108	.02	-	.2	31	100	100	62.0
19	10.8	0	2	-	8.1	110	.02	-	.1	56	100	100	60.0
20	4.2	6	3	-	8.0	109	.06	-	-	44	100	17500	65.0
21	3.2	5	5	-	7.9	114	.04	-	.2	44	100	1750	65.0
22	4.4	0	5	-	6.1	3	.04	.12	.5	7	4000	35000	69.0
23	3.6	6	16	-	7.7	43	.23	2.20	3.4	25	2000	45000	68.0
24	1.4	4	13	-	6.8	8	.09	.02	.6	13	250	3000	69.0
25	1.8	4	5	-	7.4	26	.09	-	1.0	26	100	12500	71.0
26	1.0	2	5	-	7.2	10	.02	-	.5	8	250	4000	70.0
27	10.2	14	18	-	7.0	10	.06	.02	.8	9	4500	13000	72.0
28	1.4	14	21	-	7.7	26	.05	-	.4	-	500	6000	70.0
29	22.6	23	18	1	6.7	10	.29	.17	.6	8	5000	22500	72.0
Mean	8.8	6	9	-	7.7	84	.08	.10	.5	34	2013	10350	67.0
Std.Dv	3.7	6	6	-	.5	43	.06	.41	.6	22	3790	12764	2.8
Skewness	1.4	1	1	-	-1.9	- 1	2.05	4.99	4.1	0	3	1	- .2
Kurtosis	1.4	1	-1	-	2.7	- 1	3.88	23.28	17.3	0	8	1	- .1

Hygenic Factors

Factors such as pathogen populations, concentrations of toxic substances, clarity, and other similar properties are included. They are most important for direct contact recreation, such as swimming, water-skiing and similar activities, but relate also to secondary contact recreation like fishing, boating and shellfishing. An important characteristic of many factors in this category is that they do not change the perceived desirability of the water and thus do not change utilization unless legal limits are prescribed.

Fecal coliform population counts and total bacteria counts were measured at each site. The possible presence of water-borne pathogenic organisms is deduced usually from the count of fecal coliform organisms, which are indicators of the fecal discharges of man or other mammals. This group of organisms normally does not multiply in the environment and tends to die out within about a month after discharge from the human or animal body.

Currently, proposed EPA maximum limits on fecal coliforms are 2000 per 100 ml average and a maximum of 4000 per 100 ml for waters judged suitable for general recreational use and about one-tenth this for waters designated for bathing or other contact recreation. Table IV-5 reveals that readings higher than these standards were found at several sites.

The presence of fecal coliforms or pathogenic bacteria or viruses does not produce any change in the appearance of the water and so tends not to alter acceptability by users unless legal action occurs or strong publicity is given to the potentially harmful condition of the water.

Standard sewage treatment will reduce fecal coliform counts in sewage by one or two orders of magnitude from about 10^8 per 100 ml. Chlorination of treated sewage will usually reduce the counts to less than recreational water maxima.

Because of lack of suitable monitoring methods and other important information, no viral limits are prescribed even though these agents may survive chlorination levels that will kill fecal coliforms. Shellfish will concentrate viruses from water and so waters to be used for the recreational taking of shellfish are more strictly controlled than other recreational waters.

Aesthetic Factors

These affect primarily the perceived desirability of the water by the recreational user. They are sensory properties, including color, turbidity, oil and grease content, odor and temperature. On occasion properties in this category may also occur in category (1) or (3). For a number of these properties the degradation in quality can be related to the intensity of the property as with color and odor, but this is not true for temperature, for example. Most of these qualities are relevant, in one way or another to both water-based and water-enhanced recreation.

The general appearance of a body of water is a strong factor in its acceptance for recreational uses. Besides properties of color, turbidity and floating plant growths, to be considered individually, the term includes the presence of settleable or of floating solids or oil matter. When these are from waste discharges, they are not only visually objectionable but have other adverse effects as well, such as coating the hulls of boats or the bodies of swimmers.

Settleable matter is obnoxious or deleterious because:

(1) if organic, it forms putrescible deposits that produce hydrogen sulfide and other noxious odorous substances during decomposition;

(2) if inorganic, it forms silt banks and tends to destroy breeding areas for benthal aquatic fauna, essential to fish life, and also egg-hatching areas for many species of fish.

The clarity or transparency of water is directly related to its use for bathing purposes. Drowning and other water hazards increase greatly when bathers cannot be seen underwater. The usual standard is a four-foot "Secchi-disk" transparency, but turbidity is also commonly measured in "Jackson Turbidity Units."

Color affects clarity to some degree, but most impairment of clarity is due to cloudiness or turbidity. Turbidity is characteristic of certain waste discharges, such as those carrying suspended clays or fibres, but my also be produced in the water by excessive growth of algae. This last factor is by far the most common one and is the primary basis for concern about discharges of phosphorus and nitrogen compounds.

