

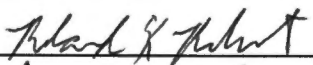
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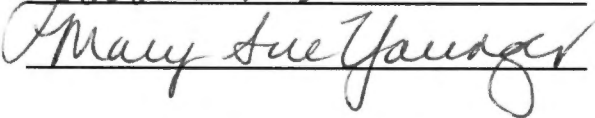
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**ANALYZING THE EFFECT OF SITE QUALITY ON TENNESSEE RESERVOIR
FISHING SITE SELECTION USING A RANDOM UTILITY MODEL**

**A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville**

**Michael Wayne Bates
December 1994**

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DEDICATION

This thesis is dedicated to my parents
Forrest and Betty Bates
who have given me advice, assistance, finances,
and most of all love over the past twenty-five
years of my life, and throughout my educational
pursuits. Great thanks are due to them. Their
support is infinitely appreciated, and for it I
will forever be indebted to them.

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To those select few special friends whose names need not be mentioned, but who have given unending aid, not only to

scholarly quests but also to personal endeavors as well.

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ABSTRACT

Random Utility Models (RUM) are an extensively used modeling structure in the field of recreational demand studies. They are particularly useful when recreationists may choose from a large number of alternative recreational sites. Anglers in Tennessee have a large number of reservoirs available for fishing, each of which varies in site quality and access costs. Using survey data, models of angler site selection are empirically estimated for the major reservoirs in Tennessee, and benefit measures for changes in site fishing quality are calculated. Because RUM models are sensitive to the set of included sites, two different regional modelling strategies were tested.

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CHAPTER ONE

Introduction

1.1 Goods and Markets

To facilitate transactions there are markets for exchange. A market is defined as "institution(s) or mechanism(s) which brings together buyers and sellers of particular goods and services", and these may take a wide range of forms (Brue and McConnell, p. 49). Most goods and services are physically tangible with well-defined property rights, and will be traded in a well-defined market. Unfortunately, there are some goods and services which are not traded in a market setting, for any of several reasons. These goods and services are broadly termed public goods. These goods, in a pure state, are defined to be a good which "if, once produced, no one can be excluded from benefiting from its availability" (Nicholson, p. 757). These goods do not have a specific price because of their non-exclusive, non-rival nature (Randall, p. 255). This condition implies that once the good has been produced, no-one can be prevented from using it (except at a very high cost), and any one individual can use the good without restricting its use by others in any way.

Another type of good closely associated with a pure public good, is a non-market good which is rival only in congestion. A public recreational area is a good example of this particular type of good. Recreational sites, such as

reservoirs, are public goods that provide desirable services. The public good properties of recreational sites prevent the formation of a competitive market to provide efficient qualities and quantities of natural resources. The market failure results in a high likelihood of allocative inefficiency and the presence of positive and negative externalities accruing to users of the resource. For this reason, it is desirable to estimate the value of these goods. These values also help make economically efficient policy decisions.

1.2 Intended Research and Overview

The purpose of this research is to measure the value of reservoir quality, and to provide policy makers a guideline when making decisions about reservoir quality. These benefit estimates, applicable to reservoirs in Tennessee and possibly the surrounding area, have never been estimated for Tennessee's reservoir resources. Benefit estimates are obtained through application of the Travel Cost Method (TCM). The TCM assumes that the price of the commodity, recreational fishing, can be estimated as the cost incurred when traveling to and from the site. Empirical models of consumer behavior may then be employed.

Tennessee has a large number of reservoirs from which an angler may choose (approximately thirty sites statewide), each with differing quality levels and characteristics. Given the large number of potential substitute sites, the TCM modeling

strategy chosen was the Random Utility Model (RUM). RUM models focus on the factors which influence the choice of the recreational site, as opposed to the continuous demand TCM model which estimates the number of trips an angler will make. RUM models are, however, sensitive to the analyst's specification of the set of choices available to a consumer. Including or excluding a relevant alternative can substantially impact a study's conclusions. The Tennessee Wildlife Resources Agency divides Tennessee into four administrative divisions, providing a natural starting point to test model sensitivity to the set of reservoirs available to anglers. Model sensitivity will be further evaluated by grouping reservoirs based on the observed choices by anglers. For this reason, analysis of reservoir use and the corresponding values for reservoir quality will be calculated on a regional basis, as well as statewide.

Random Utility Models will be estimated regionally and statewide to determine the value that anglers place on reservoir quality. The model predicts the probability an angler will choose one site over another as a function of the travel cost to the reservoir and reservoir quality. Then the value of a quality change to an angler on a single trip can be calculated.

Random Utility Models will not yield an aggregate value of the unaltered resource, but will only give the value of a specific quality change per trip to an individual angler. A

rough measure of aggregate value can be calculated by multiplying estimated per trip benefits by the estimated number of trips in a single season to obtain an aggregate value of a quality change. This aggregate value is then appropriate to give to policy makers to aid in their decision making tasks.

1.3 Research Outline

A brief outline of the remainder of this thesis is given as follows. **Chapter two** contains the theoretical basis for the models. **Chapter three** details the data collection process. **Chapter four** reports the results from the empirical models. **Chapter five** is a summary of the research process.

CHAPTER TWO

The Travel Cost Method and the Value of Quality Change

2.1 Introduction

Because there are no observable markets present, the value of recreational resources is difficult to determine. There are, however, two distinct approaches which can be used to estimate the value. These are the direct and indirect methods of measuring the consumer's value for the good or service. With the direct method, the consumer is simply interviewed and asked what amount of one good they would give up to get an amount of another. Indirect methods are quite different, however. These methods use information about actual behavior, which is acquired in a variety of ways, to obtain or infer values of goods and services to consumers. The travel cost method has been the primary indirect method used to value recreation resource quality. This modeling strategy recognizes that out of pocket travel expenses and time spent in transit to and from the recreational site represent an implicit price for access to the resource.

Two types of travel cost models are summarized here. Continuous Demand Models try to establish a demand curve for recreational sites and services. The demand curve shows the relationship between the number of trips made to a recreational site (within a given time period) and the factors believed to influence trip-making behavior. These factors

include the cost of travel to and from the site, the travel cost to substitute sites, and the various measures of site quality. Random Utility Models, in contrast, focus on the selection of a single site for a single visit. Site selection is hypothesized to be influenced by the cost of site access (i.e., travel cost) and site quality variables. For reasons outlined in the following sections the RUM model does a better job than the continuous TCM in incorporating the effects of substitute sites.

This chapter first reviews the theoretical base for travel cost models, in general, then examines the continuous travel cost model and its associated benefits measures in detail. The problems introduced by substitute sites are outlined. Random Utility Models are then presented, along with welfare (benefit) measures which can be determined from this modeling strategy. The advantages and disadvantages of RUM models are then presented.

2.2 Measuring The Demand For Recreational Sites And Site Quality

The travel cost method came about because of the need to value recreational benefits accruing from the development of new recreational sites. This problem was originally addressed in a letter to the National Park Service in 1947 by Harold Hotelling. The letter suggested a method for measuring benefits at recreational sites by measuring demand based on travel cost. Because an individual gets utility from consuming a recreational service, a connection can be made

between an individual's demand for recreational services and the demand for recreation sites. Prior to Hotelling, the benefits to be derived from a new site were thought to be intangible.

Modern recreational demand models have focused on valuing existing sites with similar characteristics, and often involve the problem of site substitution. As various features and characteristics influencing recreational activities at different sites are identified and measured, there has been a better ability to explain why one individual might have a different demand function for two different sites (Smith, 1989). This is why the physical and service attributes of a recreational site (physical attributes being things such as size or quality and service attributes being things such as congestion or the like) should be distinguished from one another. It is also why there must be more accurate site definition in these models.

