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The direct and indirect estimation of recreational benefits for Reelfoot Lake

Scott N. Ralston

To the Graduate Council:

I am submitting herewith a dissertation written by Scott N. Ralston entitled "The direct and indirect estimation of recreational benefits for Reelfoot Lake." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

William M. Park, Major Professor

We have read this dissertation and recommend its acceptance:

Roland Roberts, Ray Huffaker, Alan Schlottmann

Accepted for the Council:

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Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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THE DIRECT AND INDIRECT ESTIMATION OF RECREATIONAL BENEFITS FOR REELFOOT LAKE

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Scott Norman Ralston

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ABSTRACT

The sedimentation and nonpoint source pollution of Reelfoot Lake has been a problem of major concern for Tennessee and federal agencies for the last decade. In fact, an application for a Rural Clean Water Program grant (RCWP) was submitted to the Soil Conservation Service, United States Department of Agriculture in July, 1979. The major objective of the RCWP was to effectively manage erosion and improve the water quality of Reelfoot Lake. To effectively manage such a resource, policymakers must have reliable estimates of the value of that resource. However, values for such a resource are not directly observable in the marketplace.

The primary objective of this study was to use the travel cost method, a nonmarket valuation technique, to generate estimates of the value of the recreational experience for visitors to Reelfoot Lake. A maximum likelihood estimation procedure was used to generate a demand function for recreation and, subsequently, consumer surplus estimates. Results from the model indicate that travel cost, travel time, income and education are significant predictors of visitation at Reelfoot Lake. A variable was also included to capture the effect substitute sites have on visitation at Reelfoot Lake. This variable was not statistically significant.

A secondary objective of this study was to use the contingent valuation method, another nonmarket valuation technique, to estimate the economic value of recreational experiences at Reelfoot Lake. A tobit

procedure for a censored sample was used to estimate the contingent valuation model. The significant variables in this model were annual number of visits and income. Variables reflecting substitute sites and education were not statistically significant.

Finally, an illustration of how the consumer surplus estimates from the travel cost model could be used was suggested. This illustration involved comparison of the recreational benefits potentially lost due to soil erosion with the costs for erosion control in the drainage area surrounding the lake.

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CHAPTER I

INTRODUCTION

The farm export boom of the 1970s sparked a new concern about soil erosion and an increase in research in this area. This research confirmed that soil erosion was indeed a growing problem and that levels of erosion were rising. More recently the topic of soil erosion has been at the forefront of the agricultural policy agenda as evidenced by the incorporation of the Conservation Reserve Program into the 1985 Food and Security Act. In fact, numerous studies have attempted to quantify the costs of both the on site and off site impacts of increased erosion (Clarke, Haverkamp and Chapman, 1985; Ribaudo, 1986; Crosson, 1986; Putman and Dyke, 1986).

On-site costs associated with the loss of soil productivity are naturally of concern to the farmer, though society may have a longer term interest. Off-site costs, including loss of recreational values, loss of lake and reservoir capacity and increased navigation costs for example, may be of little concern to the farmer and thus represent external costs borne by others in society. This study will focus on the off-site costs of soil erosion for Reelfoot Lake in West Tennessee. Specifically, this study will examine the potential loss of recreational opportunities due to the sedimentation of Reelfoot Lake.

Statement of the Problem

The sedimentation and agricultural nonpoint source pollution of the Reelfoot Lake drainage area has been a problem of major concern for local residents, state and federal agencies for many years, but particularly since the mid 1970s. In fact, an application for a Rural Clean Water Program (RCWP) grant was submitted to the Soil Conservation Service, United States Department of Agriculture, in July, 1979. The major objectives of the RCWP proposal were to reduce erosion and improve water quality of the Reelfoot Lake drainage area.

The majority of the Reelfoot Lake drainage area is located in northwestern Tennessee with about 25 percent located in southwestern Kentucky. The total drainage area is 153,600 acres, of which 115,600 are located in Tennessee and 38,000 are located in Kentucky. Reelfoot Lake is the only large natural lake in Tennessee and is fed primarily by Indian and Reelfoot creeks in Obion County. (The detailed information in the above and subsequent paragraphs concerning erosion rates, size of drainage area, etc., for Reelfoot Lake is taken from the 1984 Annual Progress Report on the Reelfoot Lake Clean Water Program Project.)

The Reelfoot Lake drainage area can be divided into upland and bottomland areas. Approximately 48 percent of the total area is classified as upland and 52 percent as bottomland. The major problem in the drainage area has been the high erosion rate on upland caused in large part by the intensive row crop production on highly erosive soils. Gross erosion from all upland acres is estimated to be 1.4 million tons annually. Cropland contributes 68 percent or 917 tons to the upland erosion problem. The remaining erosion comes from grassland, forestland, urban and idle land. It has been estimated that approximately 60 percent, or 850,000 tons, of the total erosion from the drainage area enters the lake each year.

Some of the bottomland that is cropped also has the potential to contribute sediment to Reelfoot Lake. Seedbed preparation begins at the first opportunity after harvest in the fall or early winter. This practice leaves the soil disturbed and unprotected for most of the rainy season. After being disturbed by periods of rainfall some soil particles may go into suspension for long periods of time. If the rainfall is sufficient to cause runoff, then the particles are carried along with the water and add to the sedimentation of the lake.

Sedimentation is found in many sections of the lake. Many recreational areas have been rendered useless because docking facilities have been blocked by sedimentation in a year's time. An associated problem with sedimentation is the uncontrolled growth and encroachment of aquatic vegetation. The excessive vegetation also has the effect of hindering access to boat docks and some parts of the lake.

The Tennessee Division of Water Quality Control believes the most serious consequence of the agricultural pollution problem is the accumulation of pesticides in the aquatic environment of the lake. Agricultural runoff may contain quantities of herbicides and insecticides that, due to the process of bioaccumulation, could pose a serious threat even in low concentrations. Aquatic organisms accumulate pesticides, thus increasing their concentrations. As other organisms eat the poisoned organisms, more concentration occurs. Therefore, a high concentration may develop in higher organisms as a result of initial low levels of herbicides and insecticides. The process of bioaccumulation poses a severe threat to Reelfoot Lake because the area serves as a major winter habitat of bald and golden eagles and the osprey. These endangered species depend on potentially contaminated fish as their major source of food. Water quality tests have indicated moderately high pesticide levels in fish flesh and sediment samples. There have also been suspected pesticide caused fish kills at the lake.

A major consequence of sedimentation from soil erosion is the loss of recreational opportunities at Reelfoot Lake. The lake is considered to be a recreational resource of regional significance. There is a state park, a national wildlife refuge and a state wildlife area associated with the lake. Estimates from the Tennessee Department of Conservation indicate that visits for sport fishing, water fowl hunting, wildlife observation and general recreation use were over half a million for the entire 1979-1984 period.

Sedimentation from soil erosion can indirectly affect the quality of the recreational experience because of the potential damage to fish and other wildlife associated with accumulated pesticides in the aquatic environment. Direct impacts of sedimentation and associated excessive aquatic vegetation on recreational opportunities include limiting boat access to some areas of the lake, land locking certain docking facilities and reduced access to swimming facilities.

To effectively manage a resource such as Reelfoot Lake and to decide how much cost is justified in reducing erosion and agricultural nonpoint source pollution through efforts like the RCWP program, it is necessary to have estimates of the recreational value of the lake. Since no market exists with which to value the recreational experience, nonmarket valuation techniques must be employed. This study will use the travel cost and the contingent valuation methods to estimate the value of the recreational experience for visitors to Reelfoot Lake, and thus the potential cost of continued sedimentation and chemical pollution.

Objectives

The objectives of this study were:

1. To use the travel cost method, a nonmarket valuation technique, to generate estimates of the value of the recreational experience for visitors to Reelfoot Lake.
2. To use the contingent valuation method, a nonmarket valuation technique, to generate estimates of the value of the recreational experience for visitors to Reelfoot Lake.
3. To explore the potential use of these estimates for assisting policymakers in the management and protection of Reelfoot Lake.

Content of the Study

This study is divided into six sections. A review of literature on the travel cost method and the contingent valuation method is provided in Chapter II. The generation of the first-stage and the second-stage demand curves for the travel cost method is discussed. Also included in this section is a discussion of the potential biases in estimates from the use of the contingent valuation method. A review of demand theory and consumer surplus is presented in Chapter III. Included in this section is a discussion of both Hicksian and Marshallian demand. Also reviewed are compensating and equivalent variation measures of consumer surplus. The specification and data requirements for both the travel cost model and the contingent valuation model are provided in Chapter IV. This chapter also contains a discussion of the survey used in this study. The results of the empirical analysis are presented in Chapter V. Finally, a summary and the conclusions of this study are presented in Chapter VI.

CHAPTER II

REVIEW OF LITERATURE

Nonmarket valuation techniques have been used to value environmental amenities since the early 1960s. Several different types of nonmarket valuation methods have been employed for various purposes. A good general discussion of the variety of methods available is provided by Alan Randall in Resource Economics, 1987, published by John Wiley and Son. The most widely used and accepted methods for valuing recreational benefits are the travel cost method and the contingent valuation method. Included in this review of the literature will be discussions of the methodology and the applicability of both of these methods, as well as several empirical issues which remain unresolved to one degree or another.

The Travel Cost Method

It is widely accepted that outdoor recreational amenities have value. However, estimates of that value are not readily available because outdoor recreation resource prices are not directly observable in the marketplace. The travel cost method, originally suggested by Hotelling (1949) and formalized by Clawson (1959), can be used to generate estimates of recreational value based on observed consumer behavior.

A lack of variation in user fees prevents the direct estimation of a demand schedule for a particular site. However, if consumers react to higher travel and use costs in the same manner as they would react to higher site fees, then a demand schedule can be estimated indirectly based on data for trip expenditures (Dwyer, Kelly and Bowes, 1979).

The travel cost method is used to estimate a trip generating equation, where visits to a recreational facility are dependent, among other things, on the total cost of using the facility. The principle costs of using the facility are travel costs and other expenditures incurred during the visit. The estimated trip generating equation is then used in conjunction with hypothetical increases in the direct cost of using the site to simulate a demand curve for the recreational resource. The area under this simulated demand curve represents an estimate of the value of consumer surplus, a concept to be discussed in a subsequent section, for a specific site. One of the key assumptions of the Clawson Method is that people react to an increase in travel costs and trip expenditures in the same manner as they would to an increase in use fees. This, of course, is a very strong and restrictive assumption.

The general form of the travel cost method can be described by the following expression. This expression is derived from work by Mansfield (1969, 1971) and Smith (1971) and is a modification of the Clawson Method (1959).

$$V_{ij} = f(C_{ij}, S_{ij}, Y_i, R_i \ldots)$$

$$C_{ij} = g(D_i, T_i, A \ldots)$$

Where:

V_{ij} = the number of visits from origin i to destination j;

C_{ij} = travel cost, which is a function of time, distance, admission charge, etc.;

S_i = the availability of substitute sites for visitors from origin i;

Y_i = socioeconomic variables representative of origin i;

D_i = distance from the ith origin;

T_i = travel time from the ith origin; and

A = admission charge.

The travel cost model is developed from data on site use (j) and user characteristics from origin (i). The wide variation in costs for different individuals at different distances from a site can provide information about the effect cost has on recreational participation. This data can then be used to derive the trip generating equation which is, in turn, used to develop the demand curve for the site.

The travel cost method is used to generate estimates of the economic value for a particular site by a two-stage process. In the first stage, a trip demand schedule is generated that expresses the number of visits an individual will make to a specific site as a function of travel cost and other variables. These variables include travel time, income, availability of substitute sites and population. This equation then predicts an average visit rate for an individual facing specific costs to a site. This is known as a first-stage demand curve and is illustrated in Figure II-1. To facilitate exposition of the concept of a first-stage demand curve, the relationship has been simplified, and visits per capita are a function of travel cost alone. The first-stage demand curve could be expressed by an equation such as the following:

$$V_{ij} = 10 - C_{ij}$$

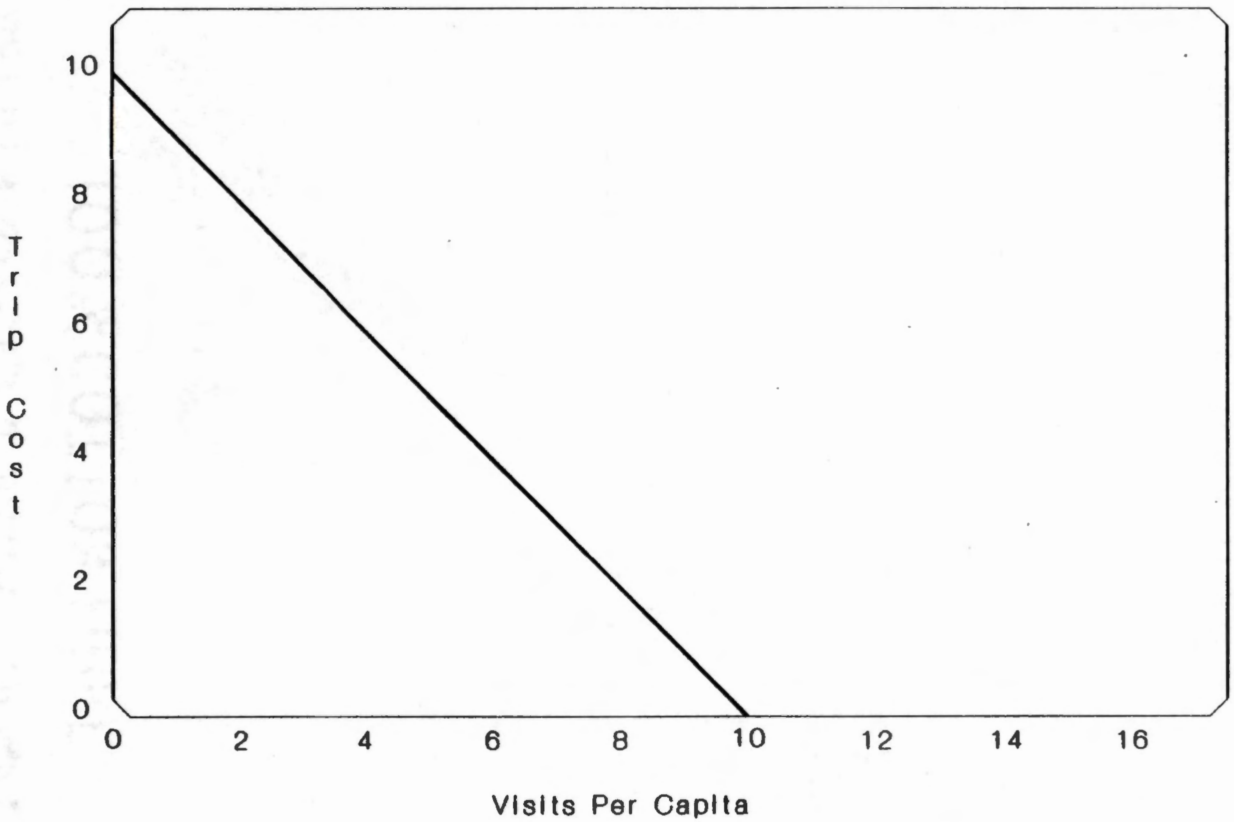

Figure II-1. Graphical Example of a First Stage Demand Curve.

Where:

V_{ij} = visits per capita from origin i to site j; and

C_{ij} = the travel cost from origin i to site j.