High turbidity has also been found to have an adverse effect on fish populations, but at low levels, increased turbidity seems to increase fish yields. Attractiveness of water and its turbidity seem nearly inversely related: so this may be one Of the best properties with which to relate water quality and recreational use.

Industrial discharges of phenolic compounds, amines, or other odorous substances may produce directly objectionable odor situations in bodies of water. Secondly, obnoxious odors may arise from the anaerobic decomposition of organic sludge or benthal deposits. Finally, algal or other heavy plant growths may produce odors as part of their natural growth or during their bacterial decomposition after death.

Such odors may provide offensive conditions not only for those in the water or close to it, such as bathers and boaters, but also to picnickers, hikers and others attempting to use the water only as an attractive amenity.

Improvements in water quality on the basis of odor elimination may be expected to occur in three stages: (1) immediately, with the elimination of odorous waste chemicals; (2) with some delay with the reduction in algal growths; and (3) with considerable delay for the odors emanating from sludge deposits unless the body of water itself is treated. Many organic substances similar to those causing odors in water may also lead to tainting of fish flesh with corresponding restrictions on this sort of recreational use.

Increase in temperature affects water quality for recreational use in a number of ways: (1) it stimulates growth of algae and other aquatic plants, thus accentuating the conditions produced by such growth; (2) it may change the relative predominance of algal or plant species to less attractive forms; (3) it has adverse effects on fish populations: and (4) it may cause physiological disturbances in swimmers. The last factor is the basis of the EPA standard that recreational waters should not have temperatures exceeding $85^{\circ}F$ ($30^{\circ}C$).

The acid or basic reaction of water, pH, is directly related to recreational use for bathing, for waters with pH far from neutral may lead to eye irritation. In addition, pH values far from neutrality will give situations adverse to aquatic life. Accordingly, water generally suitable for recreational use should have pH 5.0 to 9.0, while acceptable bathing water should have pH 6.5 to 8.3, and deviations from neutrality (7) are a useful linear measure of this effect.

Indirect Nuisance Factors

There are two major subcategories of properties that indirectly bring about nuisance or an undesirable environment: algal nutrients that stimulate undesirable aquatic growths and substances that directly or indirectly have adverse effects on aquatic life, including fish. In this last subcategory are toxicants, oxygen-consuming substances, temperature, silt-forming materials and substances that cause tainting of fish flesh. Some of these were described under Aesthetic Factors above. As with aesthetic properties, the adverse effects here may discourage both water-based and water-enhanced activities.

Excessive growth of algae, particularly in lakes, ponds, pools and estuaries is a principal factor which impairs recreational use of water. Often it is also a principal manifestation of the intrusion of wastewater or polluting substances.

Algae require many elements and growth factors to achieve maximum growth rates and maximum total production. Among them are two forms of substance relatively scarce in most pristine waters, but abundant in domestic sewage and other wastewaters. These are combined nitrogen (ammonium ion, organic nitrogenous material, nitrite or nitrate) and phosphate. When degradation in water quality is the result of increased supply of these substances, treatment for their removal may bring about sharp improvement in water quality. Usually, it is phosphate that is the limiting material in inland waters; in estuaries and the open ocean, combined nitrogen tends to be more critical. The dry mass of algal material is 3 to 8%N and 0.2 to 0.8%P. The total amount of algal material that can be produced at any one time is thus dependent on the amounts of combined nitrogen and phosphate that are available.

No specific acceptability limits have been set for these nutrient substances, but acceptable limits of phosphorus for a situation where it is a limiting constituent for nuisance growth are 0.025 mg per liter of Phosphorus within lakes and reservoirs, 0.05 mg per liter at inlets to lakes and reservoirs, and 0.10 mg per liter in flowing streams.

There is no way to deal adequately in a brief presentation with the large numbers of substances, both inorganic and organic and including radioactive materials, that may find their way on occasion into natural waters and that may be inimical to recreation uses because of toxicity either to man or to some forms of aquatic life. Usually such substances are not directly detected by the user and so tend to inhibit recreational possibilities by proscription rather than by lessened seeming attractiveness. Occasions when any of these types of substances are determining factors in recreation use are rare enough except for catastrophic events--accidental spills or deliberate illegal dumpings--that they generally need not be considered individually in a first-order consideration of relation of water quality to recreational use.

2.4 Factor Analysis of Water Quality Variables

The potential for reducing the number of water quality variables was explored using a cross-sectional factor analysis. (A good reference to the general technique is in Rummel [20].) In addition to reducing the magnitude of the subsequent analytic tasks, this analysis promised a composite index of water quality.

Prior to initiating the analysis, we hypothesized certain relationships among the variables. First, the nutrient variables--

total phosphate (TPOS), organic nitrogen (NITR), and ammonia (AMMO)--would be highly intercorrelated. Similarly the two bacterial variables-- coliforms (COLI) and total bacteria (TBAC) would be correlated, and the two measures of acidity/alkalinity--squared deviations of pH from 7(pH) and alkalinity. Turbidity (JTU) and color (COLOR) were hypothesized to correlate as we'll.