The notion of the travel cost recreational demand models can be described through a household production framework. By using this framework, the connection between the demand for recreational services and the demand for recreational sites can be explained.

The household production model states that an individual gets utility from services produced using time, market commodities, and environmental resources. The associated utility function is specified in terms of service flows. A

simplified model is shown in **Equation 2.1**.

$$U=U(S_o, S_r) \quad \text{Eq. 2.1}$$

In this equation U = utility, S_r = recreational service flows, and S_o = all other service flows (Smith, 1989).

The model hypothesizes that recreational service flows will be produced by combining marketed recreational goods, on site recreation time per visit, and the number of visits to the site. This can be specified in **Equation 2.2**.

$$S_r = f_r(X_r; T_1, \dots, T_n; d_1^1, \dots, d_{T_1}^1, d_1^2, \dots, d_{T_2}^2, d_1^n, \dots, d_{T_n}^n) \quad \text{Eq. 2.2}$$

This equation requires S_r = recreational service flow, X_r = marketed recreational goods, T_j = trips to site j , and d_l^j = duration of time on site, with j designating site, and l ($l=1 \dots T_j$) designating the specific trip to site j (Smith, 1989). Specifying S_r in this way implies that the time horizon must be long enough to allow multiple visits to different sites. However, RUM models which are based on this framework can circumvent this restriction by incorporating substitute sites into a modelling structure to determine site selection. The model will usually specify non-recreational service flows (S_o) in simple terms because they make up only a small part of the analysis.

The rest of the model is made up of budget and time

constraints. Total or full income of the individual, Y_i , will be the budget constraint, and can be specified as wage plus non-wage incomes, as shown in Equation 2.3.

$$Y_i = (I^w + I^t + I^o) \quad \text{Eq. 2.3}$$

This assumes I^w = wage income, I^t = income from transfer payments or the like, I^o = income from other sources, and i designates the individual. Income can be spent on goods used in recreation and those that do not produce recreational service flows. Total time available to the individual, H_i , is made up of labor and pleasure time. Equation 2.4 shows this breakdown.

$$H_i = (d^l + d^p) \quad \text{Eq. 2.4}$$

This stipulates d^l = duration of time spent on labor, and d^p = duration of time spent on pleasure. Thus, there must be an inherent trade-off between duration of labor time and duration of pleasure time, when it is assumed that all individuals must spend some positive amount of time duration on labor (Harrington and Portney, 1987).

The cost of the trip to the recreational site will include the vehicle-related travel cost of time, the opportunity costs, and any entry fees. However, by specifying the trip cost this simply, the opportunity costs of different types of time are not defined, but will generally be specified

as some fraction of the wage rate.

This has resulted in some modifications to the specified simple model relating to the descriptions of the opportunity cost of travel time. One modification was the proposal to separate travel costs and time costs in the demand function, with the time costs being priced at the wage rate. The second modification is the argument that the time constraints facing an individual should be determined because of the effect of work time flexibility on the individual's opportunity cost of time.

Individuals may have different demand functions for different recreational sites because the features or characteristics of the recreational site may affect the recreational activities produced there. When describing these characteristics, the physical attributes, such as size or quality must be distinguished from the service attributes, such as congestion, at the specific site. The site demand parameters may be viewed as functions of each specific site's characteristics because the household production framework increases the influence of a site's services based on the site's own characteristics.

The three central elements to the household production framework are: the individual's utility, the service flows producing that utility, and the budget and time constraints of the individual. The model's activities can be specified as the services that the household produces, with the services of

a recreation site (its characteristics) serving as an input into that production process. This implies the travel cost demand model is a derived demand for the services of a recreational site.

Within the scope of these travel cost methods are the traditional (continuous) travel cost demand model and the random utility (site selection) model. The essential difference between these two models is the assumed time frame for household production decisions. The continuous model usually consists of the number of trips within a specific time frame, while random utility models are based on a single visit time horizon. Both methods generally hold on-site time constant. The demand functions can include separate travel costs and cost of time (generally using the wage rate as the price of time), and assume a consumer must visit a site to use its resources.

2.2.1 Recreational Demand Modeling

2.2.1.a Continuous Travel Cost Models

The continuous travel cost approach models demand for a site's services over an extended period of time, such as an entire season. This is usually done by estimating a demand curve for trips to a recreational site by an individual. A Hicksian demand function holding utility constant is desirable for benefit estimation but a Marshallian function is all that can be estimated without adding more restrictions on preferences. The individual's Marshallian demand curve is a

function of the individual's price to get to the recreational site, the recreational site's quality characteristics (physical and service attributes), and the individual's income, while holding duration of time spent on site constant. The Marshallian function is given in **Equation 2.5**.

$$T_{ij} = f(P_{ij}, Q_j, Y_i) \quad \text{Eq. 2.5}$$

This function requires T_{ij} = trips to recreational site j by individual i , P_{ij} = price or travel cost to recreational site j by individual i , Q_j = site quality characteristics of recreational site j , and Y_i = individual i 's income. This is actually the derived demand for trips which is necessary to produce the recreational service flow, S_r . Trip demand is measured here because it can be empirically measured, while measurement of recreational service flows is not yet possible. This trip demand can then be used as a proxy for S_r .

Site quality characteristics, Q_j , act as shifters of the travel cost demand curve. Improvements in site quality would, all else equal, increase the number of visits at any given travel cost. Deteriorating site quality would lead to decreased visitation. It is this type of response that permits recovery of an estimate of the value of changes in site quality.

2.2.1.b Welfare Measures From Continuous Travel Cost Models

In the continuous travel cost model, welfare measures can be calculated by measuring the area under the travel cost

demand function. The "access value" of a recreational site is the use value of the site to an individual. An "exact" welfare measure is calculated as the area under the Hicksian demand curve for the site, where the Hicksian demand is the utility constant demand curve associated with site use. This measure is denoted in **Equation 2.6**.

$$\begin{aligned}
 W &= \int_{P^0}^{\tilde{P}} \frac{\partial e}{\partial P} = \int_{P^0}^{\tilde{P}} X^h dP \\
 &= e(\tilde{P}, Q^0, U^0) - e(P^0, Q^0, U^0)
 \end{aligned}
 \tag{Eq. 2.6}$$

In this equation W = willingness to pay, P^0 = current trip price, $\tilde{P}$ = choke trip price, X^h = compensated Hicksian demand, U^0 = the reference utility level and $e(P, Q, Y)$ denotes the corresponding expenditure function. The willingness to pay (welfare measure) for this price change can be defined as a compensating variation. Compensating variation measures the change in income that leaves the consumer at the point of indifference (between the price change of the resource and the original level of utility), subsequent to the actual price change. This access value can be graphically represented as the area under the Hicksian demand curve between P^0 and $\tilde{P}$, which is shown by the shaded area in **Figure 2.1**.