The second stage of the process involves the derivation of an aggregate demand curve. This curve predicts how many total visits will be made to a particular site at various levels of a hypothetical use fee. This curve is developed under the critical assumption that individuals will react to an increase in travel costs in the same manner as they would to an increase in entrance fees. The second-stage demand curve is derived as follows. Using the first-stage demand curve and increasing the travel cost (C_{ij}) for individuals at each origin, a new per capita visitation rate is found. The visitation rate is an average and reflects average behavior at each origin.

Essentially, the derivation of the second-stage demand curve involves adding the hypothetical entry fee to the actual trip cost and then solving for V_{ij} using the trip demand function $V_{ij} = f(C_{ij})$. Various points on the aggregate demand curve, which reflect total use at each level of hypothetical use fee, are derived by multiplying the population at each origin by the appropriate predicted per capita visitation rate. This process yields total predicted visits from each origin at a specific fee level. These numbers are then summed over all origins to get an estimate of total use at a particular fee level. This is one point on the second-stage demand curve. This process is repeated for all hypothetical fee levels (i.e., up to the point where per capita visits are equal to zero for all origins) and generates the necessary points to derive a second-stage demand curve. The area under the aggregate demand curve is an estimate of the net willingness of users to pay for a site.

The travel cost method is most applicable when: 1) there is sufficient variation in travel costs among users to allow estimation of demand, 2) the travel expenses have been made mainly for the purpose of recreation at the resource which is to be evaluated, and 3) the travel is made for the single purpose of visiting the site which is to be valued. The travel cost method may be difficult to apply when: 1) visitors come from a very small geographic region, thus, lacking sufficient variation in travel costs to allow for demand estimation, 2) if visitation to a site is just one of many parts of a total recreational experience, and 3) if travel expenditures are not incurred for the sole purpose of visiting a particular site. The travel cost method is strongly recommended where applicable because this method recognizes the spatial characteristics of a recreational market (Dwyer, Kelly and Bowes 1979). Also, this method derives benefits based on the actual market behavior of individuals.

Empirical Issues

The above discussion on the methodology and application of the travel cost model was simplified to give the reader a clearer understanding of the basic ideas and theory underlying the travel cost method. Of course, in such a simplified discussion many problems with this method are overlooked, avoided or ignored. The following section addresses these problems. This section will focus on empirical issues related to the Travel Cost Method. These issues include: 1) measurement of variables, 2) functional form, 3) inclusion of travel time, 4) substitute sites, and 5) multiple trip destination bias.

Measurement of the quantity variable. The appropriate measurement of the quantity variable (V_{ij}) is a problem that has several proposed solutions. There are two methods to specify the quantity variable in a travel cost study. These are: the zonal method and the individual method. The zonal or aggregate method suggested by Clawson (1959) and Clawson and Knetsch (1966) groups individuals living similar distances from a site into zones. These zones can be classified by county, region, zip code or other method as deemed appropriate by the researcher. The quantity variable for the zonal method is visits per capita per time period from origin i to site j (V_{ij}). A per capita specification accounts for differences in population size from various zones around a site. This adjustment captures the effect of population density on site usage. Therefore, the reduced rate of participation at higher travel costs is accounted for. One critical assumption of the zonal method is that demographic variables such as taste, preferences, income and education are similar within distance zones. The use of aggregate data leads to coefficient estimates that reflect average behavior. Consequently, one of the major disadvantages of the zonal method is the loss of information and efficiency that results from aggregating data. The coefficients generated from aggregate data are not as precise as those generated from individual observations. Therefore, some useful information on demand shifters such as income, tastes and preferences and substitutes is lost to the researcher.

A principle statistical problem associated with per capita specification is heteroskedasticity. This problem arises when the units of aggregation are of extremely different size. This is quite likely to happen since population in various zones can range from a few thousand to millions. One suggested remedy for heteroskedasticity is to transform the equation by the appropriate form of the variable responsible for the problem (Kmenta, 1986). This could involve dividing all observations by the square root of population (Bowes and Loomis, 1980). This type of weighting will reduce heteroskedasticity in travel cost models and therefore improve use and benefit estimates. Another suggested remedy for heteroskedasticity involves the choice of appropriate functional form (Strong, 1983; Vaughan and Russell, 1982). Both studies demonstrate that if the natural log of visits per capita is chosen as the functional form of the equation then heteroskedasticity will not be a significant problem.

Another statistical problem associated with the zonal method is multicollinearity. This problem arises because aggregating site users by similar distances creates a high correlation between travel cost and travel time. A suggested solution to this problem is to use individual observations rather than aggregate observations for the travel cost data.

The use of individual observations will reduce the problem of multicollinearity and increase the precision of the estimators (Ward and Loomis, 1986). This method, developed in the early 1970s, defines quantity consumed as the number of trips taken per year or season by each site user or household. This dependent variable is then regressed on travel time, travel cost and socioeconomic characteristics. Because this method uses unique observations for each site user, the amount of information about demand shifters and the price variable is greatly increased, and the correlation between travel cost and travel time is greatly reduced.

One potential problem with the individual observation approach is that a typical recreationist may only take one trip per year. Therefore, it is often difficult to estimate an individual travel cost model because many observations are equal to one (Freeman, 1979). This lack of variation in the dependent variable causes the estimation of a demand curve to be quite problematic.

A second problem associated with the individual observation method is the overestimation of consumer surplus for a site. The individual observation approach models current users' demand for a particular site but will underestimate how aggregate visitation would increase if a closer similar site were added because potential site users have been excluded (Ward and Loomis, 1986). In other words, this method does not account for the probability of participation at a site decreasing as distance to the site increases. This leads to biased estimators of the travel cost coefficients and, therefore, incorrect consumer surplus estimates. One suggested remedy for this problem is to transform the individual observations to a per capita basis (Brown, et al., 1983).

Measurement of the price variable. The specification of the price variable is another problem confronting the researcher. Knetsch (1963) argues that travel costs should include things such as transportation, plus lodging and food costs above those an individual would normally incur. Pearse (1968) argued that variable costs such as food and lodging are dependent on the length of stay and not on the cost of reaching a site and, therefore, should not be included in the price variable. More recently, research by McConnell (1975) and Mendelsohn and Brown (1983) has indicated that quantity demanded of a particular site will depend on the marginal cost of obtaining that site. Therefore, food and lodging expenses should not be regarded as components of the travel cost variable because they do not effect the marginal cost of obtaining a site. Ward and Loomis (1986) conclude that, in general, the variable costs of transportation should be the only costs included in the price variable.

Selection of functional form. Historically, linear models have been used as the functional form for travel cost studies. However, quadratic models, semilog models and log-log models have also been considered. Ziemer, Musser and Hill (1980) have demonstrated that different functional forms can produce significantly different estimates of consumer surplus. In their case study on warm water fishing in Georgia, they demonstrate that the consumer surplus derived from a linear travel cost model is approximately three times as great as that of a semilog model and about four times as great as a quadratic model. Strong (1983) demonstrated that in a zonal model with unequal populations a semilog form is an appropriate alternative to the linear form. Although no rules exist for the selection of the functional form of the model, the above studies indicate that appropriate consideration must be given to the selection of functional form. Care must also be taken in the selection of estimation techniques. Most recently, research has determined that the use of ordinary regression techniques on truncated samples will lead to biased coefficient estimates (Judge, et al., 1980; Maddala, 1983; Smith and Desvousges, 1985). This is because ordinary regression methods require that the dependent variable take on a full range of values while recreation demand behavior is only defined for nonnegative values. Thus, the use of maximum likelihood estimators is recommended for truncated samples to avoid biased coefficients and, therefore, incorrect estimates of consumer surplus (Kealy and Bishop, 1986).

Inclusion of travel time. Knetsch (1963) was one of the first researchers to recognize the importance of travel time costs in the recreational decision. He argued that the omission of travel time costs will lead to underestimation of the value of a recreational resource. The bias in the demand curve arises because people from various zones are faced with the dual constraints of time and money. Groups farther away from a site will face increased time as well as money costs and both of these variables affect the decision to use a recreational resource. In other words, as distance increases from a site, so will required travel time. This time has value (opportunity cost) and must be included in the model to correctly represent the consumers' decision-making process. Therefore, if only travel cost is varied in the generation of a second stage demand curve, only one decision factor is altered and the result will be an underestimation of a resource value. Similar conclusions have been reached by Cesario (1976), Gum and Martin (1975) and McConnel (1975).

Additionally, Wilman (1980) suggested the inclusion of on-site time costs for the correct specification of the model. However, Knetsch and Cesario (1976) contend that if the dependent variable is the number of trips to a site, then on-site time costs should not be included in travel costs since the length of stay does not effect the marginal cost of obtaining a site.

Two problems arise with the inclusion of travel time in the model. They are the statistical problem of multicollinearity that results due to the high correlation between travel costs and travel time and the problem of determining the appropriate value of time for the model. One method to mitigate the problem of multicollinearity is to combine travel time and travel cost into a single variable (Cesario and Knetsch, 1970). Brown and Nawas (1973) and Gum and Martin (1975) argue that the aggregation of time and cost will reduce the multicollinearity. The simplest approach to value time is to choose a fraction of an hourly wage rate. The Water Resources Council suggests the selection of one-third as the appropriate fraction of the wage rate at which to value the opportunity cost of time. McConnell and Strand (1981) propose a methodology by which the researcher can empirically measure the opportunity cost of time from observations on an individuals behavior. They indicate that this rate can be objectively determined from the sample data and can vary from study to study. Recent work by Smith, Desvousges and McGiveny (1983) has attempted to more accurately value the opportunity cost of travel time by the incorporation of worker characteristics into a hedonic wage model. Bockstael, Strand and Hanemann (1987) have developed a model where the inclusion of travel time is conditional on the recreationist's labor market situation. Although there is a lack of unanimity on the correct method by which to value travel time, it is clear that this variable must be included in a travel cost study.

Substitute site variable. Basic economic theory specifies quantity demanded as a function of price, the price of substitutes and other variables. Therefore, any demand estimation that ignores substitute sites would be incorrectly specified and lead to biased coefficient estimates. If substitute sites exist for a recreational resource and are not included in the demand model, the direction of the bias cannot be determined (Caulkins, Bishop and Bowes, 1985).

Research by Burt and Brewer (1971) and Cicchetti, Fisher and Smith (1976) has led to the specification of a system of demand equations to address the issue of substitute sites. In the systems context all sites are classified into types and a demand curve is estimated for each type. The price of own and cross effects are included in each equation. Consequently, when a new site is created or an old site closed, this is treated as a price change to recreationists in the consumption of that particular type of site. If a single equation model is specified for a travel cost study, then substitutes can be included in the model by the use of a "substitute" variable (Knetsch, 1963; Cesario and Knetsch, 1976). This variable can be an index value (Cesario and Knetsch, 1976) or can be a price variable such as the travel cost to the nearest similar site (Huang, 1986). The effect of substitute sites will be discussed in greater detail in a subsequent chapter.

Multiple destination bias. One of the key assumptions of the travel cost method is that all travel costs are incurred exclusively to visit the site under study. If this assumption holds, then travel costs can be considered an appropriate proxy for price. However, if travel costs are incurred to visit multiple destinations, then the travel costs may not be an appropriate price variable, since travel costs are shared jointly by many sites. The bias from multiple destinations will lead to an overestimation of benefits for a particular recreational resource.

One proposed solution to the multiple destination bias problem is to delete observations for which multiple destinations are present. However, if the majority of recreationists are obtaining multiple sites, then this method obviously fails. Haspel and Johnson (1982) suggest the use of itinerary data to mitigate the effects of multiple destination bias. This method uses the average distance between major destinations on the same trip as an estimate of travel cost for each site. The estimated benefits from this type of model were found to be more consistent with those estimated from a direct survey (i.e., contingent valuation study) than the traditional travel cost study. Unfortunately, there is no theoretical basis for disaggregating travel costs for multiple destination trips. Therefore, any attempt to do so could be considered arbitrary. Clearly, this is one area of the travel cost methodology where further theoretical work is needed.

The Contingent Valuation Method

The contingent valuation method is a survey technique best described by Randall, et al. (1983), as follows:

> Contingent valuation devices involve asking individuals, in survey, or experimental settings, to reveal their personal valuations of increments (or decrements) in unpriced goods in contingent markets. These markets define the good or amenity of interest, the status quo level of provision and the offered increment or decrement therein, the institutional structure under which the good is to be provided, the method of payment, and (implicitly or explicitly) the decision rule which determines whether to implement the offered program. Contingent markets are highly structured to confront respondents with a well-defined situation and to elicit a circumstantial choice contingent upon the occurrence of the posited situation. Contingent markets elicit contingent choices.

The contingent valuation method can, therefore, be defined as a set of techniques and hypothetical institutions that can be used to elicit values for a nonmarket good. A correctly designed contingent valuation survey must have the following three components:

1. A comprehensive description of the good being valued and the situation under which this good would be available to the consumer must be provided.
2. Questions that elicit a respondent's willingness to pay for the good being valued must be developed. The most common form of these questions are bidding games and the open-ended question approach. In a bidding game, a recreationist is asked if he would be willing to pay a prespecified price for unlimited access to the resource being valued. A positive answer leads the interviewer to increase the price while a negative response leads him to decrease the price. This

process continues until a recreationist's maximum willingness to pay has been determined. In the open-ended question approach, a respondent is asked the maximum he is willing to pay for access. Therefore, he is allowed to determine a monetary amount based on his own judgement. Willingness to pay questions provide a theoretically correct measure of benefits associated with a new or existing site. However, for the evaluation of benefits lost from the elimination of existing resources (e.g., waterfowl hunting opportunities lost when wetlands are drained), it may be more appropriate to measure the lost benefits in terms of users' willingness to sell their existing rights to a resource (Dwyer, Kelly and Bowes). Therefore, the appropriate type of question to ask in a contingent valuation survey will depend on the site under study and the existing set of property rights at that site.

3. Questions are needed to determine the socioeconomic characteristics of the visitors to the site.

The survey information collected from the above questions is used to develop an equation which can be used to predict any other users' valuation of a particular site or a new site or benefits lost from the elimination of an existing site. Basically, the survey information is used to generate a regression equation of the following form:

$$WTP = f(V, Y, M, S, D)$$

Where:

WTP = willingness-to-pay for a recreational resource;

V = number and length of visit to a site;

Y = years of experience with a site;

M = miles traveled to a site;

S = availability of substitute sites; and

D = socioeconomic variables

Total recreational benefits are derived by summing individuals' willingness to pay over the appropriate population. Essentially, the contingent valuation method is a technique to measure equivalent surplus or compensating surplus (alternative measures of consumer surplus which will be discussed in a subsequent chapter). The derivation of willingness to pay is based on two key assumptions. The first is that consumers can assign an accurate value to a recreational experience. The second is that this value can be elicited from them with a properly constructed series of questions (Dwyer, Kelly and Bowes, 1977).

Biases in the Contingent Valuation Model

Four types of potential biases in contingent valuation measures can be identified. They are starting point bias, vehicle bias, information bias and strategic bias.

Starting point bias can be defined as a bias resulting from the starting point of the bidding procedure. Two sources of starting point bias can be identified. First, the initial bid may imply (incorrectly) the appropriate range of bids for valuing an environmental good. Therefore, the individual may give different values for a good based on the initial bid suggested to him. Second, if a person becomes bored or annoyed with a long bidding game he may state a value closer to the starting bid than his actual willingness to pay. This results because the respondent is unwilling to go through the lengthy process of reaching his maximum willingness to pay.

