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Alfred Lawrence Birch

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A. Allan Schmid
Major professor

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OFF-SITE BENEFITS FROM SOIL CONSERVATION: A METHODOLOGICAL AND DISTRIBUTIONAL INVESTIGATION

By

Alfred Lawrence Birch

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ABSTRACT

OFF-SITE BENEFITS FROM SOIL CONSERVATION: A METHODOLOGICAL AND DISTRIBUTIONAL INVESTIGATION

By

Alfred Lawrence Birch

This study is concerned with the off-site benefits resulting from agricultural soil conservation and consequent improvements in downstream water quality. The questions which it seeks to answer are: How can these off-site benefits best be measured, what is their size, and to whom do they accrue? The study's fundamental hypothesis is that a reduction in sediment delivery and turbidity would have beneficial effects on various environmental services for which people would be willing to pay.

Two objectives have been pursued here. The first was to measure the size and incidence of off-site benefits from soil conservation in Michigan. This rather broad objective was narrowed by selecting three categories of environmental services which might be affected by changes in sedimentation or turbidity. These were recreation, municipal water treatment and the dredging of navigational channels and inland lakes.

Recreational effects from water quality changes were studied at three lakes in southwestern Michigan using a cross-sectional experimental design. Data were collected through on-site interviews with recreationists. The survey instrument was designed to allow the use of both the Clawson-Knetsch travel cost method and a bidding game in analyzing recreational benefits. With respect to the analysis of water treatment effects,

potential cost savings were examined using data from three small municipal treatment plants in southeastern Michigan. Potential cost savings in the area of dredging were investigated using data provided by the U.S. Army Corps of Engineers and an environmental engineering firm.

A second objective of this study was to compare the travel cost and bidding game techniques. While the former has been a standard analytical tool in recreational studies for some time, the latter has gained increasing attention. The comparison of these techniques in the context of a single recreational sample adds a distinctive aspect to the research.

The travel cost analysis of recreational benefits yielded two important results. First, there was no statistically significant relationship detected between the money costs of travel and the level of recreational demand. This supports the hypothesis that money costs of travel are an inappropriate surrogate for entrance fees in the context of short distance travel since such costs may be dispersed or deferred and thus not easily perceived. A second result of the travel cost analysis was that no statistically significant relationship between turbidity and recreational demand was found. This approach, therefore, did not attribute any recreational benefits to water quality improvement.

The bidding game revealed an average willingness to pay for a reduction in turbidity at Thornapple Lake (the study lake with high turbidity) of $0.92 per recreational party visit, or a benefit of approximately $15,600 per year at the present level of recreational use. It was impossible to generalize this result to a statewide estimate of potential recreational benefits from reduced turbidity.

Due to serious data limitations it was also impossible to make an accurate estimate of potential cost savings from reductions in sediment delivery and turbidity in the areas of water treatment and dredging. Nevertheless, it appeared that these benefits were not large: less than $40,000 per year in the category of water treatment and approximately $13 million for dredging. Both of these figures are on a statewide basis and both assume a fairly complete elimination of sediment and turbidity.

The methodological comparison and evaluation of the travel cost and bidding game methods dealt with a number of important technical and public choice issues. One of these is the apparent minimum average driving distance for the valid application of the travel cost method due to poorly perceived costs. Another issue concerns the fact that the travel cost and bidding game measure recreational demand for an environmental change at different levels of consumer information. Demand and the level of estimated benefits are likely to be sensitive to the level of such information. The "correct" level of information at which to estimate benefits is a matter of public choice.

Further methodological conclusions are presented as are policy implications and suggestions for further research.

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I. INTRODUCTION

A. Problem Setting

Extensive public debate is currently underway concerning the broad issues of environmental quality, the conservation of the nation's natural resource base, the distribution of costs and benefits from environmental and natural resource programs, and the design of institutions for decision making and program administration in these areas. While the existence of such debate is not a new phenomenon, its present fervency seems to be due in large part to the convergence of the environmental movement of the past decade and more recent public concern over the magnitude and incidence of costs and benefits from environmental programs.

Public concern and legislative action dealing with natural resource programs have been evident for many years. The soil conservation movement has had a well documented history since the early 1930s, while the conservation of forests and other broadly defined natural resources was promoted in a social and political movement a generation earlier (Held and Clawson). One of the distinctive features of the environmental movement of the past decade is, however, that it has been based on an increased awareness of natural resource scarcity and of interdependence among participants and interest groups. The many instances and aspects of pollution, for example, demonstrate the existence of scarcity in ecosystems which are called upon for multiple environmental services.

The increased awareness of scarcity and interdependence means that there are potentially greater conflicts over the design of environmental programs and the definition of performance criteria for them. For example, as non-point source pollution increases and its effects become more apparent there is increasing competition over the right to determine resource use, including both environmental and financial resources. Where the effects of pollution are dispersed or delayed or where the connection between the source and consequence of pollution is not perceived, the competition over resource use will be reduced.

Where increasing scarcity is perceived there is an accompanying demand for information on the consequences of alternative public programs. Without such information public policy is based on conjecture and contestation over ideological principles. Information is needed to inform the public and public decision-makers on the consequences of alternate choices. This information would treat both the physical linkages and the environmental, economic and social results. Of particular importance is information on how alternative policies affect different groups. An example of the demand for performance evaluation in natural resource programs can be seen in the passage of the Soil and Water Resources Conservation Act (1977) which requires the extensive review of resource conservation policy and programs administered by the U.S. Department of Agriculture.

Soil conservation policy has typically been formulated from the perspective of the farmer. Conservation programs, reflecting a particular set of rights, have been oriented toward education and voluntary participation. While there has always been a recognition that the rest of society benefits from resource conservation and while this recognition has provided the basis for the provision of various forms of assistance for the implementation of conservation practices, the exact nature and extent of the impact of soil conservation practices on the rest of society has never been clearly understood. An appreciation of the values associated with reductions in sediment delivery and its impact on various environmental services would be an important informational component for designing the distributional features of programs, such as conservation cost sharing levels.

The demand for such information raises many research possibilities. In addition to the need for a description of the results of alternate programs and policies there is often the opportunity for methodological development. A common characteristic of many environmental services is that they are not provided through normal market channels. In order to assess the incidence of benefits and costs from environmental changes it is often necessary, therefore, to devise indirect techniques for economic valuation. These techniques are not well developed at the present time and thus provide many potentially fruitful research topics.

B. Problem Statement and Objectives

The problem addressed in the present research concerns the size and incidence of off-site benefits resulting from agricultural soil conservation.[1] Specifically, the effects of changes in the level of erosion and sediment delivery have been singled out for investigation. The fundamental hypothesis which has been tested is that a reduction in

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[1]Some studies refer to these effects as "damages" (Maler and Wyzga). The benefit terminology is chosen here because the actual policy choice is, in most cases, one of whether or not to reduce a pollutant's level of concentration (Freeman, 1979, p. 3).

sediment delivery will have beneficial effects on various environmental services for which people will be willing to pay. These effects, it is hypothesized, extend to people besides the farmer or other land use decision maker faced with the choice of whether or not to implement soil conservation practices. These off-site effects are commonly called externalities. The effects of erosion on agricultural input and product prices have not been investigated.

In order to limit the scope of this research, three potential areas of sediment impact were selected for investigation. The first of these is the effect of sediment on recreation and associated aesthetic appreciation. Since recreational resources and changes in their environmental characteristics are usually provided at low or zero prices to users, the recreational value of sediment reduction requires the use of indirect valuation techniques. Two of these, the travel cost analysis developed by Clawson and Knetsch and the bidding game technique were selected for use in the present study. The purpose for using both was to allow a comparison to be made between them based on their application to a single recreational sample. This has made possible a methodological investigation of each of the techniques.

The other areas of investigation were the potential cost savings for municipal water treatment and the dredging of navigational channels and inland lakes. In these areas the procedure was to investigate the cost accounts of the respective production processes. Although the questions being asked were simple and straightforward, they have not been widely investigated before, particularly with respect to sediment as a single pollutant.[2]

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[2]Brandt, et al., is apparently the only other study dealing with sediment effects in a small region. (Tihansky)

C. Study Outline

Because of the potential for methodological development with respect to the recreational impacts of sedimentation, this study begins with a review of the theory of benefit evaluation in Chapter II. After a general discussion of the nature of economic benefits from an environmental improvement the two selected techniques for deriving such benefit estimates are discussed. Also, the use of the consumer surplus concept in deriving benefits from demand functions is critically reviewed. Chapter II concludes with a brief presentation of the theory of productivity benefits as it bears on municipal water treatment and dredging. Although Chapter II is basically a literature review, it contains some suggestions and draws together methodological material not compiled in this form elsewhere.

Chapter III gives a brief review of the physical processes which are involved in erosion and sediment transportation and their impact on environmental services. These physical relationships are the basis of the economic relationships which are the subject of this study. While the research is not directed at the determination of such things as sediment delivery ratios or physical damage (or dose-response) functions, the basic nature of these must be appreciated in order to interpret the economic relationships. They also have critical significance for the determination of an appropriate experimental design.

In order to identify the recreational consequences of changes in the level of sediment delivery, a cross-sectional design for data collection was selected. Three lakes were chosen which represent a range of sediment conditions and a fairly high level of recreational use. Chapter IV describes the experimental design and data collection procedures used. The method of selecting these lakes and the interview and water quality measurement procedures are described. This chapter also describes the procedures for collecting data on nonrecreational impacts.

Chapter V presents details on the analytical techniques which this study employed. While this parallels the discussion in parts of Chapter II, the emphasis here is on actual procedural details.

Chapter VI gives the results of the empirical analysis and an estimation of the magnitude of benefits in both the recreational and non-recreational categories. Difficulties encountered in the analysis of cost savings in both water treatment and dredging prevented accurate estimation of the benefits in these areas. Very approximate figures are, however, presented.

Chapter VII concludes this study by discussing both the methodological and distributional results. It also discusses this study's policy relevance and presents recommendations for future research.

II. THE THEORY AND METHODOLOGY OF ENVIRONMENTAL BENEFIT EVALUATION

A. What are Environmental Benefits?

There is an extensive literature in the areas of welfare economics, public expenditure theory and cost benefit analysis dealing with the subject of economic benefits (see, for example, Prest and Turvey; Weisbrod; and Haveman and Weisbrod). While it is unnecessary to review that literature here, a few of the basic concepts upon which the definition of economic benefits is based will be reiterated. The most important of these is the concept of allocative efficiency. Values are determined in a competitive market through the interaction of supply and effective demand, the latter being determined by consumer preferences and the distribution of income and wealth. Economic benefits are the desirable results or outputs which are defined by this conjunction of preferences, purchasing power, and production.

It is commonly, though often parenthetically, acknowledged that the determination of optimum allocative efficiency is dependent upon a given distribution of income, wealth and rights. The normative nature of the efficiency criterion and the fundamental interdependence of allocative and distributive choice should not be ignored in economic analysis, whether of public or private choice. Economic benefits cannot be defined apart from a given distribution of rights.

Given these qualifications, the allocative efficiency of competitive markets can be demonstrated. There are a range of circumstances in which markets do not operate, however. These asserted "market failures" include cases such as public goods (those which have high exclusion costs and/or low marginal costs of provision), externalities and high transactions costs. The concept of "market failure" is of particular importance in public expenditure analysis since it constitutes an asserted rationale for public economic intervention. Cost benefit analysis presumes an allocative efficiency goal or criterion for public policy and generally ignores the question of distributional consequences. Haveman and Weisbrod state that "insofar as cost benefit analysis is directed at allocative efficiency, it can be viewed as an attempt to replicate, for the public sector, the decisions that would be made if private markets worked satisfactorily" (p. 39). Not only does cost benefit analysis presume a given distribution of income, wealth and rights, but also, since costs and benefits are seldom borne by the same individuals, it presumes that income redistribution resulting from the program in question is acceptable, or that actual compensation will be paid.

Freeman (1979) defines environmental benefits in the following terms: "We define the benefit of an environmental improvement as the sum of the monetary values assigned to these effects by all individuals directly or indirectly affected by that action. These monetary values are often referred to as 'willingness to pay' " (p. 3). This definition correctly distinguishes between benefits as monetary values and the environmental changes which give rise to those economic values. The immediate results of an environmental program are changes in ambient environmental quality. The secondary results are changes in the environmental services flowing from the resource. Third, there are consequent changes in economic welfare and benefits. Environmental benefits are only defined at the third stage.

Perception and response are also involved in this third stage. The element of time is introduced by the fact that there may be lags in both of these. The availability of information over time will influence perception. Often a significant amount of time is involved in gathering information on the full effects of environmental changes. Response, which involves attitudes, may also be delayed as changes in people's frame of reference, evaluation and intensity of feelings occur. These dynamic factors are very important in assessing the size and incidence of environmental benefits.

B. Recreational Benefit Estimation Techniques

Environmental changes may produce direct benefits for consumers where environmental services or environmental quality are arguments in consumers' utility functions. The estimation of these benefits poses a number of problems, however. One of these is the estimation of demand functions for environmental services in the absence of a market. Another problem concerns the derivation of benefit measures from the estimation demand functions.

The Clawson-Knetsch travel cost method was used in this research to estimate a demand function for water-based recreational services. The next section of this chapter reviews the theoretical basis of this approach. When a demand function is estimated for an environmental service, a second step must be taken to derive a benefit measure from the demand function. The most common procedure for doing this is to use the concept of consumer surplus. This concept will be examined below and its political-economic implications will be presented.

The bidding game presents a second alternative for environmental benefit estimation. This approach produces a benefit estimate directly, rather than producing a demand function as does the travel cost technique. The bidding game has been criticized because of potential problems of inaccuracy which are involved.

1. Clawson-Knetsch travel cost method.

The most frequently used approach for estimating demand functions for outdoor recreation was initially suggested by Hotelling and later developed by Clawson and Knetsch (Clawson and Knetsch, Part II; Dwyer, Kelly and Bowes, Chapter 5). The basis for the travel cost approach is that, while there is usually insufficient variation in entrance fees for recreational locations to make demand estimation possible, there are various costs which recreationists face and to which they may respond in the same way that they would to an entrance fee. These costs are primarily those which are associated with travelling to the recreational site, though the response to any costs which vary among recreationists would provide a sufficient basis for estimating the demand relationship.[1] It is this marginal response to variable costs which is the key relationship being sought.

The approach developed by Clawson and Knetsch starts by defining concentric origin zones around the particular recreational site of

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[1]While this technique is called the "travel cost" approach, it might better be called the "variable cost" approach since the response to other variable costs would reveal the desired information on marginal willingness to pay just as well (Schmid, 1980, p. 135).

interests. For each of these zones an average travel cost to the recreational site is estimated. Observations on the visitation rate are taken by sampling visitors to the site. The visitation rate is defined as visitor days per capita for each origin zone. Next, visitation rates are regressed on average travel costs and socioeconomic variables such as average income and educational attainment. The observed total visitation for the site from all origin zones represents the horizontal intercept value for the desired demand relationship (assuming the actual entrance fee is zero). Other points are found by assuming that visitors will respond to given increases in a hypothetical entrance fee in the same way in which they respond to changes in travel cost. Hypothetical increments to the cost variable are inserted in the equation and predicted visitation rates are calculated, thus tracing out the full demand curve.

A second alternative exists for defining the visitation rate in the travel cost approach. It may be defined as the total annual number of visits to the recreational site by each recreational group or household. The practicability of this definition will depend on the predominant visitation pattern for site or sites involved. It would not be workable where multiple annual visits per recreational party are rare. This approach was advocated by Brown and Nawas and has been used by Gum and Martin and Bouwes and Schneider. Further issues involved in this definition of visitation rate will be discussed below.

The key to the reliability of the estimated demand relationships is the accuracy of the assumptions on which the technique is based. Much of the subsequent refinement in this approach, since its initial presentation by Clawson and Knetsch, has served to relax some of the restrictive assumptions which had been made. A number of these assumptions and the related methodological adjustments will be discussed here.

a. Homogeneous origin zone characteristics. One of the assumptions which is made in the original Clawson-Knetsch model is that populations within origin zones are homogeneous with respect to socioeconomic characteristics which may affect the demand for recreation. While zone averages for these characteristics may be included in the model, the individual effect of various characteristics are muted by the aggregation process (Brown and Nawas, p. 249). Also, measurement error may be introduced if the origin zones do not correspond to geographical units within which socioeconomic data are collected. Boyet and Tolley suggest two approaches for dealing with this problem. The first is to use larger origin zones, such as states, for which more accurate socioeconomic data are available. This solution presumes a predominance of long distance trips to the recreational site being studied. In many cases this presumption would clearly not hold.

The second solution which they present is to use data on individual characteristics, such as income and the number of days of paid vacation, to refine the definition of origin zones. "Rates of visitation from each distance-income-vacation class are estimated and are used as a basis of projecting" (Boyet and Tolley, p. 994). This revised origin zone definition has the advantage of taking into account additional factors which are likely to affect recreational demand. Its disadvantage is that as the number of factors which are used to define origin zones increases, the methodology becomes unwieldy and the sample size requirement grows. The approach proposed by Brown and Nawas and used in this study carries this disaggregation farther and defines the recreational group or household as the observational unit. It therefore completely avoids the problem of the assumption of internally homogeneous origin zones, yet at the cost of lower efficiency of observational grouping. This approach will be discussed further below.

b. Travel time. Another assumption of the original Clawson-Knetsch model was that money expenditures are the only costs of recreation. The result of this assumption, which neglected time as a constraint, was to bias benefit estimates downward (Cesario and Knetsch, 1970). The assumption that money costs accounted for differences in visitation rate neglects the fact that more distant groups are also faced with time costs which would not be imposed on closer groups facing an entrance fee. When time costs are ignored, the elasticity of demand is overestimated. Attempts to incorporate time as a separate independent variable in the recreational model were, however, frustrated by the high correlation between time and money costs when aggregate data were used, thus making an accurate estimation of their independent effects impossible.

Among the many attempts to solve this problem two major directions have been taken. The first is to apply an independently determined shadow price for travel time, making it impossible to incorporate time and money costs into a single money cost variable. The second, and less common, approach is to redefine the observational unit, thus reducing the correlation between time and money costs of recreation and making it possible to include these as separate independent variables in a regression model. When the first of these alternatives is chosen the observational unit is the origin zone. What is required in this context is an average shadow price for travel time for all recreationists from each zone.

The traditional starting point for determining the value of leisure time is the simple economic model of the labor-leisure tradeoff. This assumes that the worker-consumer adjusts his hours of employment so as to equate the marginal value of leisure time to his (marginal) wage rate (Hirschleifer, ch. 15). There are a number of weaknesses in this simple model, however. First, the selection of weekly employment hours has very little flexibility for most employees. Second, to the extent that the individual is able to adjust his employment hours, he will equate his marginal utility from leisure time to the sum of the marginal utility of money earned by spending the time in work and the marginal (dis)utility of labor:

$$\delta U/\delta t_L = P\delta U/\delta Y + \delta U/\delta t_W$$

$$\frac{\delta U/\delta t_L}{\delta U/\delta Y} = P + \frac{\delta U/\delta t_W}{\delta U/\delta Y}$$

where t_L is leisure time, t_W is work time, Y is income, and P is the wage rate. Making the usual assumption that $\delta U/\delta t_W$ is negative, the second equation indicates that the marginal value of leisure time will be less than the wage rate. In other words, "the marginal utility of leisure time is equal to the wage rate less the marginal disutility of work" (Harrison and Quarmby, p. 180). Third, because of the possibility of purchasing convenience goods and labor saving devices, the consumer can divorce his marginal value of leisure time and his wage rate.

The simple labor-leisure tradeoff model assumes that the opportunity cost of leisure is foregone labor time. Because of the inflexibility in choosing employment hours and because many recreationists (e.g., housewives, students, workers on paid vacation) are not faced with the labor-leisure tradeoff on particular recreational trips, the opportunity cost of leisure time will be the foregone opportunity to undertake other nonemployment activities, bearing no necessary relationship to the wage rate. Finally, the possibility of perceptual thresholds and their relationship to time valuation should be recognized. The value of incremental changes in travel time costs will depend on the way in which, or whether or not, they are perceived by recreationists. The value of a saving of five minutes from a ten minute trip may be greater than the same saving from a two hour trip; the value of a single saving of 30 minutes may be greater than that of 30 reductions of 1 minute each.

While the approach to time valuation described above has started from the labor-leisure tradeoff, considerable work has been done, particularly in the area of transportation economics, to value travel time by examining the time-consumption expenditure tradeoff. Reviews of empirical work in this area are provided by Nelson, Harrison and Quarmby, and Cesario. From his review, Cesario concludes

> ...that on the basis of evidence collected to date the value of time with respect to nonwork travel is between one-fourth and one-half of the wage rate. It is, of course, necessary to point out that this is an "average" valuation which may not apply strictly to any one individual since the value of time to an individual varies not only with the purpose of the trip, but may also vary with its length, time of day, and other factors. (p. 37)

Cesario's emphasis on the variability of the marginal value of travel time has relevance for the recreational context. All of the studies which he reviewed dealt with commuter valuations of travel time. Although they deal with travel time, their direct applicability to recreational travel is questionable, though it seems safe to conclude, as Cesario does, that "the use of the marginal wage rate for the value of travel-time values in recreation benefit estimation is inappropriate, both from the theoretical and practical points of view" (p. 37). The true value is very likely lower than the marginal wage rate.[2]

It was mentioned earlier that a second alternative for dealing with the travel time problem was to redefine the observational unit in such a way as to reduce the multicollinearity between time and money costs when these are included in a regression model as separate, independent variables. The possibility of using the recreational group or household as the observational unit was also mentioned above. This approach is possible because of the independent variation of time and money costs which exist for the individual or among individuals. Such things as gas prices, average driving speeds and vehicle fuel efficiency levels vary between individuals and result in some independent variation between time and money costs.

The advantage of this approach is that it avoids the problem of determining an average shadow price of recreational travel time. The separate inclusion of time as an independent variable measured in minutes

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[2]Bishop and Heberlein report on a study in which three techniques for valuing goose hunting permits were compared. The calculated value per permit, using actual cash offers, was $63. They compare this with the (consumer surplus) value calculated by using the travel cost method. In the latter approach, three different time value assumptions were made (zero, one-quarter and one-half of median income) and average permit values of $11, $28, and $45, respectively, were calculated. While they restrict their conclusions with respect to the value of travel time to the statement that their results "...support those who have voiced concerns about adequately accounting for time costs in [travel cost] studies, "a possible implication would be that the value of time should be set closer to the marginal wage rate. Such a conclusion would be unfounded, however, because of a variety of experimental weaknesses and the lack of support for the assumption that a willingness to sell (reservation) price should theoretically be equivalent to a consumer surplus measure of benefit derived from a travel cost demand curve. Bishop and Heberlein's results do illustrate the crucial nature of the travel time assumption.

rather than dollars does not attribute a zero value to time, but simply treats it as a separate constraint on recreational demand decisions. It is also assumed that the response to a hypothetical entrance fee is equivalent to the response of recreationists to travel money costs alone and that the inclusion of their response to time costs would not improve the "predictive" nature of the estimated coefficient of the money cost variable (Brown and Nawas, p. 248). This approach to solving the travel time problem is practicable, of course, only where disaggregated data on recreational travel can be used; that is, where multiple visits per recreational group per year are common.

This section has dealt with recreational travel, or off-site, time only. The matter of on-site time will be dealt with in Chapter V.

c. Substitute locations. The most common application of the travel cost technique has been in the estimation of demand functions for single recreational sites. Such studies implicitly assume that there are no close substitutes for the site in question. In most cases, however, the existence of imperfect or near substitutes should be recognized. The bias which results from a failure to make this recognition may be due to either a correlation of distance and substitute availability or the possibility of a diversion of activity from one site to another if the characteristics (such as accessibility or environmental quality) of one are changed.[3]

There are, of course, many alternatives which may be considered substitutes for a recreational site. Recreationists may feel that

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[3]Example of multi-site models may be found in Burt and Brewer; Cicchetti, Fisher and Smith; and Cesario and Knetsch (1976).

substitutes for fishing at lake A include fishing at lakes B, C and D, swimming at lake E, or even staying home and reading a book. Talhelm suggests the use of opinion surveys or observations of consumer choice among products as methods of identifying substitutes. The present study has used the former alternative, restricted, however, to the identification of substitute sites for the same type of recreation. This is further described in Chapters IV and V. Whatever approach is taken to defining a substitute, a degree of judgment and approximation is involved.

d. Site characteristics. A clear theoretical definition of the "product" being investigated is a prerequisite of sound empirical demand analysis. In the case of recreational demand there are three important issues which must be considered in this regard. These are site characteristics, crowding and the enjoyment gained from travel.

The site characteristic of primary concern in the present study is water quality, specifically turbidity. As mentioned in Chapter II, a measure of water quality at the lake at which an interview is conducted can be included as an independent variable in the regression model based on individual data. The hypothesis which this method of inclusion tests is that changes in water quality affect the nature of the "product" which recreationists demand, therefore influencing the level of demand at each price. The hypothesis that changes in water quality affect the marginal relationship between travel cost and visitation rate can also be tested by including an interaction term between water quality and travel cost.

If the quality of water at other (substitute) recreational sites is omitted, it must be assumed that changes in quality at those sites do not affect the level of demand at the site in question. This is not likely to be a valid assumption since the characteristics of substitute products can be expected, in general, to affect the demand for a particular product. If a measure of water quality for each substitute site is included in the demand model for each recreational group, these quality levels will not vary between individuals and it will thus be impossible to estimate the recreational response to changes in quality. Freeman (1979, p. 210-214) outlines two possible approaches for including water quality measures in the regression model. One of these, employed by Cesario and Knetsch (1976), employs a gravity model in which quality variables for competing sites are weighted in inverse proportion to their distance from the recreationists' home. Freeman refers to this as a rather ad hoc approach, pointing out that it is not derived from an underlying model of behavior. The second possibility is to estimate demand functions separately for each quality level (or recreational location) and then, in a second step, to regress estimated price coefficients on a quality variable in order to determine the effect of the latter. A lack of information on water quality at substitute sites prevented the use of either of these theoretically correct approaches in the present study, as described in Chapter V below. The effect of other site characteristics on recreational demand would be correctly handled in a manner similar to that with water quality.

e. Crowding. A second important issue in defining the recreational product has to do with the matter of congestion or crowding at recreational sites. The level of use or crowding will, particularly for some forms of recreation, influence the amount of enjoyment which the recreationist receives from the experience and thus his willingness to pay. Since willingness to pay can be considered dependent on the position of the demand curve, the amount of crowding can be seen as differentiating the nature of the recreational product.