The value of a quality change is done in much the same way. Suppose site quality improves from Q^0 to Q^* , shifting the Hicksian demand curve from $X_{Q^0}^h$ to $X_{Q^*}^h$. The value of the

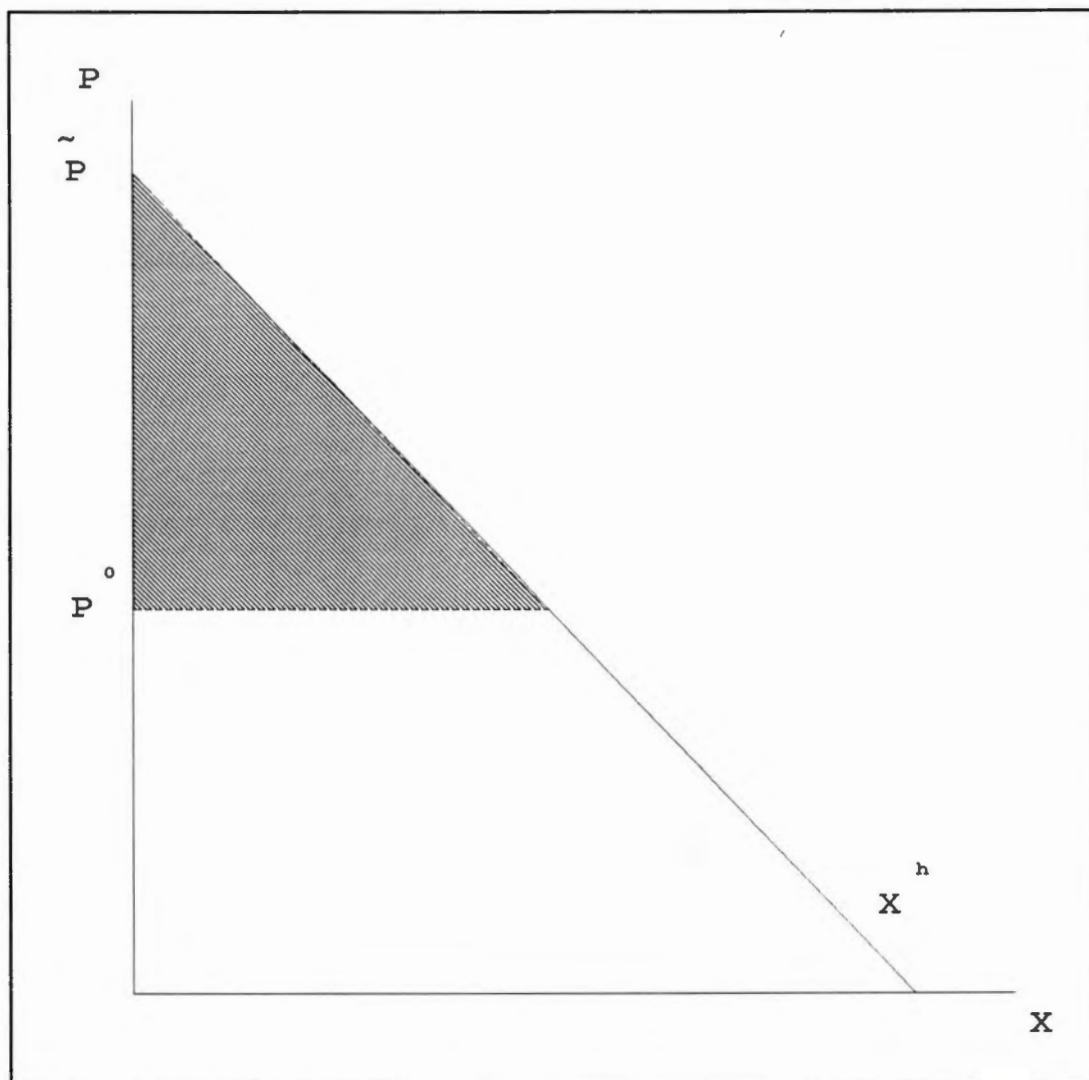


Figure 2.1 Welfare Measurement: Recreational Site Access Value

quality change (compensating variation) is simply calculated as the difference in access values at the respective quality levels. In this case the area between two Hicksian demand curves (one function for Q^0 and the other for Q^*) is calculated above P^0 . This quality measure is given in **Equation 2.7**.

$$\begin{aligned}
 W &= \int_{P^0}^{\tilde{P}} X^h(P, Q^*, U) dP - \int_{P^0}^{\tilde{P}} X^h(P, Q^0, U) dP \\
 &= [e(\tilde{P}, Q^*, U) - e(P^0, Q^*, U)] - [e(\tilde{P}, Q^0, U) - e(P^0, Q^0, U)] \\
 &= e(P^0, Q^0, U) - e(P^0, Q^*, U)
 \end{aligned}
 \tag{Eq. 2.7}$$

This measure assumes Q^0 = original quality level, Q^* = changed quality level, and $e(.)$ represents the expenditure function (Bockstael, et. al., 1991). W measures the value of change in site quality; depending upon the reference utility level, it will be a measure of a compensating variation (initial level) or equivalent variation (subsequent level). W can also be shown graphically as the shaded area in **Figure 2.2**. This welfare measure requires two restrictive assumptions. First, the consumer must have equivalent substitute goods with which they can be compensated in return for, or instead of, the recreational site. This implies that the recreational good is non-essential, and implies that the compensating variation or equivalent variation will be finite. The second assumption

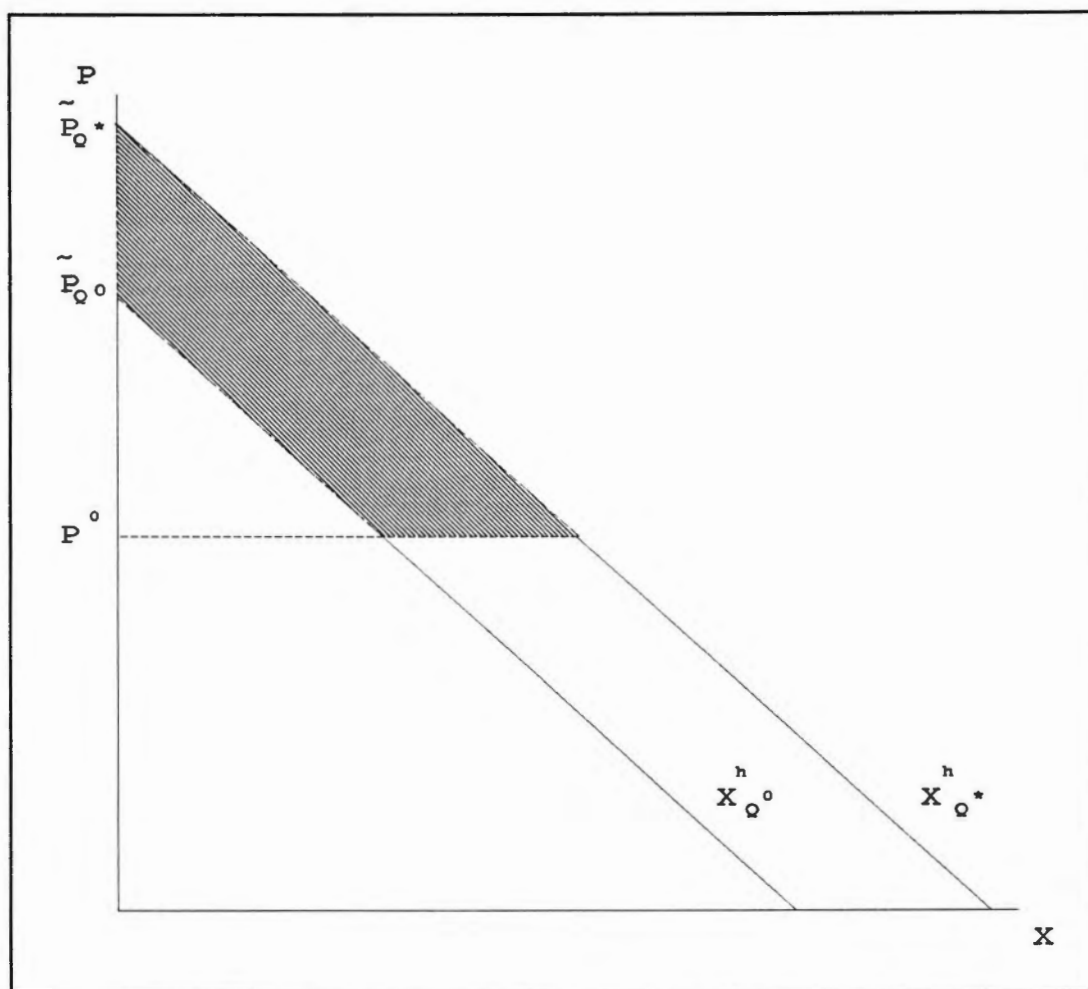


Figure 2.2 Welfare Measurement: Recreational Site Quality Change Value

is that weak complementarity holds. This requires the marginal utility of quality changes ($\partial U/\partial Q$) to equal zero when the quantity demanded by the individual is zero. In other words, if there are no trips made to the site (demanded) then the individual will gain no benefit (i.e. have no welfare) from the site ($T=0 \rightarrow \partial U/\partial Q=0$).