Vehicle bias is related to the proposed hypothetical payment method in the bidding game. These payment methods could include tax payments, entrance fees, utility bills or higher prices for goods and services. An example of this type of bias is that someone who objects to higher taxes might understate his willingness to pay due to his feelings about the tax system. A great number of empirical studies (Randall, et al, 1978a, 1978b; Brookshire, Randall and Stoll, 1980; Brookshire, d'Arge, Schulze and Thayer, 1981; and Cronin and Horzeg, 1982) support the vehicle bias hypothesis. However, the literature is unclear on how to mitigate this bias.

Information bias is due to a lack of information provided to the respondent concerning the hypothetical market in which he is asked to value an environmental good. If an individual does not clearly understand the good he is bidding on he cannot accurately state his maximum willingness to pay. A suggested solution to this problem is the correct and complete specification of the survey instrument (Randall, Ives and Eastman, 1974).

Strategic bias in the contingent valuation method results from respondents trying to influence the outcome of a study by incorrectly stating a maximum willingness to pay. A classic example of strategic bias is when a respondent understates his willingness to pay in order to avoid a use fee sometime in the future. Cummings, Brookshire and Schulze (1986) state that if a person bids zero on the grounds that he has the inherent right to the environmental good, the bid is not an indicator of his true valuation. Consequently, an effort should be made to distinguish protest bids from true zeros so that the protest bids may be dropped from the sample. A suggested way to help correct the problem of strategic bias is to carefully design the survey instrument and to pretest the questions to see if they stimulate protest behavior.

Applicability of the Contingent Valuation Method

The contingent valuation method is recommended in situations that involve: 1) small changes in quality at existing sites which would not affect the travel cost of a visit or the number of trips taken to a particular site, 2) estimating the value of a site that is one of many destinations on a trip, and 3) studying the effects of congestion on a particular site (Dwyer, Kelly and Bowes, 1977).

Comparison of Empirical Travel Cost and Contingent Valuation Studies

Five major studies have been completed that compare benefit estimates that are derived from the travel cost methodology and the contingent valuation methodology. These studies are: Knetsch and Davis (1965), Bishop and Heberlein (1979), Thayer (1981), Desvousges, Smith and Mcgiviney (1983) and Seller, Stoll and Chavas (1983).

Knetsch and Davis (1965), Bishop and Heberlein (1979) and Thayer (1981) compared travel cost model results with those of contingent valuation models on a purely qualitative basis. None of the comparisons were subjected to any statistical analysis. Knetsch and Davis (1965) concluded that the travel cost and contingent valuation measures were "close," while Bishop and Heberlein (1979) reported measures that were "not close." Finally, Thayer (1981) concluded that the benefit estimates from his travel cost and contingent valuation models were "similar" in nature.

Desvousges, Smith and McGiveny (1983) subjected their travel cost and contingent valuation model results to both nonstatistical and statistical comparison. The nonstatistical comparison of sample means indicated that the difference in the estimates was quite large. Their statistical test supported the conclusion reached by the nonstatistical test. Seller, Stoll and Chavas (1983) also employed a statistical test to compare estimates from a travel cost model and a contingent valuation model. They concluded that the mean values for the two nonmarket methods were not significantly different.

Conclusion

Both nonmarket valuation methods, the travel cost method and the contingent valuation method, have gained wide acceptance since their inception. Advances in research continue to validate these methods as useful in valuing environmental amenities. However, there are problems with both methods, as have been discussed in this chapter. The researcher should apply these methods with a clear understanding of their limitations. The appropriate technique to use will depend upon many things, such as data limitations, available funding and study objectives.

CHAPTER III

DEMAND FUNCTIONS AND CONSUMER SURPLUS

The literature reviewed in the previous chapter indicates that although the travel cost method and the contingent valuation method do have certain weaknesses, they are empirically sound techniques for measuring the value of environmental amenities. This section will focus on the measurement of recreational benefits as it relates to the economic theory underlying the travel cost method. The concept of consumer surplus is discussed, and a proof of the validity of Marshallian consumer surplus as a valid welfare measure is included. In general, the purpose of the travel cost model is to develop demand equations to allow estimation of consumer surplus for a particular site. To better understand the estimates derived from a travel cost model, a concise definition and a complete understanding of consumer surplus is necessary.

Consumer surplus is a measure of benefits or welfare changes resulting from a change in prices or quantities. It can be defined as the difference between a buyer's willingness to pay and the market price. This amount is represented by the area under the Marshallian demand curve and bounded by the price line. This quantity is referred to as the Marshallian measure of consumer surplus.

Hicks also identified two principle measures of consumer surplus, compensating variation and equivalent variation, which can be defined as follows:

1. Compensating Variation--How much compensation must a consumer receive at price p_1 (higher price) so that he will be as well off as he was at price p_0 (lower price)? This assumes that he may purchase any quantity of the good at the new price.
2. Equivalent Variation--How much income must be taken away from a consumer at the new price p_0 (lower price) so that he is no better off than he was at price p_1 (higher price)? This assumes that he may purchase any quantity of the good at the old price.

Variation measures are specifically related to Hicksian demand curves, which are different from Marshallian demand curves. Hicksian demand curves can be said to represent a consumer's response to a change in the price of a particular commodity while the individual remains at a specific level of utility. A Marshallian demand curve, however, represents the consumer's response to a change in the price of a commodity while he remains at a given level of income. The fundamental difference between the two types of demand curves is that Hicks holds the consumer's level of utility constant during a price change while Marshal does not. Therefore, these curves will yield different measures of consumer surplus.

In computing actual values for the above measures of consumer surplus, it is assumed that a utility function exists that characterizes an individual's tastes and preferences for a set of goods. Given a budget constraint, the utility function implies the existence of demand functions for the set of goods. Subsequently, to fully understand the calculation of Hicksian or Marshallian consumer surplus it is necessary to derive both types of demand functions and then discuss the relationship between them. Also, it is necessary to indicate how changes in welfare can be calculated from these demand functions.

Derivation of Marshallian and Hicksian Demand Functions

Assumptions about consumer behavior are represented by a utility function. This utility function measures the level of satisfaction an individual receives from consuming a particular bundle of goods. The amount of goods an individual may consume is limited by his income or budget constraint. The problem facing the consumer is to maximize his satisfaction subject to his limited income. A formal mathematical statement of this problem is as follows (Johnson, Hassan and Green, 1984):

Maximize $u(X)$

Subject to: $P'X = m$

Where:

$X = (x_1, x_2, \ldots, x_n)$ is a vector of commodities;

$P' = (p_1, p_2, \ldots, p_n)$ represents a column vector of corresponding commodity prices; and

m = the consumers money income.

Maximization of the utility function subject to the budget constraint is done with the Lagrangian method. This yields the following expression:

$$L(X, \lambda) = u(X) - \lambda(P'X - m)$$

Differentiating the Lagrangian function with respect to x_i and λ yields the following first order conditions:

$$u_x - \lambda p = 0 \quad P'X - m = 0$$

Where:

u_x = a vector of derivatives of the utility function with respect to the quantities x_i (i= 1, 2, ...n); and

λ = the Lagrangian multiplier interpreted as the marginal utility of income.

The second order conditions for a maximum can be written as follows:

U = the relevant Hession matrix must be negative definite

Where:

$$U = \begin{bmatrix} u_{11} & u_{12} & \cdots & u_{1n} \\ u_{21} & \cdots & \cdots & u_{2n} \\ \vdots & & & \vdots \\ u_{n1} & \cdots & \cdots & u_{nn} \end{bmatrix}$$

u_{ij} = the second partial derivative of the utility function; if U is negative definite, then all principle minors will alternate in sign beginning with negative

The solution to the utility maximization problem yields n Marshallian demand functions and a function that represents the marginal utility of money. These can be written as follows:

$x_i^* = x_i^* (P,m) \quad i = 1, 2,\ldots n$

$\lambda = (P,m)$

Where:

x_i^* = the utility maximizing amount of each commodity as a function of prices and income; and

λ = the marginal utility of money.

The demand function x_i^* is important because it describes how the consumer will react to different sets of prices and a specific income. The term λ represents the marginal utility of income. Alternatively stated, λ denotes the consumer's reaction to increments in income.

Properties of the consumer demand function can be obtained from manipulating the first order conditions for utility maximization. Specifically, these restrictions, or properties, are derived by examining the results of parametric shifts in the first order conditions with respect to prices and income. These restrictions on the demand functions are described by the partial derivatives of the first order conditions for prices and income. The properties of the demand function are as follows:[1]

1. Homogeneity Condition--The Marshallian demand functions must be homogeneous of degree zero in prices and income. Alternatively stated, if all prices and income change by the same proportion, the quantity demanded is unaffected. This result is significant because it states that consumption decisions are made in response to relative prices and income. A mathematical statement of the homogeneity condition is:

$$\left[\frac{\partial x_i}{\partial p_j} + \left(\frac{\partial x_i}{\partial m} \right) x_j = \frac{\partial x_j}{\partial p_i} \left(\frac{\partial x_j}{\partial m} \right) x_i \right]$$

[1] See Johnson, Hassan and Green (1984), pp. 26-27.

2. Engle Aggregation--This condition implies that the demand function must be such that the sum of all expenditures on all goods must equal total income. Put simply, the consumer must spend all of his money to maximize utility. This condition can be expressed in the following way:

$$\left[\sum_{i=1}^{n} \frac{\partial p_i \; x_i}{\partial m} = 1 \right]$$

3. Cornot Aggregation--This condition implies that the price of one good affects the quantity purchased of all goods. This restriction indicates that a consumer must be on the budget constraint to maximize utility. Stated formally this condition is:

$$\left[\sum_{i=1}^{n} p_i \left(\frac{\partial x_i}{\partial p_j} \right) - x_j \right]$$

4. The Symmetry Condition--This implies the Slutsky matrix (to be discussed in a subsequent section) is symmetric and negative semidefinite. Formally stated this restriction is:

$$\left[\frac{\partial x_i}{\partial p_j} + \left(\frac{\partial x_i}{\partial m} \right) x_j = \frac{\partial x_j}{\partial p_i} \left(\frac{\partial x_i}{\partial m} \right) x_i \right]$$

Substituting x*(P,m) into the direct utility function U(x) yields the indirect utility function u(x*(P,m)) = v(P,m). The indirect utility function indicates that utility is a function of the optimal bundle of goods which in turn is a function of prices and money income. This function indicates the maximum level of utility a consumer can reach given a set of prices and income. The indirect utility function will exhibit the following properties.[2]

1. v(P,m) is continuous at all P > 0, m > 0.
2. v(P,m) is nonincreasing in P; that is, if P' > P, v(P',m) $\leq$ v(P,m) similarly, v(P,m) is nondecreasing in m.
3. v(P,m) is quasiconvex in P; that is, {P:v(P,m) $\leq$ k is a convex set for all real numbers k.
4. v(P,m) is homogeneous of degree zero in (P,m).

These properties are useful for relating the Marshallian and Hicksian demand functions and the derivation of the Slutsky equation.

The utility maximization problem of the consumer can be viewed in a different way. If the consumer must minimize expenditures subject to a given level of utility, the solution to this problem will yield Hicksian demand functions. The optimization problem can be formally stated as follows:

Minimize P'X

Subject To U(X) = u'

Where:

P' = a column vector of prices (p_1, p_2, ... , p_n);

X = a vector of commodities (x_1, x_2 ..., x_n); and

u' = a fixed level of utility.

---

[2]See Varian (1978), pp. 89-90.

Solving the above cost minimization problem yields n Hicksian demand functions.

$$x_i^h = x_i^h(P,u') \quad i = (1, 2, \ldots n)$$

$$\mu = \mu(P,u')$$

Just as the Marshallian demand function satisfies certain conditions, so do the Hicksian demand functions. These are: 1) the homogeneity condition and 2) the Slutsky matrix will be negative semidefinite. The second condition implies that all compensated own-price elasticities will be ≤ 0. This leads to the distinguishing property of Hicksian demand functions that they must always have a negative slope.

A cost function can be constructed through the minimization problem stated above. A Lagrangian function can be used to complete the minimization problem.

$$L' = P'X - \delta(u' - u\,(X))$$

Differentiating L' with respect to X and δ will yield a set of first order conditions that can be solved for the cost function.

$$c(P,u')$$

Compensated demand functions can be derived from the cost function with the use of Shepard's Lemma. The cost function will demonstrate certain properties. These are:[3]

1. Nondecreasing in prices;
2. Homogeneous of degree one in prices;
3. Concave in prices; and

[3]Ibid., pp. 91-92.

4. If H(P,u) is the expenditure minimizing bundle necessary to achieve utility level u' at prices P then $h_i(P,u) = \frac{\partial c(P_i ul)}{\partial p_i}$ for i,...,n assuming the derivative is defined and P > 0.

There are several important identities that relate the cost function, the indirect utility function, the Hicksian demand function and the Marshallian demand function. These properties are as follows:

1. $c(P_1 v(P_1 m)) \equiv m$. The minimal expenditure to reach utility $v(P_1 m)$ is m;
2. $v(P_1 c(P_1 u)) \equiv u$. The maximal utility from income $c(P_1 u)$ is u;
3. $h_i(P_1 u) \equiv x_i(P_1 c(P_1 u))$. The Hicksian demand at utility u is the same as the Marshallian demand at income $c(P_1 u)$; and
4. $x_1(P_1 m) \equiv h_i(P_1 v(P_1 m))$. The Marshallian demand at income m is the same as the Hicksian demand at utility $v(P_1 m)$.

The above discussion was intended to provide a brief but clear summary of demand theory and the properties of demand functions. Also, the relationship between Hicksian and Marshallian demand was described with the use of the four identities above. To further illustrate the relation between the two types of demand and the difference in the measure of consumer surplus a discussion of the Slutsky equation is essential.

The Slutsky Equation

The Slutsky equation is an equation that decomposes the demand change induced by a price change into two separate effects: the substitution effect and the income effect. Property 3 above leads to the Slutsky equation:[4]

$$h_j(P_1u) \equiv x_j(P_1c(P_1u^*))$$

Differentiating the above identity with respect to p_i yields

$$\frac{\partial h_j(P_1^*u^*)}{\partial p_i} = \frac{\partial x_j(P_1^*m^*)}{\partial p_i} + \frac{\partial x_i(P_1^*m^*)}{\partial m} \cdot \frac{\partial c(P_1^*u^*)}{\partial p_i}$$

when evaluated at P^*; however,

$$\frac{\partial c(P_1^*u^*)}{\partial p_i}$$

is equal to x_i^*. Therefore, after rearranging terms:

$$\frac{\partial x_i(P_1^*m^*)}{\partial p_i} = \frac{\partial h_j(P_1^*u^*)}{\partial p_i} - \frac{\partial x_i(P_1^*m^*)}{\partial m} x_i^*$$

Which is the Slutsky equation. Rewriting the above equation yields the following:

$$\underbrace{\Delta x_j = \frac{\partial x_j(P_1m)}{\partial p_1} \Delta p_i}_{\text{Change in Demand}} = \underbrace{\frac{\partial h_j(P_1u)}{\partial p_i}}_{\text{Substitution Effect}} - \underbrace{\frac{\partial x_j(P_1m)}{\partial m} x_i \Delta p_1}_{\text{Income Effect}}$$

The term

$$\frac{\partial x_j(P_1m)}{\partial p_i}$$

is the slope of the Marshallian or ordinary demand curve. The term

$$\frac{\partial h_j(P_1u)}{\partial p_i}$$

[4]Ibid., pp. 95-96.

is the slope of the Hicksian or compensated demand curve. Therefore, the Hicksian demand curve will always have a steeper slope than the Marshallian demand curve. In fact, the Hicksian demand curve must always have a negative slope while, under certain circumstances, the Marshallian demand curve may slope upwards. Since Marshallian demand includes both the substitution effect and the income effect and Hicksian demand includes only the substitution effect, the measure of consumer surplus derived from each demand curve will be different unless the income effect of a price change is equal to zero.