As outlined by Freeman (1979, p. 220-223), an increase in crowding can be expected to shift the demand curve to the left. Where the specific effect of crowding on recreational demand is not of interest, however, there is no need to include it as a separate independent variable. Since crowding is determined by such things as access cost (travel or entrance fee) and environmental quality, it may be regarded as an intermediate variable and excluded from the regression model.

f. Multipurpose trips. A final aspect of recreational "product" definition is the matter of enjoyment or utility gained from traveling to the recreational site. This can be seen more generally as the issue of multipurpose trips. The enjoyment which the recreationists gain from the trip itself, as opposed to on-site recreation, and any other purposes for which he may make the trip, will influence his willingness to pay or the definition of the product for which he expresses a demand. As with the matter of site characteristics, it is important to estimate the demand for a standardized product so as to avoid biased estimates of recreational benefits.

A useful approach to this issue is that of consumer production theory, as presented by Becker and Lancaster. This approach to consumer theory holds that individuals' utility functions are defined in terms of characteristics of goods or the services which they yield, rather than in terms of the goods themselves. Goods and time are seen as inputs into a consumption technology, the outputs of which are the services which consumers value. Becker's formulation of this theory involves a series of independent, fixed-coefficient production functions which express the consumption technology. The models employed by Lancaster and by Cicchetti and Smith involve joint production of consumption services, though the former deals only with single commodities and time as inputs into the consumer production process.

Taking this general view, recreation can be seen as a complex process in which the consumer employs recreational resources, equipment and time in a process which yields a variety of recreational services. These services include such things as on-route scenic enjoyment, relaxation, socializing with travel companions, and fish for later consumption. In some cases, such things as business accomplishments, visits with friends or relatives or other recreational pursuits along the way may also be provided. The relevant aspect of Becker's model for present purposes is that the provision of each of these services is a separable function, allowing a unique attribution of costs to the production of each service. Lancaster and Cicchetti and Smith, on the other hand, would hold that "... the nature of consumer production activities is such that many are interdependent and consequently the costs of each of the final service flows cannot be uniquely determined" (Cicchetti and Smith, p. 251).

The implication of Becker's model is that recreationists may be able to provide information which would allow total trip costs to be attributed to the various consumption services such as travel enjoyment, transportation to and from the recreational site, on-site services, and other trip benefits. This would, in turn, allow for a degree of standardization of the recreational "product" across recreationists. The Lancaster and Cicchetti and Smith models would hold, however, that there are joint production costs which are not attributable among consumption outputs. The empirical approach taken in the present study relied implicitly on the Becker model, as indicated in Chapter V.

g. Travel costs and entrance fees. The final and perhaps most important assumption of the travel cost method concerns the equivalence of travel costs and entrance fees.[4] Bishop and Heberlein state

> [The travel cost method] requires that recreationists treat travel expenditures as equivalent to admission costs, yet this is a questionable assumption which no one has examined empirically. Travel costs represent an aggregation of many smaller costs, some of which (e.g., tire wear) may not be obvious to the recreationist and which are not actually imposed on the recreationists at the time when recreation is demanded. Admission fees are paid immediately, usually in cash. Particularly in a world of satisfycing, travel costs may not be perceived as equivalent to admission fees. (p. 926-927)

The problem referred to by Bishop and Heberlein is potentially serious and yet, as they mention, largely unexplored. Since the issue involved is one of recreational consumer behavior, a thorough investigation would need to take into account the psychological basis for the assumption of economic equivalence.

There appear to be two categories of potential problems with respect to the equivalence of recreationists' response to travel and admission costs. First, do recreationists perceive travel and admission costs in the same way? The above quotation from Bishop and Heberlein suggests that they may not. The nature of travel costs and their equivalence to an entrance fee is related to the distance involved. Travel costs may be more scattered than admission costs, as suggested by Bishop and Heberlein, and on short trips where travel costs are small a single cost will likely be more easily perceived than a series of costs with equal sum.

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[4]The significance of an entrance or admission fee with respect to the measurement of value is that the recreationist is faced with the requirement of making a tradeoff between access to the location and other goods or services which he values. Any other mechanisms which revealed willingness to pay in the face of opportunity cost would serve as well.

Second, travel costs are more likely to be deferable than are admission fees. Credit cards or other credit sales make the payments for gas, oil, and other travel costs easily deferable and thus, particularly on short trips, not as directly associated with recreational consumption. Furthermore, many of these travel costs associated with vehicle operation may be seen as fixed rather than variable costs, particularly when they are deferred. Finally, a large part of the variation in travel costs when measured across recreationists is due to variation in fuel efficiency. Recreationists are not likely to perceive the effect which the fuel efficiency of their vehicles has on the travel costs which they incur in the same way in which they perceive the effect of variations in admission fees.

A second category of potential problems with respect to the equivalence of recreationists' response to travel and admission costs has to do with attitudes toward these costs. In psychological terms there may be a difference between recreationists' affective response to travel and admission costs (Markin, Ch. 10). One of the bases for this difference may be differences in the internalized conception of property rights in these two areas. There is common and fairly routine experience in paying for the goods and services associated with travel. There may be a much different response to an introduction or even an increase in the fee for use of a recreational location such as a lake. Such attitudinal differences may significantly distinguish the resulting elasticity of demand.

It is clear that there are a variety of theoretical problems associated with the use of the travel cost method. To varying degrees these problems can be dealt with by appropriate adjustments in the way in which the technique is applied. Some of the problems which have been discussed, however, present more serious difficulties. The empirical results of this study suggest that in some cases the results of travel cost analysis of the demand for recreational resources have "looked right" because of model misspecification. For example, the omission of time as an independent variable may confound the effects of time and money constraints on recreational demand. While these problems have been more or less widely recognized, there should be greater attempts to solve them and closer examination of other approaches to environmental benefit evaluation. The present study pursues the latter goal.

2. Consumer surplus[5]

Having estimated the demand function for a recreational site or set of sites, a further step must be taken in order to estimate economic benefits from environmental improvements. It was mentioned above that an environmental quality measure can be included in a regression model of the demand function on the assumption that a change in quality will cause a shift in the demand curve. The most common approach to deriving economic benefit estimates is to use the area between the two demand curves and above the price line as a measure of such benefits (Maler). This involves the use of the concept of consumer surplus which will be reviewed in this section. An alternate approach which has been advocated by some authors has been the use of a single-price definition of benefits (Stevens, Burt). The question of which of these is preferable will be dealt with at the end of this section.

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[5]While some authors distinguish between "consumers' " and "consumer's" surplus, the more general "consumer" surplus designation is adopted here.

The concept of consumer surplus has received considerable attention from both theoretical welfare economists and applied economists. It is a concept which, on the one hand, has aroused heated debate among theorists, yet on the other, has won wide acceptance among practitioners. This section will review the concept of consumer surplus as presented by Marshall and Hicks, discuss some of the criticisms of the concept, and finally, give some political implications of the benefit measurement technique which is chosen along with suggestions on resolving the issue.

a. Marshall and Hicks. There have been two major presentations of the consumer surplus concept, the first by Marshall and the second by Hicks. Marshall's treatment was given a cardinal utility interpretation. He defined consumer surplus as "the excess of the price (i.e., total expenditure) which [the consumer] would be willing to pay for the thing rather than go without it, over that which he actually does pay" (Currie, Murphy and Schmitz, p. 743). Although expressed in terms of dollar units, Marshall's emphasis was on the surplus utility derived from participation in the transaction. Following an earlier treatment by Dupuit, Marshall used the triangular area above the single price line and below the demand curve (the Dupuit triangle) as a measure of this surplus utility.

Following a period of disuse, the consumer surplus concept was revived by Hicks and brought into conformity with the ordinal approach to demand theory. Hicks defined consumer surplus as "the amount of income variation that would leave the consumer on his original indifference curve following the introduction of the commodity at the particular price" (Currie, Murphy and Schmitz, p. 745). Hicks' diagramatic treatment of consumer surplus is useful for clarifying both his and Marshall's

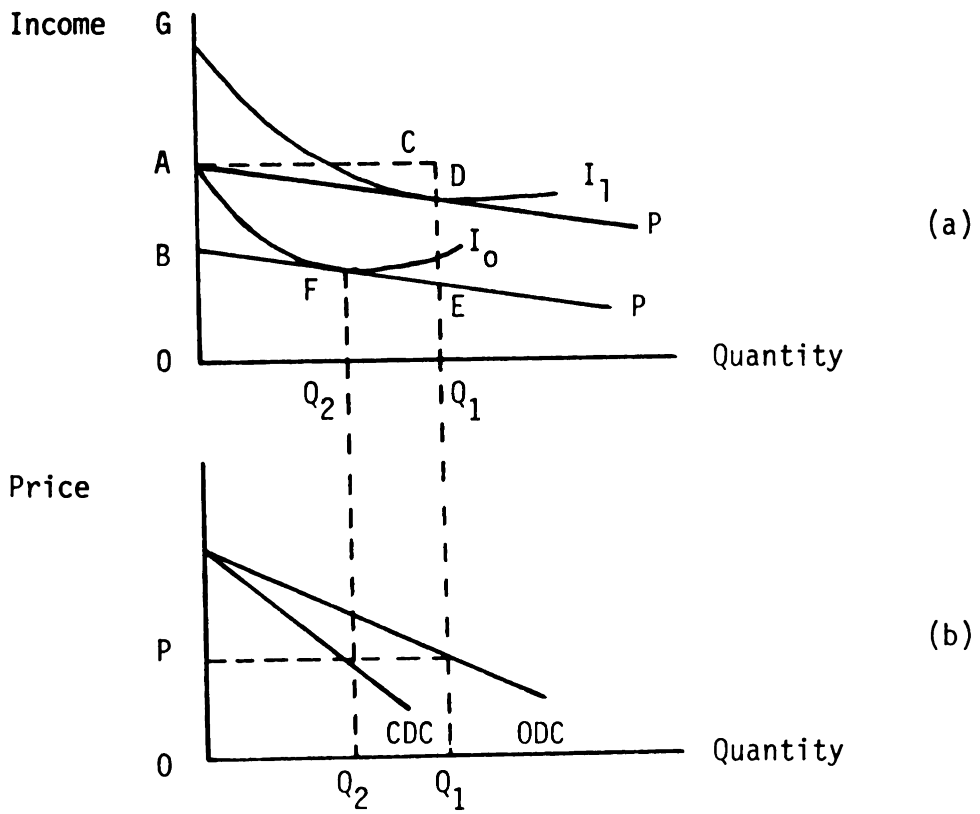

Figure 1. Marshallian and Hicksian Consumer Surplus.

notions of consumer surplus and some of the assumptions underlying these notions.

In Figure 1 the individual is initially at point A, with income OA, and he is on indifference curve I_0. If the good in question is introduced at price P, the consumer will move to point D on I_1, consuming Q_1 and paying CD. He would be willing to pay up to AB for the opportunity to purchase the good at price P, provided he is free to adjust the quantity purchased, since at F he is still purchasing the good at price P, but he has given up enough income to bring him back to I_0. Hicks called AB the compensating variation (CV) and used it as a measure of consumer surplus. Another measure of consumer surplus is AG, the amount the consumer would have to be compensated to make him as well off as he would be after the introduction of the good at price P. AG is called the equivalent variation (EV). It can be seen that CV corresponds to a bid price and assumes the consumer does not have the right to the new price (or good) unless he pays for it. EV corresponds to a reservation price and assumes that the consumer has the right to sell his access to the new price (or good). Marshall's definition of consumer surplus constrains the consumer to continue to purchase Q_1 of the good after the consumer surplus has been collected. This would be the amount DE, which is smaller than AB, the compensating variation.

One of the problems with the use of the ordinary demand curve and the Dupuit triangle to measure consumer surplus has to do with the income effect or the marginal utility of money. If the consumer is actually forced to pay the full value to him of the initial units of the good (i.e., to relinquish his consumer surplus) his available income will be reduced and, provided the good in question is a normal good, he will demand fewer additional units than he otherwise would have. This is shown in Figure 1 as the difference between Q_1 and Q_2. Marshall dealt with this possibility by assuming that the marginal utility of other goods was unaffected by changes in the consumption of the good in question and that the price elasticity of demand for that good was unity. The latter assumption would be approximately true if the good accounted for only a small portion of the consumer's income. These assumptions allowed Marshall to treat the marginal utility of money as constant (and therefore a useable measure of utility from consumption) and the Dupuit triangle as a satisfactory representation of consumer surplus.

Hicks' treatment of consumer surplus avoids the necessity of these assumptions. By using AB (or AG) in Figure 1 as representations of consumer surplus, the income effect is taken into account. It is then possible to redefine the demand curve, as in Figure 2, to "net out" the income effect. The compensated demand curve (CDC), therefore, represents the consumer's demand schedule assuming that he forfeits his consumer surplus on the previously purchased units. If there had been no income effect in the consumption of the good in the first place, the two indifference curves would have been parallel at each quantity, E and F would have coincided, as would the ODC and CDC in Figure 2, and the area under the ODC would have been a correct measure of consumer surplus.

b. Problems with consumer surplus. The above discussion does not resolve the problems inherent in measuring and using consumer surplus. While it can be agreed that the compensated demand function yields the correct version of consumer surplus (the choice between CV and EV still being necessary), such demand functions are not directly observable. Freeman (1979) makes the following statement about the general equilibrium approach to estimating CDC's:

> It is in principle possible to calculate Hicks-compensated demand functions from market data in the following manner. The first step is to estimate the complete set of demand functions as a system of equations. ... If the integratability conditions are satisfied, the expenditure function can be derived from the system of demand equations. Given the expenditure function, computing the Hicks-compensated demand functions and EV or CV measures is relatively straightforward. The practical difficulty in all this lies in the econometric problems of estimating complete systems of demand functions in sufficient detail to permit the derivation of the appropriate compensated demand functions for specific commodities. (p. 44)

Though Freeman believes in the theoretical possibility of deriving a compensated demand function, he acknowledges the impracticability of the procedure by saying "On the criterion of practicability, the ordinary consumer surplus measure gets the nod" (p. 44).

There may, however, be error introduced into the calculation of benefits by using the ordinary demand curve as a proxy for the correct, compensated demand curve. Randall and Stoll point out that the consumer surplus measure taken from the ordinary demand curve will fall between the CV and EV measures, and that the divergence between CV and EV will depend on the income elasticity of demand (or price flexibility of income) for the good in question, the size of the consumer surplus as a percentage of income or expenditure, and the costliness of consumption adjustment.

In an earlier article in which he discussed the error introduced by the divergence between EV and CV, Willig concluded that this error would likely be overshadowed by the errors involved in estimating the demand curve. Gordon and Knetsch challenge this conclusion, however, in light of empirical evidence which they review. They state that "The willingness to pay of an individual is, at least in the extreme, limited by the person's available income or riches. No such constraint limits the demanded compensation. This assymetry may indeed cause a variation in response for particular individuals" (p. 3). Brookshire, Randall and Stoll also found significant differences between measures of willingness to pay and willingness to accept compensation. They attributed these differences, however, to the differential efficacy of the bidding game formats which they used, rather than to income effects.

The significance of these findings lies in the fact we are not living in an idealized world of economic theory and "economic men." There may be important effects from such things as strategic behavior, learning and the distribution of rights on the demand response and utility levels of consumers. The income elasticity of demand may be quite different, for example, when measured by ordinary means or when measured by a "willingness to sell" bidding game. These results do not add any confidence to the practice of using the ordinary demand curve to measure consumer surplus.

Another problem with consumer surplus has to do with economic rent and profit. Producers may be earning rent or profit as a result of such things as resource immobility and imperfect competition. A new project can reduce this rent or profit by shifting demand away from other goods and thus reducing prices (unless those goods are produced under constant marginal cost conditions). These pecuniary externalities are the normal signals for resource movement to occur, but they may cause short or long term losses, depending on the mobility of factors of production. To be correct, therefore, the project evaluator could not use the simple criterion of comparing resource costs with total benefits (including consumer surplus) for the project, but would have to include these diverse profit and rent losses in the rest of the economy as social costs from the project, a clearly impossible task.

A further consideration on the use of consumer surplus in project evaluation has to do with consistency in accounting. If consumer surplus is credited as a benefit from a proposed project or price change, then it should also be counted as a cost of opportunities foregone as a result of reallocation of resources. There is an obvious bias in the accounting procedure if the total value available to a discriminating monopolist were counted as benefit, but a non-discriminating, single price were enforced with respect to costs. In other words, if the consumer surplus from a project is to be counted as a benefit, then the loss of consumer surplus at other locations in the economy as a result of resource shifting should be counted as a cost. Crutchfield says,

> It is neither essential nor desirable that total benefits be obtained by estimating consumer surplus. This would require integrating the demand function (i.e., charging each individual the maximum he would be willing to pay rather than do without). Perfect discrimination of this type would not yield a net benefit figure comparable to that derived from other uses of the resource which would normally be subject to a single price or single prices for each different class of user.
> (p. 151)

This asymmetry in accounting procedure appears to be one of the major objections given by opponents of the use of consumer surplus in project evaluation. Two possible exceptions can be raised to this objection, however. The first is that the good being evaluated is independent of other goods and its introduction has no impact on other prices. The second is a similar argument--resources used in the production of the good in question cause only marginal changes in other areas and thus do not change any consumer surplus amounts in those areas. The answer to these objections is partially a matter of empirical evidence. Where the production of a new good draws on previously unemployed resources, there is no negative impact on consumer surplus in other locations in the economy. Regarding the second point, while a marginal change in any one location may not have an impact on consumer surplus, the sum of all such changes, from resources being shifted to the production of the good in question, may be significant. One would at least have to keep in mind the possibility, when consumer surplus was to be employed in benefit estimation, that conventional cost estimates undervalued true costs.

The discussion to this point has dealt with the nature of consumer surplus and some of the problems inherent in its use in project evaluation. In light of these problems it must be asked what reason there is for using the concept in benefit evaluation. The argument in favor of the inclusion of consumer surplus in the benefit category is that it constitutes or represents a portion of the utility gained by consumers from participation in the transaction or that gained by beneficiaries of publicly provided goods. The arguments against the use of consumer surplus, as presented above, are of two types--the empirical problems involved in correctly measuring consumer surplus and the perhaps unavoidable ommission of the impact of project selection on other surplus categories such as consumer and producer surplus in other areas of the economy. It may be that the ommission of consumer surplus from the benefit category of the project or good in question will provide more accurate results than would its inclusion. This might be the case since ommission of the consumer and producer surplus measures from the cost accounts appears inevitable. There is no way to tell if the two components are of similar magnitude, yet exclusion of two factors of opposite sign seems preferable to exclusion of only one and a resulting bias in favor of one class of goods in the decision making process (Little, p. 175).

c. Political implications. A number of authors have recognized the problem of asymmetry which is introduced by using a consumer surplus measure of benefits while ignoring the consumer and producer surplus effects in other parts of the economy which would be caused by project implementation. The most common suggestion for dealing with this problem has been to use a single-price measure of benefits (Crutchfield, Merewitz, Scott). Single-price measures draw a distinction between the economic value of a good and the benefit to the consumer. This distinction maintains the comparability of the accounting practices for public goods with that of private goods. In the latter case, inframarginal consumers receive benefits from purchase which exceed the revenue which they pay for them, yet it is the revenue which the producer receives which is taken into account in determining whether to undertake production. In very few cases is price discrimination permitted and the producer allowed to recover part of the consumer surplus which his customers derive. Clearly, the issue of whether or not, or the degree to which, price discrimination is permitted is a matter of public choice. To presume that the full consumer surplus should be credited as a benefit to a public program is simply to usurp this public decision making function (Schmid, 1980).

The suggestion that a single-price measure of project benefit should be used is in accordance with the common practice in the private sector, but it does not avoid the decision of whether or not some degree of price discrimination is to be allowed nor the distributional consequences of such a choice. Another way in which the single-price measure involves a distributional choice is in the selection of a price level at which to evaluate benefits. Those who advocate the single-price measure usually assume that it should be measured at the revenue maximizing price level. There is, however, no reason to make this assumption. Selection of any particular price level at which to evaluate benefits is as justifiable as any other level or as the use of the consumer surplus value. In other words, the issue is one of public choice and should be treated as such. The procedure followed by the analyst should be to display the benefit value calculated by several different pricing rules, indicating the distributional significance of selecting any one of these. While the consumer surplus measure cannot be rejected on the basis that price discrimination is technically infeasible or wrong, it has less to recommend it as a benefit measure than does a single-price approach. Considering its empirical weaknesses, as described above, and the fact that price discrimination is so generally forbidden in the rest of the economy, the public program analyst may choose to briefly indicate these reasons for not employing the concept.

3. Bidding game

While estimates of recreationists' willingness to pay for an environmental service or improvement can be inferred from demand curves estimated by the travel cost approach, it is also possible to elicit these values directly from recreationists. This approach has a variety of names, the most common likely being the bidding game approach.[6] This approach commonly asks respondents to state in some form their willingness to pay for some specified level or change in level of a publicly provided good, or their willingness to be compensated for a comparable loss. There is great variety in the general format of bidding games and in the phrasing of questions, both of which can be expected to have considerable significance for the results which are obtained.

Two general issues with respect to the use of bidding games for environmental benefit assessment will be discussed here. The first is the relationship of individual and aggregate bids to demand relationships derived through the use of the travel cost approach. The second is the issue of validity or predictive accuracy of responses.

a. Assumptions of bidding games and demand curve estimation. Bidding game questions may be framed so as to measure either respondents' willingness to pay for a specified quantity of a publicly provided good

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[6] See, for example, Randall, Ives and Eastman; Brookshire, Ives and Shulze. Bishop and Heberlein refer to this general class of procedures as "hypothetical valuation" techniques, yet they need not be hypothetical (Bohm, 1972).

rather than do without it entirely or their willingness to accept compensation in order to forego a specified quantity of the good. These are usually regarded as measures of consumer surplus: compensating and equivalent variation, respectively. Freeman (1979) says

> An individual could be asked his total willingness to pay to receive a specified quantity of the public good rather than do without it entirely. His answer, if it is unbiased, is a compensating variation (CV) measure of the welfare gain if the public good is provided in the specified quantity. In other words, it is the integral of the Hicks-compensated demand curve for the public good which holds utility constant at the level associated with zero public goods supply. (pp. 87-88)

In order to be equivalent to the compensated demand curve measure of consumer surplus as Freeman states, the results of the bidding game must be amenable to the same assumptions which apply to the compensated demand curve. These include the normal ceteris paribus conditions such as constant price and quality of all other goods and constant preferences of consumers. The compensated demand curve entails an additional assumption, however. This is that the real income of consumers is held constant by means of perfect price discrimination. The consumer is assumed to forfeit the surplus value associated with all inframarginal units of the good, thus leaving him with the same real income as he had prior to the proposed change (price reduction, etc.).

It is not clear what the effect on respondents' bids would be if they were explicitly told that perfect price discrimination was going to be practiced, that they would have to pay different prices for different units of the environmental service and/or that others would be paying different prices than they would. The evidence from Bohm (1972) suggests that there is no difference in mean bid when price discrimination is practiced, yet the basis of legislation prescribing price discrimination appears to be a general aversion to it (Schmid, 1980). It may be that total willingness to pay would be reduced due to consumers' unwillingness to pay under a price discrimination scheme. In the present study's bidding game a single price was specified in an attempt to make the hypothetical bidding situation seem more fair and thus reduce the rate of refusal to cooperate with the game.

There are two further assumptions which bidding games and estimated demand functions have in common. The first is that effective demand rather than preferences are being measured. This is clearly recognized in the case of demand curve estimation and the influence of income variation is taken into account by including a measure of income in the regression model. In the case of bidding games the influence of income is less commonly recognized. It is argued by some that since the respondent does not have to actually pay his bid, there will be no constraints by income on that bid. Victor, however, believes that bids will be constrained by income levels and will reflect effective demand. This is clearly an important issue in evaluating the bidding game as a mechanism of preference articulation, though it is unlikely to be resolved without empirical evidence.

A final point of comparison between bidding games and conventionally estimated demand curves has to do with their assumptions regarding, and treatment of, the informational basis of demand. Preferences and the consequent demand for goods are clearly influenced by the level of knowledge which people have concerning the characteristics and prices of those goods. The conventional theory of consumer demand assumes complete knowledge of these factors by consumers (Ferguson and Gould). Bidding games share this assumption.[7] The important distinction between the two is, however, that demand estimation techniques do not provide the consumer with additional information, whereas the bidding game does. For goods such as environmental improvements where consumer perceptions of the situation in question are highly variable, this provision of information in the bidding game may appreciably affect the measured demand. This issue will be discussed further in Chapter VII.

b. Bidding game accuracy. The issue most frequently discussed in the literature on bidding games is that of accuracy of response. How accurately can and do respondents predict the maximum price which they would be willing to pay for a given quantity of the good in question (or the minimum compensation they would be willing to accept for loss of the good)? While the bid may be viewed as a measure of preference for or attitude toward the good, it is actually a statement of behavioral intention regarding the probability of purchase at different price levels. As such it might be expected to have a somewhat higher correlation with subsequent behavior than would a more general attitudinal measure (Schuman and Johnson). There are, however, a number of factors which may affect the predictive accuracy of the respondents' bid. One of these is the degree of anticipation and planning which is involved in this type of purchase decision. This likely explains part of the success of consumer surveys regarding anticipation of the purchase of durable consumer goods, though it may have less applicability with respect to recreational expenditure. Another factor affecting the predictive

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[7]The normative significance of demand estimates, derived from either technique, are considerably changed if this assumption is relaxed. There are obvious distributional consequences if "expert" opinions are substituted for consumer choice.

accuracy of the bid is the stability of the intention-behavior relationship. This will depend on the involvement of stable sets of attitudes and the elapsed time between a bid and subsequent actual purchase decision (Markin, Ch. 10). In this respect, since there is often no subsequent check of bid accuracy, the bid itself must be taken as the relevant preference measure.

The most frequently discussed problem regarding bid accuracy is that of strategic response. Respondents may perceive an incentive to give biased responses if they believe this will influence a public decision in their favor. Strategic bias can be defined here as the divergence of the bid from what it would be if the respondent saw no chance to influence a public decision. Bias should not be defined as divergence of the bid from some "true" willingness to pay that reflects true marginal preferences, since that would also include non-strategic error.