When the quality of a recreational site is changed, the change in the area under the Hicksian demand curve is an exact welfare measure (the compensating variation). However, the Marshallian demand curve is often the only demand curve available to an analyst, so its welfare measure, consumer surplus, is used. Consumer surplus is only an approximation of the true (exact) welfare measure, however, because Marshallian welfare measures do not hold utility constant.

To determine if the Marshallian measure is the appropriate measure to use or not, the discussion now turns to the role of income effects. As already stated, the welfare calculations are most often made using a Marshallian demand function, but how reliable an approximation will this be is not known a priori. One needs to know when the compensating variation is equal to the consumer surplus.

This can also be shown in another fashion through the use of the Slutsky equation for a price change's effect on the Marshallian demand function. The Slutsky equation is given in **Equation 2.8**.

$$\frac{\partial X^m}{\partial P_x} = \frac{\partial X}{\partial P_x} \Big|_{\bar{v}} - X \frac{\partial X}{\partial Y} \quad \text{Eq. 2.8}$$

The left hand side of the equation is the slope of the Marshallian demand function. The right hand side is composed of the substitution effect (the slope of the Hicksian demand curve), $\partial X / \partial P_x \Big|_{\bar{v}}$, and the income effect, $X \partial X / \partial Y$. The difference between the Marshallian and Hicksian functions is attributable to the income effect. When there are no income effects present then the Marshallian and Hicksian measures are equivalent. This means that a small income effect will only produce a small difference between the Marshallian and the Hicksian measures. Graphically, the difference between the Hicksian and Marshallian demand functions can be shown in **Figure 2.3**. The lighter shaded area below the Hicksian demand function but above the Marshallian demand function is the welfare resulting from the substitution effect, whereas the darker shaded area below the Marshallian demand function and above P^0 is the welfare from the income effect. The entire shaded area is the total welfare measure.

According to Bockstael, et al., whether or not the income effects that are present in recreation demand are small depend upon the exact resource in question. Many recent recreational studies have failed to show a coefficient on income that is significantly different from zero. It appears that in most recreational activities, income tends to distinguish whether

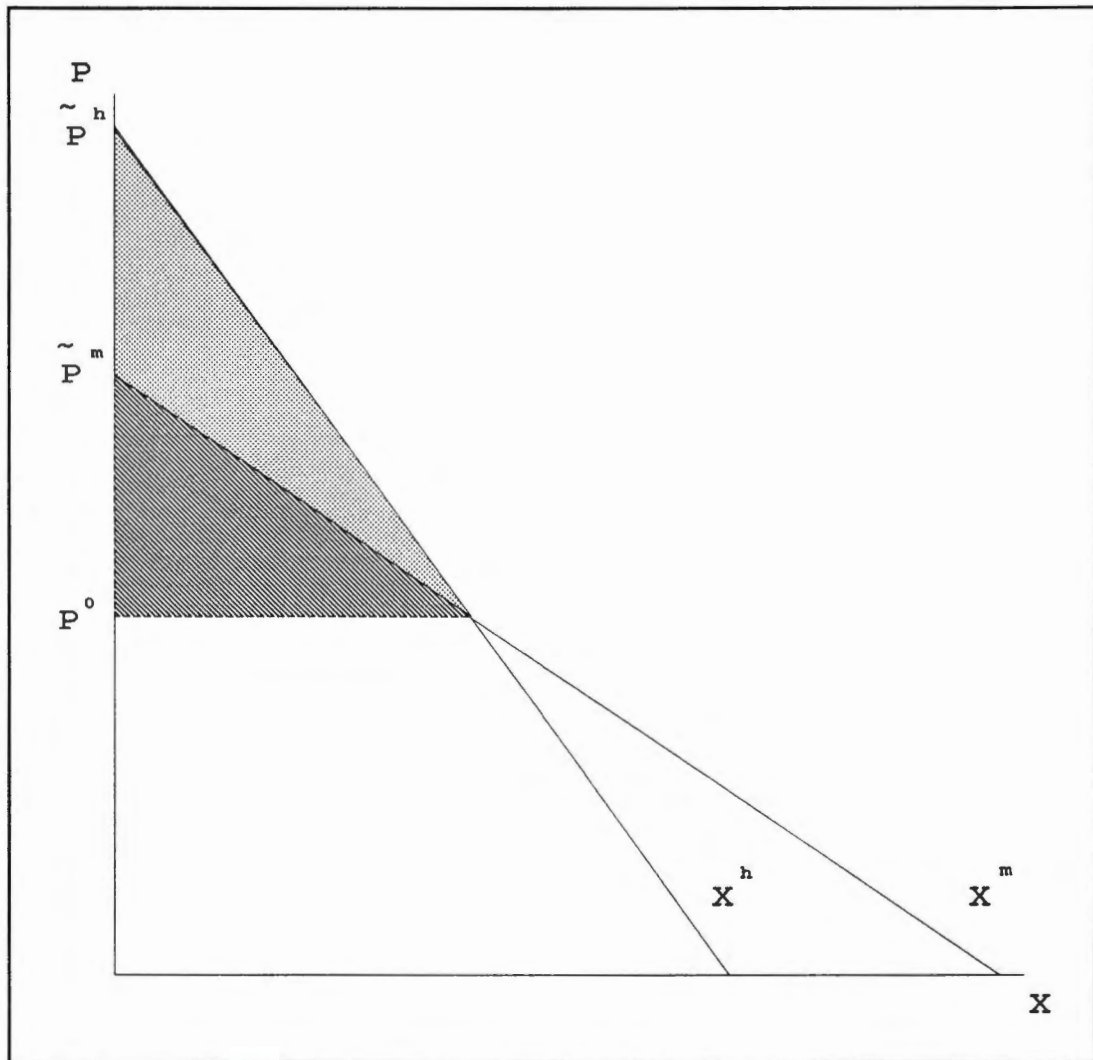


Figure 2.3 **Income Effect: Difference Between Marshallian Demand and Hicksian Demand**

or not an individual is a participant, rather than determining or affecting the amount of recreational activity that is demanded by the individual. As far as income changes go, this means that as long as a participant's income remains above a given threshold they will continue to be a participant and the quantity demanded of the recreational activity will not change due to changes in income. However, until a non-participant's income reaches the given threshold, their quantity demanded of the recreational activity will remain at zero.

2.2.1.c Problems With Continuous Travel Cost Models

The major problem with the continuous travel cost model is its inability to consider all of the variables influencing demand, particularly the role of substitute sites. A better model will recognize that an individual values a wide range of recreational experiences expressed not only by the number of trips taken but also by the substitute sites considered. The problem is that the analyst has no way of knowing the appropriate set of substitute sites considered by an angler.

Bias can arise from omitting these substitute site prices and their characteristics. Bias is present when the expected value of a random variable is not equal to its actual value, or $E[\hat{\beta}] \neq [\beta]$.

Where the random variable is the estimate of compensating variation, Kling (1989) has shown that compensating variation will be biased under a variety of conditions related to the substitute site prices and quality. We are particularly

interested in the bias associated with welfare measures derived for a change in site quality. Table 2.1 summarizes Kling's results, which hinge on the order in which the integration of the Hicksian demand curves occurs.