Consumer Surplus Measures

If the price of a commodity such as a recreational experience changes, the welfare of the consumer is affected. One convenient way to measure this welfare change is through the use of consumer surplus. The idea of consumer surplus can best be illustrated with the use of the demand curves developed in the above section.

To determine the welfare gains from a change in price from p_0 to p_1 in Figure III-1, it is necessary to ask the question: How much would the consumer be willing to pay to move from p_0 to p_1?" This amount can be decomposed into two parts. The first part is the amount the consumer is willing to pay as a result of direct savings on total expenditures for the good at the original amount x_0; this is equal to $(p_0 - p_1)x_0$. The second part is the additional amount of the good the consumer can purchase at the new lower price. The question then is how much this extra consumption is worth? The total amount the consumer is willing to pay for the extra consumption is:

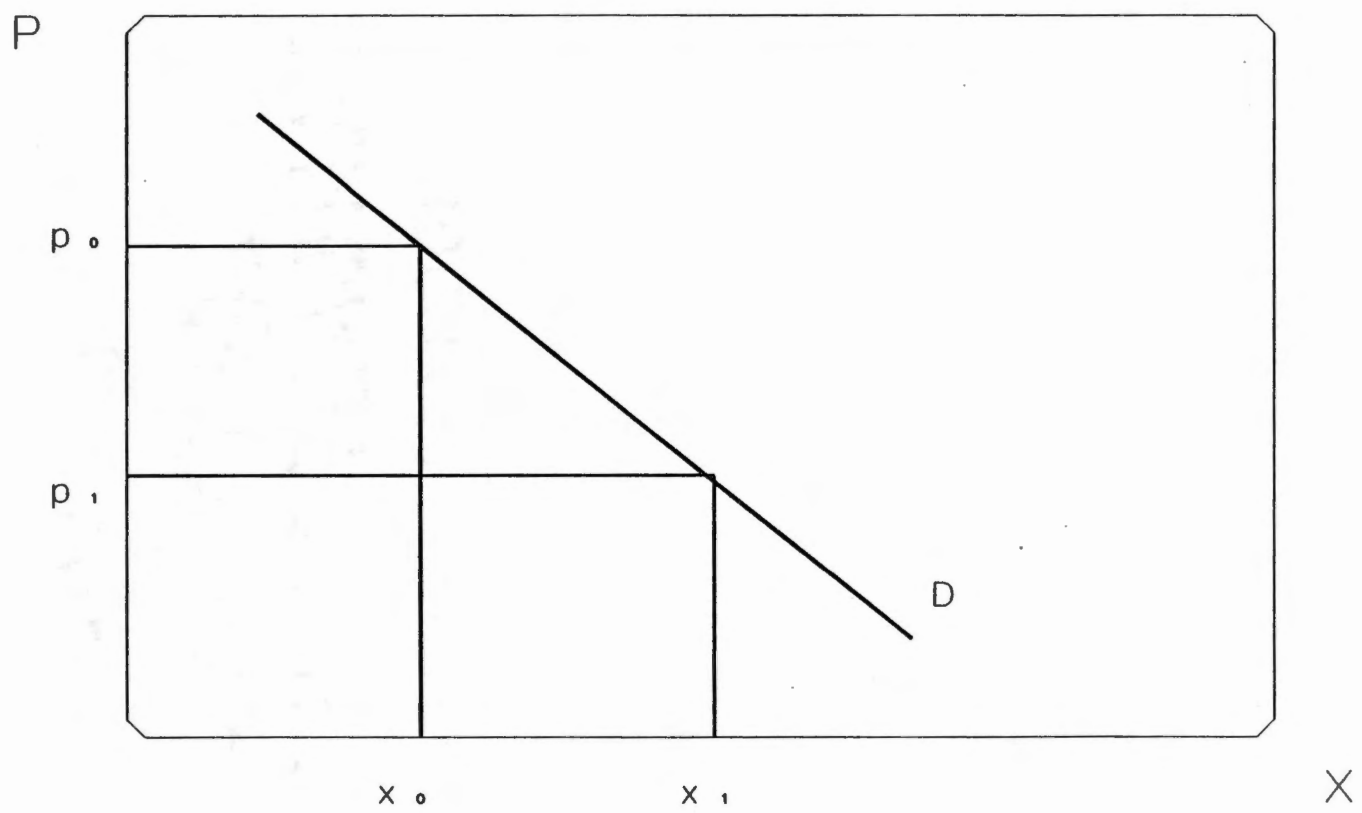

Figure III-1. Graphical Example of Consumer Surplus with Marshallian Demand.

$$\int_{x_0}^{x_1} p(x)dx$$

The amount the consumer must actually pay for the extra consumption is:

$$p_1(x_1 - x_0)$$

Therefore, the net gain from the extra consumption is what he is willing to pay minus what he must pay. More formally stated:

$$\int_{x_0}^{x_1} p(x)dx - p_1(x_1 - x_0)$$

Adding the amount he is willing to pay at x_0, $(p_0 - p_1)x_0$, to the net gain from the price change yields total Marshallian surplus which can be defined as the single integral.[5]

$$MCS = \int_{p_1}^{p_0} x(p_1, p_2, \ldots p_n)dp$$

This integral simply defines the area under the Marshallian demand curve bounded by the price lines.

Compensating and equivalent variation can similarly be expressed as the area under the Hicksian demand curve and bounded by the price lines. The integral which defines compensating variation is:[6]

$$CV = \int_{p_1}^{p_0} x(p_1, p_2, \ldots p_n, u'(p_1, p_2, \ldots, p_n | p_1, p_2, \ldots p_n, m))dp_1$$

The integral which defines equivalent variation is:[7]

$$EV = \int_{p_1}^{p_0} x(p_1, p_2, \ldots p_n, u''(p_1, p_2, \ldots, p_n | p_1, p_2, \ldots p_n, m))dp_1$$

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[5]Ibid., pp. 207-209.

[6]See Willig (1976), p. 592.

[7]Ibid., p. 592.

These formulae express the compensating and equivalent variation as areas under demand curves, between old and new price horizontals. The demand curves are not Marshallian in that income parameters are not constant. Instead, they are Hicksian compensated demand curves because the income parameters include compensation which varies with the price to keep the consumer at a constant level of utility. The only distinction between CV and EV is the level of utility the compensation is designed to reach.[8] All three measures are graphically illustrated in Figure III-2.

Referring to Figure III-2, the three measures of consumer surplus can be represented for an increase in price from p_1 to p_0. The area p_0p_1ea (M), p_0p_1eb (C) and p_0p_1fa (E) are, respectively, the Marshallian measure, the compensating variation and the equivalent variation.

Unfortunately, Hicksian demand curves are unobservable and, therefore, it is impossible to calculate measures of compensating and equivalent variation. However, Willig (1976) demonstrates that the observed Marshallian measure can be utilized to estimate the unobservable compensating and equivalent variation measures which he contends are the theoretically correct measures of the welfare impact of a price or income change.[9]

The Slutsky equation indicates that the Hicksian demand curve must always be steeper than the Marshallian demand curve. This information helps to establish boundaries on Marshallian consumer surplus.

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[8] Ibid., p. 592.

[9] Ibid., p. 592.

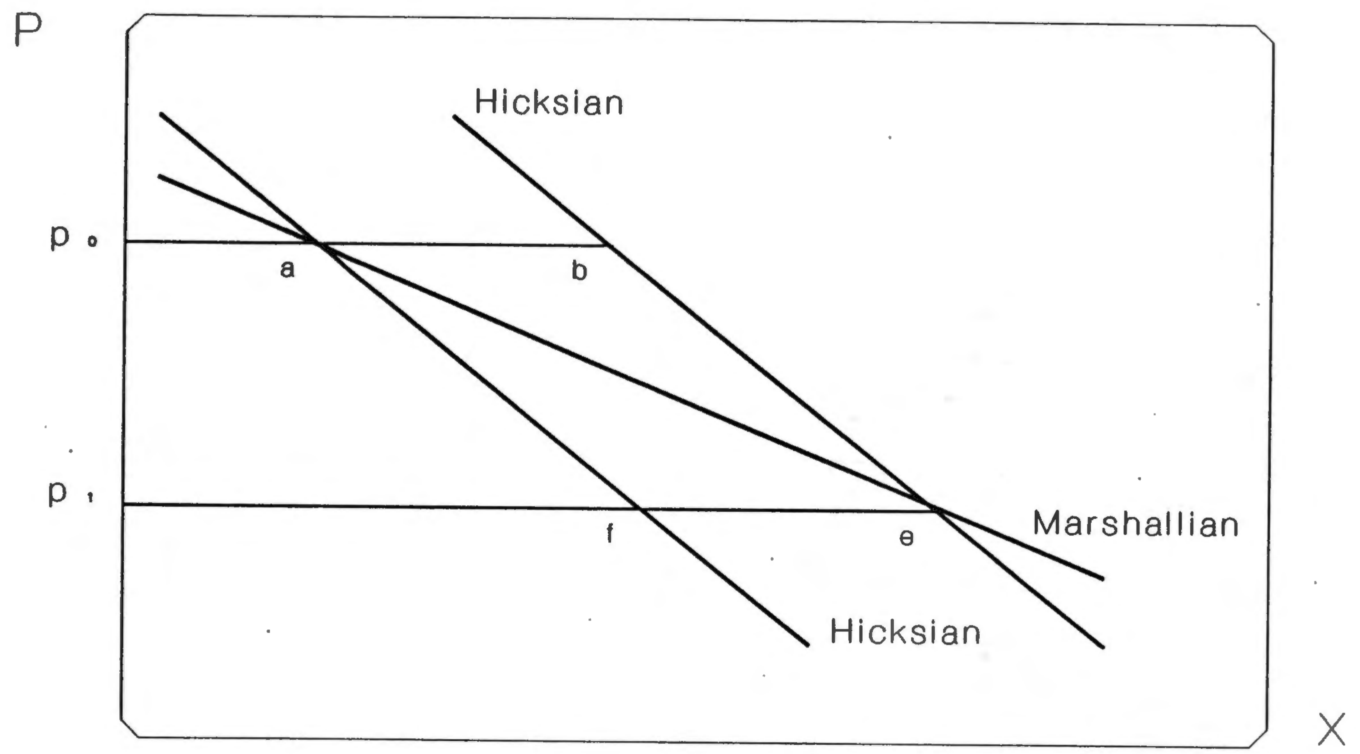

Figure III-2. **Graphical Example of the Marshallian Measure of Consumer Surplus and the Hicksian Measures of Compensating and Equivalent Variation.**

Inspection of Figure III-2 indicates that the relationship $E \leq M \leq C$, holds. This says that the equivalent variation will be less than the Marshallian measure which in turn will be less than the compensating measure. This relationship may have useful implications for public policy decisions. Willig (1976) states that if a cost benefit study indicates that the cost of the project outweighs the area under the Marshallian demand curve, then the cost must certainly be greater than the compensating variation. This information can be of some usefulness, but a more precise relation between Marshallian measures and variation measures would be ideal. Such a relationship has been proposed by Willig (1976). He specifies two situations under which equivalent and compensating variation measures can be estimated from Marshallian surplus measures. These situations are where income elasticity of demand measures are held constant and where they are allowed to vary.

When income elasticity of demand is held constant, the formula to convert a Marshallian measure to a compensating or equivalent measure is:[10]

$$C \approx M + \frac{\eta M^2}{2m}, \quad E \approx M - \frac{\eta M^2}{2m^0}$$

$$\frac{C - M}{M} \approx \frac{\eta M}{2m^0} \text{ and } \frac{M - E}{M} \approx \frac{\eta M}{2m^0}$$

Where:

M = Marshallian consumer's surplus area under the demand curve and between the two prices (positive for a price increase and negative for a price decrease);

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[10]Ibid., p. 593.

C = compensating variation corresponding to the price change;

E = equivalent variation corresponding to the price change;

m^0 = consumers base income; and

η = the values of the income elasticity of demand in the region under consideration.

When income elasticity of demand is allowed to vary, Willig[11] (1976) provides us with a formula to estimate compensating and equivalent variation from the observable Marshallian measure. Willig concludes that in the limit, as the smallest and largest values of income elasticity converge the variable elasticity formula reduces to the constant elasticity formula. Perhaps the most useful result of Willig's seminal work in the area of consumer surplus is a formula that places observable bounds on the percentage errors of approximating compensating and equivalent measures from Marshallian measures. These formulas are:[12]

$$\frac{\underline{\eta}|M|}{2m^0} \leq \frac{C - M}{|M|} < \frac{\overline{\eta}|M|}{2m^0}$$

$$\frac{\underline{\eta}|M|}{2m^0} \leq \frac{M - E}{|M|} < \frac{\overline{\eta}|M|}{2m^0}$$

Where:

$\underline{\eta}$ and $\overline{\eta}$ are, respectively, the smallest and largest values of income elasticity.

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[11]See Willig (1976) for a complete discussion of estimation when income elasticity is allowed to vary.

[12]Ibid., pp. 589-590.

These bounds can be calculated from observable demand data and Willig contends that in most empirical studies the errors of approximation will be very small. Moreover, the error will most likely be small compared to the errors involved in estimating the demand function. The conclusions reached by Willig in no way depend on the marginal utility of money being constant. Therefore, this work allows the researcher to use the concept of consumer surplus without the usual apologies that accompany surplus measures. Finally, the most significant result of this work implies that Marshallian surplus is usually a very good approximation of the appropriate compensating and equivalent variation measures.

Benefit Measures from the Travel Cost Method

Generally, as stated before, the travel cost method is used to estimate the recreational benefits of an existing site or to measure the potential benefits of a proposed site. In applying the travel cost method, recreation is assumed to be a normal (noninferior) good, and the travel cost to and from the site is used as a proxy for price. The previous assumption implies that the travel cost model is based on a utility maximizing problem for the consumer. In other words, the consumer must maximize utility from a bundle of consumption goods, a set of prices and a fixed income. Included in the consumption bundle as one of the goods is recreation. Similarly, one of the prices in the set that the consumer faces is the cost of recreation which is represented by the travel cost to and from the site.

Since the travel cost method is based on a utility maximizing problem, any welfare measures derived from the model will be Marshallian measures of consumer surplus. The aggregate demand curve developed in Chapter II is illustrated in Figure III-3. The area under the curve and bounded by the price lines represents an estimate of the economic benefits generated from a particular site. This area is represented by the integral:

$$\int_{tc'}^{tc''} v(tc)dtc$$

Where:

tc' = travel cost reported in the survey; and

tc" = is the hypothetical use fee where aggregate visits are equal to zero.

This is a Marshallian measure of consumer's surplus and, as was discussed earlier, will be very close to the theoretically correct welfare measures of compensating and equivalent variation.