Beyond these obvious relationships further speculation was difficult for reasons outlined in Section IV.2.3, above. Temperature (TEMP) was expected to correlate with bacteria counts, turbidity, and possibly the nutrient measures. Chemical oxygen demand could correlate with oil and grease (OIL), the bacteria measures and the nutrient measures.

The 29x12 data matrix transformed to standardized variables was factored using the SPSS (Statistical Package for the Social Sciences) Version 5.2 classical factor analysis routine. Four factors had eigenvalues greater than one (Table IV-6) and the factoring was stopped. The conventional varimax rotation performed.

Table IV-6
Eigenvalues of Inferred Factors

Factor	Eigenvalue	Percent of Variance
1	4.59685	49.5
2	1.84255	19.9
3	1.80303	19.4
4	1.03523	11.2

At this point let us note a criticism commonly levelled on factor analysis. The eigenvalues are a weighted combination of all water quality variables even though only a few are emphasized in each factor. In terms of standardized variates, the factor analysis accurately trades off the influence of different water quality measures. But management alternatives may not impact the different water quality measures in a standardized way, i.e., proportional to mean level, inversely proportional to the standard deviation. Thus, in a prescriptive analysis, some added computation would be required to use these factors as surrogates for direct water quality measures. However, since we do not simulate the response of recreationists to specified changes in water quality and certain sites, this difficulty does not arise.

The rotated factor matrix is shown in Table IV-7. It depicts both the composition of each variable as a linear function of the factors, and, since the factors are orthoganal, it shows the correlation matrix of factors and variables as well. This matrix tells us the composition of factors.

Factor 1 loads heavily on PH and ALK, as hypothesized. COD also has a substantial correlation, equal to .56, and TEMP has a large positive correlation (.74). This factor distinguishes fresh and salt water sites by its high loading on alkalinity.

Factor 2 accounts for the nutrient variable, loading heavily on NITR, AMMO, and TPOS. It also has a substantial correlation with TBAC. This could be expected because the source of these nutrients is principally domestic wastes, and because they are beneficial to bacterial growth as well. This agrument also suggests that a higher correlation with COLI would be expected.

The third factor represents the clarity measures--JTU and COLOR. OIL also loads heavily, possibly as a surrogate or suspended organic materials. TPOS and TEMP are both positively correlated, which might represent the influence of algal growth on turbidity and color.

Factor 4 is almost exclusively a bacteria factor, with loadings of .90 and .79 on COLI and TBAC, respectively.

Table IV-9 shows the factor score coefficients which represent the transformation between the standardized values of the variables to the factor scores for a particular observation (site). In other words, the cross product of the columns of this table with a row of the standardized data matrix yields the factor score for that site. These factor scores are presented in Table IV-9.

Table IV-7

Varimax Rotated Factor Matrix

	Factor 1	Factor 2	Factor 3	Factor 4
OIL	.19945	-.09860	.59208	-.07898
JTU	-.30753	-.01743	.75006	.36329
COLOR	-.31014	.15834	.76775	.17260
pH	.89853	-.12446	-.14773	-.04908
ALK	.97166	-.17796	.03848	-.08687
TPOS	-.20549	.45742	.64521	.31424
NITR	-.04033	.99361	.07668	.06023
AMMO	-.24947	.91755	-.01047	.08932
COD	.56333	-.04997	-.00028	-.09096
COLI	-.00870	-.04961	.21102	.90023
TBAC	-.17298	.49110	.06150	.79158
TEMP	.74402	.09180	.41616	-.04271

Table IV-8

Factor Score Coefficients

	Factor 1	Factor 2	Factor 3	Factor 4
OIL	-.10537	-.01658	-.05551	.08788
JTU	.02241	.11661	.36451	-.00152
COLOR	-.02258	-.26698	.24888	.06400
pH	.27239	.14010	.32193	-.27116
ALK	.95039	-.10043	.28964	.14454
TPOS	.11528	-.08479	.49527	-.11428
NITR	.11068	1.38445	.26472	-.52784
AMMO	.00819	-.20316	-.24286	.18315
COD	-.16040	.06872	-.12032	.01611
COLI	-.01242	.15560	.13901	.28402
TBAC	.02510	-.21013	-.49892	.89755
TEMP	.01702	.21583	.42160	-.31918