Table 2.1 Determination of Welfare Measure Bias Based on Substitute Site Price and Quality Conditions

Own Price - Omitted Price Correlation	Change in Quality	Biased - ?
1) Uncorrelated	Single-Site	No
2) Uncorrelated	Multiple-Site	Yes
3) Perfect	Single-Site	Yes
4) Perfect	Multiple-Site	No

Kling assumes there is zero correlation between site qualities and that weak complementarity holds. In case (1), the effect of the omitted substitute site price and quality measures are subsumed by the intercept of the demand model, so no bias to the welfare measure occurs. In case (4), both prices are perfectly correlated and the own-price coefficient captures the cross price effect as well, so the welfare measure remains unbiased. In case (2), however, each Hicksian demand incorrectly holds (omitted) substitute site quality constant, so the compensating variation measure is biased. Finally, in case (3), omission of a correlated substitute site price will bias the own-price coefficient, biasing the resulting benefit estimate.

Problems remain even after attempting to adjust for bias

in the welfare estimate by including prices and qualities of the relevant substitutes. This is because the individual's expenditure function will become more of a non-linear function of the demand parameters (Smith, 1993). To alleviate these and other problems, site selection models have been devised which allow the incorporation of site substitution effects to play the major role in measuring the individual's benefits.

2.2.2 Site Selection Modeling

2.2.2.a Random Utility Models

There have been several other models proposed which help deal with the influence of other sites and their characteristics. One of the more frequently used is a second type of travel cost model, the random utility model (RUM). This modelling structure focuses on the choice among substitute sites on any given trip, and is a step removed from the continuous travel cost demand approach. First, the simple RUM assumes a single trip time horizon and cannot explain the total number of trips that an individual might take over a period of time. Second, this model works in a total utility maximizing framework, rather than optimizing at the margin. The individual is assumed to choose the site which yields the greatest level of utility for a given trip occasion. Given n possible sites, such a choice is shown in **Equation 2.9**.

$$V(Y, P_a, Q_a, \dots, P_j, Q_j) = \text{Max}[V_a(Y, P_a, Q_a), \dots, V_j(Y, P_j, Q_j)] \quad \begin{array}{l} \text{Eq.} \\ 2.9 \end{array}$$

This function stipulates Y = income, P = travel cost, Q = site quality, a = selected site, j = all other site choices ($j=1\dots n$, $V_j \neq a$), and V = indirect utility function (Bockstael, et. al., 1991). This means that the consumer maximizes utility (influenced by the individual's income, site costs, and site qualities) by choosing the site which yields the most utility. However, all of the factors influencing the individual's decision are not known to the researcher, and the model must contain a random element. This random element encompasses all site characteristics, site quality measures, and individual attributes which influence the site selection, but are not included in the model. It is, however, random only from the analyst's perspective, not the consumer's. We re-write the model with this random error, ϵ , as specified in **Equation 2.10**.

$$E V = E \text{Max}[V_1 + \epsilon_1; V_2 + \epsilon_2; V_3 + \epsilon_3; \dots; V_n + \epsilon_n] \quad \text{Eq. 2.10}$$

After re-writing, the total utility is now a random variable, and all arguments of $V_j(\cdot)$ are suppressed.

With the model in this form, we can now use probabilistic choice methods to estimate the parameters of the RUM model. In the two site choice, the probability that the recreationist will choose site 'a' over site 'n' is given in **Equation 2.11**.

$$\text{Prob}(a) = \text{Prob}[V_a(Y, P_a, Q_a) + \epsilon_a > V_n(Y, P_n, Q_n) + \epsilon_n] \quad \text{Eq. 2.11}$$

This states that the probability of selecting site 'a' is equal to the probability that utility derived from site 'a' is greater than the utility derived from substitute site 'n'.

This model has a number of binding assumptions that go along with it, however. These include a time span of only a single trip, independence of decisions across trips, and utility from each site is conditional on having selected the site. There is an additional error term in this model which will vary by individual, or by recreational site, which reflects all other outside factors that might influence the individual's site choice. The errors are assumed to be independently and identically distributed as a type I extreme value distribution from the family of Gumbel distributions.

The indirect utility function is usually a function of, site characteristics, the site price, and income. Although a normal distribution could be used, the model becomes empirically intractable with a large number of choices. Assuming a logistic distribution for the errors, ϵ , results in a multinomial logit model. The probability of choosing site 'a' can be expressed simply, as shown in Equation 2.12.

$$Prob_i(a) = \frac{e^{V_{ai}}}{\sum_{j=1}^n e^{V_{ji}}} \quad \text{Eq. 2.12}$$

This designates V = indirect utility function, a = selected

site, i = individual, and j = number of choices (Smith, 1989), where the arguments of the indirect utility function include price, quality, and income. This estimation of the multinomial logit model yields the parameters of the indirect utility function which allows a proper transition into the calculation of welfare measures.

2.2.2.b Welfare Measures From The Random Utility Model

When site substitution influences are important to explaining a consumer's behavior, the RUM model is more effective than the continuous model, because it allows for a wide range of alternatives, and allows site characteristics to play important roles in influencing consumer choice. Because these models do not come from an estimated demand function, welfare measures can be calculated directly from the estimated parameters of the indirect utility function (welfare measures are based on utility, not quantity demanded).

The welfare measure calculated from a RUM model is the willingness of a consumer to pay for a quality change at a recreational site such that the individual is left at the point of indifference. Letting the compensating variation of the quality change at site j from Q_j to Q_j^* be denoted by C , compensating variation can then be shown in **Equation 2.13**.

$$V_{ij}^*(P_{ij}, Q_j^*, Y_i - C) + \epsilon_i^* = V_{ij}(P_{ij}, Q_j, Y_i) + \epsilon_i \quad \text{Eq. 2.13}$$

This means V_{ij} is equal under both levels of quality. The associated error terms in this case, ϵ_j and ϵ_j^* , can be equal,

but this is not necessary.

However, the analyst does not always know which specific site will be chosen. This becomes a problem when the quality change occurs at a site which is not chosen. For example, when there is a change in quality at site j , but the individual consumer still chooses another recreational site, there will be no gain for the individual consumer. This is the result of our weak complementarity assumptions and implies that $\partial V / \partial Q_j = 0$ if site ' j ' is not chosen.

For the compensating variation to be correct it should take into account the analyst's uncertainty about the site chosen by the individual. Utility is measured by the maximum of the expected values of the indirect utility functions being compared as shown in **Equation 2.10**. The welfare measure can then be expressed in **Equation 2.14**.

$$E[V(P, Q^*, Y-C)] = E[V(P, Q, Y)] \quad \text{Eq. 2.14}$$

This specifies $E[V(P, Q, Y)]$ as the expected maximum of all the possible indirect utility functions.

If the marginal utility of income is constant, and the logistic distribution is assumed, compensating variation is calculated as specified in **Equation 2.15**.

$$C = \frac{\ln\left\{ \sum_{j=1}^n \exp[V_j(Q^*)] \right\} - \ln\left\{ \sum_{j=1}^n \exp[V_j(Q^0)] \right\}}{\gamma} \quad \text{Eq. 2.15}$$

For the measure specified here, γ is the income coefficient, or the marginal utility of income (Hanemann, 1982), with price and income being suppressed for clarity. If the marginal utility of income is not constant, but varies by alternative, we can recover only a close approximation of the true compensating variation, which is shown in **Equation 2.16**.

$$C \approx \frac{\sum_{j=1}^n \exp[V_j(Q_j^0)] - \sum_{j=1}^n \exp[V_j(Q_j^1)]}{\sum_{j=1}^n \gamma_j \exp[V_j(Q_j^1)]} \quad \text{Eq. 2.16}$$

Both measures give the compensating variation for one choice occasion only. A graphical representation of 'C' is shown in **Figure 2.4**.