Benefit Measures from the Contingent Valuation Method

The benefit measure that will be derived from the contingent valuation model in this study will be a compensating variation measure. This is because the initial level of utility for the consumer is the reference point from which a change in welfare is measured. Alternatively stated, the consumer is asked to bid on a one year pass to Reelfoot Lake, and at the time the bid is solicited the consumer is already able to use the site. Therefore, the initial level of utility is the reference level and the consumer is treated as if he is willing

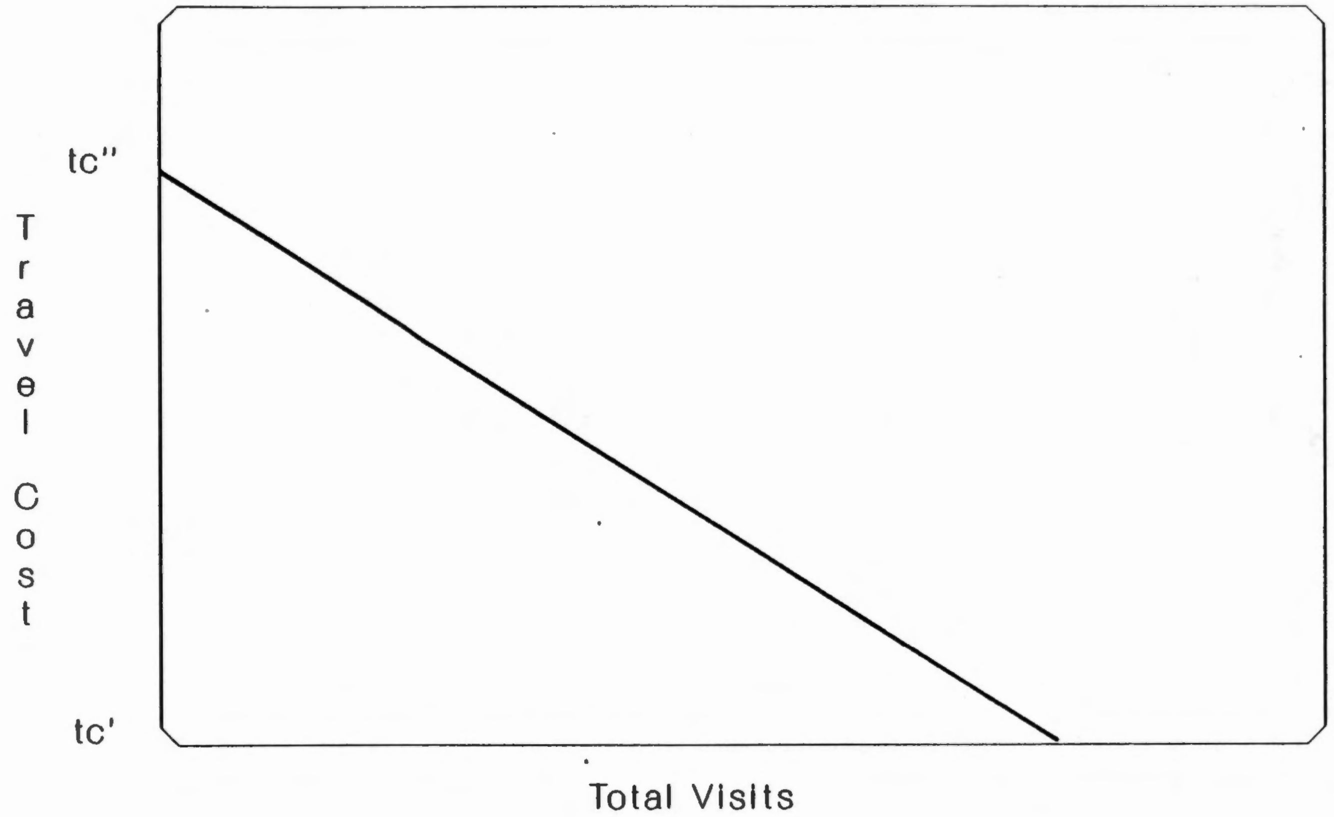

Figure III-3. Graphical Example of an Aggregate Demand Curve.

to accept a less preferred situation or is willing to pay to move to a more preferred situation. Conversely, had the consumer initially been denied access to Reelfoot Lake and was asked to bid on a entrance pass, the consumer surplus measure would be the equivalent variation. This is true because the subsequent level of welfare would be used as the reference point from which the consumer makes his decision.

CHAPTER IV

METHODOLOGY

The specific models used in this study are discussed in this section. Two models are presented: first, a travel cost model and, second, a simple form of a contingent valuation model. The procedure used and the data required to estimate each model are presented. Also presented in this section is the survey from which the data for this study were taken. Finally, the methodology used to calculate a total household value curve and an aggregate total value curve for the contingent valuation model is explained.

Travel Cost Model Specification

One of the principle objectives of this study was to generate estimates of the value of the recreational experience for visitors to Reelfoot Lake. This objective was accomplished with a travel cost model. In general form the travel cost model can be described by the following expression, derived from work by Mansfield (1969, 1971) and Smith (1971) and is a modification of the Clawson method (1958).

$$V_{ij} = f(C_{ij} \quad P_{ij} \quad Y_i \quad R_i \ldots) \qquad \text{IV-1}$$

$$C_{ij} = g(D_i \quad T_i \quad A \ldots) \qquad \text{IV-2}$$

Where:

V_{ij} = number of visits from origin i to destination j;

C_{ij} = trip cost, which is a function of time, distance, admission charge, etc.;

P_i = the population at the ith origin;

Y_i = socioeconomic variables, representative of origin i;

R_i = some index of alternative sites available to visitors from origin i;

D_i = distance from the ith origin;

T_i = travel time from the ith origin; and

A = admission charge.

Specifically, the demand for recreation at Reelfoot Lake can be specified as follows:

$$LnV_{ij} = B_0 + B_1WQ_1 + B_2WQ_2 + B_3WQ_3 + B_4WQ_4 + B_5D_{ij} + B_6T_{ij} + B_7Y_i + B_8S_i + B_9F_i + \varepsilon \qquad \text{IV-3}$$

Where:

LnV_{ij} = the natural log of annual average visits per capita to Reelfoot Lake from origin i;

WQ_1 = proportion of visitors indicating that water quality was not perceived as a problem at Reelfoot Lake;

WQ_2 = proportion of visitors indicating that water quality was perceived as a slight problem at Reelfoot Lake;

WQ_3 = proportion of visitors indicating that water quality was perceived as a moderate problem at Reelfoot Lake;

WQ_4 = proportion of visitors indicating that water quality was perceived as a serious problem at Reelfoot Lake; the fifth WQ variable which characterized water quality perceptions as very serious was deleted to avoid perfect collinearity in the model;

D_{ij} = distance traveled to Reelfoot from origin i;

T_{ij} = travel time to Reelfoot from origin i;

Y_i = average income from origin i;

S_i = a measure of substitute sites available for visitors from origin i;

F_i = average years of education at origin i; and

ε = error term.

Due to the problem of multicollinearity between D_{ij} and T_{ij}, it was necessary to establish a time money trade-off so the two variables could be combined. The model was thus rewritten as follows:

$$LnV_{ij} = B_0 + B_1WQ_1 + B_2WQ_2 + B_3WQ_3 + B_4WQ_4 + B_5C_{ij} + B_6Y_i + B_7S_i + B_8F_i + \varepsilon \qquad \text{IV-4}$$

Where:

$$C_{ij} = (tc + tt*k)$$

Where:

tc = round-trip travel cost, i.e., the distance traveled times the appropriate cost per mile;

tt = round-trip travel time; and

k = the opportunity cost of time; and all other variables are defined as before.

Although the zonal approach results in a loss of information about certain parameters and demand shifters, this method was considered superior to the individual observation approach for two reasons. First, the individual observation approach can lead to great difficulty in demand estimation since often the average number of trips an individual makes in a year is one. This lack of variation in the dependent variable can present serious problems in the estimation procedure.

The second difficulty with the individual observation approach is that this method does not account for the proportion of nonparticipation increasing as distance from a site increases. This can lead to a serious overestimation of consumer surplus (Brown, et al., 1983). One proposed remedy (Brown, et al., 1983) to the overestimation of consumer surplus from the individual observation approach is to adjust the observations to a per capita basis. However, even if adjusted to a per capita basis the measurement error of travel costs, for studies where individuals are asked to recall trip mileage and travel expenses a month or more after the trip, would be serious enough to mitigate any efficiency gains from individual observations. Brown, et al. (1983), suggest a single equation travel cost model with a low level of aggregation will yield good results with only a small loss of efficiency. The data for this model were collected at least one month after an individual's visit to Reelfoot Lake. Therefore, a single equation zonal approach with a low level of aggregation is justified as the appropriate specification for this model.

A semilog functional form was selected for this model for two principle reasons. First, when the dependent variable is specified on a per capita basis, the statistical problem of heteroskedasticity is likely to be a problem. This problem arises when the units of aggregation are of extremely different size, as discussed earlier. The appropriate choice of functional form can mitigate the problem of heteroskedasticity. Strong (1983) and Vaughan and Russell (1982) demonstrate that if a semilog form is chosen, heteroskedasticity will be a significant problem.

The second reason for choosing a semilog form is based on the rate at which trips per capita falls off as distance from a site increases. The linear functional form will predict negative visits for a few high distance (high cost) origins. This is, obviously, contrary to intuition and common sense. Ziemer, et al. (1980), Vaughan and Russell (1982) and Strong (1983) argue that the semilog functional form will eliminate this problem and is, therefore, the preferred functional form. Finally, McConnell (1985) argues that a researcher who cannot choose a functional form based on statistical or theoretical considerations will find that the bulk of the evidence in the literature supports the semilog form.

Data Source and the Measurement of Variables

The data used for estimating the demand equation IV-4 were from a Reelfoot Lake visitor survey conducted by the Department of Forestry Wildlife and Fisheries, University of Tennessee, during spring, 1985, through winter, 1986. A total of 900 questionnaires were initially sent to the target respondents. A total of 38 were undeliverable or ineligible for use in the study. Of the 862 qualifying questionnaires 719 were returned, representing a response rate of 82.4 percent.

Sample design and questionnaire. The survey population for this study consisted of those individuals currently using the park's facilities. Three sampling periods were used in this study: Phase I--Spring (April-May, 1985); Phase II--Summer (July-August, 1985); Phase III--Winter (December, 1985-January, 1986). Initially, "contact cards" were used to make contact with the lake visitors. These cards contained a short explanation of the study, some preliminary questions and reference to a follow-up questionnaire to be mailed at a later date. A randomly selected group of 300 "contact cards" was drawn from each phase of the sample. The follow-up questionnaire was then mailed to each of these 900 randomly selected individuals.

The questionnaire was designed to elicit information about visitor characteristics, perceptions about Reelfoot Lake management problems and visitor expenditures. The questionnaire format was divided into four main sections. The first section contained questions concerning the recreationist's visits to the lake. The second section contained questions pertaining to perceptions about lake management. Visitor expenditures were addressed in the third section and socioeconomic information was obtained from the fourth section. The variables taken from the survey information are discussed individually below.

Trips per capita (LnV_{ij}). Annual average trips per capita from origin i to Reelfoot Lake was taken directly from the survey and represents the annual average number of trips over the five years prior to the survey. It was felt that an annual average number of trips over five years would more accurately reflect visitation than the number of visits over a one-year period. To derive visits per capita, the individual observations were grouped according to zip code. By dividing population for each zip code area into average visits per capita for each zone was calculated.

Water quality (WQ). Although the possible influence of water quality perceptions on recreational participation was of interest in this study, measurement problems with this variable were anticipated from the start. The information on water quality came from a poorly worded question that asked individuals to rank, on a scale of one to five, their perceptions concerning the seriousness of the water quality problem at Reelfoot Lake. No attempt was made to establish any water quality scale for the respondents; therefore, the ranking is on a purely subjective basis. Additionally, this question was one of a list of questions similar in design covering, for example, litter at the lake, camping facilities and parking areas, any of which could provide information on potential shifters of the demand curve. This variable was included in the initial model runs to see if it proved to have a statistically significant relationship with visits per capita. If so, this would suggest improving "water quality" could affect the visitation and the value of recreational activities.

Travel cost variable (C_{ij}). Total travel cost is a function of time and distance. The main criterion for defining the travel cost variable is its ability to mimic the effect of site entry fees on visitation (Ward and Loomis, 1986). This is because the travel cost model assumes that individuals will react to increases in travel costs in the same manner as they would to an increase in site entry fees. The decision faced by the researcher on which costs to include in the travel cost variable is complicated by people's perception of costs. Therefore, in almost all empirical studies, only the variable costs of transportation are included in this component of the price variable. For this study this information is available from the survey. Round-trip transportation costs are equal to the total number of miles traveled times the appropriate cost per mile. The cost per mile represents the average cost of operating an automobile as defined by the Internal Revenue Service and is equal to $.1386 per mile. Total round-trip travel time is taken directly from the survey instrument. However, the opportunity cost of time must also be established. There has been a continuing debate in the literature concerning the appropriate value of time to be included in the travel cost model. Recent work by Smith, Desvousges and McGiveny (1983) has attempted to more accurately value the opportunity cost of travel time by the incorporation of worker characteristics into a hedonic wage model. Bockstael, Strand and Hanemann (1987) have developed a model where the inclusion of time is conditional on the recreationist's labor market situation. Although these models provide a theoretically correct valuation of the opportunity cost of time in a travel cost model, the detailed data requirements of such models prevent their use in many empirical studies.

A methodology proposed by McConnell and Strand (1981) allows the researcher to empirically measure the opportunity cost of time directly from observations on an individual's behavior. They argue that the opportunity cost of time is some proportion of an individual's wage rate which will vary from person to person and sample to sample. Their procedure allows for this variation, thereby eliminating the need to use fixed proportions of the wage rate for all individuals and samples. The methodology for estimating the opportunity cost of time can be described as follows:

Recall the original demand function for recreation at Reelfoot.

$$Lnv_{ij} = B_0 + B_1WQ_1 + B_2WQ_2 + B_3WQ_3 + B_4WQ_4 + B_{52}(tc + tt*k) + B_6Y_i + B_7S_i + B_8F_i + \varepsilon \quad \text{IV-5}$$

Where:

k = the opportunity cost of travel time; and

all other variables defined as before.

Assume that k is a function of the wage rate, i.e., $k = f_k(w)$ IV-6.

Where:

$f_k(w)$ can take any functional form; and

w = the wage rate.

Substituting IV-6 into IV-5 results in the following expression:

$$Lnv_{ij} = B_0 + B_1WQ_1 + B_2WQ_2 + B_3WQ_3 + B_4WQ_4 + B_5(tc + tt*f_k(w)) + B_6Y_i + B_7S_i + B_8F_i + \varepsilon \quad \text{IV-7}$$

Assume the opportunity cost of time is some constant (c) times the wage rate, i.e., $k = c * w$; where: $0 < c < 1$ and is usually arbitrarily chosen. However, this method allows estimation of (c) directly from the sample data as follows. Rewriting IV-7:

$$Lnv_{ij} = B_0 + B_1WQ_1 + B_2WQ_2 + B_3WQ_3 + B_4WQ_4 + B_5(tc + tt*(c*w)) + B_6Y_i + B_7S_i + B_5F_i + \varepsilon \quad \text{IV-8}$$

Rewriting the above equation:

$$Lnv_{ij} = B_0 + B_1WQ_1 + B_2WQ_2 + B_3WQ_3 + B_4WQ_4 + B_5tc + B_6(w*tt) + B_7Y_i + B_8S_i + B_9F_i + \varepsilon \quad \text{IV-9}$$

Where:

$$B_6 = B_5 * c$$

A maximum likelihood procedure can be used to estimate c; where:

$$c = \frac{\hat{B}_6}{\hat{B}_5}$$

The principle advantage of estimating (c) directly by maximum likelihood methods is that its asymptotic properties are known. Specifically, the coefficient will always be asymptotically unbiased, asymptotically efficient and consistent. One would expect (c) to vary by site and region. Therefore, it is better to estimate time values based on information revealed by recreationists. Simply stated, this method eliminates the need for the arbitrary valuation of time.