Table IV-9

Factor Scores by Site

Site Number	Factor 1	Factor 2	Factor 3	Factor 4
01	.330650	-.037110	-.602331	-.492970
02	.770742	-.357569	-.632318	-.032098
03	.671290	-.090507	-.476255	-.048942
04	.536167	-.150214	-.424191	-.583751
05	.344646	-.206782	-.846099	1.301178
06	.733737	-.119188	-.233960	-.549294
07	.455647	-.221862	.273409	-.686301
08	.584022	-.180872	.574992	-.715547
09	.636439	-.146644	.291845	-.696832
10	.299133	-.021942	2.052254	-.898088
11	.240946	-.033968	1.401489	-.811897
12	.609568	-.473277	.465519	.553688
13	.310409	.053247	.032738	-.687993
14	.450082	-.210344	.769322	1.717302
15	.707299	-.506396	.793623	3.468664
16	1.023437	-.395671	-.018591	-121545
17	.718979	.134167	.066118	-1.063389
18	.626749	-.275875	-1.001652	-.363595
19	.537515	-.213165	-1.289540	-.229208
20	.703423	-.158402	-.513387	.397690
21	.614024	-.125579	-.247239	-.448357
22	-1.515222	.127071	-1.747724	1.289062
23	-.016647	5.157724	.066998	-263602
24	-1.965580	-.463486	-.400823	-.556174
25	-1.517143	-.309996	-.834642	-.057191
26	-1.985935	-.066204	-1.220096	-.556484
27	-2.057007	-.309797	.265104	.432863
28	-1.197863	-.417920	.933337	-.599095
29	-1.649507	.020561	2.503201	.531601

2.5 Subjective Measures of Site Characteristics

The objective measures presented above were supplemented by perceived site characteristics from the household survey. Respondents were asked:

> For each site you visited would you please rate each of the following characteristics on a scale from 1-5. For this rating, 1 means bad, 2 means moderately bad, 3 is fair, 4 is moderately good, and 5 is good.
>
> A. Water temperature
> B. Water quality (clarity, color, weeds, odor, etc.)
> C. Beach facilities (availability)
> D. Beach quality (setting, maintenance)
> E. Crowding.

Summary statistics of these ratings, by site and in total, are shown in Table IV-10.

Table IV-10

Subjective Variables: Summary Statistics

Variable	Mean	Std. Dev.	Skewness	Kurtosis
Water Temperature Eating	2.656	.660	-.652	.607
Water Quality Bating	2.881	-929	.250	-.611
Beach Facilities Bating	2.703	.710	-.370	.112
Beach Quality Eating	3.207	.832	.592	.835
Crowding Eating	2.838	.799	-.427	.797

3. The Household Survey

As explained above, an extensive review of secondary information sources revealed none was adequate to estimate the demand and benefit models desired. The paucity of data indicated a survey was required to assemble the information necessary for the desired analyses. Several methods are available for obtaining that sort of information. First, structured interviews with recreationists could be held at a sample of sites in the network. This technique has been used in several previous studies of recreation demand;* it has the advantage of being very convenient to organize and relatively cheap. However, for our purposes, it is conceptually unsound. We wish to focus on the recreational preferences of a given population faced with a network of competing sites. We need to know how often a representative member of that population attends each of the different sites; we also need to know the preferences of those persons who do not visit any site. Thus, for our purpose, the relevant sample population is the population to which the network of sites is available, not the population of users of specific sites and alternatives.

Four types of population-oriented surveys are possible: personal, telephone, mail and diary. The telephone survey would have been used if the survey instrument had been brief (less than five minutes for the interview). The problem of telephone ownership bias is not important in a major metropolitan area. Mail surveys offer a low cost method for obtaining responses to a longer questionnaire, but significant problems of self-selection exist. Telephone *or* personal follow-up could reduce, or at least quantify the selection bias, but such follow-up proved to be not cost-effective. The Bureau of Outdoor Recreation surveys are now done

---

*For example, Herbert H. Stoevener [21], S.D. Reiling, K.C. Gibbs, and H.S. Stoevener [19].

by mail, and for most water-related recreation activities they report comparable participation rates between mailed and personal interviews.

Although there have been several recreation mail surveys with response rates well in excess of 50%, these surveys have generally been directed to special interest populations such as licensed fishermen and wilderness users. The general experience with mail surveys directed to the public at large is much less encouraging; with no follow-up the response rate is commonly in the range of 10%-15% and even with one or several follow-ups the response rate is often less than 35%.

Finally, the diary method could provide more accurate responses, more careful selection of respondents but may be difficult to administer. Many consumer surveys are presently performed via the diary method, and this approach should be examined further.

After evaluating the cost, reliability, timing and response bias of the alternative technique, personal in-home interviews were selected as the best medium to collect the needed data. The details of the sample design are presented in the first subsection below. Then the sample population is described in relationship to the universe population. This section closes with a discussion of the survey instrument.

3.1 Sample Design*

The objectives of the sample design were to produce a sample of the Boston SMSA population which approximated the socioeconomic characteristics and geographic dispersion of the SMSA's entire population to meet simultaneously both objectives, a cluster point procedure was adopted.

---

*The survey design, sampling, and fieldwork were completed by Cambridge Survey Research, Inc. of Cambridge, Massachusetts, under a subcontract to USR&E. We are particularly indebted to Mr. John Gorman of that organization for his assistance in refining the survey instrument and sample design.