There are additional implications from using **Equation 2.15** or **Equation 2.16** to arrive at the compensating variation. If the specified quality change occurred at a recreational site which has a low probability of being selected by the individual, even after the quality change, then the compensating variation for the individual will be small. If probability is higher, the compensating variation will naturally be larger. This is an appealing trait of the model.

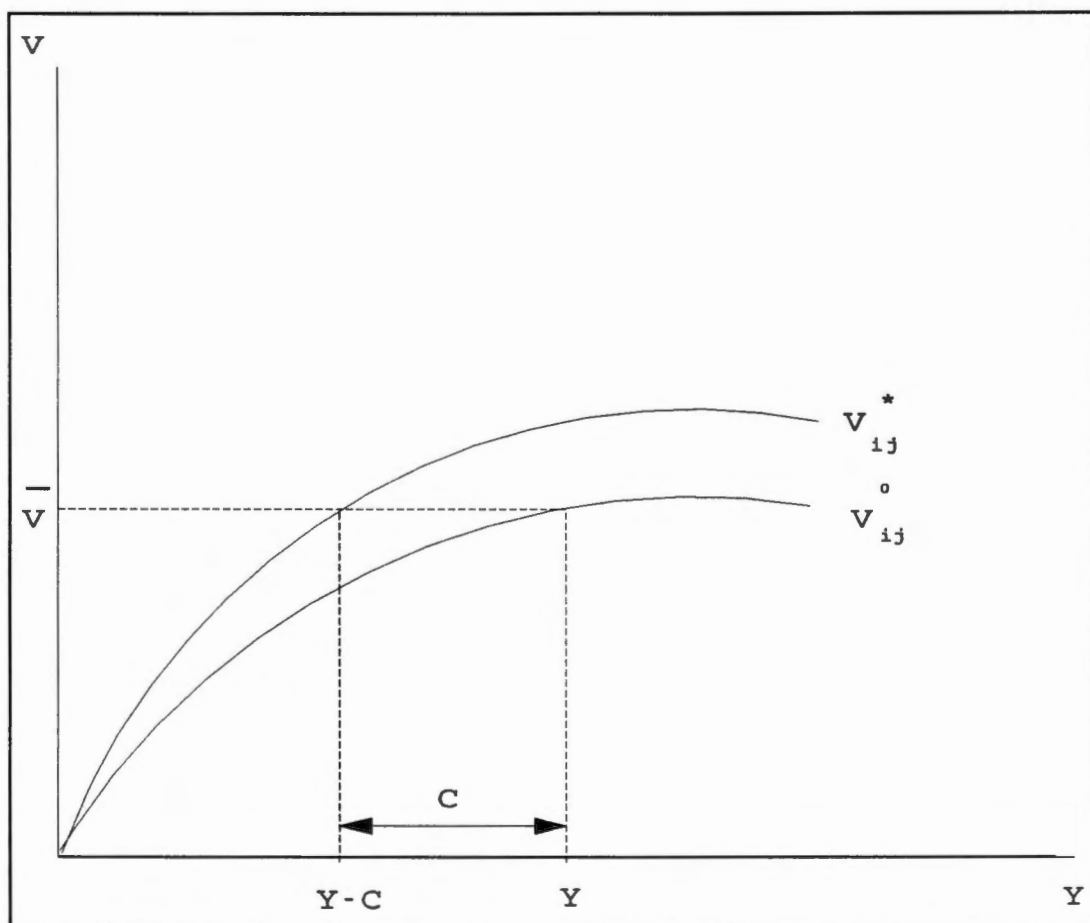


Figure 2.4 Welfare Measurement: Recreational Site Quality Change Value Calculated from the Change in the Indirect Utility Function

2.2.2.c Problems With The Random Utility Model

Although RUM models are limited to single choice occasions, they do work very well with site selection issues. Nonetheless, the multinomial logit model has a major drawback because it restricts itself to the assumption of the Independence of Irrelevant Alternatives (IIA). This assumption implies that the odds of choosing any alternative pair of sites (the ratio of the probabilities) is constant, no matter what happens to all other substitutes. In other words, the probability of choosing one site over another, will depend only upon the characteristics of these two sites, and will not be influenced by any other available alternatives.

This restriction may be overcome by using the Generalized Extreme Value model. This turns the multinomial logit model into a nested multinomial logit model. This involves a stepped decision making process, such as whether or not to take a trip, what trip to take, and then what the destination will be. While some studies will include the alternative of not taking a recreational trip as one alternative in a group of several, this will clearly violate the assumption of the independence of irrelevant alternatives, and if this option is included, the assumption must be relaxed (Bockstael, et al., 1991). This restriction can also be overcome by using a multinomial probit model assuming a normal distribution which does not suffer from this restriction. The extensive calculations that go into a multinomial probit model make it

prohibitive with more than five or six choices, so the multinomial logit model is frequently the only option. The IIA restriction, however, can be tested to determine the validity of the multinomial logit modeling strategy.

2.3 Applying Travel Cost Models to Tennessee Reservoir Angling (TCM vs. RUM)

As previously discussed in preceding sections the continuous TCM method estimates a trip demand function, whereas, a RUM model estimates the probability of choosing one site over all others. Tennessee and the surrounding area has approximately thirty major reservoirs which represent potential substitute sites from which anglers may choose. The density of reservoirs increases from west to east in Tennessee, with the eastern third of the state containing about half the reservoirs. Most anglers visit reservoirs within 100 miles of their residence, (mean of 32.6, standard deviation of 26.8 miles) so that most anglers have more than one, and frequently three or four, reservoirs within easy driving distance. However, considering the size of the state of Tennessee, an angler would not consider all reservoirs in the state, only a certain group of the reservoirs. This means there must be some issues raised as to the grouping of reservoirs into choice sets (regionality) to determine the full extent of the market. Because RUM models handle site substitution issues relatively well, it is an appropriate method to model angler reservoir choices.

CHAPTER THREE

Data Collection

3.1 Angler Survey Data

The data used in this paper were collected through a state-wide telephone survey of Tennessee anglers in November of 1992. Tennessee has approximately 542,000 annual fishing license holders with 92% of those being combination hunting/fishing license holders and the remaining 8% being sportsman's license holders (a sportsman's license allows for a wider variety of sporting, mostly hunting, activities). The sample taken to collect this data reflected this break-down between license holders and contained 1838 combination license holders and 162 sportsman's license holders. From this sample 949 names were matched to telephone and address listings and of those there were 78 unusable, which left 871 usable telephone listings.

After attempting to make contact a minimum of five times, 79 were unable to be contacted. Of the remaining 792, 80 people hunted exclusively and could not complete the angling survey. Of the 712 eligible respondents, 67 refused to be interviewed, yielding a raw response rate of 91%. A total of 645 interviews were completed with anglers, but only 506 of those were presently holding a license. Among license holders, only 450 had actually fished in 1992. This decline from 645 to 450 can be attributed to a wide variety of reasons

varying from loss of interest in fishing to a lack of time to pursue the sport. Of these 450 active and licensed anglers who make up the final sample of anglers, there were 363 reservoir anglers whose responses were used for this thesis. The telephone survey was cost effective, accurate, easily conducted, and had a high response rate.

3.2 Data Requirements

Relative to in-person or mail surveys, a telephone survey must address four clear needs. These needs consist of (1) getting a completed survey of a representative sample, (2) getting answers to all of the questions that need to be asked, (3) getting accurate answers to those questions, and (4) meeting the administrative requirements (i.e. cost, staffing, implementation, etc.). The issues surrounding these methods can be addressed by analyzing the characteristics within each of these four needs. Although each need will be addressed in detail with respect to each survey method in **Section 3.3.1** through **Section 3.3.4**, a summary appears in **Table 3.1**.