Average income (Y_i). Average income for recreationists at Reelfoot Lake is taken directly from the survey instrument. Respondents were asked to classify their total household income based on the following categories: 1) less than \$5,000; 2) \$5,000 to \$10,000; 3) \$10,000 to \$20,000; 4) \$20,000 to \$30,000; 5) \$30,000 to \$40,000; 6) \$40,000 to \$50,000; and 7) over \$50,000. The midpoint of each category is used as household income. A figure of \$55,000 was arbitrarily selected to represent families with incomes greater than \$50,000. The values used in the estimation of the demand equation represent an average income for each zip code group. This number is the midpoint of each income category times the number of households in each category divided by the total number of households in each zip code zone.

Substitute sites (S_i). Substitute sites available for visitors to Reelfoot Lake were established for each origin i. Economic theory indicates that the price of substitutes must be included in a demand function for correct specification. If travel cost to a substitute site and the site under study are positively correlated, then omission of the price of the substitute will lead to a bias in estimation of consumer surplus (Calkins, Bishop and Bowes, 1985). Consequently, the solution to the problem is to include the price of substitutes into the model.

Knetsch, Brown and Hansen (1976) developed an index value to include both price and quantity of substitutes into a travel cost model. Specifically, they used a ratio of site quantity of the substitute site (e.g., surface acres, harvest) divided by distance from the origin to the substitute site. If the ratio for a specific origin-substitute site combination is greater than the ratio for the given origin study combination, then the substitute site is considered competitive.

The above type of index value was adopted for this study. To characterize substitute sites for visitors to Reelfoot Lake, the ratio of surface acres of water to distance from the substitute site for each origin was used. The ratio is defined as follows:

$$\frac{\text{surface acres of water}}{\text{distance of site from origin i}}$$

It was felt that this variable could capture both price and quantity effects of a substitute site. Admittedly some recreationists who visit Reelfoot Lake State Park may not be interested in water related activities. However, the survey indicates that the largest percent of respondents listed fishing, a water related activity, as their main activity while at the park. Also, when asked what areas recreationists visited while at the park, 57 percent indicated they visited the water area (shoreline, beach, boating facility), while only 15 percent indicated they visited the forest portion of the state park. Therefore, based on the heavy use of the lake itself, surface acres of water was the most appropriate way to quantify substitute sites.

The interpretation of this variable is somewhat different than for a "price" of substitutes variable. Since S_i is a ratio with a large numerator indicating a large quantity of substitute sites and a small denominator indicating a favorable price for a substitute, an inverse relation is expected between S_i and V_{ij}. Alternatively stated, as the value of S_i rises, indicating a large substitute lake, a short distance from origin i, or both, the demand for recreation at Reelfoot Lake is expected to decrease. Although this substitute variable is only a proxy for the real cost of substitutes, it should help to more accurately specify the demand function for recreation at Reelfoot Lake State Park. Simply omitting the substitute variable will clearly lead to a mis-specified demand function. The information for this variable was not available from the survey and was therefore calculated indirectly. The calculation of this variable involved the selection of a lake site, believed to be comparable to Reelfoot, that was near each of the origins in this study. The surface area of each lake was obtained from a U. S. geological survey. The lake surface area was then divided by the distance by road from each origin to the substitute site. The observations were grouped according to three digit zip codes, and substitute sites were calculated from the center of each three digit zip code. One hundred different substitute site ratios were calculated, and only three zip code zones did not have a substitute site. Consequently, these observations were dropped from the data set.

Education level (F_i). Years of education is taken directly from the survey. Respondents were asked to reveal the number of years of education they had received. Those who indicated 19+, the highest amount, were assigned a value of 21. This would allow for five years beyond a bachelors degree. Again, as with all other variables in the demand function, this variable represents an average at each origin.

Model Estimation

The demand function for recreation at Reelfoot Lake State Park was estimated using a maximum likelihood technique. Maximum likelihood estimation was chosen because recent research (Judge, et al., 1980; Maddala, 1983; Smith and Desvousges, 1985) has determined that the use of ordinary least squares regression techniques on truncated samples will lead to biased coefficient estimates. This is because ordinary regression techniques require that the data take on a full range of value, while the demand for recreation is only defined for nonnegative values. Thus, the use of maximum likelihood estimation is recommended for truncated samples to avoid biased coefficients and, therefore, biased estimates of consumer surplus (Kealy and Bishop, 1986).

Maximum likelihood estimation can best be described as follows: The random variable x has a density function f(x). The joint frequency or density function of the random sample $(x_1, x_2, \ldots x_n)$ can be written as

$$L(x_1, x_2, \ldots x_n) = \prod_{i=1}^{n} f(x_i)$$

and called the likelihood of the sample $(x_1, x_2, \ldots x_n)$. The frequency of the random variable can be given as a function of the parameters σ_1, $\sigma_2, \ldots \sigma_k$ and be written as $f(x \mid \sigma_1, \sigma_2, \ldots \sigma_k)$. The likelihood of the sample $(x_1, x_2, \ldots x_n)$, written as

$$L(x_1, x_2, \ldots x_n \mid \sigma_1, \sigma_2, \ldots \sigma_k) = \prod_{i=1}^{n} f(x_i \mid \sigma_1, \ldots \sigma_k)$$

can then be denoted as the likelihood function of the sample $(x_1, x_2, \ldots x_n)$. Therefore, the maximum likelihood estimate of σ is that estimate for which the likelihood function

$$L = \prod_{i=1}^{n} f(x_i \mid \sigma_1 \ldots \sigma_k)$$

is at a maximum. Alternatively stated, different populations generate different samples, and a sample may be more likely to come from one population than another. Therefore, maximum likelihood estimates maximize the probability that a sample will come from a population with certain parameters (Kmenta, 1986).

This concept is illustrated graphically in Figure IV-1. The points $x_1, \ldots . x_n$ represent 10 specific observations. These observations can come from any normal population since the range of a normal population extends from $-\infty$ to $+\infty$. However, the probability of drawing the sample observations from population A or C is very small. But if the true population from which the sample was drawn is B, then the probability of drawing such observations is very high. Thus, maximum likelihood estimators are values of parameters that will generate the sample most often. These parameters are generated by maximizing the likelihood function of a random variable.

If the demand for recreation at Reelfoot Lake is specified as:

$LnV = X'B + e$

Where:

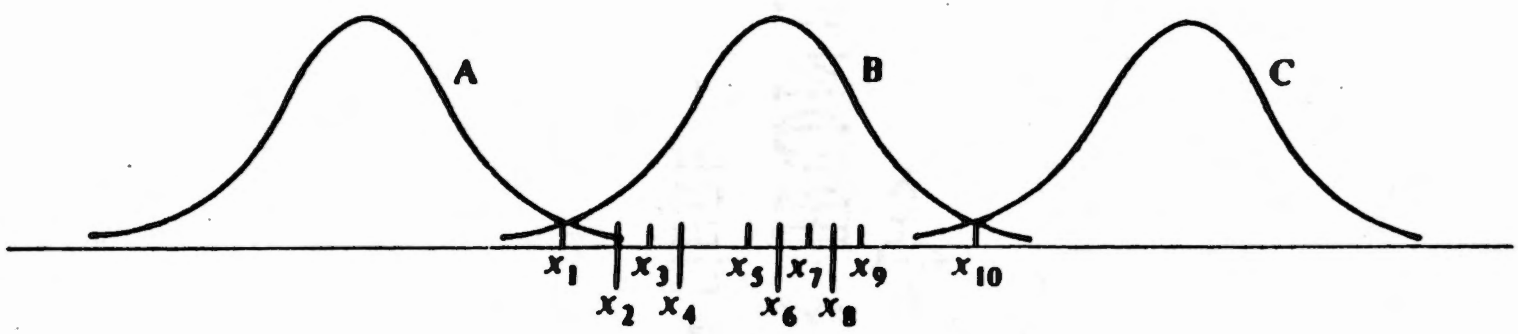

Figure IV-1. Illustration of the Maximum Likelihood Estimation Principle.

LnV = a vector of the natural log of the dependent variable; the truncation takes the form $V > 0$;

X' = a matrix of the independent variables;

B = a vector of parameters to be estimated; and

ε = the disturbance term which is assumed to be normally and independently distributed with a mean of zero and a standard deviation of σ (Maddala, 1983).

The density function of V is defined as follows:[13]

$$f(V) = \frac{\frac{1}{\sigma}\ \varphi[(V - B'X)/\sigma]}{\Phi[(0 + B'X)/\sigma]} \quad \text{if } V > 0$$

$$f(V) = 0 \text{ otherwise}$$

Where:

φ and Φ are, respectively, the density function and the distribution function of the standard normal.

To derive estimates of B, it is necessary to maximize the appropriate likelihood function. This function can be specified as follows:[14]

$$\text{Log } L = -N\ \text{Log}[(2\pi)^{1/2}\sigma] - \frac{1}{2}\ \Sigma\ \frac{V - B'X}{\sigma}^{2} - \Sigma\ \text{Log}\ \Phi\ \frac{0 - B'X}{\sigma}$$

The first order conditions for the above function as defined by Hausman and Wise (1976) are:

$$\frac{2\ \text{Log } L}{2B} = \frac{1}{\sigma^2}\ \Sigma(V - B'X)X + \Sigma\ \frac{x\varphi(di)}{\sigma\Phi(di)} = 0$$

$$\frac{2\ \text{Log } L}{2\sigma} = \frac{-N}{2\sigma^2} + \frac{1}{2\sigma^4}\ \Sigma(V - B'X)^2 + \frac{1}{2\sigma^2}\ \Sigma\ \frac{di\varphi(di)}{\Phi(di)} = 0$$

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[13] See Maddala (1983), p. 166.

[14] See Maddala (1983), p. 166.

Since the derivatives for the above equations are nonlinear, it is necessary to use an iterative process to find solutions. Maddala contends that since the likelihood function is globally concave using OLS estimates for starting values in the iterative process will lead to unbiased maximum likelihood estimates of B. These coefficients will also be asymptotically efficient and consistent.

The program used to estimate the coefficients for the demand for recreation at Reelfoot Lake was LIMDEP. This package computes maximum likelihood estimates in a manner consistent with the above criteria stated by Maddala. Therefore, these coefficients are asymptotically unbiased.

Contingent Valuation Model Specification

A secondary objective of this study was to use a simple form of the contingent valuation method to estimate the economic value of recreational activity at Reelfoot Lake. This model was severely limited by the quality of the survey information. Unfortunately the survey instrument likely introduced strategic and starting point bias into the model. However, regardless of potential bias resulting from the survey an argument can be made that a contingent market was established. A correctly specified contingent valuation study must include the following:

1. A comprehensive description of the public good being valued and the situation under which this good would be available. In a purely hypothetical market the base and proposed levels

of a public good must be clearly defined and the maximum willingness-to-pay for each level of that good recorded.

2. Questions that reveal information about the socioeconomic characteristics of visitors to the site.

The simple form of the contingent valuation method in this study specifies the public good and the conditions under which it will be available. Respondents are asked to state a maximum willingness-to-pay for a one-year pass to Reelfoot Lake. Therefore, in a very basic way a contingent market is established. Respondents are aware they are bidding on a specific level of a good. In this case, the contingent market they are faced with allows them to bid for use or no use of Reelfoot Lake. Since the survey, through the use of detailed questions, describes the lake and the surrounding park, it is believed that the respondents were sufficiently familiar with the public good to accurately bid on it. Also, a simplified market was established. Thus, this basic form of the contingent valuation method should be an empirically sound technique to generate an estimate of the value of recreation activity at Reelfoot Lake.

In general form the contingent valuation model can be written as follows:

$$WTP = f(V, Y, M, S, D)$$

Where:

WTP = willingness-to-pay for use of a site or improvements in the quality of the site;

V = number and length of visit to a site;

Y = years of experience with a site;

M = miles traveled to a site;

S = availability of substitute sites; and

D = socioeconomic variables.

The conceptual model presented above is based primarily on other studies valuing environmental amenities (Brookshire, et al., 1976; Brookshire, et al., 1980; Randall, et al., 1976; Bergstrom, et al., 1985). In the above studies total willingness-to-pay was considered to be a function of quantity, quality and socioeconomic variables. In this study willingness-to-pay is a function of quantity, distance, substitutes and income.

Once the model is specified, a household total value curve can be derived. A total value curve relates willingness-to-pay for a nonmarket good to the quantity of that good provided. In this study the quantity variable is defined as the number of trips an individual makes to Reelfoot Lake on a yearly basis. Theoretically, the relationship between total willingness-to-pay and the number of trips taken per year should be a direct one. The expected relationship is that total willingness-to-pay increases at a decreasing rate as the number of trips taken per year increases. Therefore, the first derivative of the total value curve will yield a compensated demand curve. After the household total value cure is calculated, an aggregate total value curve can be generated. The derivation of the household and aggregate value curve will be detailed in a subsequent section.

The relationship expected between distance traveled and willingness-to-pay for a one-year pass is an inverse one. It seems reasonable to assume that those who live closer to the park will be willing-to-pay more for a one-year pass. This expectation is based on the fact that those who live closer would be able to more fully utilize a one-year pass due to the reduced travel time and cost necessary to obtain entrance to the lake. Conversely, those who live a greater distance from the park would most likely make a limited number of visits to Reelfoot due to the time and money constraints. Thus, they would be expected to have a lower willingness-to-pay for a one-year pass.

The expected relationship between willingness-to-pay and the availability of substitute sites is also an inverse one. The availability of substitutes is measured by the index described previously. As the index value increases, this indicates that the availability of substitutes increases, or the price decreases. Basic economic theory suggests that, as the quantity of substitutes increases or the price decreases, a consumer's willingness-to-pay for a good decreases. In this case, as more recreational areas are available or travel cost to these areas decreases, the willingness-to-pay for a one-year pass to Reelfoot Lake would be expected to decrease.

Income and willingness-to-pay are expected to be directly related. Economic theory indicates that as income increases, a consumer will be willing to pay more for a commodity. Consequently, as a recreationist's income rises, it is reasonable to expect his willingness-to-pay for a one-year pass to increase.

The model used in this study expresses willingness-to-pay as a function of quantity, education, availability of substitutes and income. This model can be formally stated as:

$$WTP = B_0 + B_1 V_i + B_2 E_i + B_3 S_i + B_4 I_i + \varepsilon \qquad \text{IV-10}$$

Where:

WTP = maximum willingness-to-pay for a one-year pass;

V_i = number of trips taken per year to Reelfoot lake;

E_i = education level for each individual;

S_i = availability of substitute sites;

I_i = total household income; and

ε = normally distributed error term.