The problem of strategic response is clearly recognized in the theory of public goods. Where exclusion costs are high the "free rider problem" arises; consumers have an incentive to understate their willingness to pay if they believe this will influence their share of the cost but not their access to the good. If they believe that the existence or availability of the good in question will be influenced by their response while the cost which they will bear is zero or a fixed amount, their incentive will be to overstate their willingness to pay. There are a number of combinations of such payment-provision condition.[8] Bohm (1972) examined the effect of a number of these conditions on bidding

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[8]The term "payment-provision conditions" should not be confused with the payment vehicle. The former refers to the pattern of costs and benefits which will accrue to the individual as a result of the proposed program, while the latter refers to the mechanism by which payments will be made.

game responses. He also employed a purely hypothetical bidding game design which either removes the incentive for strategic response, or allows the respondent to imagine what the payment-provision condition might be by "second guessing" the reason for the question.

One of the approaches which has been employed to deal with strategic bias is to control or eliminate strategic incentives. Bohm (1971) says that bidding games which either specify that future payment for the good in question will be a function of the average bid, or those which specify that payment will have no relation to the bid,

> put the individual in a situation where the choice of strategy is very simple. Then, one possible way to achieve a solution lying between the two extremes [strategic bias upward or downward] would be to make the formation of strategies more difficult, preferably so difficult that the individual would tell himself something like: "Since I cannot find a way to beat the system, I had just as well tell the truth. Then, at least, I can't lose." (p. 56)

Bohm realizes that strategic response may not be eliminated by the deliberate creation of uncertainty regarding payment-provision conditions, but suggests that the removal of incentives might mean that overstatements and understatements are stochastically distributed, making the aggregate stated willingness to pay a good estimate of the sum of the consumers' true valuations. Tideman and Kurz have also proposed counter-strategic techniques for bidding games, though these assume complex calculations on the part of respondents. Both Tideman's and Kurz's models are designed to make the expected payoff from a biased bid equal to zero, given certain assumptions or information concerning payment-provision conditions.

The second technique for dealing with the effects of strategic response bias is to attempt to measure it and discount responses appropriately. Brookshire, Ives and Shulze assume that honest bids are distributed normally and that strategic bias will tend to "flatten" the distribution of bids. They visually examine a plot of the bids and conclude that strategic response is not a problem in their data. In this study an attempt is made to test for the presence of bias by examining certain attitudinal measures also taken during the interview. While the incentive to give a biased bid depends on the respondent's belief that his answer will affect a public choice, it is also necessary that he believe his preferences differ from the average preference of other respondents. The respondent may not achieve the rational sophistication implied by these conditions, yet if he is to undertake strategic behavior in a bidding game, he cannot explicitly hold the opposite position to either of these conditions. The test which will be presented and applied in this study, and which is described in Chapter V, is based on a weak assumption of rationality involving only the correlation of preferences and bid levels.

The second problem relating to the predictive accuracy of bidding games has to do with the correct assessment by the respondent of his preferences and attitudes. Freeman says

> An accurate response to a question about willingness to pay is one which is consistent with the underlying preference ordering or utility function and with the behavior that would be revealed if the public good could be offered in a market where exclusion was possible ... The implicit assumption [in the survey research literature] is that the true value is an objective magnitude that can be observed independently for purposes of verification or measurement of response error. But the essence of the problem of preference revelation is that the true value is subjective and typically cannot be observed independently. (p. 97)

While Freeman refers to this simply as "accuracy," the issue will be termed "preference assessment accuracy" here (where the context requires) in order to distinguish it from such things as predictive accuracy.

Preference assessment accuracy is not a matter of freedom from strategic response bias, nor is it simply a matter of correct attitude measurement, though the latter is involved. A statement of behavioral intentions regarding purchase decisions requires fairly complex mental calculations which are only approximated by the consumer demand model of constrained utility maximization. This calculation may involve multiple products and constraints as well as uncertainty. Furthermore, it may prove difficult because of the respondents' unfamiliarity with bidding for public goods, though in some cases the bidding game may be closely related to a routinized market choice. If the resulting bid is to correspond to Freeman's definition of accuracy, considerable effort may have to be put into the process of deriving it. It is easy, however, for the respondent to give a bid which is inaccurate though reasonable. Preference assessment accuracy is, therefore, a scarce or economic commodity.

Freeman (1979) suggests a useful approach to analyzing preference assessment accuracy by saying that "resources are devoted to increasing the accuracy of responses only so long as the marginal net utility gain to greater accuracy is positive." Efforts to increase accuracy can be directed, therefore, at adjusting the costs and returns to the respondent.

One of the common prescriptions for increasing the accuracy of bid responses is to reduce the hypothetical nature of the question. Consumer choice is essentially a complex process and the rational consumer will develop standardized procedures for dealing with classes of purchase decisions. When forced to respond to a hypothetical purchase choice, the mental costs are increased and accuracy reduced. A number of factors will determine the hypothetical nature of the question, including the familiarity with the proposed payment vehicle, the interview setting, and the length of recall required. Davis, for example, conducted interviews at the recreational location, thus allowing respondents relatively easy visualization of many of the concepts being used. This study used a similar approach. One of the implications of this is that accuracy of responses may suffer considerably if non-users of a recreational resource are questioned such as in an attempt to determine option demand. Another way in which the cost of preference assessment can be reduced is through appropriate interview techniques. Respondents should be allowed adequate time for carefully considering their responses. They may also wish to discuss their determination of an appropriate bid in direct interview situations (Knetsch and Davis, 1966, p. 135). On the other hand, the total time required to complete the questionnaire should be kept to a minimum. Finally, bidding games should be made as simple and clear as possible.

With respect to maximizing the returns to greater accuracy, Freeman (1979, p. 89-90) makes the important point that attempts to reduce the incentive for strategic response bias may also reduce the incentive to provide, or returns to, preference assessment accuracy. One of the important benefits of participation perceived by the respondent may be the opportunity to influence public decisions at a low cost to himself. When the hypothetical nature of the survey is emphasized or strategic incentives are removed through deliberately created uncertainty, the returns from greater accuracy will also be reduced. While there is likely an inevitable tradeoff here, there are other returns to the respondent which can be increased at less cost. One of the reasons for respondents' cooperation in a survey is their belief that the topic is interesting and important, even apart from the desire to influence public choice in their favor. It may be possible to take this factor into consideration at an early stage of research design. A final factor in maximizing returns to increasing accuracy has to do with the degree of personal commitment to the survey which can be generated in the respondent. Personable interview techniques, such as periodic reinforcement of the respondent's performance, can increase his desire to cooperate with careful responses. The major problem in survey design and administration, in terms of increasing the returns to the respondent from greater accuracy, is devising a way in which to make those returns contingent on the degree of accuracy which cannot itself be measured.

A complete assessment of the consequences of strategic bias and preference assessment accuracy requires information on both the causes of these errors and on their expected distribution. While there is no empirical evidence on the expected distribution of errors from these two sources, it is expected that they both lead to an increase in the variance of bids. In addition, strategic response bias, as the name implies, can be expected to result in biased estimates of the mean bid (Bohm, 1971, p. 56). Both of these consequences are important. Although most previous bidding game studies have not explicitly tested the null hypothesis that the mean bid equals zero, this hypothesis can and should be tested. Of perhaps greater importance is the biasing effect which strategic response has on the estimated mean bid, causing biased estimates of aggregate benefits. If these expectations are correct, the implication is that where a tradeoff between strategic bias and preference assessment accuracy is faced, such as in the decision on whether to disassociate the bidding game from an actual public choice, it may be preferable to increase the disassociation, accepting an increase in bid distribution variance, but avoiding strategic bias.

Before concluding this discussion of bidding games two additional issues must be dealt with. The first has to do with the assumption, implicit in the discussion of preference assessment accuracy, that preferences are preexistent psychological entities which the respondent can, with some degree of mental effort, discover and report. This view of preferences has been employed in conventional economic theory and has formed part of the basis for the claim of allocative efficiency for the market. It has, however, been widely recognized that preferences are formed in the process of economic interaction. Whether this is explained in terms of a cognitive theory of learning or a behavioral theory of reinforcement, it is clear that individuals do more than simply reveal, or even discover, their preferences in market interaction. Preferences are continually readjusted and formed as information is acquired by the individual in all phases of his experience.

With respect to bidding games, the relaxation of the assumption of fixed, discoverable preferences implies that the values attached to benefits and costs are not fixed either. The values which are obtained in a bidding game must be seen as dependent upon the techniques which generate them and as open to continual alteration as learning takes place. This latter characteristic is particularly important in that bidding games involve a situation which is both novel and hypothetical. The respondent is faced with the availability of a good which he is not used to buying. The bid which he gives will clearly be dependent upon the amount and type of information which he receives as well as on his ability to relate the choice to his other attitudes and beliefs. Also, his bid may not indicate the value which he will place on the good in the future. Therefore, the term "accuracy" must be seen in the context of a set of developing and changing preferences, although this is not to say that there is no distinction between accurate and random response.

A second and closely related issue has to do with the degree to which an explicit tradeoff in consumer expenditure is brought to the respondent's attention in a bidding game. For many of the goods or environmental services dealt with by bidding games the respondent may be willing to pay some small amount which is below a level at which he commonly begins to consider tradeoffs or the opportunity cost of purchases. If such a "standard operating procedure" is interrupted by asking the respondent to consider tradeoffs or by lumping goods together so that their total value to him exceeds this lower boundary of economizing behavior, changes in the bid will likely be seen. Just as it should not be assumed that the respondent has a preexistent set of preferences upon which to base his bid, it should not be assumed that he will be consistent in his explicit consideration of economic tradeoffs. The possible effect of explicitly constrained choice in the context of public opinion surveys in general is discussed further in Chapter VII (Birch and Schmid).

C. Productivity Benefits

The definition of benefits resulting from changes in environmental quality or the nature of environmental services as an input in the production of goods and services draws on the theory of production in firms. This topic has been adequately dealt with elsewhere (Freeman, 1975, 1979, Chp. 9; Maler and Wyzga, Ch. 5). The purpose here will be to give a brief review of the theory of environmental productivity benefits in order to set the stage for this study's investigation of that topic.

Where environmental quality affects a production process, benefits may be derived by both producers and consumers of the goods involved. Environmental quality can often be treated as a close substitute for some production cost. If minimum standards exist for the quality of some environmentally derived input factor such as water, their costs will be incurred by producers when quality is below this standard. Improvements in environmental quality will, therefore, cause a reduction in production costs. If perfect competition is assumed, three possible cases may be examined (Freeman, 1975).

Where the industry involved faces constant costs and an improvement in environmental quality affect a significant number of producers, there will be a downward shift in the aggregate supply curve, a drop in price and an increase in the quantity of the output demanded. These changes are shown in Figure 2a. The benefit from such a change is commonly defined as the increase in consumer surplus, P_1ABP_2. In light of the earlier discussion on that topic, it may be preferable to define it as the resources saved by the price reduction, P_1ACP_2 (Schmid, 1980, Ch. 6).

A second possibility is where one or a small number of producers are affected by an improvement in environmental quality. The benefit here accrues to the owners of fixed factors of production or the recipients of residual income in the form of a rent, area ABCD in Figure 2b. In the case where environmental quality is a perfect substitute for some group of inputs and where output does not increase (either because total costs but not marginal costs are affected or because output decisions are not affected by the given change in marginal cost), the change in rent will be an exact measure of the benefit from the environmental quality change. This will be the case, for example, in

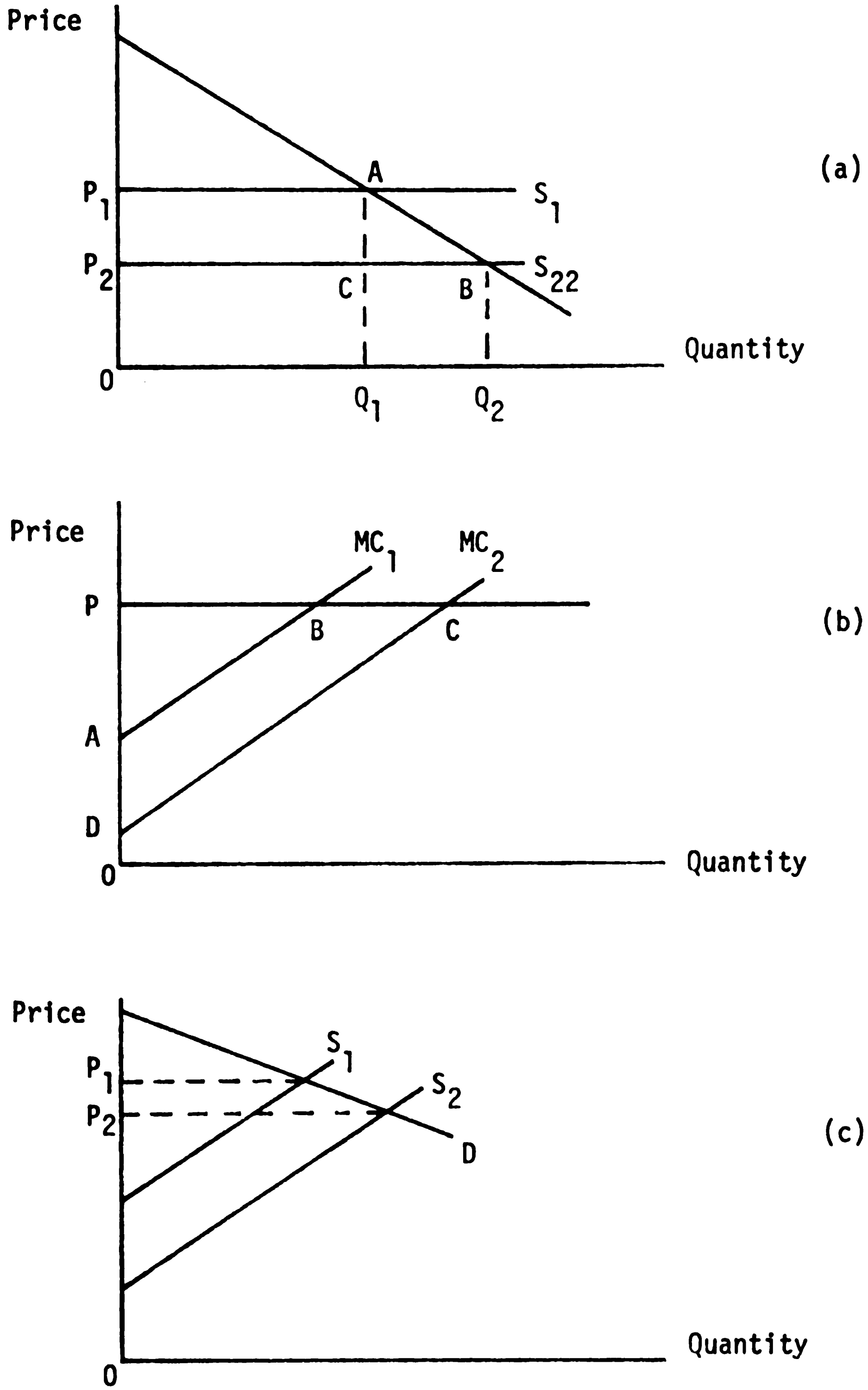

FIGURE 2. Effects of Environmental Quality Change on Production Costs

(Source: Freeman, 1975)

the provision of municipal water supply or navigational channel maintenance. In such cases a "cost saving" measure of benefits is valid.

The third possibility is shown in Figure 2c. The industry experiences increasing costs and the change in environmental quality affects enough producers to shift the industry supply curve downward. Here there are changes in consumer surplus (and resources saved) and producer rents.

In each of these cases attention must be paid not only to the cost saving to producer, but also to changes in prices and even the nature of the product for consumers. This last consideration is relevant in the case of dredging of navigational channels. Since dredging produces large amounts of material which require disposal and since the method of that disposal may have significant environmental consequences (with respect, for example, to the filling of wetlands or the reintroduction of pollutants from the dredged material into the water body), it is important to control for a standard "product" when considering benefits due to dredging cost reduction.

This section has discussed the evaluation of environmental benefits in the context of cost savings in production processes. Although the cost savings approach has been applied most frequently in non-recreational areas such as municipal water treatment and navigational channel dredging there are cases where it may be used in evaluating recreational benefits. One possibility is the savings in sport fish stocking costs which might result from a drop in sediment delivery or turbidity. This would be the case if the fish management objective was to maintain fish numbers in a lake at a given level and if reproduction or survival were adversely affected by turbidity or sedimentation.

The cost savings approach was not used for recreational benefit evaluation in this study for two reasons. First, the stocking program did not appear to be related to turbidity levels in the lakes which were investigated (Tables 2 and 6). That is, stocking was undertaken at both a clean and a turbid lake. It is not known whether stocking of game fish at the turbid lake would be reduced if water quality was improved. Second, it was not known whether turbidity levels in the observed range have a detrimental effect on reproduction or survival of the fish species found in the study lakes (Table 2). Without such evidence it was impossible to predict a potential cost saving.

III. SOIL CONSERVATION AND OFF-SITE IMPACTS

The purpose of this chapter is to set the stage for the economic analysis which will be described in subsequent chapters by describing the physical systems and relationships which are associated with soil erosion and sedimentation. Understanding the processes which are involved in these systems, together with the human perception of environmental changes, is basic to the economic valuation of such changes. The complexity of the physical, chemical and biological linkages present some important limitations for this type of economic analysis, however. First, although the goal of this study is to evaluate the off-site impacts of soil conservation, it has not been possible to establish the nature of the relationship between the adoption of soil conserving land use practices and changes in sediment level at downstream locations. Second, because of the interdependence of numerous parameters in the physical systems, it has not been possible to identify the way in which changes in sediment level may be perceived and reacted to by individuals. While it would be ideal to be able to vary the level of soil erosion while holding "all other relevant variables" constant, and to measure changes in economic response, this is clearly impossible.

The objectives of the present chapter are to define and explain certain terms and concepts which will be used through the remainder of the study and to give a brief overview of the major physical processes involved in the generation of off-site impacts from soil erosion.

Comments will also be made on the experimental design used in the present study in light of the complexity of these physical processes.

A. Definition of Terms

The term "sediment" is commonly used to refer to particulate material which has been deposited following suspension and possibly transport by water. This definition corresponds to the process of "sedimentation" which refers to the deposition of suspended material. In other contexts, however, "sediment" is more loosely used as a reference to both suspended and deposited material (Farnworth, et al., p. 183). The units employed in measuring suspended material are usually milligrams per liter of water or some other weight/volume ratio. Sediment may also be transported as "bed load," material moved but not suspended by the flowing water. This will be described further below. In this report the term "sediment" will be used as a general reference to particulate material and will be qualified as suspended or deposited, where necessary.

Sediment may be of either organic or inorganic composition. While inorganic sediment originates almost exclusively with the erosion process, organic sediment may come either from erosion or from aquatic or riparian plant growth. The process of lake eutrophication is largely one of organic sedimentation resulting from the growth and decay of aquatic plants, a process enhanced by delivery of nutrients to the water body. The focus of the present study is on sediment generated by upland erosion but, because of the difficulty in establishing sediment source and because of a lack of information on any differences in impact by sediment from different sources, the source of sediment is assumed here to have no effect on the production of environmental services.

Light which passes through water containing suspended particles will be scattered and absorbed rather than transmitted in a straight line. "Turbidity" refers to this optical property, though it is usually perceived by the casual observer as murkiness, cloudiness or mudiness. Turbidity may be determined by measuring the scattering of a light beam passing through a water sample, or by measuring the length of a light path through a sample which just causes a given intensity of light to disappear. The former technique is used in a turbidimeter, such as those used in water treatment plants (Duchrow and Everhart). The latter is the basis of the Secchi disk measurement of turbidity used in the present study's recreational analysis.

A Secchi disk is a weighted disk, eight inches in diameter, with alternating black and white quadrants. It is used by lowering the disk into the water and measuring the depth at which it just disappears. Although unsophisticated, this technique has been shown to be reasonably reliable and consistent.

"Water quality" is used throughout this report to refer to either suspended or deposited sediment and other pollutants which would normally be associated with soil erosion unless explicitly stated.

B. Overview of Physical Systems

1. Erosion and sediment transport

Weathering and erosion of the land surface are natural phenomena which are perpetuated largely through the energy of flowing water. The three fundamental stages to this overall process are detachment, transportation, and sedimentation or deposition. These should be seen as interdependent parts of an overall materials transfer process.

One approach to the investigation and description of the erosion process is to use "mechanical" models which explain erosion by reference to such things as detachment and transportation of soil particles by rainfall and runoff. Research of this type seeks a detailed description of the physical movement of soil particles. A more common approach to erosion research, however, is to explain the overall process in terms of major causal factors. The development of the Universal Soil Loss Equation is an example of this type of "empirical" model (Wischmeier and Smith). It predicts soil loss due to runoff as a function of climate, vegetation, geology (soil type), topography and land use.

The Universal Soil Loss Equation predicts gross erosion, the total amount of soil being transported. Gross erosion exceeds the amount of sediment delivered to a downstream location, however, because not all eroded soil reaches a stream channel. The ratio of the amount of sediment delivered to some downstream location to gross erosion is termed the sediment delivery ratio and depends on such things as watershed size, type of soils, land use and conservation practices (Robinson; Great Lakes Basin Commission, Section 2).

As mentioned above, sediment may be transported either in suspension or as bed load which moves along or near the streambed. The manner in which material is transported depends on particle size, shape and specific gravity and the velocity and turbulence of the streamflow. The erosive energy of flowing water is a function of the volume of water and its velocity. When the volume of runoff is increased or is concentrated in channels, its erosive energy is increased. As this erosive energy increases, more and larger particles will be moved both in suspension and as bed load. If the streambed or other land over which the water is flowing is erodible, erosion will tend to occur. Conversely, as erosive energy decreases, less material will be transported both in suspension and as bedload and deposition will occur. Thus, deposition and resuspension are repetitive as the rate of discharge and stream velocity vary.

Given a volume and velocity in a stream flow, other things such as turbulence and soil characteristics being constant, a transportation potential or capacity will be determined. When the current sediment load is less than this capacity, streambank erosion will tend to occur. The implication of this is that where soil conservation reduces sediment delivery to a stream and thus reduces sediment load below the stream's average transport potential, streambank erosion may take place and the reduction in sediment delivery at a downstream point may be less than would otherwise be the case. This effect will be less evident, however, where soil conservation measures also reduce or delay total runoff and thus reduce the erosive capacity of stream flow.

A final factor to consider with respect to soil conservation and sediment delivery is that of time. Changes in gross erosion may take considerable time to be reflected in downstream sediment delivery. One of the implications of this is that experiments designed to examine this relationship through the use of time series data must cover a sufficient period of time to detect this relationship in its full extent.

This discussion has illustrated some of the complexities in the relationship between the adoption of soil conservation practices and the delivery of sediment to a downstream location. A later section in this chapter will describe the approach which has been taken in this study in making a logical connection between soil conservation and off-site economic consequences.

2. Impacts of sediment on environmental services

The importance of sediment transport from point of origin to impact site has been established. Of equal importance is the impact of the delivered sediment on some environmental service, what may be called the physical damage function. Unless the level or change in level of sediment resulting from soil erosion has some impact on the uses which people make of water at the downstream location, no economic consequences will occur. Furthermore, the nature of the impact of sediment on environmental services will critically determine the nature of the economic consequences. This section will describe some of these potential impacts and then discuss some general issues which may affect the nature of the physical damage function.

Nemerow and Faro present a list of "beneficial water uses" which may be affected by water pollution. These include recreational uses, withdrawal water uses, wastewater disposal uses, bordering land uses, and instream water uses (p. 7). In the last category, they include such things as commercial fishing, navigation and hydroelectric power generation. Similar lists are presented by Tihansky and Jordening. With respect to sediment pollution, the following impacts would appear to have particular importance:[1]

a. Recreational/aesthetic--both the direct visual appearance of suspended soil material and the biological impact on such things as game fish and aquatic plants.

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[1]These include only off-site impacts--those which involve transportation of sediment from the general area of erosion. Some studies also list as a sediment impact the overwash of infertile material on fertile soil. This may or may not be an off-site consequence.

b. siltation--affecting such things as reservoirs, navigational channels.

c. withdrawal--for municipal and industrial water supply.

The focus of the present study is on recreational impacts of sediment. In addition, the consequences of sediment for navigational channel dredging, recreational lake dredging, and municipal water treatment costs will be briefly examined. The results of other studies dealing with reservoir and drainage channel siltation are also reported.

As mentioned in the previous chapter, environmental services can be categorized as either inputs to productive processes or as direct consumer goods. With respect to environmental services as production inputs, the impact of sediment is defined by the physical production function into which water services enter. With respect to environmental services as consumer goods, the relationships of interest are those between the level of sediment and various recreational services of water. The direct effect of suspended sediment (turbidity) on aesthetic enjoyment has been mentioned. There are also many connections between the level of sediment and various biological processes (Farnworth, et al., Ch. 9). For example, sediment deposition in game fish spawning areas will reduce spawning success by smothering eggs, resulting in reduced game fish availability for some species. Turbidity will also affect water temperature and light penetration, thus influencing the growth of aquatic plants. These may be algae, causing turbidity or at times a greenish appearance in the water, or they may be larger plants, which may be seen as either weeds or game fish cover.

There are a number of potentially important issues in the definition of the physical damage function. The first is the problem of dealing with a single pollutant, such as sediment, which is often associated with or travels with other pollutants. Small sediment particles may absorb chemicals such as nutrients or pesticides, thus causing the two to travel in association. The impact of this is particularly evident in the case of dredged material. Because open water disposal of dredged material will reintroduce chemicals which are trapped in deposited sediment, current environmental regulations require disposal of such material in diked disposal areas in order to prevent this reintroduction of chemical pollutants. To correctly assess the impact of sediment on environmental services, therefore, the effect of associated pollutants must also be taken into account.

Another potentially important issue in determining the relationship between sediment and environmental services is that of threshold effects. While some physical damage functions such as the relation between siltation and reservoir life are linear, others may show a sharp change in response over a small range of sediment delivery levels. For example, the dosage of chemical coagulants in municipal water treatment may be directly related to turbidity levels up to some point. Above this level of turbidity no further increase in chemical dosage may be required. Threshold levels may also be important with respect to aesthetic perceptions, a matter which will be discussed in later chapters. Recreationists may not notice a change in the level of sediment until it exceeds some amount (Markin, p. 201).