3.2.1 Obtaining Surveys From A Representative Sample

Completing a representative survey is not an easily achieved task. The first question is whether or not each member of the population has an equal chance of being included in the sample. Telephone and mail surveys are based upon a list that has been acquired, and may introduce potential problems if the actual list does not come straight from the actual population. These problems include not being on the

Table 3.1 Characteristics of Survey Methods

	In-Person	Mail	Telephone
1) Representative Sample	Tend to Get Most Active	Good	Good
2) Minimal Survey Non-Response	N/A	Poor	Good
3) Accuracy	Good	Poor	Good
3a) Minimal Recall Problem	---	---	---
3aa) Discrete	Good	Good	Good
3ab) Continuous	Best	Poor	Good
3b) Minimal Item Non-Response	Best	Poor	Better
4) Survey Cost	Most Expensive	Least Expensive	Moderate

list, being on the list more than once, the list being out of date, or the list containing incorrect information. This is not as much of a problem as it had been in the past with the advent of random digit dialing, but with small limited surveys (such as a local or limited application as in this study's case) the problem is still present. Most in-person interviews are based on area probability sampling, however, and this does not pose a problem for the in-person method (Dillman, p. 43). The sample taken to collect these data was random and was taken from the yearly licensed population, but it did rely on a telephone listing to obtain the individual's telephone number. We are forced to assume that those for whom no telephone number could be obtained were part of a complete homogeneous sample and not unlike those individuals whose

telephone numbers were obtained.

The next issue the researcher can control is the selection of subjects within the sample. To avoid bias the researcher would need to insure that problems such as interviewing only those who might just happen to be at home at the time of the interview will be avoided. Each of these methods are able to implement selection procedures quite easily in order to meet this criteria (Dillman, p. 45). There was an attempt to alleviate this problem in these data since there were repeated attempts made to contact specific individuals.

A closely related action that must be taken to get a representative sample is for the subject to be located. This is a major problem with in-person interviewing and can be time consuming and expensive. However, with the telephone interview repeated return calls can be done quickly and inexpensively. There still remains the problem of getting by any "gatekeeping" devices the subject has constructed that will be associated with both methods (Dillman, p. 46). Mail surveys are not as prone to these problems and can be used more effectively here.

A major point with all types of surveying is whether or not the desired response rate can be reached. Because of the different ways in which these rates can be calculated, and made to appear to give various results, this is sometimes a questionable approach for determining a method's quality.

However, as a general rule, one can expect about 80% - 90% from in-person, about 70% or a bit higher for mail, and around 85% for telephone, when the rate is computed based on the percentage of contacts made (Dillman, p. 51). The actual data used here had a relatively high response rate at about 90.6%, which is good for this type of survey.

Another closely related problem is refusal bias, but this may pose less of a problem when all members of the group have characteristics that are closely similar. If there are a large number of refusals, some indirect methods may be used to determine whether or not there is any difference between those who respond and those who refuse, but usually the extent of the differences cannot be determined. This remains a problem for all methods and no method has any special quality which makes it any better than the others (Dillman, p. 53). There was a low refusal rate for this recreational survey, which is encouraging and should indicate a low refusal bias.

3.2.2 Getting The Questions Answered

Obtaining responses to all questions is an important matter and careful consideration must be given to the characteristics of the particular method chosen. The length of the survey is a critical factor when it comes to subjects completing the survey and giving accurate answers and the length will introduce interview termination problems. The in-person surveys are much more effective when the length of the interview increases. Telephone and mail surveys can, however,

utilize follow-up interviews or other such methods to collect additional information with little additional cost over a single lengthy interview.

The types of questions that can be asked for the methods differ though. With in-person interviews the researcher can pose more complex questions or questions that will tend to be boring or tedious. This is not the case for the telephone or mail surveys, and the questions employed in this survey were not complex or tedious. Both in-person and telephone survey methods can, however, make use of open-ended and screening questions, and both can use question sequencing and other tools to avoid problems of non-response. These tools were used in this survey application. Mail surveys tend to have larger problems in this area because people tend to respond only to what they want to respond to more often (Dillman, p. 54).

Greater attention must also be given to question construction procedures with mail and telephone surveys because the interviewer is more restricted in compensating for the survey's imperfections (Dillman, p. 54). Questions must be designed so that the subject can answer. There is also a need to know if the subject even knows the correct answer and how well that answer can be remembered (Casley and Lury). Appropriate question construction was used in this survey, and an attempt was made to use simple, discrete, and direct questions. However, with regard to specific enumerative

variables, such as the number of reservoir trips taken, there are problems due to recall error.

The prevailing notion here is to make the benefits of responding greater than the costs, or to have a net gain to the subject (Dillman, p. 14). For this study, one would expect anglers to be interested in and respond to an angling survey because of a hope that their response would improve management of fisheries resources. This will also help insure an adequate response rate to the angling survey. This introduces the possibility of bias because anglers who fish more avidly might be more likely to respond than those who fish less.

3.2.3 Accuracy Of Survey Question Answers

Obtaining accurate answers is crucial to any survey attempt. There is a large difference between getting answers and getting accurate data. A common problem in this area is for the subject to give the interviewer a "socially desirable answer": the response that the subject thinks the researcher wants to hear. This is a major problem with in-person interviews because the interview is very interpersonal. However, if the interviewer is removed from the scene, as in mail and telephone surveys, the interpersonal contact is less and decreases the probability that this problem would occur (Dillman, p. 62). For angling surveys such as this, there may not be a particular socially desirable answer, thus this may not pose a large problem for this survey.

Other problems that tend to affect the accuracy of the data might possibly come from the interviewer. This may arise from the way in which the survey is presented from subject-to-subject, from interviewer-to-interviewer, by the interviewer's negligence and inattention to detail throughout the interview, and the interpretation of questions by respondents. Such problems are controlled more easily with mail and telephone surveys than with in-person surveys. The telephone survey also tends to lessen the effect of influence of other people, or data contamination, upon the responses (Dillman, p. 64). With surveys being conducted by professional survey research firms (as was done with this survey), there is a reduced probability of interviewer bias.

All survey methods are subject to recall error and measurement error. Mail surveys are particularly subject to these problems. When attempts are made to alleviate these problems, the survey method preference ranking is in-person, telephone, and mail (Mitchell and Carson).

Measurement error might occur when subjects too easily agree with statements or agree to each of two statements which are contradictory. However, in many cases it is almost impossible to construct a survey which will appropriately eliminate all of these problems. An associated factor is the random measurement error and systematic measurement effects which can be associated with low attitude or opinion strength of the subject. However, research shows that measurement

error and recall error have completely different origins and that attitude strength is reflected most strongly in middle-of-the-road answers and only random error can be influenced by the attitude strength (Schuman and Presser, p. 269), but this should matter little when viewed in the context of the survey conducted here.

When the subject is asked to recall information from a particular period, or a recall period, then the recall period must be accurately and correctly defined in order for the interviewer to be able to get the subject to produce acceptable data, otherwise there will be recall bias introduced. If the data from a survey are based on the subject's ability to recall facts, in most cases there will be major problems that must be confronted. Much of the bias that arises in the data comes from the lack of an optimum recall period. As a general rule the recall period should be kept as short as possible, however, very short recall periods will introduce high variation into the data and the researcher needs to know if this is a possibility. Recall periods can vary depending upon how significant the item to recall is: major items will tend to have a longer recall period than will minor items. Demographic types of data will also be able to tolerate a longer recall period. Two major points to keep in mind when dealing with recall issues are that the recall period should be set out at the start and also be straight forward, closed and fixed in order to eliminate any error in

the data. If the subject does not know the correct answer, then the recall period is irrelevant (Casley and Lury). In these data the recall period for fishing activity is twelve months, which may introduce some bias. However, from the outset the recall period was specifically set. As stated earlier, with the exception of some unconstrained whole integer variables such as number of reservoir trips taken, an attempt was made at employing questions which were simple, discrete, and direct in order to eliminate problems of the subject having an obscured memory over such a long period of time.