A linear relationship was hypothesized for the functional form of the contingent valuation model since there did not seem to be a consensus in the literature as to a preferred functional form for a contingent valuation study. WTP is only defined for nonnegative values with zero being a common value. Consequently, a tobit procedure for a censored sample is a correct technique to generate asymptotically unbiased coefficient estimates.[15]

Measurement of Variables in the Contingent Valuation Model

Willingness-to-pay for a one-year pass to Reelfoot Lake State Park was taken directly from the survey. Respondents were asked to assign a maximum dollar value that they were willing to pay for a one-year pass. The respondents understood that they were bidding on the right to use the lake or to be excluded from it in a hypothetical sense.

The number of trips per year taken to Reelfoot Lake by individual i was taken directly from the survey and represents the average number of trips an individual has made over the last five years. It was

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[15]See Maddala (1983) for a complete discussion of the tobit estimation procedure.

believed that an average visitation rate over five years would be more representative of visitor behavior than the number of visits over a one-year period.

Education level for each individual was also taken directly from the survey instrument. Respondents were asked how many years of formal education they had received.

The availability of substitute sites at origin i was an index number designed to capture both the quantity effect and price effect of substitutes. This variable is the same as that used to characterize substitute options in the travel cost model. The index value is defined as the ratio of surface acres of water of a substitute site to the distance that site is from origin i. Formally stated the index equals:

$$\frac{\text{surface acres of water of a substitute site}}{\text{distance to the substitute site from origin i}}$$

If the above ratio for a specific origin-substitute site combination is greater than the ratio for the given origin-study combination, then the substitute site is considered competitive. The information for this variable was not available from the survey.

Income for recreationists at Reelfoot Lake comes directly from the survey. Respondents were asked to classify their household income based on seven categories, as outlined previously for the travel cost model.

Benefit Estimation

The estimation of benefits for the contingent valuation model in this study is fairly straightforward. Benefit estimates are generated in two steps. The first step is to derive a household total value curve. The second step involves estimation of an aggregate total value curve.

Household total value curve. A household total value curve can be estimated from the regression equation expressing willingness-to-pay as a function of trips taken, education, substitutes and income. The estimation of a household total value curve requires that the regression equation be solved for the mean values of the independent variables. A simple example of a household total value curve can be expressed as follows:

$$WTP = 4.00 + .01V_i - .02E_i - .015S_i + .001I \quad \text{IV-11}$$

If the mean values for the independent variables trips taken, distance, substitutes and income are 15, 10, 100 and $20,000, respectively, then the total value of recreation at Reelfoot for the average visitor is $21.85. This value is calculated by solving equation IV-11 for the above values.

Aggregate total value curve. Once the household total value curve is estimated, it is relatively easy to calculate an aggregate total value curve. An expression for annual aggregate willingness-to-pay is derived by multiplying the right-hand side of equation IV-11 by the total number of visitors to Reelfoot for a one-year period. Assuming that 50,000 people visited Reelfoot Lake State Park annually, the expression for aggregate total value would be:

$$\text{aggregate } WTP = 200{,}000 + 500V_i - 1000E_i - 750S_i + 50I \quad \text{IV-12}$$

To generate estimates of aggregate total value, equation IV-12 is solved for the mean values of the independent variables.

Summary

The exact specification and data requirements for each model in this study were provided in this chapter. Two models were presented, a travel cost model and a contingent valuation model. Also included in this chapter was a discussion of the survey from which the data were obtained for both of these models. Finally, benefit estimation for the contingent valuation model was discussed. Benefit estimation for the travel cost model was explained in the preceding chapter.

CHAPTER V

RESULTS

The results generated from both the travel cost model and the contingent valuation model are detailed in this section. The estimated equations and estimates of consumer surplus are presented for each model. Also included in this chapter is a discussion of each of the variables used in the models and their significance as predictors of recreational activity at Reelfoot Lake. Finally, a comparison of the results from the two models is presented.

The Travel Cost Model Estimates

Initial runs of the model were done with the inclusion of the water quality variables to see if a significant relationship existed between water quality perceptions and visitation. Only one of the water quality variables proved statistically significant, and it had a negative sign. The negative sign raised questions as to whether these variables actually measured the effect that perception of water quality has on visitation. A negative sign implies that as people's perceptions of water quality move from no problem towards a serious problem, visitation at the lake increases. This is, of course, contrary to expectations and logic. A proposed explanation for the negative sign is that the probability of noticing water quality problems increases with increased visitation. Alternatively stated, a person who visits the lake more frequently is more likely to notice a deterioration in water quality over time, or to have been at a particular place at a particular time where the water quality proved a problem. The implication of this is that the water quality variables in this study did not appear to measure the expected relationship between perceptions concerning water quality and visitation rates, but, if anything, captured the effect frequency of visitation has on perceptions concerning water quality. Therefore, since these variables did not appear to capture the conceptually modelled relationship, they were dropped from the model.

Before estimating the first stage demand curve from which consumer surplus estimates were to be made, it was necessary to derive an estimate of the opportunity cost of travel time. The opportunity cost of time is equal to some fraction (c) multiplied by the wage rate. To determine this fraction, it was necessary to estimate equation IV-9. The regression equation used to calculate the fraction of the wage rate at which to value the the opportunity cost of travel time for the travel cost model is given by equation V-1.

$$Lnv_{ij} = 5.885 - .015tc_{ij} - .0021wtt_{ij} - .000014Y_i - .000053S_i$$

t values (8.69) (-4.50) (-.732) (-1.346) (-.969)

$$- .019E_i \qquad \text{V-1}$$

t values (-2.02)

n[16] = 268

Where:

LnV_{ij} = the natural log of annual average visits per 100,000 from origin i to destination j;

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16 Thirty-six percent of the visitors listed fishing as their main activity, 15 percent listed eagle watching and 6.5 percent listed wildlife observation. The rest of the visitors listed some other activity.

tc_{ij} = round-trip travel cost from origin i to Reelfoot Lake;

wtt_{ij} = round-trip travel time from origin i to Reelfoot Lake multiplied by the average wage rate for each zip code zone; the wage rate is determined by dividing yearly income by 2,000 hours;

Y_i = the average income for origin i;

S_i = an index of available substitute sites for visitors from origin i; and

E_i = the average education level at origin i.

It should be noted that although the travel time variable in equation V-1 is not statistically significant, this is not particularly surprising. One of the principal reasons the travel time and travel cost variables are combined is to avoid the problem of multicollinearity which causes inflated standard errors and consequently, insignificant coefficients. Examination of the Pearson correlation matrix for the variables in equation V-1 indicates that a fairly high level of correlation existed between travel time and travel cost and income. Therefore, multicollinearity is believed to be responsible for the lack of significance of the travel time coefficient. Combining the variables in equation V-2 reduced the level of multicollinearity.

Recall from Chapter IV that (c) (the fraction of the wage rate at which to value travel time) can be estimated directly from the sample and is equal to B_3 divided by B_2. Therefore, (c) is equal to 14 percent of the wage rate. This value for (c) was then substituted into equation IV-4 and resulted in equation V-2 which is the first-stage demand curve for recreation at Reelfoot Lake.

$$LnV_{ij} = 5.886 - .015C_{ij} - .000014Y_i - .000054S_i - .087E_i \quad \text{V-2}$$

t values (8.82)*** (-6.99)*** (-1.60)* (-.975) (-2.206)**

n = 268

*** = indicates significance at the .01 level;

** = indicates significance at the .05 level; and

* = indicates significance at the .15 level.

Where:

C_{ij} = $((tc_{ij} + tt_{ij} * (c*w))$ total travel cost from origin i to destination j;

c = the fraction of the wage rate at which to value travel time from origin i to Reelfoot Lake;

w = the wage rate from origin i; this value equals the income from origin i divided by 2000 hours; and

all other variables are defined as before.

Statistical Significance of Variables

Examination of the coefficient for travel cost in equation V-1 and total travel cost in equation V-2 indicates that they are equal. This is to be expected since the technique developed by McConnell and Strand (1981) has the effect of scaling the travel time coefficient in equation V-1 to be equal to the travel cost coefficient in equation V-1 so they may be combined. Alternatively stated, the estimation of (c) equates the travel time and travel cost coefficients in equation V-1 so they can be combined into one coefficient in equation V-2.

The total travel cost coefficient (C_{ij}) was statistically significant at the 1 percent level and had the expected negative sign. This variable indicates that as total travel cost increases, either in the form of higher transportation costs or higher time costs, visits per capita decrease. The inclusion of both travel time and travel cost in a single variable eliminates the correlation between the two as separate predictors and yields a price coefficient that will not understate consumer surplus (Ward and Loomis, 1986).

The income coefficient (Y_i) had a negative sign and was significant at the 15 percent level. One implication of the negative coefficient is that visits to Reelfoot Lake are inferior goods. The term inferior does not imply any social value judgment about recreation at Reelfoot Lake; it simply indicates that an inverse relationship exists between income and visits to the lake. This inverse relationship seems consistent in this case. It is reasonable to assume that higher income individuals may visit Reelfoot Lake on a limited basis due to a desire and ability to recreate in different places and activities over the year, while lower income individuals may visit Reelfoot Lake on a repetitive basis to participate in relatively low-cost fishing or camping activities. In fact, one of the most popular activities at Reelfoot Lake is crappie and bluegill fishing, an activity which may appeal more to lower income individuals.

The substitute site coefficient was statistically insignificant. There are two possible explanations for why this variable was insignificant. First, it may be that the variable does not truly reflect the availability of substitute recreational sites for visitors to Reelfoot Lake. Alternatively stated, the variable may be misspecified. The problem of correctly identifying and including variables that reflect the availability of alternative recreational sites in a travel cost model is one for which the literature offers no guaranteed solutions. Various researchers (Burt and Brewer, 1971; Chiccettii, Fisher and Smith, 1976; Knetsch, Brown and Hansen, 1976; Sorg, Loomis and Donnelly, 1984) have attempted to quantify the effect substitute sites have on the demand for recreation. However, no one has been able to clearly define and specify the appropriate measure of substitutes for recreational valuation.

The second possible explanation for the lack of significance of the substitute variable is that Reelfoot Lake may truly be a unique site for which no good substitutes exist. Reelfoot Lake is the only large naturally formed lake in the state of Tennessee. Additionally, it is one of a very few wintering habitats for bald and golden eagles and the osprey. All of these birds are endangered species. Finally, there are unique cultural and historical aspects to the lake and the surrounding area. All of the above factors may, in fact, make Reelfoot Lake a unique site.

The education variable (E_i) was significant at the 5 percent level and had a negative sign. Again, as with income, an inverse relationship exists between visitation and education. This type of relationship seems quite plausible. It is not difficult to believe that more highly educated people may visit Reelfoot Lake or any other site on a limited basis, having a greater desire to recreate at different sites over time. Conversely, one might expect individuals with a lower level of education to be more content to vacation and recreate in the same area and participate in the same activities on a yearly basis.

First- and Second-Stage Demand Curves

Equation V-2 is the equation for the first-stage demand curve for recreation at Reelfoot Lake. This curve is represented graphically in Figure V-1. The curve plots visits per capita against travel costs. All other variables in the demand equation are held constant at their mean.

The first-stage demand curve was used to derive an aggregate demand curve for total visitation to Reelfoot Lake. The aggregate demand curve was calculated using sample mean values for income education and the substitute site variable. The travel cost variable for each zone was increased from zero by successive $10 increments until the cost equaled the highest regularly observed travel cost values in the data set. The highest regularly observed travel cost values were around $230. After the $230 values there was a large gap with the next value being equal to $290. The cost limit was used as a cutoff point because the natural log of visits per capita would never equal zero regardless of how high travel costs went. This cutoff procedure was developed by Wennergren (1967) and subsequently used by Smith and Kopp (1976) and Sorg and Nelson (1982). This methodology yields a conservative estimate of consumer surplus since it eliminates a few observations. The loss in this study is believed to be quite small since only five observations were eliminated due to the $230 cutoff.

The aggregate demand curve for recreation at Reelfoot Lake is illustrated in Figure V-2. The area under the curve is an estimate of Marshallian consumer surplus. This measure is a net measure since the dollar increases in travel costs used to generate this curve were over

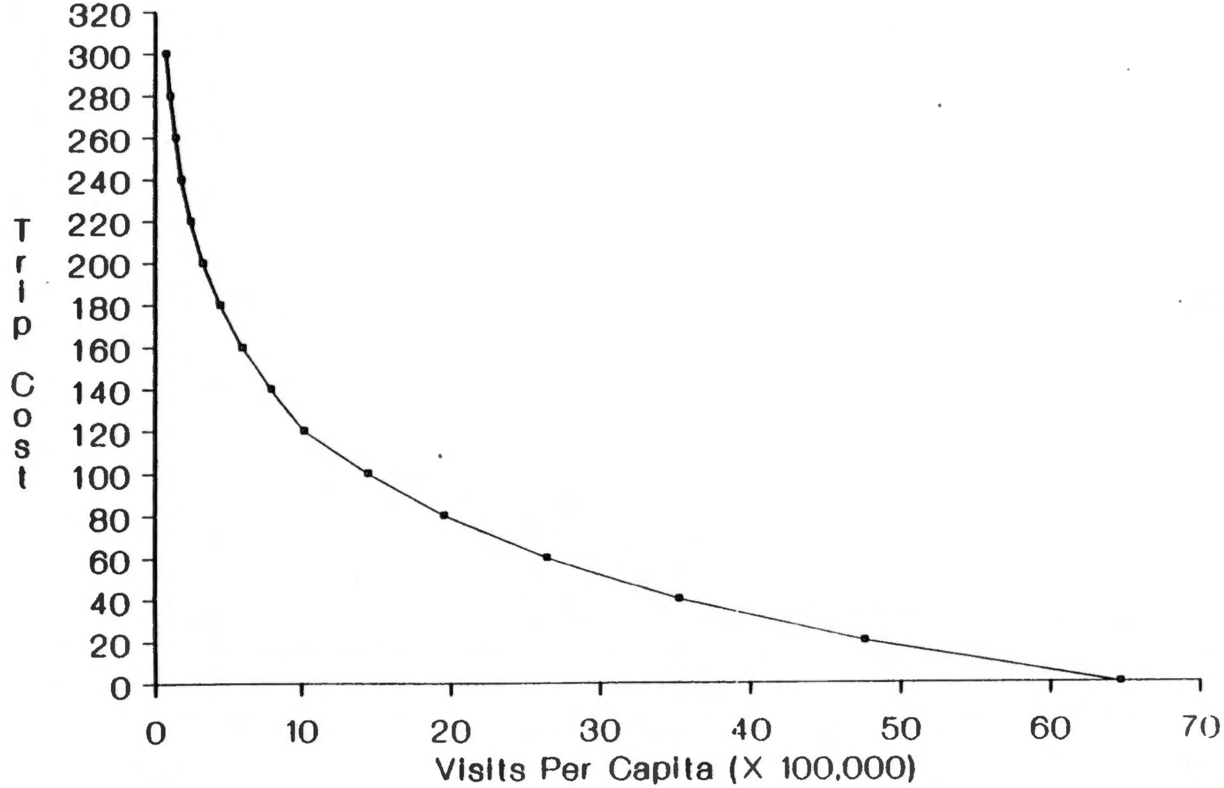

Figure V-1. First Stage Demand Curve for this Study.