Households were the target respondents, and any available adult member of the household was asked to respond. A probability sample of about 500 interviews was determined which would produce an approximation of the non-institutional population between the ages of 14 and 65 of the Boston area SMSA. This would constitute an overall sampling fraction of 500/661650 or about 7.6 households per thousand. This is about the same sampling frequency as that of the Harvard-MIT Joint Center for Urban Studies in a 1970 survey of outdoor recreation and leisure activity in the Boston SMSA which was conducted for the Massachusetts Department of Natural Resources.

Towns were picked as primary sampling units. Each town falling in the SMSA was proportioned for a specific number of interviews according to its population between the ages of 14 and 65. Some of these towns were proportionately too small to warrant a sufficient number of interviews to be sampled. A certain number of towns which were most representative on demographic variables of all the towns were chosen to be sampled. Twenty-three towns from the total 77 towns comprising the SMSA were sampled. Table IV-11 shows the distribution of sample points and respondents between towns, and Figure IV-2 shows a map of the sample points and sites.

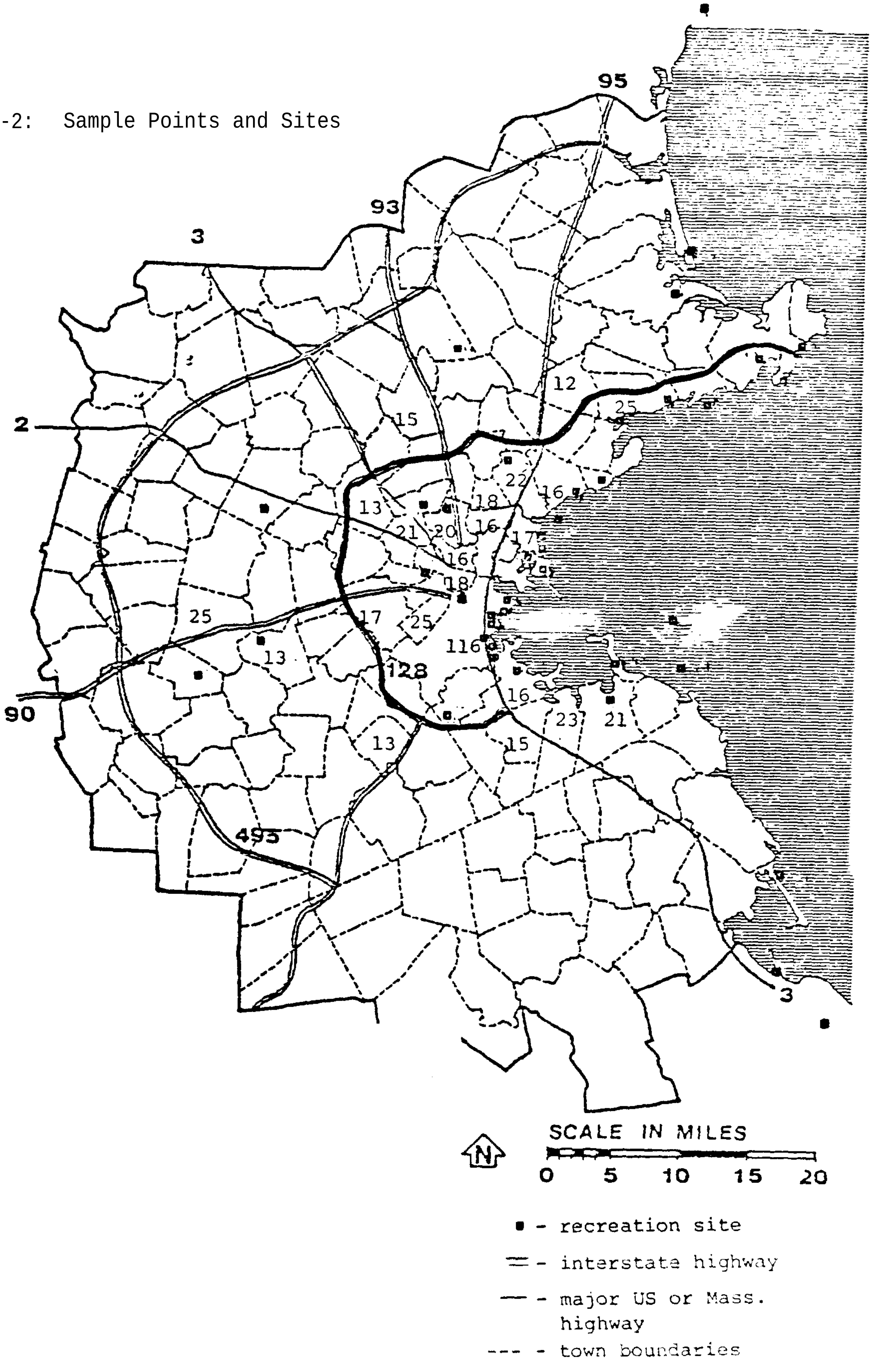
Each town was then systematically sampled. Towns were sub-divided down to the Census block level. A sampling fraction was computed for each town, and blocks were chosen at specific intervals by the sampling fraction with a random start. Thus, within each town, we had specific census tracts picked and specific blocks within that census tract to be interviewed. Each block area was assigned a cluster of five interviews.