A final important issue in the definition of physical damage functions is the possibility of tradeoffs, or substitution effects. One of these has been mentioned already: the possibility of increased channel erosion when upland erosion is reduced. Upland and channel erosion may be "substitutes" in the physical "production" of downstream sediment delivery. Another example of this effect is the tradeoff between suspended soil material and algae in causing turbidity in a water body. If the input of soil particles is reduced, light penetration and algae growth may both increase, resulting in only a very small, or even no change in turbidity. Such substitution effects may at times counteract other main effects, making the net results difficult to predict.

It was stated earlier that the approach which this study takes in dealing with the physical process which is involved in the off-site impacts of soil erosion is to employ empirical rather than mechanistic models. In other words, general causes and consequences are examined, rather than specific explanations of the complex interconnections which are involved. The significance of the sediment transportation and impact considerations which have been presented here are, however, that to employ empirical models successfully, some understanding of causal connections must be available. Thus, these considerations have significance for this study's experimental design which is described in the next chapter.

IV. EXPERIMENTAL DESIGN AND DATA COLLECTION PROCEDURES

The purpose of this chapter is to describe the experimental design and data collection procedures used in evaluating the off-site benefits of soil conservation. The present chapter will be primarily concerned with the experimental design and data collection having to do with recreation. The final section of the chapter will deal with the investigation of water treatment and dredging costs.

A. Experimental Design

In order to identify the recreational response to changes in soil conservation, the ideal experimental design would be to examine recreational consumption patterns with and without the particular conservation practices in effect. An alternative for accomplishing this would be to estimate the recreational response to changes in water quality which are due to changes in soil conservation. The problems of finding a site at which water quality changed to a sufficient extent and of controlling for other variables which might affect recreational demand made this alternative infeasible. Also, it is desirable to identify the long run response of recreation to changes in water quality. This means that considerable time would have to be allowed in a time series study for the full impact of adjustments in soil conservation to be registered on water quality and for recreationists to perceive and react to water quality variation. A cross sectional approach, on the other hand, allows for this since it can generally be assumed that (or determined if) current water quality conditions and differences have existed for long enough to allow long run physical changes and demand responses to take place.

In specifying an experimental design for investigating recreational response, it was necessary to ensure that sufficient time was allowed for recreationists to learn about quality differences among, or changes at, recreation sites and that the quality characteristics at a site were sufficiently observable to recreationists. These characteristics should be observable at times when recreationists are present (primarily from late spring through early fall) and they should be long enough in duration so that recreationists will have a chance to see the condition and associate it with a location in question.

While rivers may display significant variation in average sediment level, most sediment comes in periods of high concentration and stream flow which are closely correlated with upstream storm events. Since fewer people participate in outdoor recreation during periods of poor weather, there would be less opportunity for recreational perception and response to high turbidity levels in rivers. Lakes, on the other hand, retain water longer and thus give more opportunity for recreational response. Since sediment deposition is usually higher in lakes, they may also give more opportunity for response to that factor. These factors made the use of lakes as recreational analysis locations desirable.

B. Selection of Lakes for Recreational Sampling

Lake selection was initially focused on southwestern Michigan because of the abundance of lakes in that area and because of the generally agricultural nature of the region, making soil erosion problems more likely. U.S. Department of Agriculture Soil Conservation Service district conservationists and Michigan Department of Natural Resources fisheries biologists were consulted in an attempt to identify lakes which had both high sediment delivery rates and reasonably high recreational use. From an extensive list of lakes which were initially considered, only Thornapple Lake in Barry County met both of these requirements.[1] Personal visits and comments from local residents confirmed these characteristics.

In order to employ a cross sectional experimental design for identifying the recreational response to turbidity it was necessary to select a number of other lakes for purposes of comparison with Thornapple Lake. In order to isolate the response to turbidity alone, it was necessary to select lakes which were cleaner than Thornapple Lake but at which other factors which might affect recreational demand were the same. In order to control for other factors which might affect recreational demand it would also be possible to use a multiple regression framework in which these other factors would be statistically controlled. The major reasons for using the experimental control approach were, however, that data were not available on lake characteristics and it was not known which of these characteristics should be considered or how they should be included in a regression model. Also, if many potentially important characteristics were to be controlled and their effects kept distinct from that of turbidity, a large number of lakes would be required.

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[1]See Figures 3-6 and the discussion in Section C of this chapter for details on locational characteristics.

A number of attempts were made to select lakes which were similar to Thornapple Lake with respect to several parameters such as size, depth, recreational facilities and other features which might be important to recreationists. It was difficult, however, to determine which characteristics are important to different types of recreationists and what amount of variation in these features is allowable before there will be differentiation between locations. No theoretical guidance was found for making this decision, complicated as it was by the fact that several recreational types (e.g., swimming, fishing and water skiing) are involved. Relevant features and their threshold levels likely vary between recreational types also. For example, lake size may be much more important to sailors and water skiiers than it is to swimmers.

The selection procedure which was used was to record lakes identified by recreationists themselves as substitutes during the pretesting of the survey questionnaire and the first two days of data collection. Recreationists were asked which other lakes they visited and which of these were "about as good" for the type of recreation involved as the lake at which the interview took place. The assumptions involved are that they would identify substitute lakes in accordance with their particular perceptions and preferences and that these factors are more relevant for determining demand than are objective measures of lake characteristics. The weakness of this approach is that the effect of varying turbidity levels is necessarily controlled along with the net effect of all other features. It is not clear whether this eliminated or reduced the effect of water quality on recreational demand. This possibility is discussed again in Chapter VII. Table 1 lists some of the results of this substitute identification procedure and the next

Table 1. Identification of Substitutes for Thornapple, Middle and Gun Lakes

Interview site Substitute Lake (county)	Fishing	Swimming	W. Skiing	Sailing	Other	Total*
	------------- no. of times identified -------------					
Thornapple Lake						
Clear (Barry)	2	1				3
Crooked (Barry)	2					2
Duck (Calhoun)	5	1	2			8
Gun (Barry)	4	8	4			16
Jordan (Barry)	2					2
Lansing (Ingham)	1	1				2
Middle (Barry)	4	1				5
Murry (Kent)	3					3
Narrow (Eaton)	3	1				4
Odessa (Ionia)	2	1				3
Middle Lake						
Gun (Barry)		1		1		2
Jordan (Barry)	3					3
Leach (Barry)	2	2				4
Thornapple	1	1		1		3
Gun Lake						
Barlow (Barry)	1	1				2
East (Barry)	2					2
Erie (Monroe)		1	1			2
Green (Kent)		3				3
Michigan (various locations)		10		3	2	15
Payne (Barry)	2					2
Thornapple	2		1			3

*Lakes mentioned only once are not listed.

section in this chapter presents some of the objective characteristics of the lakes which were chosen.

C. Characteristics of Selected Recreational Locations[2]

This section describes the location and relevant physical characteristics of the sites selected for recreational analysis in order to provide a basis for evaluating this lake selection procedure and to compare this location to others not investigated. Four interview locations at three lakes were selected. These were the Michigan Department of Natural Resources public access sites at Thornapple and Middle Lakes, and at the beach areas and boat launches at Charlton Park on Thornapple Lake and Yankee Springs Recreation Area on Gun Lake. Charlton Park is operated by Barry County, and Yankee Springs is a state park under the administration of the Michigan DNR Parks Division. Figures 3 to 6 indicate the locations of these sites. Tables 2 and 3 give some relevant lake and interview site characteristics.

D. Sample Selection

Most of the data for the present study's recreational analysis were collected by administering a 4 page questionnaire in direct personal interview, commonly taking 5 to 10 minutes each.[3] Interviews were conducted by the author and Carmen Sandretto, employed with USDA's Natural Resource Economics Branch.

The survey period was May 24 to July 6, 1980. During this period interview days were chosen somewhat randomly, with a little more emphasis being given to weekends when more recreationists were present. Weather

[2]Further information on Thornapple Lake can be gained from the U.S.E.P.A., National Eutrophication Survey report on Thornapple Lake.

[3]This questionnaire appears in Appendix A.

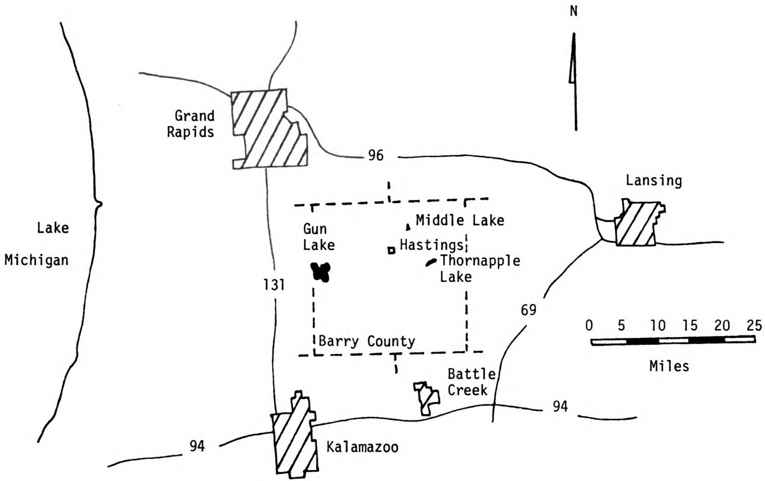

Figure 3. Location of Recreational Survey Lakes

Source: Michigan State Highway Map

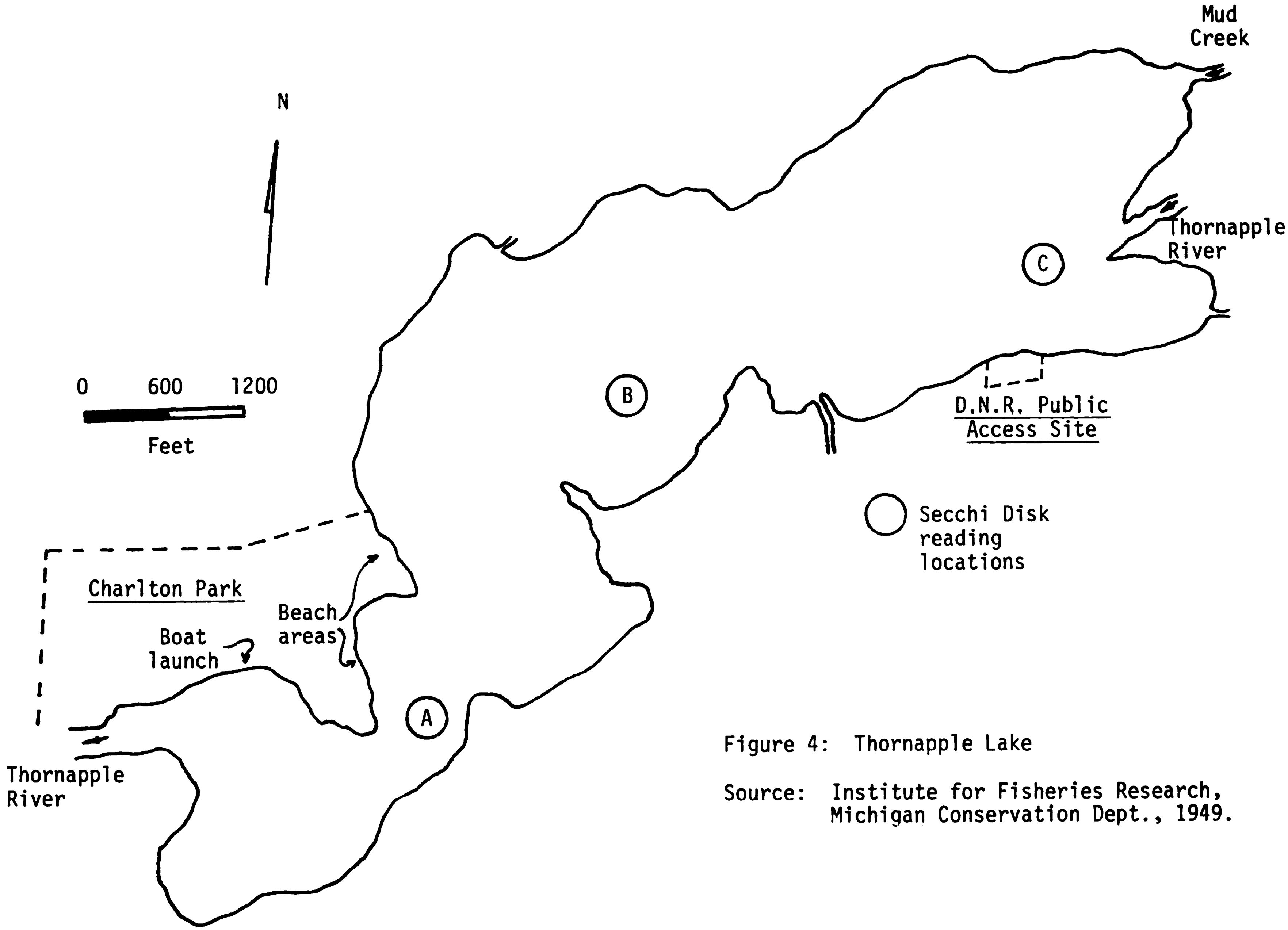

Figure 4: Thornapple Lake

Source: Institute for Fisheries Research, Michigan Conservation Dept., 1949.

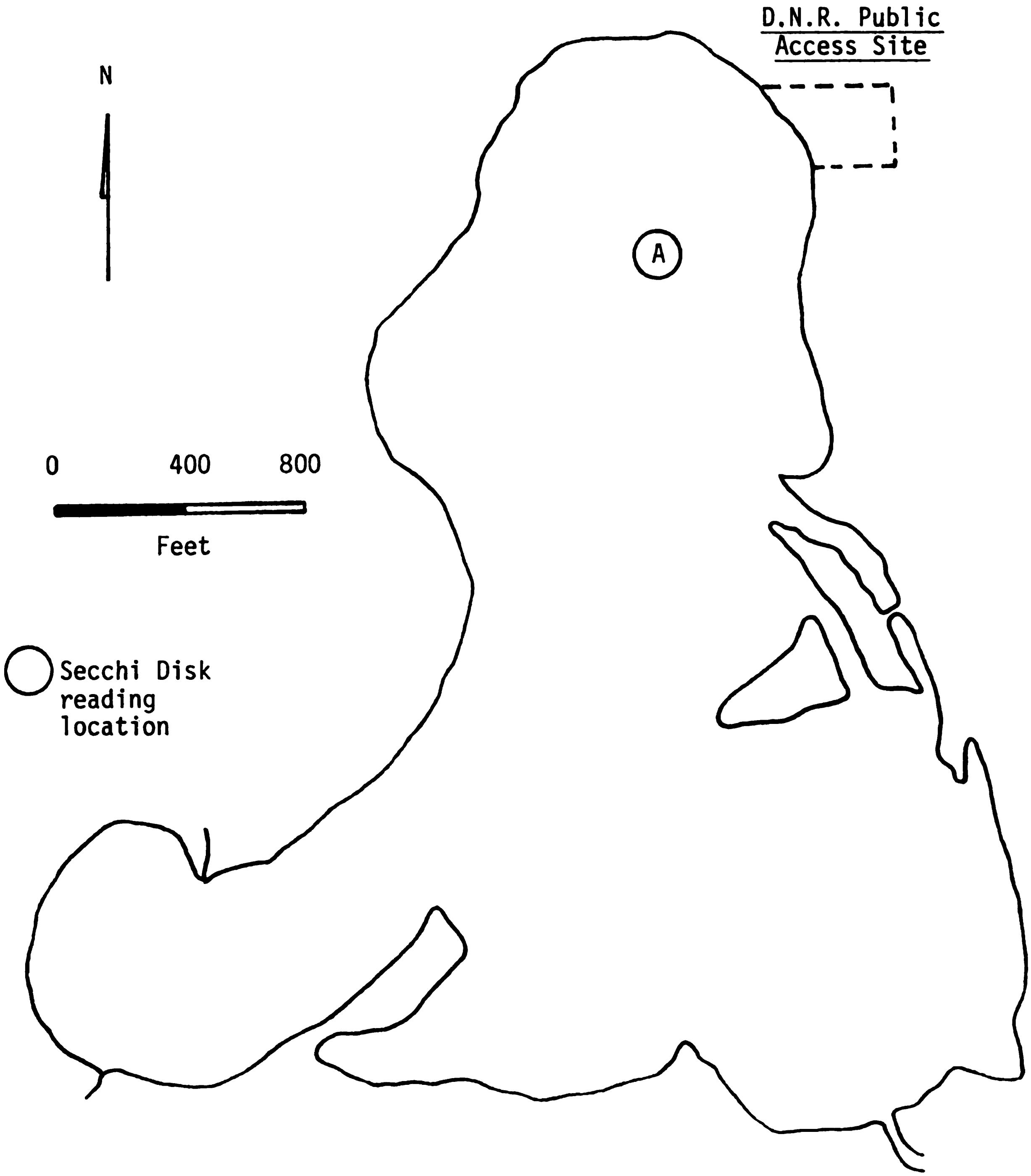

Figure 5: Middle Lake

Source: Institute for Fisheries Research,
Michigan Conservation Dept., 1951.

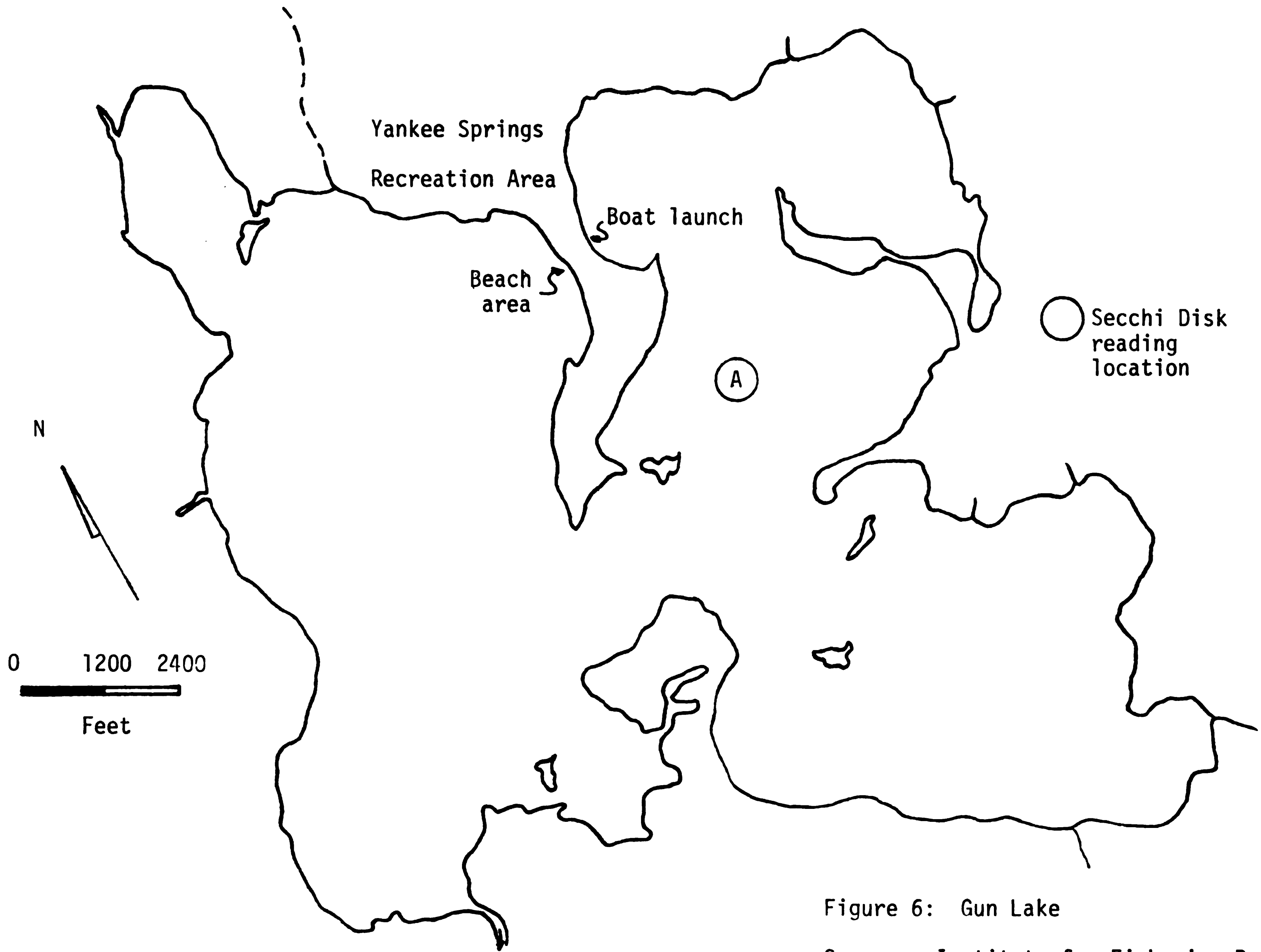

Figure 6: Gun Lake

Source: Institute for Fisheries Research, Michigan Conservation Dept., 1945.

Table 2. Recreational Lake Characteristics

	Thornapple	Middle	Gun
Area (acres)[a]	409	131	2680
Average Depth (feet)[a]	14	20	10
Maximum Depth (feet)[a]	33	40	68
Percent of Area Less Than 10 Feet Deep[a]	32	27	80
Percent of Shoreline Developed[b]	60	60	85
Game Fish Available[c]	Large mouth bass Bluegill Black croppie N. pike Yellow perch N. muskellunge Pumpkinseed sunfish	Large mouth bass Bluegill Black croppie N. pike Yellow perch N. muskellunge Pumpkinseed sunfish	Large mouth bass Bluegill Black croppie N. pike Yellow perch N. muskellunge Rock bass Walleye Small mouth bass
DNR fish stocking[c] species (date)	N. muskellunge (1977, 78, 79, 80)	None	Walleye (annually) N. muskellunge (1974, 77, 79, 80)

Sources: a. Institute for Fisheries Research, Lake Inventory Maps, distributed by Michigan United Conservation Clubs (see Figures 4 to 6).

b. Estimated by Michigan DNR, Inland Lakes Unit.

c. Michigan DNR, Fisheries Division.

Table 3. Recreational Site Characteristics

	Charlton Park	Thornapple Pub. Acc. Site	Middle Pub. Acc. Site	Yankee Springs
Boat Launch Type	hard surf.	gravel	gravel	hard surf.
Toilets	yes	yes	yes	yes
Picnic Area	yes	no	yes	yes
Camping	no	no	no	yes
Beach	yes	no	yes	yes
Lifeguard	no	no	no	yes
Admission fee:				
daily - car	$2.00	nil	nil	$2.00
daily - boat	$1.00	nil	nil	nil
seasonal - car	$7.00	nil	nil	$7.00
seasonal - boat	$2.00	nil	nil	nil

Source: Personal observation.

conditions on these days included both cloudy, cool and rainy weather and sunny, warm weather. The distribution of responses over both interview days and locations can be seen in Table 4.

Survey periods within each chosen day were randomly assigned between the various locations. During a survey period at a location an attempt was made to interview all possible recreational parties, usually as they were preparing to leave the site, thus ensuring that they had had time to familiarize themselves with water quality conditions. The procedure for interviewing swimmers was somewhat different. In this case a section of beach was randomly chosen and interviews were solicited from every group in that section.

Table 4. Interview Frequencies, by Date and Location

Date (Month/Day)	Thornapple Pub. Acc. Site	Charlton Park	Middle Lake Pub. Acc. Site	Yankee Springs	Total
	no. of interviews				
5/24	20	9	6		35
5/26	24		7		31
6/5	4				4
6/13	4	2		14	20
6/14	1	2	1		4
6/16	3		1	7	11
6/20				14	14
6/21	16	20	3		39
6/26			6	17	23
6/27	6	10			16
6/28			1	29	30
7/2	7	7	6		20
7/4	1	24	5		30
7/6	17	1	5		23
Total	103	75	41	81	300

Interviews were usually conducted with an adult member of the recreational party who was willing to answer questions. In many cases other members of the party also participated in providing responses.

This procedure was believed to have produced a sample which was randomly drawn from the population of all recreationists visiting these locations during the overall interview period. In order to draw inferences from this study's analysis it is necessary to estimate how representative this sample was of recreational patterns at other periods. While the major sampling period for this study was early in the summer, an additional 20 interviews were conducted at Thornapple Lake (at both the DNR public access site and Charlton Park) on August 23, 1980. It was believed that this end-of-summer check on the characteristics of recreationists would allow greater confidence to be placed in the representativeness of the data from the interviews conducted earlier in the summer. Table 5 presents the results. While it is not possible to determine the probability of concluding that these sample means are equal when in fact they are not (i.e., the probability of a Type II statistical error) without an hypothesis concerning the difference between the means, it would appear from Table 5 that there is not much difference between the characteristics of recreationists from the two samples and that the results of the earlier interview period could be generalized to the whole year.[4]

Table 5. Comparison of Recreationists' Characteristics, May 24 - July 6 and August 23, Thornapple Lake, DNR Public Access Site and Charlton Park

Characteristic*	Mean, May 24-July 6	Mean, Aug. 23
One way trip mileage (2)	29.53	29.80
Annual visitation rate at Thornapple (4 & 5)	12.50	11.05
Total water recreation days (7)	27.14	27.35
Age (26)	37.02	33.40
Sex (Male = 1, Female = 2) (27)	1.19	1.35
Party size (28)	3.64	3.10
Income (coded, see questionnaire) (30)	4.20	4.50

*Figures in brackets indicate question number on questionnaire (See Appendix A).

[4]It is unclear if there is any influence of turbidity on ice fishing. In Section F of this chapter the estimate of total annual use of Thornapple Lake excludes ice fishing and any other winter use.

E. Water Quality Measurement

The preceding chapter and the first section of this chapter described the difficulties in experimentally distinguishing the effects of turbidities from different sources on recreational demand. It is therefore assumed that recreationists are not able to distinguish, or at least do not respond to a distinction between turbidity from eroded soil and that from sources such as algae or resuspension of bottom sediments as a result of power boat activity. It is also assumed that the identification of a relationship between water clarity and recreational demand would imply a response to changes in soil erosion if those changes could account for the observed changes in water clarity.

On each day that interviews were conducted at a lake, turbidity measurements were taken by means of a Secchi disk as described in Chapter III. Table 6 lists the results.

F. Estimation of Total Annual Recreational Use of Thornapple Lake

In order to determine aggregate demand for Thornapple Lake and the value of water quality improvements there it is necessary to estimate total annual recreational use of the lake. Recreationists can be classified as residents (those who own lakeshore property) or non-residents. Non-residents may gain access to Thornapple Lake through the Michigan Department of Natural Resources public access site, through Charlton Park, or by boat along the Thornapple River (usually from downstream). Because of the difficulty of counting or estimating the number of resident recreationists and those entering the lake from the river, these users had to be ignored for the purposes of this study. The number of recreationists using the public access site and Charlton Park were determined as follows.