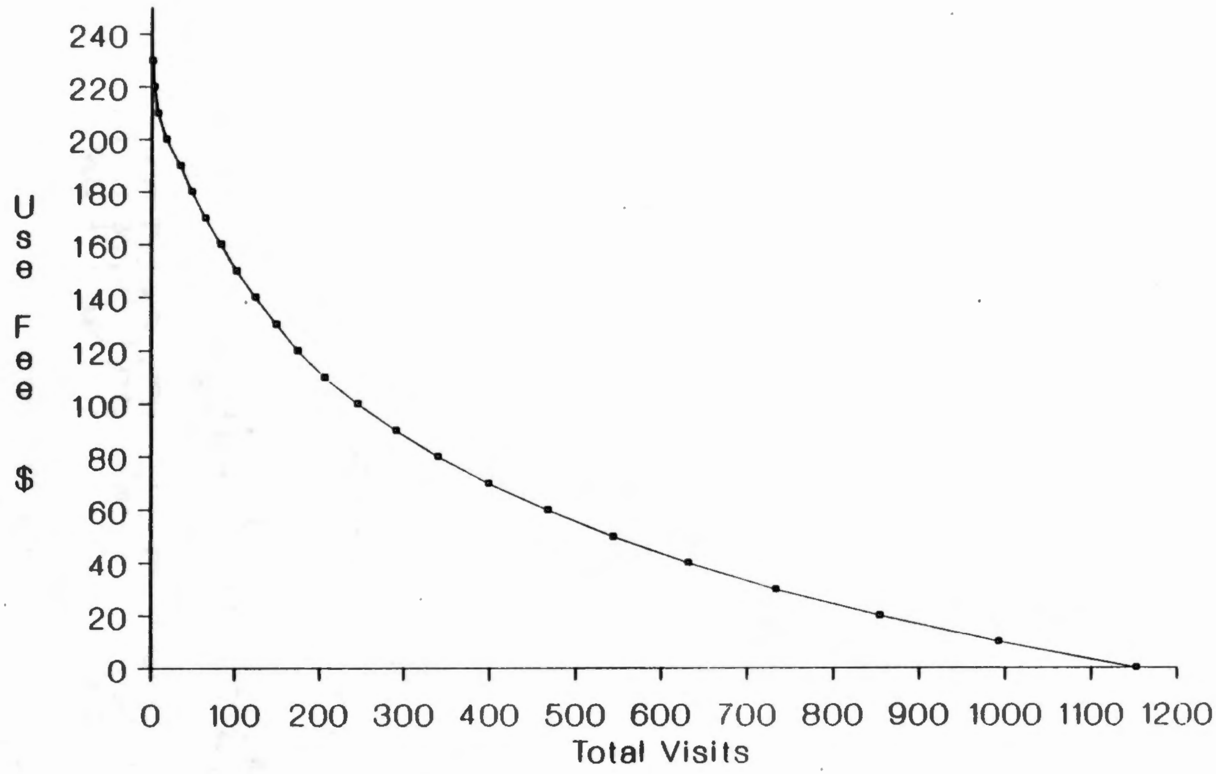

Figure V-2. Second Stage Demand Curve for this Study.

and above what the consumer actually paid to obtain the site. As noted in Chapter III, the Marshallian measure is approximately equal to the more theoretically correct Hicksian measure of consumer surplus.

<u>Consumer Surplus</u>

The calculated consumer surplus area under the aggregate demand curve is an approximation due to the piecewise linear nature of the demand curve. The area between each of the 23 points (one point for each level of the increased hypothetical use fee) used to derive the aggregate demand curve was calculated and then summed to get an estimate of total consumer surplus. This area was then divided by the total number of predicted visits from the sample at zero use fee to generate an estimate of per trip consumer surplus. These numbers appear in Table V-1.

Table V-1 indicates that total consumer surplus for those in the survey was equal to \$70,652. Converting this to a per trip basis yields a value of \$61.33. The average number of people to visit Reelfoot Lake per car during the sample period is 3.5; therefore, the average consumer surplus per individual per trip was \$17.50. This estimate is fairly consistent with similar studies. Seller, Stoll and Chavas (1983) estimated average consumer surplus per individual per trip for four lakes in Texas to be \$32.06, \$24.42, \$102.09 and \$13.01. Ziemer, Musser and Hill (1980) estimated a value of \$26.46 for consumer surplus per individual per trip for warm water fishing in Georgia. Finally, an estimate of total annual use value for the site was generated by multiplying the total number of visits to Reelfoot Lake annually during the

Table V-1. Estimated Points for the Second Stage Demand Curve and Consumer Surplus Estimates.

Increase in Use Fee	Predicted Visits	Consumer Surplus Between Estimated Points
$0	1152	
$10	992	$800
$20	854	$2070
$30	733	$3025
$40	631	$3570
$50	543	$3960
$60	467	$4180
$70	398	$4485
$80	339	$4425
$90	290	$4165
$100	244	$4370
$110	205	$4095
$120	173	$3680
$130	148	$3125
$140	123	$3375
$150	101	$3190
$160	83	$2790
$170	64	$3135
$180	47	$2975
$190	34	$2405
$200	17	$3315
$210	7	$2050
$220	3	$860
$230	.3	$607

Total Consumer Surplus	Per Visit Consumer Surplus
$70,652.00	$61.33

sample period,[17] 212,645, by the average consumer surplus per visit. This yields a total annual use value estimate for Reelfoot Lake of $3,721,287.

The Contingent Valuation Estimates

The equation used to predict willingness to pay for a one-year pass to Reelfoot is given by equation V-3.

$$WTP_i = 14.02 + .55V_i - .000017I_i + .00018S_i - .235E_i \quad \text{V-3}$$

t values (2.19)** (3.12)** (-1.78)* (.292) (-.516)

n[18] = 393

** = indicates significance at the .01 level; and

* = indicates significance at the .10 level.

Where:

WTP = willingness to pay for a one-year pass to Reelfoot Lake;

V_i = a five year annual average of visits to Reelfoot Lake;

I_i = household income for individual i;

S_i = substitutes available to individual i; and

E_i = education level for individual i.

Average annual visits made to the site (V_i) was significant at the .01 level with the hypothesized positive sign and indicates that as an additional visit is made to the site the willingness to pay for a

[17] For a complete discussion of how this number was generated, see Linda Weaver, Research Assistant, Department of Forestry, Fisheries and Wildlife, University of Tennessee.

[18] Thirty-seven percent of the visitors listed fishing as their main activity, 22 percent listed eagle watching and 15 percent listed sightseeing.

one-year pass to the lake increases by $.55. Income was significant at the .01 level and had a negative sign. Thus, the higher the income level, the lower the willingness-to-pay, which is consistent with the results from the travel cost model. Both education and the substitute site variable were statistically insignificant.

The estimates generated from the contingent valuation model in this study are Hicksian compensating variation measures of consumer surplus. This is true because the consumer is asked to state a maximum willingness-to-pay for a one-year pass to Reelfoot Lake when initially access to the lake is free. Therefore, the consumer is asked how much he would be willing to pay to keep himself at the initial level of welfare. The compensating variation measure is, as discussed earlier, approximately equal to a Marshallian measure of consumer surplus. This equivalency allows for a comparison of the welfare measures from the travel cost and the contingent valuation models to be presented in a subsequent section.

As presented earlier, the household total value curve for recreation at Reelfoot Lake is described by equation V-3 below.

$$WTP = 14.02 + .55V_i - .00017I_i + .00018S_i - .235E_i \qquad \text{V-3}$$

When all of the independent variables are held constant at their respective sample means, an average willingness-to-pay for entrance to Reelfoot Lake on a yearly basis can be generated. This is a net measure of consumer surplus since it is a value over and above the present zero entrance fee. This amount is equal to $7.50 and represents an estimate of the total willingness-to-pay for recreation on a yearly basis for the average visitor to Reelfoot Lake. Converting this to a per trip basis yields a value of \$2.35, given the mean number of annual visits (3.18) individuals in the sample made to Reelfoot Lake.

The next step in the benefit estimation process is to derive an aggregate total value curve. This is done by multiplying the right-hand side of equation V-3 by the total number of individuals to visit Reelfoot in the year in which the sample was taken. The number of individuals to visit the lake during the year was 66,869. This number is equal to the total number of visits at Reelfoot (212,645) divided by the mean number of visits per person (3.18) from the sample. The expression for aggregate willingness-to-pay for recreation at Reelfoot is given below by equation V-4.

$$AggrWTP = 937{,}503 + 36{,}778V_i - 11.36I_i + 12.03S_i - 15714E_i \qquad \text{V-4}$$

Substituting the respective sample means for each of the independent variables and then solving the equation yields a total willingness-to-pay for recreation at Reelfoot Lake on an annual basis. This amount is \$499,715.

Comparison of the Travel Cost Model and the Contingent Valuation Model

Unfortunately, no direct statistical comparison of the consumer surplus estimates from both models can be made. This is because the standard error for the second-stage demand curve for the travel cost model is unknown. However, if one simply looks at the per trip consumer surplus estimates from both models, it is easy to see that they are quite different. The travel cost model yields an estimate of consumer surplus of \$17.50 per individual per trip. On the other hand, the contingent valuation model yields an estimate of consumer surplus of $2.35 per individual per trip. The travel cost estimate is thus 7.4 times as large as the contingent valuation estimate.

An explanation for the difference in the estimates is that the contingent valuation estimate was most likely severely affected by starting point bias and strategic bias. In the survey it was implied that a yearly fee might be implemented based on the answer to the willingness-to-pay question. This might make some people underbid their true willingness to pay in the hope that they could continue to use the park for free or at a cost less than their actual willingness-to-pay. Additionally, in another question the survey also implied that $10 was an appropriate amount to pay for a one-year pass. Had $10 not been suggested as an appropriate amount for a pass to Reelfoot, bids in excess of $10 may have been more common. Even if starting point and strategic bias are not present, large differences in the estimates of consumer surplus from the two models are not that unusual. Studies by Bishop and Heberlein (1979) and Desvousges, Smith and McGiveny (1983) using both qualitative and quantitative comparison measures for travel cost and contingent valuation models indicate that the mean values derived from each nonmarket technique will not necessarily be equal. Additionally, there is no consensus in the literature as to whether one method yields consistently higher or lower estimates than the other method.

In summary, due to the nature of the survey questions, the contingent valuation estimates of consumer surplus are likely severely biased. Therefore, in consideration of policy or management decisions about the protection of Reelfoot Lake, more confidence should be placed in the estimates from the travel cost model. The travel cost estimates are likely to be less biased.

CHAPTER VI

CONCLUSIONS

In this chapter the principal findings of this study are summarized. The policy implications of the study are also discussed. Finally, the limitations of this study and suggestions for further research are addressed.

Summary of Study Results

The travel cost method and the contingent valuation method were used in this study to generate estimates of the value of recreation at Reelfoot Lake. The travel cost model yielded an estimate of total annual consumer surplus equal to $3,721,287. Individual consumer surplus per visit to Reelfoot Lake was equal to $17.50. The statistically significant predictors of visitation rates for the model were travel costs, income and education. The substitute site variable was not significant. The estimate of consumer surplus from the contingent valuation model was equal to $2.35 per individual per trip to the lake, and the estimate of annual consumer surplus was equal to $499,715. The significant predictors in the contingent valuation model were the number of visits to the site and income. Both the education and substitute site variables were insignificant. While the estimates of recreation value from the two models were quite different, this was not particularly surprising for two reasons. First, it is believed that the contingent valuation estimates were severely biased due to starting point and strategic bias. Second, other studies (Bishop and Heberlein

1979; Desvousges, Smith and McGiveny, 1983) have indicated that estimates from both techniques will not necessarily be equal. Finally, the travel costs estimates are considered less biased than the contingent valuation estimates and are the ones on which the policy implications of this study are based.

Policy Implications of This Study

Having an estimate of the annual recreational benefits for Reelfoot Lake allows the researcher to gain a perspective on the cost of reductions in the quantity or quality of future recreational activity at the lake, and thus the justification for efforts to reduce the sedimentation and nonpoint pollution of the lake. A scenario of how this information can be used is outlined below.

Though there is a divergence in opinions about how quickly the lake is filling up, it is not unreasonable to suppose that the lake might be rendered useless in 200 years at the present rate of sedimentation. In fact, the most recent projection, based on sedimentation rates for the 1954-1983 period, suggests the depth of one of the major basins at the lake would be reduced to two feet or less within 200 years (McIntyre and McHenry, 1984). If the annual cost of lost recreational benefits due to erosion were discounted over a period of time that could be considered a realistic planning horizon, then the present value of the costs associated with the sediment entering the lake would be known. These calculations are presented below for an example. The figures used to compute the present value of sedimentation costs are reasonable and the best available to the researcher. Two discount rates are used in the calculations below, 5 and 10 percent. While the scenario below must be viewed as more of an illustration than a definitive analysis, it demonstrates the potential usefulness of an estimate of recreational benefits for Reelfoot Lake. This kind of information can help policy-makers plan for the cost effective protection of Reelfoot Lake.

Discounting the annual cost of erosion of $18,606 (the estimated annual benefits from the travel cost model, $3,721,287, divided by the expected 200-year life of the lake) at 10 percent for 50 years yields a present value of $184,475 associated with the average yearly amount of sediment entering the lake. This figure is interpreted as follows: one year's sedimentation results in a cost of $18,606 per year in lost recreational opportunities, and the total present value of these lost opportunities when discounted over a 50-year planning horizon is equal to $184,475. The Rural Clean Water Project Program established in 1980 a goal of reducing erosion rates to five tons per acre per year on 80 percent of the 34,388 acres in the watershed that exceed this rate. Under the assumption that reducing sedimentation to five tons per acre on 27,510 acres (i.e., 34,388 * .8) would prolong the life of Reelfoot Lake indefinitely, then a cost of $6.70 (the present value of lost recreational opportunities $184,475 divided by the 27,510 acres responsible for the sedimentation of the lake) per acre per year exceeding the five ton per acre goal exists. Alternatively stated, federal state or local agencies would be justified in spending up to $6.70 per acre for soil erosion abatement on the land eroding at greater than five tons per acre per year. The figure would be $12.34 if a 5 percent discount rate were used.

Limitations of the Study and Suggestions for Future Research

This study was limited in several ways. First, the survey from which the data for the contingent valuation and travel cost models was taken was less than ideal, having been developed by other researchers for slightly different purposes. As mentioned previously, it is suspected that the consumer surplus estimates from the contingent valuation model are severely biased. Second, due to the poor design of the water quality question in the survey, it was necessary to delete this variable from the final demand equation for the travel cost model. Obviously, information concerning water quality and recreational participation would be useful to policymakers in evaluation of programs to protect the lake. Third, the substitute site variable was not significant in the travel cost or the contingent valuation model. Two potential reasons for this lack of significance were presented in Chapter V. If Reelfoot Lake is, in fact, a unique site for which no substitute site exists, then there should be no bias in the estimates of consumer surplus from the substitute site variable. If, however, the variable was misspecified, then the consumer surplus estimates may be biased.

Further research in the area of nonmarket valuation should stem from its present limitations. For Reelfoot Lake future research could address the proper construction of a contingent valuation survey. Perhaps the results from such a survey could be compared with those of the travel cost model in this study. Additionally, more work is needed in the area of accurately linking water quality with recreational participation at Reelfoot Lake. Finally, more research is needed in the area of correctly specifying a variable that will accurately reflect substitute sites in both the travel cost and contingent valuation models.

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