Table IV-11

Distribution of Sample Points Between Towns

Town	
Lynn	16
Saugus	11
Danvers	12
Beverly	23
Cambridge	18
Newton	17
Somerville	16
Wilmington	15
Framingham	25
Arlington	21
Natick	13
Norwood	13
Lexington	13
Malden	16
Medford	20
Melrose	18
Hingham	21
Boston	116
Revere	17
Quincy	16
Brookline	25
Weymouth	23
Braintree	15

Figure IV-2: Sample Points and Sites



This survey was administered in the respondents' homes during December 1974 by supervised professional interviewers, specially trained for this survey. We had planned to conduct the survey during the first week in September (immediately after Labor Day which is commonly considered the end of the summer recreation period), but a three-month delay in obtaining OMB clearance which was completely beyond our control forced postponing the survey until the first week in December. The effect of this delay on the survey results is unknown, but previous studies have found that respondents' recollections of the recreation experience becomes more favorable as time passes. Subjective quality ratings may, therefore, overstate true perceptions, possibly accounting for the poor correlation between objective and perceived quality found in the next chapter. No doubt, the accuracy of numeric information, such as number of visits, expenditures, etc., suffered from the deterioration of recall during the long hiatus.

Interviewers began at a randomly chosen starting point. A skip pattern of housing units was also determined in order to distribute the five clustered interviews evenly over the sample point. Interviewers were instructed to keep a one-to-one male/female ratio. The person most qualified to speak regarding family activities was designated as the proper respondent.

Where no one at the household selected was available for interview, random replacement was used to find a substitute. To 'find a substitute, the following pattern was employed until a respondent was found. First, the housing unit on the right is tried, then the one to the left, then the one across to the left, then across to the right and finally, the housing unit directly across is tried. Within the various cluster points substitutes are not of concern because within the cluster, respondents and non-respondents are statistically indistinguishable.

Finished interviews were returned as they were completed, and were checked and edited for accuracy. About 10 percent of each interviewer's work was selected randomly and was validated for authenticity.

3.2 The Sample Population

Selected socioeconomic characteristics of the sample of respondents and the Boston SMSA population are presented in Table IV-12. Median income of the two groups is nearly identical; average income is within the error of projections in the poisson distribution. The sample contains slightly more men than the population as a whole, and in general, is better educated. The racial composition of the sample is somewhat anomolous , because 20.8% of the respondents listed their race as "other unspecified." This may have been a reaction to the question which was designed to discriminate between Irish and Italian Caucasion as well as between Blacks from all Caucasians:

How would you describe your ethnic background?

a. American Indian
b. Asian-American
c. Black
d. Irish
e. Italian
f. Spanish Surname
g. Other Caucasian
h. Other (please specify) ____________

The "Other" category is likely to include people of diverse backgrounds (Russian, German, Jewish, Armenian, etc.) who would normally describe themselves as "White."

Table IV-12

Comparison of the Boston SMSA Population and the Sample

	Sample	Boston SMSA (1970)
Number of Households	467	661,650
Family Income ($)		
Median	11,445	11,449
Mean	13,214	13,284
Sex (%) of Respondent,		
Male	46.9	45.5
Female	53.1	54.5
Education of Respondent		
not completed high school	20.3	35.6
completed high school	32.5	36.8
some college	22.6	4.9
completed college	14.7	8.1
post-graduate	9.9	7.6
Race (%)		
White	68.9	94.5
Black	4.8	4.6
Other	26.6	.9

3.3 The Survey Instrument

The survey instrument contained in Appendix III is designed to elicit information on the sensitivity of demand for water-based recreation to changes in water quality. Three types of behavior in response to altered water quality are explicitly examined: substitutions between sites, substitutions between activities (including non-water-based outdoor recreation), and loss of benefit when no substitution occurs. This section describes the general development of this instrument and then concludes by discussion in detail the intent of each question or group of questions.

The survey instrument was developed after a careful analysis of the data required and review of previous similar recreation surveys.*

---

*The survey instruments reviewed include those found in:

Boston Area Study: 1970 [11].

Water Quality Criteria for Selected Recreational Uses: Site Comparison [2].

The Recreational Uses of Green Bay: A Study in Human Behavior and Attitude Patterns [6].

Benefits of Water Pollution Control on Property Values [7].

Stream Quality Preservation Through Planned Urban Development [4].

A Case Study of Yaquina Bay, Oregon [21].

Economic Benefits from an Improvement in Water Quality [19].

Benefits of water Quality Enhancement [18].

Transactions of American Fisheries Society [1].

The Demand for Motorboat Use in Large Reservoirs in Arizona [12].

An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fisheries [3.]

Metropolitan Washington Council of Governments Water Quality Survey [22].