Table 6. Secchi Disk Readings at Thornapple, Gun and Middle Lakes, in Inches*

Date (Month/ Day)	Thornapple Lake				Middle Lake	Gun Lake
	Site A	Site B	Site C	Average of all Sites		
5/24	49	53	57	53	200	
5/26	60	66	69	65	190	
6/5	45	27	22	31	144	
6/13	55	62	66	61		156
6/14	74	80	80	78	180	
6/16	98	98	90	95	162	150
6/20	68	72	72	71		150
6/21	74	68	62	68	116	
6/26					122	150
6/27	68	58	70	65		
6/28	66	58	68	64	114	128
7/2	44	36	42	41	102	
7/4	44	42	42	43	108	
7/6	34	34	30	33	114	
Average				59	141	147

*Figures 4-6 show Secchi disk reading locations and interview sites at each lake. A description of the Secchi disk procedure is given in Chapter III, Section A. The higher numbers in this table indicate greater clarity or lower turbidity.

1. DNR public access site

Because the sampling procedure involved the interviewing of all recreationists using the access site during the time an interviewer was at the site, the number of interviews conducted was considered an accurate estimate of total party visits during these periods. From vehicle counts and personal observations taken during the interview periods it appeared that recreational use was fairly constant between mid-morning and early evening. From this information, total party visits per interview day were estimated.

The Waterways Division of the Michigan Department of Natural Resources maintains electrical vehicle counters at Duck Lake in Calhoun County, a lake which was frequently mentioned as a substitute for Thornapple Lake (see Table 1). The assumption was made that the average ratio of visitors between access sites at Duck and Thornapple Lakes on days on which this study's interviews were conducted is an accurate estimate of the ratio of total annual visits between these sites. Using this ratio and the total group visits recorded by the DNR for Duck Lake (May through October), a total visits figure for Thornapple Lake access site was derived.[5]

Average ratio of visits on interview dates,

Thornapple/Duck = 0.394

Total group visits to Duck Lake (May - October)

= 13,295

Estimated total group visits to Thornapple Lake

DNR access site = 5,238 (approx. 5,200)

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[5]The accuracy of the vehicle count at Duck Lake was not verified. Both this figure and the assumption regarding the ratio of visits at the public access sites at Duck and Thornapple Lakes could introduce an unknown amount of error into the estimate of total visitation at the access site at Thornapple Lake.

2. Charlton Park

Daily attendance figures are kept at Charlton Park by county park staff. Average annual group visits in 1979 and 1980 were approximately 11,800, slightly more than twice as many as were estimated to have used the DNR public access site. This is a reasonable ratio, given the apparent distribution of recreational use between the two locations on interview days.

The estimated recreational use of Thornapple Lake, excluding residents and recreationists entering the lake by boat along the river, is approximately 17,000 groups per year, or 61,880 individuals, given an average party size of 3.64.[6]

G. Data Collection for Non-Recreational Sediment Impact Analysis

In addition to recreational consequences, the impact on municipal water treatment and on dredging of navigational channels and recreational lakes has been investigated in this research. This section will briefly describe the selection of locations for empirical study and the data collection procedures which were used in the investigation of these non-recreational impacts.

1. Water treatment cost analysis

Municipal water treatment plants may draw from either groundwater or surface water sources, or may use a combination of these. While groundwater usually contains materials such as dissolved minerals which must be removed prior to distribution of the water to municipal customers, it does not contain turbidity resulting from soil erosion.

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[6]The average party size figure (3.64) was calculated from this study's recreational survey data. See Table 8.

In the investigation of the impact of soil erosion and conservation, therefore, attention is limited to water treatment plants which draw from surface sources. It was also assumed that soil erosion would have little effect on water quality in the Great Lakes, at least for water treatment plants withdrawing from these lakes. Attention was therefore directed to those plants using inland lakes and streams as their source. For convenience this was further limited to Michigan's lower peninsula. Table 7 lists all such plants as identified by the Michigan Department of Public Health.

Table 7. Maximum and Average Monthly Maximum Turbidity Levels at Municipal Water Treatment Plants Withdrawing From Inland Lakes and Streams in Michigan's Lower Peninsula, January 1978 to June 1980, in NTU*

Location (County)	Maximum Turbidity	Average of Monthly Maximum Turbidities
Adrian (Lenawee)	180	45.8
Alma (Gratiot)	240	26.2
Ann Arbor (Washtenaw)**	42	11.2
Big Rapids (Mecosta)	34	11.3
Blissfield (Lenawee)	260	75.2
Deerfield (Lenawee)	450	48.1
Dundee (Monroe)	700	122.4
Flat Rock (Wayne)	144	37.7
Grand Rapids (Kent)**	21	12.9
Rockford (Kent)	21	7.5
Ypsilanti (Washtenaw)	12	6.6

*Nephalometric turbidity units. Higher numbers indicate greater turbidity (Duchrow and Everhart).

**Combined surface and groundwater sources.

Source: Michigan Department of Public Health, Division of Water Supply.

It can be seen from Table 7 that the three locations with the highest turbidity levels are Blissfield, Deerfield and Dundee. These are all small communities in southeastern Michigan and each withdraw water from the Raisin River. On the assumption that any relationship which exists between turbidity and water treatment cost would be most easily detected where turbidity was high, these three locations were selected for analysis. Another reason for selecting these plants is that none of them soften the water which they treat. The softening procedure creates a large amount of chemical percipitate which must be removed in the same way that natural turbidity is. Variations in raw water turbidity will therefore produce much smaller proportional changes in treatment costs in softening plants than in non-softening plants. It was expected that a relationship between raw water turbidity and treatment costs would be much harder to detect in plants which soften their treated water.

Data on turbidity levels and on treatment procedures and costs were collected from the Michigan Department of Public Health, from water treatment plants themselves, and from municipal offices in the three communities.

2. Dredging cost analysis

As mentioned in Chapter III, sediment impacts on environmental services may result either from turbidity or from sediment deposition. Dredging involves the removal of deposited sediment in order to maintain a service, such as navigation, which is dependent upon the maintenance of a particular depth of water in certain locations.

This study examines dredging and disposal costs reported by the U.S. Army Corps of Engineers for its Michigan operations. Data were collected from annual reports and personal communication with the Detroit office of the Corps. Because of some serious limitations in the availability of data, the conclusions which are drawn with respect to the magnitude of potential benefits from a reduction in sediment deposition are of a very general nature.

In addition to the analysis of navigational channel dredging, information was collected from the Snell Environmental Group, a Lansing, Michigan engineering firm which has undertaken two recent dredging contracts involving Lake Lansing in Ingham County and the Messenger-Hodunk chain of lakes near Coldwater in Branch County.

The analytical procedures and results for all of the sediment impacts which have been mentioned are discussed in the next two chapters of this dissertation.

V. ANALYTICAL METHODOLOGY

Chapter II presented a discussion of a number of the theoretical and methodological issues involved in the use of the travel cost and bidding game methods. It also dealt briefly with the evaluation of benefits where environmental services are inputs to production processes. This chapter will extend that discussion by describing the analytical procedures which were used in investigation of the benefits from water quality improvement. It will also give a detailed description of the data which were used in pursuing this investigation.

Chapter IV described the procedures used in collecting most of the data used in the study. This chapter will give an account of the data manipulation that was required before the analytical operations could be performed. Further details will also be given on the data collection procedure. These details are important for evaluating the analytical methodology and results.

A large part of the data analysis in this research was carried out by means of a regression analysis. The major tool for this analysis was the regression subprogram in the Statistical Package for the Social Sciences (SPSS) (Nie, et al.). Other SPSS subprograms were also employed for accomplishing such things as frequency and correlation analysis. As can be seen in the Appendix, the recreational survey questionnaire was precoded. This allowed keypunching of the recreational data directly from the questionnaires, and reduced the chance for transcription error in the data. Data for the analysis of water treatment costs was keypunched directly from photocopies of Michigan Department of Public Health monthly operating reports.

A. Travel Cost Analysis: Dependent and Independent Variables

1. Visitation rate.

The visitation rate was used as the dependent variable in the regression analysis models. It was defined as the annual number of visits to the study lake by the recreational group. There are two potential ambiguities in this definition. The first is that such groups are clearly not consistent over all recreational trips; many different combinations of people may be involved in recreational travel. It is not known to what extent or in what way this variation in group composition will affect the results of a travel cost analysis based on disaggregated data such as this. Fifty-four percent of the interviewed groups identified themselves as single households and many others were households plus one or two friends. The effect of variation in group composition likely depends on the way in which recreational decisions are made within each group. This question was not addressed here. In the relatively few cases where the respondent expressed uncertainty as to how to express a visitation frequency because of variation in group composition he was instructed to give a visitation rate for himself. This problem is not dealt with by the proponents of this definition of the observational unit (Brown and Nawas, Gum and Martin, Bouwes and Schneider).

A second potential ambiguity involved in this definition of visitation frequency concerns the cases where the frequency is sharply different from one year to the next. Recreationists may have just found out about the location or they may be expecting to make a major household move, they may have recently made a large purchase such as a boat which will enable them to make greater use of a lake, or they may have had a change in their employment situation which will alter their visitation frequency. In this research, recreationists were asked to give a frequency for last year (1979) and an expected frequency for this year (1980) (Questions 4 and 5 in Appendix). In cases where these figures differed appreciably, the reason for the difference was determined and either an average of the two figures, or a visitation rate which the respondent considered indicative of his preference for the lake was recorded. It is acknowledged that this procedure allows a degree of error in the model, yet unless the model treated numerous personal circumstances this error would remain. Bouwes and Schneider also employed questions about visitation frequency in the past and present year.

2. Cost of travel.

The primary intent of the travel cost approach is to identify the marginal relationship between the cost of travelling to a recreational location and the frequency of making that trip. Usually the major cost of the recreational trip is that of transportation. However, other costs should also be included. Those which are correlated with distance will influence the nature of the relationship between cost and visitation frequency. Those which are not correlated with distance will not affect this marginal relationship, though they will affect the intercept of the demand function (i.e., the constant term in the regression model) and must also be taken into account because of their influence on the estimate of total benefits.[1]

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[1]Freeman (1979, p. 207) makes this point with respect to the treatment of on-site time, a point which will be discussed below.

In the present study two alternate definitions of travel cost were used:

$$\text{Transportation cost} = \left(\frac{\text{one way mileage x 2}}{\text{miles per gallon}}\right)\left(\text{gas price}\right)\left(\begin{matrix}\text{lake as \% of}\\ \text{reason for trip}\end{matrix}\right)$$

$$\text{Total trip cost} = \text{transportation cost + entrance fee + boat operation cost + other on-site costs}$$

Respondents reported the one way mileage from their homes to the interview site, the type of fuel used by their vehicle, the fuel efficiency (miles per gallon) of their vehicle, and how much of their reason for leaving home was accounted for by the purpose of visiting the particular lake. They also reported the non-transportation components of the total trip cost (Questions 2, 9-13 in Appendix). It was assumed that gasoline costs are the only off-site costs of the recreational trip and, in accordance with the discussion in Chapter II regarding multipurpose trips, these were assigned to the various trip reasons in accordance with the respondents' estimate of the relative importance of the various reasons. Statewide average gas prices were obtained from the American Automobile Association by week and type of fuel (e.g., regular, no lead, diesel). Chapter VI discusses the reasons for and results of using two different definitions of the cost of recreational travel.

3. Travel time.

The use of the recreational group as an observational unit allowed the separate inclusion of travel money and time cost in the regression model. Travel time was reported by respondents (Question 3). The correlation of travel time and transportation cost was 0.58, showing considerable independent variation, as expected. There are several reasons for this lack of close correlation between time and money costs. These include variations in vehicle fuel efficiency, variation in average driving speed and variation in gasoline price paid by different recreationists. Greater fuel efficiency, faster driving speed and lower gasoline costs (due, for example, to the use of regular rather than no-lead gas) would each have the tendency of lowering money costs more than time requirements. The interaction of these factors is not explicitly considered here.

As mentioned in Chapter II, the separate inclusion of time and money costs in the regression model does not attribute a zero value to time as a constraint on recreational consumption, but simply treats it as a separate constraint. The estimated coefficient for the money cost variable can therefore be interpreted as the partial derivative of visitation frequency with respect to changes in money cost, holding time constant.

There has been a divergence of opinion regarding the inclusion of on-site time in recreational demand models. McConnell (1975, 1976) suggests that both travel and on-site time should be taken into account. He assumes that the limitation on recreational time availability will mean that on-site time will vary as trip length varies. Knetsch and Cesario (1976) suggest that recreationists choose a type of recreation first, then in a second step, choose the location, treating on-site time as fixed.

During the pretesting of the questionnaire for the present research, recreationists were asked to state the time spent on-site. While they were able to give an answer for the present trip, almost all stated that the amount was so variable from one visit to the next that they couldn't give an average. On-site time depended almost entirely on such things as fishing success or weather. Questions regarding on-site time were therefore excluded from the final questionnaire.

While there are differing hypotheses about the way in which on-site time varies with travel distance (indicating either a positive or negative correlation), they all depend on significant variation in travel distance. For the recreationists which were sampled in this study, however, average one way trip distance was 28.4 miles and the standard deviation was 31.3 miles (Table 8). There was therefore insufficient variation in trip length to lead to a significant on-site time variation.

4. Preference variables.

In specifying a demand model it is necessary to control for personal preferences and tastes which may affect the level of demand. Since an individual (or single recreational group) demand curve is being estimated, it can be expected that preferences may affect the level of demand and the position of the demand curve. While it is impossible to measure preferences directly, it is possible to include several proxies such as age, sex and income. Mueller and Gurin found the relationship of socioeconomic characteristics to the demand for outdoor recreation was significant. They also found substantial correlation among characteristics such as age, sex, income, educational attainment and occupation. The implication of this is that the inclusion of measures of a small number of these characteristics may be sufficient for controlling the effect of preferences on recreational demand.

Gum and Martin included a measure of the total annual days of outdoor recreation in their demand model as a "surrogate for positive tastes and preferences for rural outdoor recreation" (p. 561). In the present study, total annual days of water-based recreation were investigated for the same purpose.

One of the advantages of dealing with aggregate data in the zone method is that differences in tastes and preferences tend to cancel out in the aggregation. Differences in tastes and preferences between origin zones may be less than between individuals. When individual or group observations are used, these heterogeneous preferences emerge as important, accounting for the lower R^2 values usually obtained through the use of disaggregated data (Brown and Nawas).

5. Substitute locations.

The potential bias resulting from failure to consider the availability of substitute recreational locations was discussed in Chapter II. This is a criticism of a number of other studies which have dealt with multiple sites and the recreational impact of water quality (Binkley and Hanemann; Reiling, Gibbs and Stoevener; Bouwes and Schneider).

In the present case recreationists were asked what other lakes they visited for the type of recreation they were undertaking at the time of the interview, up to a maximum of five other locations. They were then asked which of these were about as good as, or which they enjoyed visiting about as much as, the present location (Question 15 in Appendix).

Both these substitute locations and the respondents' home locations were then coded by means of a Michigan Department of State Highways and Transportation code which covers in and out of state locations with 547 origin-destination zones. (Michigan Department of State Highways and Transportation) The Department of Transportation calculated average driving times for all identified origin-destination pairs using minimum distance routes between zones (using the state highway trunkline system and some county roads) and adding average intrazone driving times. Assuming that driving times to substitute locations are a proxy for the "cost" of these substitutes, the identified travel times to substitutes were averaged for each individual and included in the regression model as an independent variable.

6. Water quality.

This study ignored water quality at substitute sites because of the lack of information on turbidity at Michigan lakes. The Inland Lakes Unit of the Michigan Department of Natural Resources collects such information, but their coverage of lakes is not complete enough to make feasible the inclusion of water quality at substitute sites.

This study included water quality measures in two alternate ways: by Secchi disk readings (Table 6) and by means of a dummy variable (Thornapple Lake = 0 = dirty, Middle and Gun Lakes = 1 = clean). The second method assumed that recreationists only distinguish between clean and dirty and not between points on a continuous clarity scale. This assumption is discussed again with respect to the bidding game.

7. Recreation type.

It was hypothesized that the type of recreation that respondents were involved in would have an effect on their demand for the site in question and their response to water quality. During the interview process several respondents said that water quality was important to them for swimming but not for fishing. Recreational type was included in the regression model by means of a series of dummy variables. In cases where more than one type of recreation was reported, one was selected at random to classify the respondent.

B. Bidding Game Implementation and Analysis

The results of the bidding game approach to environmental benefit estimation are at least as dependent on the details of question design and implementation as are those of the travel cost approach. It is therefore necessary to make these design and implementation details clear in order to analyze and evaluate the results of this procedure. The wording of the bidding game which formed part of the interview conducted with recreationists at Thornapple Lake can be seen in the Appendix. Several of its important features will be discussed here.

1. Question design.

While the bidding game was essentially hypothetical in nature, it was based on the actual water quality situation at Thornapple Lake, a situation which respondents could see during the interview and with which previous questions in the interview had dealt. The effects of increasing the realism of a bidding game were discussed in Chapter II. It was pointed out there that this is an important part of the reduction of the cost of providing accurate answers by respondents.

The first part of the bidding game question described the actual physical setting believed to be responsible for reduced clarity in Thornapple Lake. The connection was made between soil erosion and water clarity. As discussed in Chapter III, soil erosion is likely not the only cause of turbidity in Thornapple Lake, yet it is definitely one of the causes. The physical connection between soil erosion and turbidity is one which respondents could fairly easily understand. These factors enhanced the realism of the question.

The second part of the bidding game question described the hypothetical institutional setting, including a public soil conservation and water quality program and a proposed payment vehicle. Here again the objective was to present a realistic and easily understood institutional setting for the bidding game so as to increase the accuracy of the responses. This was one of the reasons for selecting the entrance fee as the hypothetical payment vehicle--entrance fees are already charged at Charlton Park. Although they are not charged at DNR public access sites, respondents had little difficulty in understanding how such a revenue collection mechanism would work.

The other reason for selecting the entrance fee was to increase the comparability of the results of the bidding game with those of the travel cost analysis.

The institutional setting proposed in the bidding game was an integral part of the question. Some respondents expressed strong feelings about the proposal of a state program to encourage soil conservation and improve water quality. Their attitude to state government appeared to substantially affect their willingness to pay. If a federal rather than a state program had been proposed, or if some other payment vehicle had been suggested bids would likely have been different. The institutional setting is part of the "product" for which the respondent expresses a willingness to pay. This does not support the suggestion by Randall, Ives and Eastman that several payment vehicles be tested in a bidding game so as to increase the response rate (p. 39). Different payment vehicles should be tested, as those authors did, but the results must be interpreted as bids for different products.

In the present case respondents were told that the hypothetical entrance fee was to be collected as a daily fee per vehicle and that the revenue generated would not be applied to any changes in related recreational facilities such as boat launch ramps or other park features.

The hypothetical nature of the bidding game was stressed to respondents before their bid was requested. This may have had the effect of reducing both the incentive for strategic response and the incentive for accurate responses. The interview and questionnaire were clearly identified with Michigan State University rather than with some branch of government.

A final and highly important aspect of bidding game question design has to do with the specification of a common water quality improvement for which the bid was to be offered. A clear definition of the product for which respondents were offering to pay is required. This definition would ideally be given in terms which were unambiguous both to the respondent and to public decision makers wishing to use the study's results. While an objective measure of water quality change such as a given change in Secchi disk reading would have been satisfactory for the latter, it would not have had sufficient meaning for recreationists. The original intention in the questionnaire design was to refer to some other lake as a standard or example of the proposed improvement. This plan was abandoned, however, because of the diversity in recreational travel. There were no lakes known by most recreationists at Thornapple Lake.

A common solution to this type of problem has been to use photographs for comparison purposes (Randall, Ives and Eastman; Brookshire, Ives and Schulze; Walsh, et al.). The use of photographs assumes that respondents can interpret the information on the photo in terms of a complex environmental good which may affect them in a variety of ways.

Lake turbidity and other sediment effects can not easily be portrayed in photographs, however.

Another approach to this problem has been to determine a recreationist's subjective rating of environmental quality in a scaled question. A hypothetical change in environmental quality is then proposed in terms of this scale (Bouwes and Schneider). This approach has the weakness of assuming the respondent can master the conceptual refinement necessary to answer the question. It also assumes interpersonal comparability of a given subjective rating change and that the hypothetical change will have meaning for public decision makers.

The approach used in the present study was simply to say that Thornapple Lake would be "cleaned up," that water clarity would be improved. While there was considerable imprecision in this specification, the underlying assumption was that respondents were only able to distinguish between clean and dirty water and not between finer increments of water clarity. This assumption is supported by the fact that the correlation coefficient between objective (Secchi disk; see Table 6) and subjective water quality measure was only 0.1279, indicating a very weak relationship between the two. The average subjective ratings for the three lakes were

Thornapple	5.96
Middle	6.29
Gun	6.43

on a scale of 1 to 10 (1 = dirty, 10 = clean; see Questions 20 and 23 in Appendix). This corresponds to the order of the average Secchi disk reading (Table 6) but does not show the amount of divergence between Thornapple Lake and the other two which might be expected.

The hypothesis that recreationists do not perceive fine distinctions in water quality is supported by the results of a study by Binkley and Hanemann. They compared subjective water quality ratings with objective quality parameters at 29 beach sites in metropolitan Boston. This comparison was accomplished by regressing the subjective rating of a site on a variety of factors such as turbidity, color and bacteria content. Their conclusion was that "while there is a significant connection between objective water quality conditions and subjective water quality ratings, the degree of association between them does not appear to be very great" (p. 110).

Bouwes and Schneider, on the other hand, found a significant relationship between objective and subjective water quality measures. Their objective water quality measure was a composite index of such factors as dissolved oxygen, Secchi disk transparency, winter fish kill and aquatic plant growth. It may be that a composite quality measure corresponds more closely to public perceptions of water quality than does a single measure such as turbidity.

Probably the most significant weakness of the definition of water quality improvement used in the bidding game in this study was that it assumed that respondents had a fairly common exposure to the range of lake water quality levels and that "clean" meant approximately the same thing to all respondents. In order to compare the results of the bidding game and travel cost approaches the assumption must therefore be made that respondents at Thornapple Lake would consider Middle and Gun Lakes clean and that their bid measures willingness to pay for the difference in water quality between Thornapple and the other two.

Finally, an error in the design of the bidding game question must be made clear. Respondents were asked, "How much would you be willing to pay before you refused to use this lake?" In the context of the preceding introduction this could have been interpreted as a willingness to pay for the proposed improvements in water quality. It could also have been interpreted, though, as willingness to pay for access to the lake in an improved condition. It is not known how much respondents would have been willing to pay for access to the lake in its present condition. This serious ambiguity was not recognized until after the completion of all interviews. As a result, the bids which were received must be interpreted as an upper limit to the amount which respondents would have been willing to pay for the improvement in water quality which the question proposed.

2. Question implementation.

Not only are bidding game results likely to be sensitive to the design of the question which is used, but also to certain details of its implementation or administration. An important factor is the starting point and increments used in deriving the bid. Randall, Ives and Eastman used \$0.25 increments above a starting point of \$1.00 and recorded the highest bid that the respondent said he would be willing to pay. Brookshire, Ives and Schulze also started at \$1.00, but used increments of \$1.00 and then decrements of \$0.25 in order to locate the highest bid for the respondent. Neither of these studies suggest what the effect might have been if the bid had been started at a high level and reduced.

In this study respondents were not prompted where to start the bid and thus no suggestion was given to indicate what the interviewer might consider a reasonable amount. However, in order to ensure that the stated amount was a maximum bid and not a randomly acceptable bid, the respondent was asked whether he would refuse to pay slightly higher amounts. If he indicated he would be willing to pay the higher amount, the process was repeated until a negative response was obtained.

A second important issue in the implementation of the bidding game concerns the treatment of zero bids. Both Randall, et al. and Brookshire, et al., suggest that a distinction should be made between those who give a zero bid because they consider the environmental improvement to have no value for them and are thus unwilling to pay anything for it, and those who give a zero bid because they object to the proposed institutional setting of the question. In all bidding games in which willingness to pay is investigated, the presupposed distribution of rights is such that the respondent cannot claim the good or service at zero cost. This is the same as the normal market situation faced by potential buyers. Therefore, willingness to pay in the face of predetermined rights should be determined and not an expression of preferences concerning those rights.

In this case, therefore, respondents who gave a zero bid were questioned as to the reason. Those that expressed disagreement with the institutional setting of the question were again asked what their response would be if faced with the choice of paying a positive amount or not using the lake in an improved condition. Zero bids were, of course, recorded if the respondent stated he would be unwilling to pay anything because of the institutional setting. Once again, the institutional context is an integral part of the "product" for which the bid is being given.

3. Bias and accuracy.

Chapter II discussed the importance of the avoidance of strategic response bias and of respondent accuracy in assessing preferences. As described there, attempts to deal with the problem of strategic bias have focused mainly on the removal or balancing of opposing incentives for strategic response. In this study the incentive to bias was reduced by emphasizing the hypothetical nature of the game.

There was also a description in Chapter II of attempts to assess the amount of strategic bias remaining in bidding game results. Bohm (1972) investigated the differences in mean bids under differing incentive conditions. Brookshire, Ives and Shulze assumed that preferences for an environmental improvement were normally distributed and that if bias was present it would tend to "flatten" the bid distribution. They concluded that bias was not a problem in their study because this flattening did not appear to have taken place.

Another test for the existence of bias was developed and applied here. Assuming, for the moment, that the true preference which respondents have for the environmental improvement or other good in question could be observed, the correlation between that preference and the bid which the respondent gives would convey important information about the way in which the bidding game question was answered. A zero correlation between the bid and the respondent's preference level (assuming that the latter is distributed somehow along a continuous scale) would mean that there was an equal chance of a high bid coming from someone with a high preference or from someone with a low preference for the environmental improvement. There are only two reasons why this might be the case. The first is that respondents were not engaging in strategic behavior and, in fact, were not even assessing their own preferences accurately. It would normally be expected that respondents with high preferences for the good would give high bids, thus causing a correlation between preference level and bid. The second possibility would be that respondents were offering strategic answers but the effect of alternate strategies cancel out any net effect. In either of these two cases the lack of correlation between the bid and the preference for the environmental improvement is strong evidence against the existence of a net bias in the bidding game results.

Although the lack of correlation between these variables would indicate no bias, the presence of correlation would not, conversely, indicate that bias was present. There are other explanations for an observed correlation between bid and preference. Honest answers would also yield such a correlation and would, in fact, be the most probable reason for any observed correlation.

It would also be incorrect to expect that zero or very low correlation between bid and preference level would not occur on the grounds that this would indicate irrational behavior by respondents. They may see no incentive for strategic or even accurate response and may quite rationally believe that the bidding game was truly hypothetical. A zero correlation between bid and preference would not only indicate that bias was absent in the bidding game responses, but would also indicate the presence of inaccuracy in respondents' answers. As mentioned in Chapter II, this inaccuracy is more likely to affect the variance of the bid distribution than its mean.

Preference for environmental improvement is, admittedly, a complex and not directly observable psychological feature. Two questions were asked in this study's recreational survey which may, however, reveal something about respondents' preferences in this area. Question 22 asked respondents to state how important the appearance of water was in their choice of a lake for recreation. Although the respondent may place a high importance on this factor and yet have a low preference for improvement in water quality (i.e., he may feel water quality is already satisfactory), it would be expected that a positive relationship exists between preference for environmental improvement and the stated importance of water quality in the choice of a recreational location. Question 24 asked respondents why Thornapple Lake did not look cleaner. Again, while there are many ways in which to interpret the responses to this question, it is likely that among those with a high preference for environmental improvement there was a greater environmental awareness and fewer respondents saying they don't know the reason for water pollution than there are among respondents with low preference for environmental improvement. These considerations are complicated somewhat by the fact that simply by coming to the lake respondents demonstrated a degree of environmental preference.

The correlation between the responses to both of these questions and the bids which respondents made was tested and the results are presented and discussed in Chapter VI. This is clearly a very weak test of the presence and extent of bias in the bidding game responses. It does, however, have potential for improvement, particularly with respect to the assessment of preferences for environmental improvement or for whatever good is the subject of the bidding game.

There are superior techniques for assessing the preference of an individual for, or his attitude toward, an environmental improvement than Questions 22 and 24 in the present study. This does not imply, however, that such techniques are superior in terms of aggregating the preferences of individuals. The measurement and aggregation of preferences through some carefully constructed attitudinal scale is no more "correct" than through a bidding game (Birch and Schmid). The advantage of using a good attitudinal scale or other preference assessment technique is that it allows a check to be made on the extent to which conscious manipulation of the bidding game results (i.e., strategic response) is taking place.

In order to derive aggregate values for the proposed reduction in turbidity at Thornapple Lake, the average bid was multiplied by the estimated total number of recreational groups using the lake each year. It was not possible to determine the marginal relationship between water quality and willingness to pay, as was done by Randall, Ives and Eastman, Brookshire, Ives and Schulze, and by Walsh, et al., since only one level of improved water quality was investigated. This study, supported by some of the other studies which have examined the relationship between subjective and objective water quality ratings, assumed that recreationists are not able to distinguish small variations in water quality, particularly for a single parameter such as turbidity. If that is true the calculation of a marginal value of turbidity reduction is misleading.

C. Non-Recreational Sediment Impacts

Throughout this dissertation a minor place has been given to the investigation of non-recreational impacts of sediment. These impacts proved to be particularly difficult to analyze and held less potential for methodological development than did the analysis of recreational sediment impacts. This section gives an account of the attempts which were made to analyze the benefits from sediment reduction in the areas of municipal water treatment and of dredging. It is hoped that this account will prove useful for future research by pointing to some areas in need of further investigation.

1. Water treatment.

Most of the economic literature on water treatment deals with the topic from a broad, cost analysis perspective, using data from a large number of plants and deriving general accounting relationships for major cost categories such as acquisition, treatment, distribution and administration (see, for example, Stevie, et al.). The few studies which dealt with the impact of environmental quality on water treatment costs made simplifying assumptions about the physical production relationships which reduced their empirical usefulness (Brandt, et al.).

This study has attempted to identify the impact of sediment or turbidity on municipal water supply. In the overall supply process it was assumed that distribution and administration costs were unaffected by the level of turbidity. It was also assumed that the price and quality of treated water is unaffected by changes in turbidity, thus limiting benefits to those gained by the producer. The two areas of supply costs which were investigated were water treatment and acquisition.

Basic information on water treatment technology was gathered from managers of the treatment plants which were selected for study (Blissfield, Deerfield and Dundee, Michigan; see Chapter IV) and from engineers with the Water Supply Division of the Michigan Department of Public Health. The three areas of potential impact which were identified were chemical costs, filtration costs, and sludge disposal costs. These impacts were considered separately.

The removal of turbidity in the raw water supply involves the addition of chemicals to aid floculation. An increase in turbidity was expected to raise the chemical doseage requirements, up to some turbidity level. The chemicals whose doseages were identified as being related to the level of turbidity were alum, soda ash, activated carbon and chlorine. The doseage rate is also dependent upon the temperature at which the treatment takes place (lower temperatures require higher doseages) and possibly on the turbidity of the finished water. Since there was some variation in finished water turbidity, an attempt was made to control for variation in the quality of the final product by taking finished water turbidity into account.

The statistical technique which was used was regression analysis, again employing the SPSS program for computer analysis. The dependent variable in this analysis was an aggregate chemical cost, calculated by converting doseage rates for each chemical into a total weight measure, multiplying by chemical prices and summing. The dependent variables were raw water turbidity, finished water turbidity, and temperature. The results of this analysis are briefly discussed in Chapter VI.

The attempt to analyze filtration costs did not progress as far. Two of the three plants selected for study backwash their filters at fixed intervals and not in response to loss of filter efficiency. They, therefore, do not display any impact of turbidity on filtration costs. Data from the third plant was seriously delayed in its arrival and was incomplete, making its use impractical.

The analysis of sludge disposal costs was similarly hampered. Information was unavailable on the relationship between turbidity levels and the amount of sludge generated. It was, therefore, impossible to relate turbidity to sludge disposal costs, despite the concensus by plant managers that sludge disposal may account for a significant portion of total treatment costs.

Water acquisition costs were also examined. As described in Chapter IV, water treatment plants may withdraw their supplies from either surface or groundwater sources. Where investment decisions concerning acquisition are influenced by water quality in alternate sources, a long run change in sediment level in a potential surface source may affect investment decisions, creating costs or benefits for municipalities or other decision making bodies. For example, a long run reduction in sediment level in a river may mean that possibly higher costs of groundwater acquisition can be avoided when the plant invests in facilities for acquiring water from one source or the other. No evidence of this having taken place in Michigan was found, but it is a potential impact which should be kept in mind.

2. Dredging.

One of the objectives of this study was to determine the relationship between the rate of sediment deposition and the cost of dredging and the disposal of dredged material. Dredging and disposal costs are influenced by many factors such as the type of equipment used and its management, the type of material dredged, environmentally related disposal regulations, and numerous local conditions. Since it was impossible to gather information on all these factors, average costs per cubic yard of dredged material over many locations were calculated. This approach was based on the assumptions that other factors would be averaged out and that there would be a linear relationship between dredging costs and the sediment deposition rate.

The cost of dredging undertaken by the U.S. Army Corps of Engineers was calculated from data reported in the 1979 Annual Report of the Corps' Detroit District. Costs reported there were based on equipment rental charges paid to a revolving fund as well as on contract costs. The accounting procedures used by the Corps mean that the reported costs may include cost adjustments for certain pieces of equipment from previous years' work. It was assumed, however, that by averaging costs over all locations reporting dredging work in 1979, the influence of this practice on the calculated cost per cubic yard of material would be minimized.

The U.S. Environmental Protection Agency and the Michigan Department of Natural Resources require that dredged material which contains levels of pollutants such as nutrients, metals and toxic chemicals which exceed allowable standards must be deposited in confined disposal areas rather than dumped in open water disposal. The cost of acquiring land for such areas and of construction and maintenance of facilities for retention of the dredged material substantially raises the cost of disposal.

The cost of construction and maintenance of confined disposal areas is subject to considerable variations in local conditions which are not reported in the available cost accounts. Such things as engineering and environmental studies, the use of temporary facilities, changes in plans, cooperative arrangements with local governments and industry make the accurate interpretation of sparse data very difficult. In this study the approach which was taken was to use a figure taken from a study of dredging in Ohio which, according to staff members in the Corps' Detroit Office, was a reasonably conservative estimate of average disposal costs in Michigan.

The two recent examples of inland lake dredging identified in this study involved Lake Lansing in Ingham County and the Messenger-Hodunk chain of lakes in Branch County. Both of these projects have been conducted by Snell Environmental Group, Inc., of Lansing, Michigan. A small amount of data and background information was provided by that firm and is reported in the next chapter. As with navigational channel dredging, a large part of the cost of dredging inland lakes is involved with the acquisition of disposal sites and the transportation of dredged material. Having only two cases of inland dredging from which to calculate average costs of dredging and disposal, the figures reported in Chapter VI are not representative of a wide range of local conditions.

VI. DISCUSSION OF RESULTS

This chapter presents empirical results obtained from the analysis described in Chapter V. Discussion is categorized under the headings used there: the travel cost and bidding game analyses of recreation benefits from environmental improvement, and a brief discussion of non-recreational impacts. The chapter begins with descriptive statistics of the data collected through the recreational questionnaire used in this study.

A. Recreational Survey: Descriptive Statistics

Table 8 summarizes the recreational survey results. These statistics are important not only because they characterize the recreational population sampled in this study, but also because they allow a more complete appraisal of the results of the travel cost and bidding game analyses. Details on the collection and definition of the data were presented in Chapters IV and V. Table 9 shows a cross-tabulation of interview frequency by recreational type and interview location. Figure 7 shows the origin of recreational trips or home location of respondents, by county and state.

B. Travel Cost Results

The basic form of the regression model which was used in the travel cost analysis was:

$$Q_{ij} = \alpha + \sum_{k=1}^{n} \beta_{ik} X_{ijk} + e_{ij}$$

Table 8. Selected Characteristics of Recreationists and Recreational Travel, Thornapple, Middle and Gun Lakes

Variable*	Mean	Standard Deviation	Minimum/ Maximum
One way distance (miles) (2)	28.4	31.3	0.5/300.0
One way driving time (minutes) (3)	67.1	62.1	3.0/720.0
Annual visitation frequency (4, 5)	12.8	20.8	1/170
Total annual water recreation days (7)	27.2	27.4	2/200
Transportation cost ($) **	4.13	5.15	0/67.00
Total trip cost ($) **	8.16	8.42	0/69.00
Age (26)	37.0	12.8	15/79
Group size (28)	3.6	2.4	1/18
Household income ($) (30) ***	19,030	10,615	2,500/45,000
Personal income ($) (30) ***	16,597	9,819	2,500/45,000
Subjective water quality rating (20, 23)			
Thornapple Lake	5.96	1.82	1/10
Middle Lake	6.29	2.11	3/9
Gun Lake	6.43	2.46	2/9

*Figures in brackets indicate question numbers on questionnaire (see Appendix).

**See definitions in Chapter V.

***See questionnaire in Appendix. Codes were interpreted as follows:

1 = $2,500	5 = $22,500
2 = $7,500	6 = $27,500
3 = $12,500	7 = $35,000
4 = $17,500	8 = $45,000

Table 9. Cross-Tabulation of Recreational Type and Interview Location

Recreation Type	Thornapple Lake D.N.R. Access Site	Thornapple Lake Charlton Park	Middle Lake	Gun Lake	Total	Percent
	- - - - - - - - - - - - - number of responses	- - - - - - - - - - - - -				
Fishing	88	17	22	17	144	48.0
Swimming	3	40	15	49	107	35.7
Water Skiing	3	14	2	2	21	7.0
Sailing	3	1	1	11	16	5.3
Other Boating	6	3	1	2	12	4.0
	103	75	41	81	300	
Percent	34.3	25.0	13.7	27.0		100

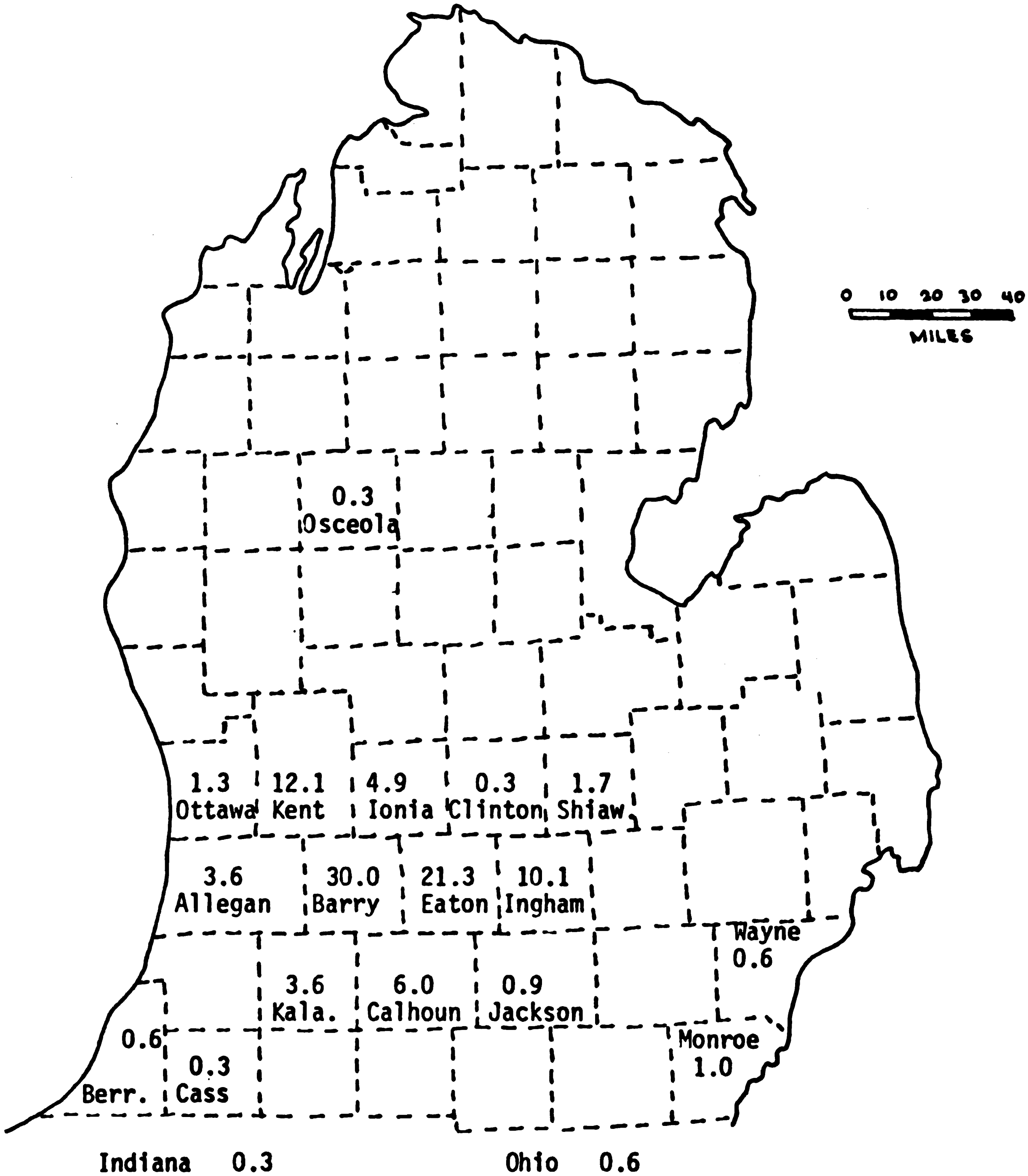

Figure 7. Origin of Recreational Trips; Percent of Total Respondents by County and State of Trip Origin
(All recreational survey locations are in Barry County)

in which Q is the annual number of visits by the recreational party (i) to the lake (j) at which the interview was conducted, X_k is the value of independent variable (K), e_{ij} is the error term, and α and β are estimated coefficients. Regressions were performed with the following variations in model specification and form:

1. various combinations of independent variables,

2. time and money cost variables and the squared values of each, following Bouwes and Schneider and Gum and Martin,

3. log-log transformations, and

4. regressions run independently for different recreational types and for each lake.

A degree of uncertainty exists concerning the specification and form of the demand model. Although Chapters II and V outlined considerable theoretical and methodological detail on which to base the analysis, many alternative models remain available. In light of this uncertainty a number of specifications and forms of the demand model were investigated here. It is clearly recognized that this is not a reliable approach to the selection of a single model since peculiarities in the data set may lead to false conclusions about recreational demand. In light of the investigative and exploratory nature of this work, however, the present approach was felt to be justified.

The presentation of results in Table 10 reflects this exploratory approach. The alternative regression model specifications and forms are shown as rows and are labeled "equations" in Table 10. The exact specification and form of each regression run can be determined from the entries in each row.

Table 10. Travel Cost Analysis Regression Results

Equations		Transportation cost	(Transportation cost)^2	Total trip cost	(Total trip cost)^2	Travel time	(Travel time)^2	Total trip cost + household income	Average travel time to substitutes	Water Quality: Secchi disk reading	Water Quality: Water quality dummy	Water Quality: Subjective water rating	Age	Sex	Household income	Total water recreation days	Recreation Type Dummy: Fishing	Recreation Type Dummy: Swimming	Recreation Type Dummy: Water skiing	Recreation Type Dummy: Sailing	Log Values (Common Logs): Total trip cost	Log Values (Common Logs): Travel time	Log Values (Common Logs): Average travel time to substitutes	Log Values (Common Logs): Secchi disk reading	Log Values (Common Logs): Age	Log Values (Common Logs): Sex	Log Values (Common Logs): Household income	Log Values (Common Logs): Total water recreation days	Constant	R^2	F
	1			-.12		-.07			....	-.02			.08	-2.11	-1.04		-18.3	-19.1	-20.6	-18.1									40.0	.07	**
	2			-.05		-.06			....		-2.0		.03	-2.22	-1.02		-18.7	-19.0	-19.9	-18.2									39.9	.07	**
	3			-.26	-.002	-.13	.0002		....	-.01			.06	-2.85	-1.05		-18.0	-19.9	-19.1	-18.6									45.5	.09	**
	4			-.85	.001	-.15	.0002		....		-1.7		.06	-2.47	-1.04		-18.1	-19.3	-18.7	-18.0									45.3	.09	**
	5			.001		-.05			....	-.02			.15	.63	-.68	.41	-20.7	-16.2	-17.4	-17.6									20.4	.37	**
	6			.02		-.05			....		-1.44		.15	.55	-.68	.41	-20.9	-16.3	-17.1	-17.9									19.6	.37	**
	7			-.57	.004				....	-.02			.07	-2.54	-1.12		-20.1	-19.7	-18.1	-19.4									43.2	.05	**
	8			-.26					....	-.02			.09	-2.28	-1.14		-19.7	-19.4	-18.2	-18.9									39.7	.04	*
	9					-.06		-.65	....	-.02			.09	-2.06	-1.68		-18.1	-19.2	-18.0	-18.0									44.0	.07	**
	10			-.09	....	-.15	.0002			-.009							-16.7	-20.0	-18.4	-18.1									40.1	.09	**
	11	-.01				-.06				-.01		-.21	.08	-2.39	-1.08		-18.4	-19.3	-20.3	-18.2									38.9	.06	**
	12	-.45	.003			-.13	.0002			-.009		.08	.06	-3.09	-1.1		-18.0	-20.0	-18.9	-18.2									44.7	.09	**
	13	.06				-.05				-.02		.36	.14	.59	-.68	.41	-21.0	-16.6	-17.2	-18.4									18.5	.37	**
	14																				-.02	-.47	.009	.09	-.25	.15	-.06		1.9	.13	**
	15																				.03	-.42	-.01	.03	-.12	.24	-.05	.66	.69	.39	**
Fishing	16			-.27		-.05			....	-.01					-.92														22.4	.06	*
	17					-.03		-1.9	....	-.01					-2.5														30.8	.10	
Swimming	18			.36		-.09			....	-.01					-.79														16.9	.05	
	19					-.07		.34	....	-.02					-.37														16.8	.03	
W. Skiing	20			.006		-.07			....	-.02					-.87														19.2	.07	
	21					-.08		.26	....	-.03					-.13														15.6	.12	
Sailing	22			-.41		-.02			....	.009					-1.98														23.0	....	
	23					-.02		1.57	....	-.04					-.99														19.5	....	
Thornapple	24			-.61	.01	-.17	....			.16							-18.1	-20.0	-14.9	-25.5									37.5	.09	*
	25																				.08	-.72	.006	.41	-.21	-.43	.04		1.6	.20	**
Middle and Gun	26			.16	-.001	-.16	....			-.03							-17.6	-18.2	-20.6	-16.1									38.7	.09	*
	27																				.01	-.28	.007	-.23	-.21	-.02	-.26		2.3	.04	

Table 10 (cont.)

Notes on Variables

Number of observations: Equations 1-15 = 300
Equations 16-27: see subcategory totals in Table 9.

Dependent variable: Equations 1-13, 16-24, 26: number of visits to interview lake by recreational party per year
Equations 14-15, 25, 27: common log transformation of above

Independent variables: (Numbers in brackets refer to question numbers on questionnaire, Appendix A)

$$\text{Transportation cost} = \frac{(\text{one way mileage x 2})}{\text{miles per gallon}} \text{ x (gas price in dollars) x}$$

(lake as % of reason for trip)

(10, 16, 17, 18)

Total trip cost = transportation cost + entrance fee + boat operation cost + other on-site costs (19, 21, 22)

Travel time = (one way travel time in minutes x 2) x (lake as % of reason for trip) (11, 12, 16)

Total trip cost/household income (31)

Average travel time to substitutes (15) (See explanation, Chapter V)

Water quality indicated by:

a. Secchi disk reading (see Table 6 and Chapter III)

b. Water quality dummy variable (Thornapple Lake = 0 = dirty, Middle and Gun Lakes = 1 = clean)

c. Subjective water appearance rating scale (Dirty = 1, Clean = 0) (20, 23)

Age (26)

Sex (27)

Table 10 (cont.)

Household income	(1 = 0-\$5,000	5 = \$20,001-\$25,000
	2 = \$5,001-\$10,000	6 = \$25,001-\$30,000
	3 = \$10,001-\$15,000	7 = \$30,001-\$40,000
	4 = \$15,001-\$20,000	8 = greater than \$40,000) (31)

Total water recreation days = total days of any type of water-based recreation per year

Recreation type dummy variable = 1 if stated recreation type, 0 otherwise

$\bar{R}^2$ = coefficient of determination, adjusted for the number of independent variables

F = ratio of regression to residual variance

** or ═ = statistically significant at 99% confidence level

* or — = statistically significant at 95% confidence level

.... = absolute value less than 0.0005

1. Cost of travel.

In order to correctly assess the empirical results derived from the travel cost analysis it is necessary to clearly state the theoretical expectations and the research hypotheses drawn from them. With respect to the cost of recreational travel the standard theoretical model asserts that there will be a negative relationship between cost and quantity (visitation frequency). In other words, recreationists from farther away will visit a site less frequently. Response to both an entrance fee (variations in which are not observed) and travel time requirements are expected to be negative and larger (more elastic) than the response to travel money costs. An alternate hypothesis is that, particularly with respect to locations where average travel distance is low, recreationists will not respond to variations in the cost of local recreational travel since these are dispersed and difficult to perceive.

The results in Table 10 show coefficient estimates for the time and money cost variables with the expected negative sign in most equations, but values consistently less than 1.00 (in absolute terms). The estimated coefficients for both the transportation cost and total trip cost variables show that a $1.00 increase in these costs would result in a reduction of less than one-half visit per year for an average recreational party. Using the results of equation 3 as an example, the elasticity of demand with respect to total trip cost is -.23; from equation 12 the elasticity of demand with respect to transportation cost is -.18. These results show very little recreational demand response to changes in money cost over the observed range.

This is substantiated by noting that, apart from equations 7 and 8, the estimated coefficients from the cost variables are statistically insignificant at the 95 percent confidence level. (The average level of significance for the estimated total trip cost coefficients is 50 percent.) Furthermore, with 300 observations this lack of statistical significance cannot be attributed to a small sample. The hypothesis that there is no recreational demand response to travel cost can, therefore, not be rejected. The only cases in which cost appears to be statistically significant at the 95 percent level or higher are equations 7 and 8 where travel time is omitted. The effect of time appears to be confounded with that of cost and the cost coefficients are biased estimates of the relationship between the cost of travel and visitation frequency. These results support the hypothesis that there is little or no recreational response to variation in travel cost within the observed range. As mentioned previously, however, there may well be a greater response to entrance fees.

Table 10 shows coefficients for the travel time variable with the expected negative sign. Although these coefficients also appear to be very small (in absolute terms) it must be remembered that the unit of time being used is minutes. ($1.00 is equal to 24 percent of the mean transportation cost; 24 percent of the mean travel time is 16 minutes.) Using the results of equations 3 and 12 as examples again, the elasticity of demand with respect to travel time is -.68 and -.65 respectively. Although this is an inelastic response, it is a larger response than to the cost of travel.

This can also be substantiated by taking into account the indications of statistical significance in Table 10. Apart from the analyses of individual recreational types and interview lakes (in equations 16 to 27), the estimated travel time coefficients are significant at the

99 percent confidence level. (One of the time coefficients in equation 3 is significant at 95 percent.)

These results support the hypothesis, stated above, that there is a greater recreational demand response to time than money costs. Since 300 observations were used throughout, the difference in statistical significance with respect to the money and time cost coefficients cannot be attributed to differences in sample size.

The conclusion that travel time is a more significant determinant of recreational demand than is the cost of travel, within the observed range of data, can be further substantiated in two ways. First, it corresponds to the conclusion drawn in a similar study by Bouwes and Schneider. Their study is particularly relevant since it is the only one which has been located which used observations on individual recreational groups, examined a small number of individual locations, and investigated the recreational consequences of changes in water quality. Bouwes and Schneider estimated a demand model which incorporated both travel cost and time, and used both normal and squared terms for each. Their results in terms of the sign and significance of the estimated money cost and time coefficients, were the same as those obtained in the present study, with the exception of their squared cost term which was significant at the 95 percent confidence level.