Where specific questions have been adapted, the appropriate references are presented in the more detailed discussion which follows below. Based on these needs and the literature review, an initial survey instrument was drafted. This draft was reviewed internally by the project staff. Once suitable form and content had been reconciled internally, experts in recreation planning and survey research, not directly involved in the project, were asked to review the instrument.* Based on this review, the instrument was pretested and then finalized. The entire interview required about one-half hour to administer.

The survey instrument is divided into three sections. Part 1 generates the multi-site visitation data required to estimate the demand model described elsewhere. Part II attempts to measure directly the behavioral response to altered water quality. In Part III, socioeconomic information on the respondent and his household is developed to provide a backdrop for the required analyses.

Part I, "Participation in Water-Based Recreation" generates the information required to estimate statistically the benefits from water pollution abatement. Question 2 elicits information on the visitation by both the respondent himself and his household to a system of sites in the Boston Study Area. Questions 3-6 obtain the details of each visit including mode, cost and time of travel, on-site expenditures and activities while on-site. Distance to the site was, as explained above, calculated from a grid imposed on the study area map. This data, along with the data on fixed costs of recreation and socioeconomic identified in Part III comprises the basis for statistically estimating the benefits of water quality enhancement.

---

*We thank William Geizentanner, Janet Marantz, John Gorman and Sherwin Feinhandler for their assistance in this review.

Question 7 of Part I leads to the measurement of perceived water quality and its relationship to recreation usage. This question assesses the reasons for not visiting the closest site. Utility is maximized with respect to distance at this point, so the tradeoffs between other characteristics (beach facilities, water quality, crowding, cost, etc.) can be more distinctly drawn.

Part II requests perceptions concerning site characteristics, and response to changes in those characteristics. First a rating is established in Question 1. This rating is used in conjunction with objective measures of water quality to ascertain the parameters which most directly affect perceived water and beach quality. Question 2 defines the decision set of sites, and obtains a ranking for those sites as well. Question 4 uses this ranking to determine directly response to altered water quality, beach characteristics, and so on.

The most frequently visited site is the focus of our probing. Presumably the respondent is most familiar with this site, and in some sense its mix of attributes optimizes his utility. First, the predominant reason for visiting that site is determined. Then the responses to declines (based on the ranking established in the previous question) in the quality of site characteristics and site closing are elicited. This series of questions attempts to determine directly the site and activity substitutions which our demand model infers. These questions provide both a check on the model and also determine more detailed information on interactivity substitutions.

More general questions on quality perceptions are asked in Questions 5 and 6.* First, the importance of water quality with respect to other site characteristics is established (Question 5). Then, focusing on water quality, the relative importance of five general parameters of water quality is established.

---

*These Questions are derived in part from Auckerman [2] and Dornbusch [7].

Part II closes with an assessment of the importance and substitutability of various activities. Question 7 relates to water-based activities, and provides the basis for turning the perceptions of water quality into recreation water quality priorities. Question 8 treats non-water-based activities to establish the basis for activitiy substitution assessed in Question 4. Then Question 9 directly assesses the potential for substitution of water-based and non-water-based activities. Part II concludes with a more general open-ended question on the recreation provided in the system of sites.

Part III, Identification, provides the respondent's socioeconomic background for use in the demand modeling effort and for analyzing the perceptions obtained in Part II. The age ranges in Question 2 were chosen to reflect categories which could affect recreational habits. Previous studies have found income, occupation and education to influence recreational behavior, and these data are solicited in Questions 4-8. The fixed costs of recreation are determined in Question 9.* Recreation economists have posited that the common omission of these fixed costs in benefit research has artifically depressed estimates of the social value of recreation.

Finally, Questions 10-13 relate to other exogenous determinants of recreation participation. Question 10 asks for weekly and annual leisure time. Questions 11 and 12 determine the potential from travel to the recreation sites by automobile and public transit, respectively. Lastly, previous research on recreation in the Boston area suggests that ethnicity is an important determinant of site choice. Question 13 elicits the information to test this hypothesis, and control for its effect in our statistical analysis.

---

*This question is adapted from Reiling, Gibbs, and Stoevener [19].

4. Measures of Attendance

Our demand models use as a dependent response variable measure of attendance at each site. Chapter II outlined some of the characteristics of an adequate measure of demand, and pointed out that our focus on one-day trips eliminated some of the vaguaries of measuring activity duration. Initially, five measures of visitation were considered:

(1) MNT: the number of times a site was mentioned and for an individual, the binary variable on whether or not a site was mentioned (number);

(2) PVS: the number of visits made to a site by the respondent (person-visits);

(3) HVS: the number of visits to a site by anyone in the respondent's household (person-visits);

(4) GVS: the number of household visits multiplied by the average group size (person-visits); and

(5) VSDR: the number of household visits multiplied by the average duration (person-hours).

All of these variables were derived in the obvious manner from four questions:

The card shows some of the major fresh and salt water beaches in the Boston Area. Could you please tell me: (hand respondent site list)

A. Which sites did you personally visit, and how many times did you visit each of those sites. Are there any sites, town beaches, ponds or other fresh or walt water areas, which you visited that are not on this list? (Record those sites and the number of visits to each. Add visits and ask:)

So you personally visited a beach, lake or stream about ____ times this past summer?