The conclusion that travel time is a more significant determinant of recreational demand than is money cost is also supported by its logical basis. The discussion of travel time in Chapter V presented several reasons why the correlation coefficient between travel time and total trip cost is no higher than 0.58. Factors such as variation in vehicle fuel efficiency, variation in average driving speeds and variation in gasoline price paid by different recreationists account for this low correlation. They may also account for differences in perception and reaction by recreationists to time and money costs since they make variation in money costs less apparent. Money costs of travel may be dispersed, deferable or seen as fixed, particularly on short trips, as mentioned in Chapter II. Filling the car's gas tank, for example, may be a weekly event whether or not one goes fishing, but spending an extra hour driving to a more distant lake is a more apparent cost because it reduces the amount of time available for fishing.

One further perspective on the relative importance of time and money costs can be gained by comparing an approximate shadow price of travel time with the reported money cost of recreational trips. It must be emphasized that this procedure is not a reversal of the decision, discussed at length above, not to use a shadow price of time so as to incorporate the two costs into one variable in the regression analyses. What is attempted here is simply an estimation of the relative significance of time and money costs for travel. If time costs converted to dollars are much greater than the normal money costs of recreational travel, that factor might explain part of the greater response to time than money cost.

Using the reported average annual personal income (Table 8) of \$16,597 and 2080 working hours per year (40 hours per week times 52 weeks per year), the average hourly wage rate for respondents in this study is \$16,597/2080 = \$7.98 per hour. The average value of recreational driving time can be calculated by using three alternate hypotheses about the relationship between wage rate and the shadow price of recreational travel time. These are that travel time should be valued, arbitrarily, at 33 percent, 66 percent or 100 percent of the wage rate, giving travel time shadow prices of $2.66, $5.31 and $7.98 per hour respectively. The average round trip driving time reported by recreationists in this study was 2.24 hours (calculated from Table 8). This then yields average recreational travel time values of $5.96, $11.89 and $17.88, respectively, for the three hypotheses about travel time and wage rate. The average money cost of transportation (gasoline only) reported in this study was $4.13 and the average total trip cost was $8.16 (Table 8).

If Cesario's suggestions regarding the relationship of wage rate and travel time value, discussed in Chapter II, are adapted, a shadow price of time of 33 percent of wage rate would appear to be the best of the three alternatives above. This would mean that the average value of travel time in this study is $5.96, very close to the reported average transportation and total trip costs. This evidence would not support the hypothesis that large time costs, relative to money costs, make time a more significant determinant of recreational demand.

2. Water quality

Water quality (turbidity) is taken into consideration in the travel cost regression models in this study through the use of Secchi disk readings, by a water quality dummy variable and by means of subjective water quality ratings. As described in Chapter II, it is hypothesized that water quality improvements will shift the demand curve to the right; at each price (distance) recreationists will visit the lake more frequently after an improvement in water quality. This implies the empirical expectation that the estimated coefficient of the water quality variable will be positive.

The estimated coefficients in Table 10 show, in most cases, an unexpected negative sign indicating a reduction in the rate of visitation associated with an improvement in water quality. This may well be explained, however, by the lack of statistical significance at the 95 percent level. (The average statistical significance level for the Secchi disk variable coefficients is 46 percent and for the water quality dummy variable coefficients is 54 percent.) The signs of the estimated coefficients are not meaningful at this low level of statistical significance. These results indicate no perceptible influence on visitation frequency by water quality variation between Thornapple Lake and Middle and Gun Lakes.

It could be argued that recreationists' perceptions of water quality have a more significant effect on visitation frequency than does a single objective water quality measure. However, when recreationists' subjective ratings were incorporated (equations 11 to 13, Table 10) the estimated coefficients were again statistically insignificant at the 95 percent level of confidence. (The average significance level was 77 percent.)

The conclusion that water quality (turbidity) does not have a perceptible effect on recreational demand is obviously of central importance in the context of this study. It can be set in perspective by a number of considerations. The first is, again, to compare this result with those of other studies. Bouwes and Schneider examined the recreational impact of changes in overall water quality. They found a significant relationship between subjective ratings of lake water quality and a composite objective measure which took into account such parameters as dissolved oxygen, Secchi disk transparency, winter fish kill, and plant growth. They then included the subjective rating measure (transformed to log values) in their travel cost regression model and detected a significant effect on re

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recreational demand. Neither of these relationships was detected in the present study. While the reason for the difference in results is not clear, it may be that composite measures of water quality reflect overall lake characteristics which are more important to recreationists than are single pollutants, as mentioned earlier. Binkley and Hanemann found a significant relationship between visitation frequency and subjective water quality ratings, but did not find that composite objective quality measures were significant determinants of the visitation rate. Again, it is not clear whether the significant relationship between recreational demand and subjective quality ratings were due to the focus on a more comprehensive water quality definition, or to some other difference in experimental design or analytical procedures.

The insignificance of the estimated water quality coefficients does not correspond to the importance which people say water quality has in their recreation or choice of recreational location. Respondents were asked how important the appearance of the water in their choice of a lake for recreation was. (Not, somewhat, or very important) The results are shown in Table 11.

The majority of respondents feel that water appearance is somewhat or very important to them in their choice of a lake. It is essential, however, to interpret these results in light of the intentionally suggestive way in which the question was asked. The subject of water appearance is explicitly mentioned and respondents may have felt that to say that the appearance of the water is not important to them would have been to display a lack of environmental sensitivity. To an earlier open-ended question with precoded response categories in which respondents were asked about the actual factors affecting their choice of a lake on the

Table 11. Importance of Water Appearance in Recreational Lake Selection*

Stated Importance of Water Appearance	Thornapple Lake**	Middle and Gun Lakes***
Not important	13.6%	10.8%
Somewhat important	41.8%	32.5%
Very important	44.6%	55.8%
TOTAL	100%	100%

*See questions 19 and 22 in Appendix.

**Dirty.

***Clean.

interview day, the responses were as shown in Table 12. Here only a small number of respondents mentioned water appearance without prompting as a reason for going to Gun or Middle Lakes. None at Thornapple mentioned this. Question 18 asked respondents at Gun and Middle Lakes, who had been to Thornapple Lake, if the difference in the appearance of water between these lakes was a factor in that day's choice of a recreational location. Only 17 percent said it was.

The major conclusion to be drawn from these results is that, although respondents may indicate, when prompted, that the appearance or clarity of water is important to them, far fewer will do so when no prompting is done or when a specific locational choice is referred to. This conclusion is in accordance with the statement above that the travel cost method does not reveal a recreational demand response to water quality variation. While recreationists may have a positive attitude toward the concept of clear or clean water, it does not appear to be a

Table 12. Factors Affecting Recreational Lake Selection*

Reason	Thornapple Lake**	Middle and Gun Lakes***
Desire for variety	13.1%	6.8%
Distance	28.8%	18.6%
Expected fishing success	23.9%	10.2%
Water appearance	0	6.8%
Related facilities	8.1%	18.6%
Other reason for being in this area	9.9%	8.5%
Other	16.2%	30.5%
	100%	100%

*See questions 17 and 21 in Appendix.

**Dirty.

***Clean.

factor which is central in their recreational choice. This proposition will be discussed again with respect to the bidding game results. The lack of statistical significance of the water quality variables' coefficients in the travel cost analysis means that the hypothesized changes in water quality do not cause a shifting of the demand curve. This made it impossible to attribute benefits to such environmental improvement by the technique described in Chapter II.

3. Other regression results.

It can be seen in Table 10 that the $\bar{R}^2$ for each of the equations is low. The highest values occur in equations 5, 6, 13, and 15 which contain the "total water recreation days" variable. Although this variable was included as a proxy for personal preference for water recreation (as suggested by Gum and Martin), it was not used in most of the equations because it was not felt to be useful in actually explaining recreational demand. $\bar{R}^2$ levels could be raised substantially by including variables such as the visitation rate at a lake which is a close substitute, but such variables would have little relevance or policy significance.

Table 10 shows insignificant coefficients for the age, sex and income variables. With regard to age and sex this result is not unexpected. Only 18 percent of the respondents in the survey were travelling alone. While it is not clear how recreational decisions are made by multi-person groups, it is likely that there are many factors affecting such decisions and the age and sex of one member of the group are not likely to be good proxies for all or most of these factors. The significance of the income factor is similarly limited. For groups made up of people from different households, information on how costs were shared would be required, as would information on each household income.

There are consistently significant coefficients in Table 10 for the dummy variables indicating recreation type. Since "other boating" is the category which has been omitted, these simply show that the visitation rate will be lower (the estimated coefficients all have a negative sign) with any other recreation type than with "other boating." This conclusion is based on a fairly small number of observations in the latter category, however, (see Table 9) and it does not likely have much policy relevance.

The attempts to analyze recreational and locational subgroups separately (equations 16 to 27) produced inconclusive results. In only one case did the calculated F value indicate significant explanatory power for the model at the 99 percent confidence level.

C. Bidding Game Results

Table 13 gives information on the results of the bidding game, including the total bid amount and the total reported visits as reported in questions 4 and 5 of the questionnaire (see Appendix). Since bids were collected on a per visit basis, the total bid amount is calculated within each bid category and then summed across these categories (column D, Table 13). The average bid per recreational party visit is $2,233.32 total bid/2,430 group visits = $0.92. Given an estimated 17,000 recreational party visits per year to Thornapple Lake, the estimated total value of the improvement in water quality is approximately $15,600. This result must be qualified in several respects, however.

First, it can be seen from Table 13 that a large number of respondents gave a bid in round numbers such as 1, $1.00 and $2.00. These figures clearly act as "focal points." Given the expectation of a continuous distribution of preferences for environmental improvement, the existence of these focal points may distort the true distribution of bids to some extent.

The second qualification has to do with the estimation of the total recreational use of Thornapple Lake as described in Chapter IV. It was mentioned there that the estimate of 17,000 party visits per year did not include recreationists who gained access to the lake other than through the DNR public access site or Charlton Park. The total use estimate is, therefore, an underestimate of actual recreational use of the lake. It is not known what value these excluded recreationists would place on an improvement in water quality.

Table 13. Bidding Game Results

A. Bid Amount Per Visit	B. Number of Respondents	C. Total Number of Reported Visits*	C. Total Bid Amount (AxC)
$ 0	38	648	$0
.13	1	40	5.20
.25	6	117	29.25
.50	15	571	285.50
.60	1	120	72.00
.66	1	2	1.32
.75	2	5	3.75
1.00	38	281	281.00
1.50	9	38	57.00
2.00	31	234	468.00
2.25	1	5	11.25
2.50	7	134	335.00
3.00	4	79	237.00
4.00	5	26	104.00
4.50	3	8	36.00
5.00	9	87	435.00
5.50	1	35	192.50
Total	172	2,430	$2,233.32
No response	6		

*Total reported visits to Thornapple Lake per year by respondents in each bid category. (Questions 4 and 5, Appendix)

Third, as mentioned in Chapter V, the ambiguity in the wording of the bidding game question, unrecognized during the administration of the survey, made it unclear as to whether respondents were expressing a willingness to pay for the improvement in water quality or for the use of the lake after such an improvement. Since recreationists would likely be willing to pay some amount for use of the lake in its present condition, the average bid of $0.92 per group visit must be considered an upper limit on the willingness of respondents to pay for water quality improvement. The net effect of underestimating the total recreational use of Thornapple Lake and possibly overestimating the average willingness to pay is not known, but is likely less than either of these effects alone.

Finally, there is a critical qualification of the estimated total value of water quality improvement which has to do with the way in which this bid might be collected. The implicit assumption was made in designing the bidding game question that the visitation rate per recreational party is fixed. Although the travel cost analysis in this study did not detect a recreational demand response to travel cost, there are strong theoretical reasons for expecting that individual demand curves will not be perfectly inelastic, particularly with respect to an entrance fee. Since no other information is available on what the individual demand response to an entrance fee is, however, it is impossible to define an aggregate demand curve from the bidding game results.

If there is a negative response of individual visitation rates to entrance fees, then the total bid amount ($15,623) could not be collected by means of such entrance fees. That estimated total value of turbidity reduction at Thornapple Lake would be a valid indication of total value if the money were not going to be collected or if it were collected by some lump sum payment not related to the visitation rate. The qualification of the estimated value has apparently not been recognized in previous bidding game studies (Randall, Ives and Eastman; Brookshire, Ives and Schulze; Walsh, et al., 1972b).

A test for the existence of strategic bias was proposed in Chapter V. As described there, this consists of the estimation and interpretation of two correlations. The first is between the importance which the respondent placed on the appearance of water in selecting a lake for recreation (question 22) and his bid level. In order to more accurately detect bias, only bids of 0 or greater than or equal to $3.00 were considered. The simple correlation coefficient between these extreme bids and the stated importance of the appearance of water was 0.227. Although this was slightly stronger than the correlation of all bids with the importance of water appearance, it still appears to be a weak relationship and thus supports the hypothesis that strategic bias is not significant in these bidding game results.

The second part of the test for strategic bias involves an examination of the correlation between bid level and the responses to a question concerning the reasons for water pollution at Thornapple Lake (question 24). In this case a cross-tabulation of extreme bids and responses to the water pollution question was used, rather than a calculation of a correlation coefficient. It would be expected that those with high preferences for environmental improvement, and thus an incentive to bias their bid upward, would have a lower than average response of "don't know" on question 24. Instead, 54 percent of those bidding $3.00 or more said they did not know the reason for water pollution at Thornapple Lake, while only 29 percent of those giving 0 said they did not know the reason for water pollution.

While the results of either of these correlations are very weak indications concerning the existence of strategic bias, their results do correspond and make plausible the proposition that little strategic bias exists in the bidding game responses.

D. Non-Recreational Impact Results

1. Water treatment.

Chapter V presented a description of the cost saving approach to benefit estimation. Three stages in the water treatment process are believed to be related to the level of raw water turbidity. These are chemical treatment, filtration and sludge disposal. With respect to the analysis of chemical treatment costs, the regression model which was suggested by treatment plant managers and engineers with the Michigan Department of Public Health was

$$CC = \alpha + \beta_1 RWT + \beta_2 TEMP + \beta_3 FWT + e$$

where CC is aggregate chemical costs per day for alum, chlorine, carbon and soda ash, RWT is raw water turbidity, TEMP is water temperature, FWT is finished water turbidity, and e is the error term. The model was estimated separately for Blissfield, Deerfield and Dundee as well as with pooled data from all locations.

The results of these analyses showed general statistical significance of the hypothesized relationships, with one major drawback. The average R^2 value for these regressions was only 0.10. It was expected that in modelling physical relationships where human perception and reaction are not involved, relatively high predictive accuracy should be possible. The very low R^2 values obtained here indicate that the model which was used was inadequately specified. Omission of relevant independent variables will bias the estimated coefficients where omitted and included variables and omitted and dependent variables are correlated (Rao and Miller, Ch. 2). The estimated coefficients from these regression analyses are, therefore, not reported here because of the apparently high probability of them being seriously biased. No attempt was made to pursue this enquiry further by seeking to improve the model specification.

Despite these poor statistical results, it is instructive to note the following means and standard deviations:

	Blissfield	Deerfield	Dundee
Mean daily chemical costs (alum, chlorine, carbon and soda ash)	$30.50	$36.65	$36.48
Standard deviation of daily chemical costs	$14.07	$10.09	$30.08

These figures are calculated for the period of January 1978 to June 1980, using June 1980 chemical prices. They give an indication of the order of magnitude of chemical treatment costs in these plants and thus of the upper bound of savings that could be realized from reduced raw water turbidity.

There would be no impact of reducing turbidity on filtration costs at Deerfield and Dundee since these plants backwash their filters at standard times. It is not believed that variation in raw water turbidity will have much effect on filtration costs at Blissfield either, since there appears to be only a very weak correlation between turbidity levels in raw and pre-filter water.

Plant managers suggested that sludge disposal costs may be the area where the greatest potential savings from reduced raw water turbidity lie. Because of a lack of any information on the relationship between raw water turbidity, measured in nephalometric turbidity units (Duchrow and Everhart), and the volume of sludge generated, it was impossible to investigate this area of potential benefits in any detail. A rough indication of the upper limit of potential benefits was, however, determined. Both Blissfield and Dundee water treatment plants pump their sludge directly into the municipal sewage system. Data from the Blissfield sewage treatment plant indicate that between July 1979 and June 1980, 235,363,000 gallons of sewage were treated at a total cost of $90,715, or an average cost of $.39 per thousand gallons. From a breakdown of this operating cost figure, it appears that approximately 15 percent or $13,500 are costs which might be variable in the short run with variation in the volume of sewage treatment. Although it is not known what volume of sludge is generated by the water treatment plant, it is unlikely to be greater than 10 percent of the total volume of treated sewage. Thus, even if the municipal water treatment plant generated no sludge, the reduction in sewage treatment costs would likely be less than $1,400. Potential savings at Dundee might be of the same order of magnitude. The Deerfield water treatment plant discharges its sludge directly into the Raisin River, thus incurring negligible sludge handling costs.

The upper limit on annual benefits from turbidity reduction for these three plants would be ($1400 per plant x 2 plants for sludge disposal) + ($34 per plant per day x 365 days per year x 3 plants for chemical costs) = $40,000 assuming (unrealistically) a total elimination of raw water turbidity, all chemical treatment, and all sludge generation. It is likely that the actual benefits from a realistic reduction in turbidity would be far below this upper limit.

2. Dredging.

Two types of dredging are considered in this study. The first is the dredging of navigational channels by the U.S. Army Corps of Engineers. The second is the dredging of inland lakes. Because of a lack of data and general information on the many factors which determine actual dredging costs the procedure which was used here was to calculate average dredging costs per cubic yard of material removed.

a. Navigational channels. The Corps of Engineers carries on dredging operations at 67 locations in Michigan. Many of these require only periodic attention in order to maintain satisfactory channel depth. For those locations at which dredging was reported during 1979, the total volume of material removed was 2,107,317 cubic yards at a cost of $5,033,688. Thus, the average cost of dredging during that year was $2.39 per cubic yard.

Many of the locations at which dredging is conducted are harbors at the mouths of rivers flowing into the Great Lakes. At some of these locations dredging must be performed to remove both sediment transported by the rivers from upland erosion and that deposited by wave action moving material along the lake shoreline (littoral drift) (Great Lakes Basin Commission, Section 8). While data on the amount of sediment which can be attributed to each of these sources is unavailable, a rough estimate of the proportions can be gained from the estimate by the Corps that 80 to 90 percent of its dredged material must be deposited in confined disposal areas. This is polluted material and comes almost exclusively from rivers, though not necessarily from agricultural sources. However, it might be safely assumed that 85 percent of the 1979 dredging cost, or $4.3 million, is attributable to river-transported sediment.

Because of the complexities of local conditions and of the accounting procedures used by the Corps it was not possible to calculate an average cost of disposal in confined disposal areas. In personal communication, however, members of the Corps staff stated that the cost of such disposal ranged from $3 to $20 per cubic yard. In a study of erosion and sedimentation in the Cuyahoga River in Ohio, the Corps of Engineers estimated the average cost of confined disposal to be $5.29 per cubic yard. While the cost of confined disposal is highly variable and an average figure would have little relevance for any single location, it might be possible to use $5.00 per cubic yard as a very conservative estimate of average confined disposal costs. Applying this cost to 85 percent of the 1979 volume of dredged material yields a disposal cost of $8.9 million for confined disposal, or a total cost of $13.2 million for dredging and disposal of river transported sediment. It must be kept in mind that this figure may have a wide margin of error in it due to lack of dependable data and the highly variable nature of some of the costs involved. Wade and Heady (p. 140) report that the proportion of sediment from cropland sources is approximately 34 percent in Michigan. Thus, a total elimination of agricultural soil erosion might result in a dredging cost saving of $4.5 million.[1] Feasible levels of conservation would mean proportionately less saving. Finally, no estimate is available of the potential benefits which may result when dredged material is disposed of in such a way as to restore or protect a shoreline wetland area.

b. Inland lakes. Two inland dredging projects were investigated in this study. The dredging of Lake Lansing in Ingham County, Michigan, involves the removal of approximately 2,022,000 cubic yards of dredged material and as of September 1980, is still underway. Approximately 39 percent of the dredged material will be deposited in upland spoil areas at a cost of $1.10 per cubic yard for dredging and disposal. The remaining 61 percent will go to wetland spoil areas at a cost of $1.05 per cubic yard. These costs were quoted at current (1980) price levels.

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[1]This may be an underestimate since soil conservation may also reduce the level of chemical contaminants and thus the need for confined disposal.

The dredging of the Messenger-Hodunck chain of lakes in Branch County was completed in 1976. It involved the removal of approximately 1,444,000 cubic yards of material at an average cost of $.48 per cubic yard. This cost is quoted at 1977 price levels and does not include the cost of disposal.

In assessing the importance of these results in terms of the potential benefits from soil conservation, two important qualifications must be made. First, since disposal costs are highly dependent upon local conditions and the availability and accessibility of disposal sites, these cost figures may have little relevance for predicting costs which might be incurred at another location. Their significance is only that they give a rough idea of the magnitude of the cost of dredging, per se, which may be more constant between locations, and of possible disposal costs.

The second qualification which must be made is that inland lake sediment is likely to be largely organic in nature, resulting from the decay of algae and other aquatic plants rather than from soil erosion. The Snell Environmental Group indicated that the cost of dredging inorganic material is somewhat higher than the cost for organic material because of the higher specific gravity of the former. Both of the projects considered here involved organic sediment almost exclusively.

VII. CONCLUSIONS AND RECOMMENDATIONS

This chapter discusses four topics. The first is the methodological conclusions with respect to the use of the travel cost and bidding game techniques for valuing environmental change. These conclusions are drawn from both the review of the theoretical and methodological literature and from the empirical results. The second topic is the size and incidence of benefits from soil conservation. Despite the impediments encountered in analyzing the distributional results, some approximate figures are presented. Third, the policy relevance of the study's results are discussed and fourth, recommendations for future research are given.

A. Recreational Methodology: Comparisons of the Travel Cost and Bidding Game Techniques

The empirical investigation of the recreational impacts of sediment reduction showed a difference in the estimate of benefits derived from the travel cost and bidding game techniques. The travel cost method revealed no recreational demand response to variations in the observed range of turbidity and thus no implied willingness to pay for a corresponding reduction in turbidity. The bidding game, however, revealed an average willingness to pay of $.92 per recreational party per visit.

Although it is not possible to draw conclusions regarding benefit evaluation methodology directly from this empirical result, there are a number of important issues raised by such a result.

1. Consumer information.

As discussed in Chapter II, a vital determinant of preferences, and therefore of demand, is the information which the consumer has on the characteristics of the product, on its price, and on the price and characteristics of substitute products (Markin). Goods such as environmental improvements are distinctive in the complexity of their characteristics, making it difficult for consumers to be fully aware of the nature of the "product" (Kapp, 1972a). The complexities of the physical relationships involved in erosion, sediment transportation and the impact of sediment on environmental services were discussed briefly in Chapter III. Recreationists are unlikely to be aware of many of these and thus the preferences which they reveal for environmental improvement are based on incomplete information. These preferences may also change as information is added.

In light of these considerations it is significant that the travel cost and bidding game techniques do not measure demand for an environmental improvement or other good with the same implicit level of consumer information. The travel cost method examines recreational patterns and the inferred demand for environmental improvement without additional information being imparted during the measurement process. The bidding game, on the other hand, describes and draws attention to the product in question. In this study the existence of turbidity in Thornapple Lake and its relationship to soil erosion were described for respondents before their bid was sought.

A second distinction between the two techniques is the extent to which they require explicit consideration of consumption tradeoffs. Although the standard economic theory of consumer demand is built on an assumption of rational choice, habitual choice is likely to be common, particularly where prices and product characteristics are not changing. The travel cost technique is based on past behavior and choice in which habit may have been important. The bidding game, however, requires respondents to consider a new product and their willingness to pay varying prices for it. Even though respondents are not necessarily restricted by their income limit, the explicit choice which the bidding game requires is likely more reflective of the conscious choice which they would have to make if faced with a newly imposed or increased entrance fee. In this respect it may be a more realistic indicator of short run consumer response to a fee.

The bidding game is also distinctive in that it draws attention to one product at a time and does not ask or require respondents to consider consequent adjustments in other purchases. It also assumes that the demand for other products will not be measured in the same way. If the bidding game were used to measure demand for all products, total stated willingness to pay might well exceed the consumer's income. A requirement of actual payment would then necessitate a downward revision of all the consumer's bids, including that on the product in question.

A final distinction between the travel cost and bidding game treatment of consumer information is that the former examines consumer response to existing static differences in environmental quality among sites while the latter asks respondents about their reaction to change in quality at a given site. Questions regarding a change may provide more information on short run than long run demand response. The closely related issue of experimental design is discussed below.

It is clear that the travel cost and bidding game techniques are potentially quite different from one another in terms of the amount of consumer information which is implicit in the measured level of demand. In actual practice this difference will depend on the good in question, the amount of prior information which respondents possess, and the amount of learning which takes place during the measurement process.

Given these differences between the bidding game and travel cost methods in the amount of information which is supplied to the consumer, what is the correct or optimal level of information on which to base a definition of benefits? This question is closely paralleled by the broader public policy question of the "right" amount of advertising by both private firms and public agencies. Since the level of demand will usually determine the price at which a product is provided or whether it will be provided at all, the level of information which is judged as appropriate or permissable will have a significant influence on who's preferences predominate.

It is impossible, without reference to a normative judgement, to say how much information consumers should be given or what minimum level they should possess in order for their preferences to be taken into consideration. It is therefore impossible to make a strictly technical choice between the travel cost and bidding game approach on the basis of their treatment of consumer information or to say, in the present case, whether the value of reduced turbidity at Thornapple Lake is 0, $.92 per recreational party per day, or some other value that might have been determined had a different amount or type of information been provided to respondents. It is important, however, to note that the difference between the benefit estimates derived by the two techniques is, at least in part, attributable to the difference in their provision of information.

2. Other methodological comparisons.

Although the differences in the provision of consumer information by the bidding game and travel cost techniques may be an important factor in explaining the empirical results of this study, it is impossible to know just how important. There are other characteristics of the two methods which could also account for such results. Several important features of the two methods will be reviewed here.

a. Income restraint. An important characteristic of the bidding game is that it does not force the normal income restraint or consideration of tradeoffs in consumer choice. It, therefore, does not necessarily give the same income weights to consumer preferences as does market-expressed, effective demand such as is measured by the travel cost method. Bids are not necessarily unrelated to income, however. Respondents with low incomes, for example, may relate their bid to their normal expenditure level, particularly if they do not consider the game purely hypothetical. In the present study the correlation coefficient between income level and bid was 0.221, indicating a weak relationship between the two, though one which was statistically significant at the 99 percent level of confidence. It is, therefore, possible that the bidding game yielded a higher benefit estimate than did the travel cost technique because respondents were, to some extent, unconstrained by their normal budget restrictions present in actual market choices.

b. Sensitivity to wording. The bidding game approach is potentially very sensitive to question wording. Although this sensitivity was not tested empirically in this research, the possibility of strategic response bias and inaccuracy in assessing preferences were discussed at length in Chapter II. The precise definition of the "product" and the information which is conveyed regarding its characteristics will likely have a decisive effect on the average bid. The travel cost technique, on the other hand, is likely to be less sensitive to question wording since more objective information is being sought. The results of this technique will be sensitive, however, to such things as the accuracy with which respondents recall the requested information and their subjective assignment of costs among multiple trip purposes. Travel costs results will also be determined by the chosen analytical procedures and the assumptions which are made. These respective areas of sensitivity may explain much of the variation in empirical results obtained by these methods.

c. <u>Benefit definition</u>. Chapter II discussed the use of the consumer surplus concept and single-price measures of benefits. The approach chosen in defining benefits will clearly affect the magnitude of the estimated benefits. In the present study the travel cost analysis did not detect a recreational response to variation in turbidity over the observed range. Thus there was no need to select a particular definition of benefits and this issue did not affect the observed difference in results from the travel cost and bidding game methods. If information had been collected on individual recreationists' visitation rate response to an entrance fee an aggregate demand curve could have been obtained from the bidding game results and both consumer surplus and single-price measures of benefits derived. Information could then have been provided on the distributional consequences of the use of a consumer surplus or single-price benefit measure.

d. Option demand. A well known feature of the bidding game is its potential capability of measuring option demand or other demand from non-users. This clearly distinguishes it from the travel cost method. Chapter II discussed the problem of response accuracy and stated that a reduction in the hypothetical nature of a bidding game question may lower the cost, in terms of mental effort, to the respondent of providing accurate answers (where accuracy is interpreted in the context of continual learning). The assessment of option demand will likely raise the cost of accurate response to the respondent since he is having to deal with very hypothetical concepts, making inaccuracy a potentially serious problem. In the present study option demand was not studied.

e. Product specification and experimental design. A critical aspect of a bidding game is its specification of a standard "product." Several potential solutions to this problem were discussed in Chapter V. None of them appeared to be ideal. In cases where potential water quality improvement is being investigated, the best definition of a standard amount of improvement will depend on the details of the particular situation. In some cases the use of photographs may be sufficient, while in others a reference lake or river may be available. Use of a reference location in a bidding game will, however, raise the problems of experimental design which are present in the travel cost method.

The experimental design problem in the travel cost method is one of controlling the influence of factors other than the one in question. For example, site characteristics other than water quality may have an effect on the demand for recreational locations and the possible variation in these other factors must be taken into account in specifying the effect of water quality changes on recreational demand. While an appropriate combination of experimental design and statistical control should be sought, this is an area of potential difficulty and inaccuracy. These problems of product definition in bidding games and experimental and statistical design in the travel cost analysis may lead to a considerable error in the results and variation between the two techniques.

f. Detection of strategic response bias. Considerable attention has been given in past theoretical and empirical studies on the bidding game to the reduction of strategic response bias and assessment of the net bias which remains in the results. This study has discussed the possible tradeoff which exists between strategic bias and response accuracy. It has also presented and applied a new test for detecting response bias, using measures of correlation between extreme bids and indicators of respondents' preference for environmental improvement. As used here, this is a very weak test for the existence of strategic bias, yet one which seems to have potential for improvement.

g. Observational unit. The observational unit used in this study's travel cost analysis was the recreational party. Chapter V pointed out some potential ambiguities which this approach raises. Also, this procedure is practicable only in situations where multiple annual visits are common. Despite these limitations it appears that the use of this observational unit can be defended. Its use allowed the inclusion of travel time in the model without raising the complex problem of the determination of a shadow price for time. It also allowed the assumption of homogeneous origin zone characteristics to be relaxed.

h. Spatial validity of the travel cost method. One of the criticisms of the travel cost method has been the lack of correspondence between recreationists' responses to travel costs and entrance fees. As discussed in Chapter II, the response to travel costs may well differ from the response to an entrance fee if recreational trips are short and travel costs are low. For example, there may be a number of recreational locations accessible to a recreationist on less than one tank full of gas for a round trip. Within this range he may not associate the cost of gas directly with the particular trip and therefore may not respond to variations in gas cost. As distance increases travel costs rise and become more easily perceptible and thus the response to them is more likely to be equivalent to the response to an entrance fee, as discussed in Chapter II.

The implication of this is that there may be spatial limits to the travel cost method defined by recreationists' response to costs of various sizes. Clawson and Knetsch (p. 77) mention the inappropriateness of the travel cost method for analyzing recreational demand at what they refer to as "user-oriented areas," those which are designed to be easily accessible to population centers. They point out that the weakness of the travel cost method in this case is due to the difficulty of accurately defining travel costs, but their discussion does not go far enough. The weakness of the technique for analyzing short distance recreational travel is also due to the fact that, below some perceptual threshold, there may be little or no response to costs. Recreational locations such as county parks, state boating access sites or small state parks, many of which cater to day trip recreational demand, may fall into this category in which there is limited perception of money costs.

The empirical results of the present study provide only indirect information on the minimum average travel distance to which the travel cost method can be validly applied. In this study's recreational sample the average one way travel distance was 28.4 miles (standard deviation 31.3 miles) (Table 8). It may be that this average distance is below the lower limit for the valid application of the travel cost method since the expected relationship between money costs of travel and the level of recreational demand was not found. The conclusion by Bouwes and Schneider, also based on a survey of predominantly day trip recreationists, that time was likely a more significant determinant of demand than was money cost supports the hypothesis that the travel cost method is inappropriate in such a context.

Smith and Kopp argue that there is a maximum spatial limit of the travel cost method imposed by the assumptions of single purpose recreational trips and homogeneous travel mode and on-site time. They believe that as average recreational travel distance increases each of these assumptions is likely to be less tenable, thus imposing an outer limit to the average trip distance to which the travel cost technique can be applied. This maximum spatial limit would not apply in cases such as the present study where the information collected allow these assumptions to be relaxed. An expanded data set would not, however, allow the minimum spatial limit described here to be avoided. This minimum distance limit is imposed by characteristics of recreational decision making and not by the use of simplifying assumptions.

B. Benefit Size and Incidence

In assessing the incidence of benefits from soil conservation and determining an aggregate benefit figure which can be compared to the costs of soil conservation there are two important objectives. The first is to make a "reasonably comprehensive" assessment of benefits. As discussed in Chapter I the decision to include or exclude particular effects will have distributional and political consequences and the definition of benefits and costs is a matter of social choice. However, the systematic analysis of the effects of policies and programs should be seen as a means of supplying information for this social choice process and as such should deal with as many effects as possible.

A second objective is that benefits and costs should be assessed within a common geographical area. While more difficulty will be encountered in providing precise information for large areas such as states or nations, benefit approximations will likely be sufficient at that level. The choice of a suitable area in which to evaluate costs and benefits will be determined largely by the level at which decision making will take place.

There have been significant limitations in the present study which have prevented the attainment of these objectives. In order to keep the scope of the project under control, three potential off-site sediment impacts were selected for investigation. Thus, both on-site effects and many other potential off-site impacts have been ignored.[1] Among the latter such things as siltation of reservoirs and drainage ditches and aesthetic impacts other than those affecting recreationists engaged in

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[1]On-site effects have been treated in studies such as those by Seitz, et al., Narayanan, et al., Wade and Heady, and Swanson and MacCallum.

water based activity. Also omitted are option and other non-user benefits and indirect benefits. Thus, the analysis conducted here is a very partial treatment of off-site sediment consequences.

In selecting the geographical locations at which to investigate these impacts, the first criterion was the probability of detecting a relationship between sediment and some environmental service. Data availability and experimental design considerations were also taken into consideration. The result was that the selected study locations were scattered around the state of Michigan. In order to make the study results more comparable with one another an attempt was made to generalize them to a statewide basis.

1. Recreational benefits.

It is almost impossible to generalize the results of this study's recreational analysis to a statewide benefit estimate. It is impossible to know how much recreationists would be willing to pay for turbidity reduction at other locations and information on the level of turbidity at other recreational locations is scarce. The only conclusion which might be drawn regarding the recreational impact of sediment on a wider basis in Michigan comes from the lake survey which was made early in this project. It was mentioned in Chapter IV that this survey of a large number of recreational lakes in southwestern Michigan revealed only Thornapple Lake as having both a high sediment delivery rate and high recreational use. There are other recreational lakes with high turbidity in that region but no others were found where turbidity might be significantly affected by soil conservation. Thus, it appears that the potential recreational benefits of $15,600 per year from sediment delivery reduction at Thornapple Lake are greater than at any other lake in that part of the state. The size of potential benefits from sediment reduction on stream and river segments is unknown.

2. Water treatment benefits.

In the area of municipal water treatment the criteria for selecting the three plants which were used in the investigation were that turbidity in their raw water was periodically very high and that they did not soften their treated water. As described in Chapter VI, the upper limit on total benefits from a reduction in raw water turbidity at these plants was a sum of $40,000 per year for the three plants. It is likely that actual benefits from some feasible reduction in turbidity would be far below this figure and possibly zero, although no basis was found for making such an estimate. Furthermore, since turbidity levels at other Michigan municipal water treatment plants which withdraw from surface sources is lower than at the three which were selected (see Table 7) and since the total number of such plants is small, it is likely that total benefits from soil conservation would be small or negligible.

3. Dredging.

Chapter VI reported that dredging costs incurred by the Corps of Engineers in Michigan during 1979 was approximately $5 million. Of this approximately $4 million is likely attributable to river transported sediment. The estimation of disposal costs is much less accurate, but using a conservative figure of $5 per cubic yard, it appears that disposal costs attributable to river transported sediment were approximately $9 million in 1979 in Michigan, making a total of approximately $13.2 million for dredging and disposal for the maintenance of navigational channels. Assuming that approximately 34 percent of total sediment in Michigan is from cropland sources (Wade and Heady, p. 140), the maximum dredging and disposal cost saving per year at 1979 price levels would be approximately $4.5 million, though significantly less at feasible levels of agricultural soil conservation. Since these benefits accrue as cost savings and it can be assumed that the rate of sediment deposition does not affect the nature of the "product" (dredged channels), the result of reduced sedimentation would be smaller budget requirements by the Corps of Engineers. Finally, as mentioned in Chapter VI, no estimate is available of the potential benefits from disposal of dredged material in such a way as to restore or protect a shoreline wetland as is being done in some locations in Michigan.

With respect to the dredging of inland lakes, such projects appear to be very sporadic and the proportion of dredged material resulting from soil erosion appears to be very small. Potential benefits in this area from soil conservation are likely to be negligible.

In order to make an accurate assessment of the actual benefits from a statewide soil conservation program it would be necessary to be able to convert a geographical pattern of conservation practice adoption into a geographical pattern of sediment reduction. This might be done through the use of the Universal Soil Loss Equation and appropriate sediment delivery ratios for individual watersheds. It would also be necessary to convert sediment delivery rates into such units as Secchi disk inches and nephalometric turbidity units, used in measuring turbidity levels in recreational lakes and water treatment plants. The complexity of the physical and biological relationships discussed in Chapter III would make this a difficult step.

C. Policy Relevance

One of the significant results of the present study is that it provides guidance for future use of the travel cost and bidding game techniques. The extent to which, or the way in which, these procedures are to be employed in the future should be determined in light of both the technical and public choice issues which this study has raised.

Many of the technical issues relevant to the travel cost method have been discussed at length above. They include such things as the spatial limits within which the technique can be validly applied, the choice of a unit of measurement for the dependent variable, and the isolation of single environmental factors through experimental design and statistical control. There are also technical issues involved with the use of the bidding game method. These include the matter of "product" specification (communication to respondents of the nature of the good for which they are to offer a bid) and the likely tradeoff between strategic bias and response accuracy in terms of the hypothetical nature of the bidding game.

The technical issues which are involved with the travel cost and bidding game methods may directly limit the applicability of the procedure or they may introduce error into the results where assumptions which are used are not well founded. In some cases the collecting of additional information may allow these assumptions to be relaxed, but the acquisition of the information may be costly. Care must be taken in applying either of the travel cost or bidding game procedures. In some cases careful design and the collection of sufficient data may make a valid application possible. In other cases the limitations of the procedure must simply be recognized.

In addition to these technical matters, there are a number of public choice issues which must be kept in mind in determining future use of either of the techniques. One of these has to do with consumer information and the sensitivity of the bidding game to question wording. Another public choice issue is the definition of benefits or the procedure by which benefit estimates are to be derived from a demand curve. The approach which should be used in dealing with these public choice issues will have three parts. First, it is essential that the analyst recognize the issue as being a matter of public choice and not a technical question. Second, the public decision maker should be informed of the issue in some way. It may be possible to display alternate results corresponding to alternate answers to the issue involved. For example, if a single-price measure of benefits is to be employed, varying benefit estimates corresponding to varying price levels can be shown. Third, it might be possible in some cases to involve the public decision maker in the design of the procedures to be used. This would be necessary, for example, with respect to the issue of the level of consumer information where the decision must be made prior to data collection.

A number of the technical issues which this study has raised with respect to the travel cost and bidding game methods have been previously dealt with in the literature. Further investigation of these issues and of the public choice questions which have been mentioned here is required. For example, is there a dependable relationship between bid level, and thus estimated benefits, and the amount of information provided to the respondent? What are the minimum and maximum spatial limits of the travel cost technique? Additional investigation is required to extend, substantiate or ammend the conclusions which this study has drawn and the policy implications which have been stated. Suggestions for further research are made in the final section of this chapter.

Although the major focus of this study has been on the methodology of environmental benefit evaluation, the distributional conclusions which have been reached are also important. Such distributional information is relevant to the public decision making process in two ways. First, it can be used in program selection and design. With information on the size and pattern of benefits resulting from program alternatives, the decision maker can make an informed choice between program alternatives. In the case of water quality improvement, the choice might be between a soil conservation program which would deal with a cause of non-point source pollution and a downstream pollution management program (Sharp and Bromley). Information on the full effects of both alternatives would be very useful in making a selection between them.

A second function of distributional information is to facilitate decisions on cost sharing. The incidence of benefits from a public program provides one pattern for sharing program costs. It would be possible to argue that large off-site benefits from soil conservation should be accompanied by large public subsidies or even some type of fees levied on beneficiaries (such as was proposed in this study's bidding game). It would also be possible to select a cost sharing pattern that differed from the pattern of program benefits. Large off-site soil conservation benefits might be accompanied by low cost sharing and land use regulation if the decision was made to shift benefits away from farmers and land owners. Whatever the public choice, information on benefit size and incidence is a vital input in selecting the net effect of public programs.

A final policy implication of this study comes from the discussion of physical relationships in Chapter III. Because of the complexity of the processes of erosion and sediment transport and because of the number of potential sediment and turbidity sources, it is impossible to attribute off-site benefits to specific soil conservation programs in anything more than a very general manner. Even if this research had made a confident identification of large off-site benefits, the implications for agricultural soil conservation programs and related cost sharing would not have been clear. Further investigation of the physical processes is needed before downstream benefits from water quality improvement can be confidently linked to soil conservation activity in the upstream watershed.

D. Suggestions for Further Research

At many points throughout this study unanswered questions have been raised and limitations due to informational gaps have been acknowledged. These present opportunity for both further research into the methodological issues of benefit evaluation and for further investigation of the distributional consequences of soil conservation. These research opportunities will be summarized here under the headings of physical and economic questions. One of the means by which future research can be enhanced is to build on the experience gained in a research project such as this. Although a number of these methodological issues have been mentioned above, they will be restated here as suggestions for the design of future research of this nature.

1. Physical questions.

There is considerable imprecision in the current understanding of the relationship between soil conservation and downstream water quality. The use of empirical models such as the Universal Soil Loss Equation and sediment delivery ratios is possible, but these need much more refinement. This may be achieved through the incorporation of information on the mechanical processes of erosion and sediment transportation, topics which are currently under investigation.

Additional information is also required on the impacts of sediment on environmental services. It is impossible to investigate the economic consequences of a change in sediment concentration, for example, if it is not known how this will affect the turbidity of water, the survival of fish species or other casually perceptible features. Investigation of this topic would enable a comparison to be made between various units such as cubic yards of deposited sediment and Secchi disk turbidity measurement.

Third, the physical relationships and "production functions" having to do with municipal water treatment are not well understood. Incomplete information on the relationship between turbidity and both chemical treatment costs and sludge disposal requirements was an impediment in the present study. Similar questions may exist in other water using processes.

Finally, additional data is required on the physical characteristics of recreational locations. For example, there is little information on turbidity levels in Michigan lakes.

2. Economic questions.

One set of "economic" questions raised by this study has to do with the psychological basis of consumer demand. These questions are fundamental to the construction of demand models such as those used here. First, are people able to distinguish fine variations in water quality without additional information being supplied? If they are not, then the basis of measuring marginal valuation of environmental quality changes is placed in question. Second, do consumers perceive various costs differently and do they hold different attitudes toward them? Also, how is the magnitude of the costs related to perceptions and attitudes? In the case of recreational demand, the magnitude of travel costs is related to distance travelled and thus the type of recreation area being studied.

In addition to these fundamental psychological issues, there are a number of researchable questions relating specifically to the travel cost and bidding game techniques. There are also a number of suggestions for designing future research projects which may use the travel cost method or a bidding game in evaluating the recreational or aesthetic impacts of environmental change.

a. Travel cost. One of the very important issues in the use of the travel cost technique is the specification and form of the demand model. The specification and form which are chosen will usually have a decisive effect on the estimated coefficients which are used. Studies which use the travel cost technique should state as clearly as possible what the theoretical expectations were which formed the basis of the chosen form and specification and then state the findings with respect to these expectations.

Another important issue raised by this study is the possibility of a minimum average travel distance to which the travel cost technique can be validly applied. It may be that recreational travel which is predominantly day trips is not suitable for analysis by this technique. The results of the study by Bouwes and Schneider give some support to this suggestion, but further investigation is clearly needed.

Closely related to the selection of model specification and form is the choice of observational unit. This study has used the individual recreational party as the observational unit, though potential problems with respect to variable group composition and definition of visitation frequency were noted in Chapter II. Future studies would do well to experiment with alternate observational units, possibly comparing more than one in a single study (Boyet and Tolley, Wetzstein and McNeely).

Another aspect of the model specification issue is the treatment of travel time discussed at length above. A key factor in determining the approach which will be used in treating travel time is the correlation between time and money costs of recreation given different observational units. This correlation will not be known, however, until the data is collected and analyzed. It would seem to be appropriate, therefore, to collect data on a disaggregated observational unit so as to leave open several optional levels of aggregation for analysis.

Experimental design is another very important issue in the use of the travel cost technique. There appears to be no substitute for a thorough familiarity with the field setting for the research project. The objective is to be able to distinguish the effect of the environmental change in question from all other factors influencing recreational demand. Some combination of experimental and statistical control will likely prove to be most satisfactory. The potential problems of unavailable data, such as on recreational location characteristics, and the complexity of recreational demand patterns must be appreciated before embarking on a research project in this area. In the present case close to one-half the total time for the research was spent on this topic.

b. Bidding game. Several interesting and potentially important issues with respect to the use of bidding games have been raised in this study. Further investigation of each of these is needed. First, what is the responsiveness of bids to variations in the amount and type of information conveyed in the bidding game. This question does not appear to have been recognized or investigated in previous uses of the bidding game. A related issue has to do with the responsiveness of bids to various incentives to strategic behavior. Most of the evidence from previous studies suggests that strategic bias is not, in practice, a serious problem. Further investigation of the relative importance of strategic bias and of the divergence between equivalent and compensating variation measures of consumer surplus would also be useful (Bishop and Heberlein).

Attention must also be given in future use of bidding games to the trade-off between strategic bias and response accuracy. The perspective of costs and returns to accuracy, suggested by Freeman (1979), seems useful in designing questions which will encourage increased accuracy without encouraging bias. Techniques such as the development of rapport between interviewer and respondent may increase the incentive for accuracy without raising the incentive for strategic response. Similarly, questions should require a minimum of effort by respondents, thus lowering the cost of accuracy which the respondent faces. This may be accomplished by reducing the hypothetical nature of the bidding game, though there is a trade-off here with strategic incentives and the capability to deal with such matters as option demand.

Finally, a very important issue in the design of a bidding game question is the manner in which the "product" will be specified. As discussed in Chapter II, it is possible to use such techniques as photographs, proposed adjustments in subjective scales, or simply a broad and possibly imprecise description such as that used in the present study. The choice of a method for conveying such information will obviously depend on the nature of the product in question. Some products can be easily defined and communicated while others, which involve multiple perceptual dimensions (e.g., sight, odor, taste) will be difficult to convey. Not only is there a question of accuracy and experimental control here, but the issue of the level of consumer information is clearly present.

APPENDIX

CARD 1

Respondent no. 1-3 ____

Interviewer 4 ____

APPENDIX

________ Date 5-7 ____

________ Time 8-11 ____

________ Weather 12 ____

________ Location 13 ____

M.S.U. Dept. of Agricultural Economics

Sediment - Recreation Survey, 1980

Hello. My name is ______. I'm from Michigan State University and I'm conducting a survey on the topic of recreation and water quality. I wonder whether I could have a few minutes of your time? The information on this questionnaire will be completely confidential. I won't even be asking for your name, address or phone number.

1. Where is your home? 14-16 ____

   State ____________

   County ____________

   City or village ____________

   (If outside city or village boundries) Township ____________

2. How far is this lake from your home? ________ miles 17-20 ____

3. How long does it take you to drive here? ________ hours 21 ____

   ________ minutes 22-23 ____

4. How many times did you come here in 1979? ________

5. How many times do you expect to come during 1980? ________ 24-26 ____

6. Reason for difference ____________

7. About how many times a month do you go fishing, swimming, boating or some other water based recreation? How many times would that make in a year? 27-29 ____

   ____

8. Do you own property on a lake or river? ___1)Yes ___2)No 30 ____

9. Did you leave home just to visit this lake, or did you have some other purpose as well? This lake as % of reason 31-33 ____

   ____

10. About how many miles per gallon does your vehicle get? ________ mpg 34-36 ____

    ___1)Reg ___2)Unlead 37 ____

11. About how much does it cost you to operate your boat when you're here? 38-41 ____

    $________

12. What entrance fee did you pay? ___1)Daily car ___2)Daily car-boat Type | 42 ___
___3)Seas. car ___4)Seas. car-boat

___5)Other ___________ $_________ | 43-46 ___

13. Are there other expenses when you come here? (Food,lodging,bait,etc)
$_________ | 47-50 ___

14. Main type of recreation today ___1)Fish ___2)Swim ___3)W,Ski ___4)Sail | 51-52 ___
___5)Other boat ___6)Other_____________

15. What other locations do you go to for this kind of recreation?

_____________________________ _____ Which of these do you | 53-55 ___
_____________________________ _____ feel are just as good | 56-58 ___
_____________________________ _____ for this kind of rec. | 59-61 ___
_____________________________ _____ as this lake? (Check) | 62-64 ___
_____________________________ _____ | 65-67 ___

NOT AT THORNAPPLE

16. Have you ever been to Thornapple Lake? ___1)Yes ___2)No | 68 ___

17. What was the main reason for coming here today rather than Thornapple?

___1)Variety ___2)Distance ___3)Fishing success ___4)Water app'nce | 69 ___
___5)Related facilities ___6)Other reason for being in this area | 70 ___
___7)Other ________________________________

18. Was the difference in the appearance of the water a major reason for
coming here? ___1)Yes ___2)No | 71 ___

19. How important is the appearance of the water in your choice of a lake for
recreation? ___1)Not important ___2)Somewhat imp ___3)Very imp. | 72 ___

20. On a scale of 1 to 10 (1=very poor, 10=very good) how would you rate water
quality at this lake? _________ | 73 ___

CARD 2

R.N. 1-3 ____

THORNAPPLE ONLY

21. Why did you decide to come to Thornapple today rather than one of these others?
___1)Variety ___2)Distance ___3)Fishing success ___4)Water app'nce 4 ____
___5)Related facilities ___6)Other reason for being in this area 5 ____
___7)Other ________________

22. How important is the appearance of the water in your choice of a lake for recreation? ___1)Not important ___2)Somewhat imp ___3)Very imp 6 ____

23. On a scale of 1 to 10 (1=very poor, 10=very good) how would you rate the water quality at this lake? ________ 7-8 ____

24. What do you think are the reasons for the water looking like it does here? (Why doesn't it look clearer?) ___1)Sediment ___2)River, other or unsp. 9 ____
___3)Boats ___4)Sewage or sep. tanks ___5)Don't know 10 ____
___6)Other ________________ 11 ____

According to the experts there is a fairly large amount of eroded soil which comes into this lake through the Thornapple River and Mud Creek, particularly following a heavy rain. Most of this sediment comes from farms upstream. It can make the water in the lake look muddy, and any fertilizer which comes with it can increase the growth of algae in the lake, also making it look cloudy.

I'd like to describe an imaginary situation to you now. Let's imagine that the State government decides to clean up the lake by encouraging better soil conservation upstream and to share the cost of this soil conservation with the farmers involved. They decide to raise the money for this by [charging a daily entrance fee for this access site] [charging an additional daily entrance fee for this park]. Let's assume that the water really is cleaned up and that everyone who uses the lake pays the same amount.

How much would you be willing to pay before you refused to use this lake? 12-15 ____

$________

26. What is your present age? ________ years		16-17	____
27. Sex (please check) ____ 1) Male		18	____
____ 2) Female			
28. How many people (Besides yourself) came with you today?			
Number over 16 years old ________		19-20	____
Number 16 or younger ________		21-22	____
29. Do you all live in the same household? ___1)Yes ___2)No		23	____
30. In which category is <u>your</u> personal income (before taxes)?			
$ Per Year (please check)	Pers.	24	____
0 - $5,000 1) ____	Hous.	25	____
$5,001 - $10,000 2) ____			
$10,001 - $15,000 3) ____			
$15,001 - $20,000 4) ____			
$20,001 - $25,000 5) ____			
$25,001 - $30,000 6) ____			
$30,001 - $40,000 7) ____			
$40,001 and over 8) ____			

31. If there is another income earner in your household, please check total household income also.

THANK YOU

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