B. Now I would like to find out about visits by anyone in this household to fresh and salt water beaches in the Boston Area. could you please tell me the number of visits by any household member to each of these sites. Are there any sites, town beaches, ponds or other fresh or salt water areas, which you visited that are not on the list? (Record those sites and the number of visits to each. Add visits and ask:)

So members of this household visited a beach, lake or stream about ____ times this past summer.

C. About how long, on average, was spent at each of the sites you listed in the two questions above?

D. For each site about how many people from your household, on average, made the trip?

The correlations between these variables is shown in Table IV-13. The measures have similar distributions across sites, and display a high degree of intercorrelation.

Table IV-13

Correlation Between Attendance Measures Across Sites*

	PVS	HVS	GVS	VSDR
MNT	.8100	.8350	.7823	.8692
PVS		.9605	.8413	.8836
HVS			.8916	.9608
GVS				.8454

*All coefficients are based on 43 observations, and all are significant at the 5% level.

CITED REFERENCES

1. American Fisheries Society, Transactions of American Fisheries Society, Vol. 102, No. 2, April 1973.

2. R. Auckerman, "Water Quality Criteria for Selected Recreational Uses - Site Comparisons," Thesis, University of Illinois, 1973.

3. W.G. Brown, E.N. Castle, & A. Singh, An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fisheries, Corvallis: Oregon Agricultural Experiment Station, 1964.

4. R.E. Coughlin & T.P. Hammer, Stream Quality Preservation Through Planned Urban Development, Socioeconomic Environmental Studies Series, Environmental Protection Agency, Office of Research & Monitoring, Washington, D.C.: GPO, May 1973.

5. Elizabeth David, "Public Perceptions of Water Quality," Water Resources Research (June 1971).

6. Robert Ditton & Robert Goodale, Marine Recreational Uses of Green Bay: A Study of Human Behavior and Attitude Patterns, Technical Report No. 17, University of Wisconsin: Sea Grant Program, December 1972.

7. D.M. Dornbusch & S.M. Barrager, Benefit of Water Pollution on Property Values, prepared for the U.S. Environmental Protection Agency, San Francisco, California: David M. Dornbusch & Company, Inc., August 1, 1973.

8. Environmental Protection Agency, Water Quality Criteria Data Book, Washington, D.C.: May 1971.

9. Hayes B. Gamble & Leland D. Megli, "The Relationship Between Stream Water Quality and Regional Income Generated by Water-Oriented Recreationists," Journal of Northeastern Agricultural Economics, Vol. 1, No. 1 (Summer 1972).

10. Mary A. Holman & James T. Bennett, "Determinants of Use of Water-Based Recreational Facilities," Water Resources Research Vol. 9, No. 5 (October 1973): 1208-1218.

11. Joint Center for Urban Studies of the MIT-Harvard University Survey Research Program, Boston Area Study: 1970 (Feb.-April, 1970).

12. W.B. Kurtz, "The Demand for Motorboat Use of Large Reservoirs in Arizona," Ph.D. dissertation, University of Arizona 1972.

13. Massachusetts Department of Natural Resources, Planning Office, 1970 Outdoor Recreation and Open Space Survey, October 1971.

14. L.D. Megli, W.H. Long, H.B. Gamble, An Analysis of the Relationship Between Stream Water Quality and the Regional Income Generated by Water-Oriented Recreationists. University Park, Pa.: The Pennsylvania State University, Institute of Research on Land and Water Resources, 1971.

15. Metropolitan Area Planning Council, Open Space and Recreation Plan and Program for Metropolitan Boston, April 1969.

16. George A. Myles, Effects of Quality Factors on Water-Based Recreation in Western Nevada, University of Nevada, Reno: Agricultural Experiment Station, 1970.

17. National Academy of Sciences, Water Quality Criteria, Washington, D.C.: Committee on Water Quality Criteria, 1972.

18. Nelson L. Nemerow & Hisashi Sumitomo, "Benefits of Water Quality Enhancement (Onondago Lake)." Water Pollution Control Research Series 16110 DAJ 12/70, Washington, D.C.: EPA, Water Quality Office.

19. S.D. Reiling, K.C. Gibbs, H.H. Stoevener, Economic Benefits from an Improvement in Water Quality, Socioeconomic Environmental Studies Series, Environmental Protection Agency, Washington, D.C.: GPO, January 1973.

20. R.J. Rummell, Applied Factor Analysis, Evanston: Northwestern University Press, 1970.

21. Herbert Stoevener, et al, Multi-Disciplinary Study of Water Quality Relationships: A Case study of Yaquina Bay, Oregon, Special Report 348, Corvallis: Oregon State University, February 1972.

22. Westat, Inc., Metropolitan Washington Council of Governments Water Quality Survey, October 1973.