3.2.4 Administration Of The Survey

Problems of survey administration may be fewer relative to survey implementation issues, but those which arise are usually harder to deal with, less likely to have a clear-cut answer, and more likely to be prone to significant complications. One major drawback to in-person surveying, despite its many advantages, is the fact that it requires a tremendous amount of time and personnel to administer. A telephone survey can, on the other hand, be performed with a greatly reduced staff, and can be finished in much less time than a in-person survey. Mail surveys, while taking a greater amount of time to complete than telephone surveys, are usually the least expensive of all three survey methods. In many cases this completion time is crucial to the researcher, who may need data quickly or when a follow-up interview must be

done in a timely fashion.

Although the time restriction may be circumvented, in most cases the main problem is accurately completing the survey subject to a cost constraint. In many cases the researcher will not have enough funding to conduct in-person interviews on a large enough scale to get adequate results. This forces the pursuit of a less expensive surveying method in most cases. Given these restrictions, mail or telephone survey methods are generally more efficient and easily administered choices (Dillman, p. 68).

3.3 Reservoir Quality Data

In addition to angler data, reservoir quality data were also obtained. Of the twenty-nine largest and most actively fished reservoirs, all were managed by the Army Corp of Engineers (COE), the Tennessee Valley Authority (TVA), or the Tennessee Wildlife Resources Agency (TWRA). For these reservoirs, twenty specific site characteristics and quality measures were obtained. These characteristics and measures are believed to have an effect upon an angler's behavior and fishing demand. The quality data included six reservoir characteristics, four reservoir catch rates, and ten reservoir water quality measures. The six reservoir characteristics obtained were: reservoir area, number of boat ramps, reservoir length, reservoir depth, reservoir elevation, and reservoir volume. Area, depth, length, and volume were measured at full pool level. Catch rates were obtained for four species of

fish: crappie, bass, catfish, and striper. Catch rates were based on electrofishing data as well as general creel data, all collected by TWRA. These data represented average hourly catch rates for each species, where rates are averaged across all anglers and all seasons. Finally, the ten water quality measures included: indices of biotic integrity at the inbay, transition, and forebay zones (available only for TVA managed reservoirs), as well as temperature, dissolved oxygen content, Ph, nitrogen content, phosphorus content, suspended solids level, and fecal coliform content. As for data collection, the catch rates were obtained from the Tennessee Wildlife Resources Agency (TWRA), water quality measures and reservoir characteristics for TVA reservoirs from TVA publications, water quality measures and reservoir characteristics for COE reservoirs through personal telephone interviews with COE personnel.

Additional information required to implement the RUM model was the mileage that each angler must drive to reach each of the twenty-nine reservoirs. The individual's mileage to each reservoir was calculated from their hometown to the most likely launching point. This was done with the aid of maps and the computer program HYWAYS/BYWAYS®.

3.4 Data Evaluation

At this point, adequate, although not entirely satisfactory, data seem to have been obtained. The sample is representative of those Tennessee anglers who are residents

and hold annual licenses, but is not, however, representative of the total Tennessee angling population (including children, senior citizens, and others who do not need licenses, non-residents, non-annual license-holders, and anglers who do not purchase a license as required by law). The sample consisted of randomly drawn annual license holders who had listed telephone numbers. Numerous attempts were made to establish contact, resulting in a survey which had a high response rate and a low refusal rate. Most questions were simple, direct, and discrete, with minimal open-ended answers available, in an effort to minimize measurement error. Other characteristics of the survey are that it had a long, but specifically set recall period, it gave anglers an incentive to respond, and it was conducted by knowledgeable professionals.

Measures which were taken to insure that adequate site quality data were collected included an attempt to evaluate all variables which might impact upon anglers trip decisions, and an attempt to collect all possible obtainable measures through every available agency. However, the quality data collected for the reservoirs were incomplete, with only twenty reservoirs having complete catch rate and reservoir characteristic data. The water quality data were complete for only a small set of reservoirs.

CHAPTER FOUR

Empirical Results

4.1 Introduction and Direction of Research Study

This chapter empirically estimates RUM models for Tennessee's reservoir resources. A number of issues raised in the theoretical chapter are addressed first. To test the IIA assumption, angler fishing patterns are examined to develop insight into site substitution patterns. The number of available site quality measures is relatively large (twenty), so stepwise regression is used to identify those quality measures which have the strongest influence on angler behavior.

RUM models are then presented and discussed with respect to their statistical properties and correspondence with economic theory. Models are estimated for the entire state and two different strategies for regional analysis. The regional models provide a natural test of the IIA assumption. Benefit measures are then calculated on a per trip basis. An estimate of aggregate benefits is also provided. Finally, the chapter addresses the validity and reliability of the results.

4.1.1 Grouping Reservoirs by Region

Given the sensitivity of RUM models to the set of sites available to the angler, the analyst must choose a set of alternatives which corresponds as closely as possible to the set actually considered by the angler. The range of area-wide

substitute sites (previously mentioned to be about thirty) are specified in **Table 4.1**. These serve as a corresponding site legend to the area-wide substitute sites displayed in **Figure 4.1**. However, due to the data limitations, which are clarified in further discussion, the available set of substitute sites drops from the area wide number of thirty-four to a narrower set of only twenty reservoirs to be used in RUM model estimation.

With the available site set, a natural starting point is grouping the reservoirs according to TWRA administrative regions. TWRA has divided the state into four regions, with each region exercising some degree of autonomy in developing management plans. The set of reservoirs used to estimate the RUM models for this regional specification are given in **Table 4.2**. This table serves as the site legend for the sites shown in **Figure 4.2**. This figure also displays the TWRA regional breakdown across the state. If these regions correspond to the alternative set considered by anglers within that region, then a RUM model for each region would prove to be a useful tool in explaining angler behavior within the region.

This hypothesis was initially tested by determining the extent of the market for each reservoir. This was determined by drawing a circle, with a radius equal to maximum observed mileage driven to the reservoir, around the reservoir. It was evident that TWRA regions did not appropriately group reservoirs since a large number of anglers (10%) crossed TWRA

**Table 4.1 Code for All Substitute Sites in Tennessee Area
(Figure 4.1)**

1	Barkley	12	Douglas	24	Percy Priest
2	Barren River	13	Fontana	25	Pickwick
3	Boone	14	Fort Loudon	26	Reelfoot
4	Center Hill	15	Guntersville	27	So. Holston
5	Cheatham	16	Hiwassee	28	Tellico
6	Cherokee	17	Kentucky	29	Tims Ford
7	Chickamauga	18	Melton Hill	30	Watauga
8	Chilhowee	19	Nickajack	31	Watts Barr
9	Cordell Hull	20	Normandy	32	Wheeler
10	Cumberland	21	Norris	33	Wilson
11	Dale Hollow	22	Occoe	34	Woods
		23	Old Hickory		

**Table 4.2 Code for All Substitute Sites Used in RUM Estimates
(Figures 4.2 and 4.3)**

1	Boone	8	Kentucky	15	South Holston
2	Center Hill	9	Nickajack	16	Tellico
3	Cherokee	10	Normandy	17	Tims Ford
4	Chickamauga	11	Norris	18	Watauga
5	Dale Hollow	12	Old Hickory	19	Watts Barr
6	Douglas	13	Percy Priest	20	Woods
7	Fort Loudon	14	Reelfoot		

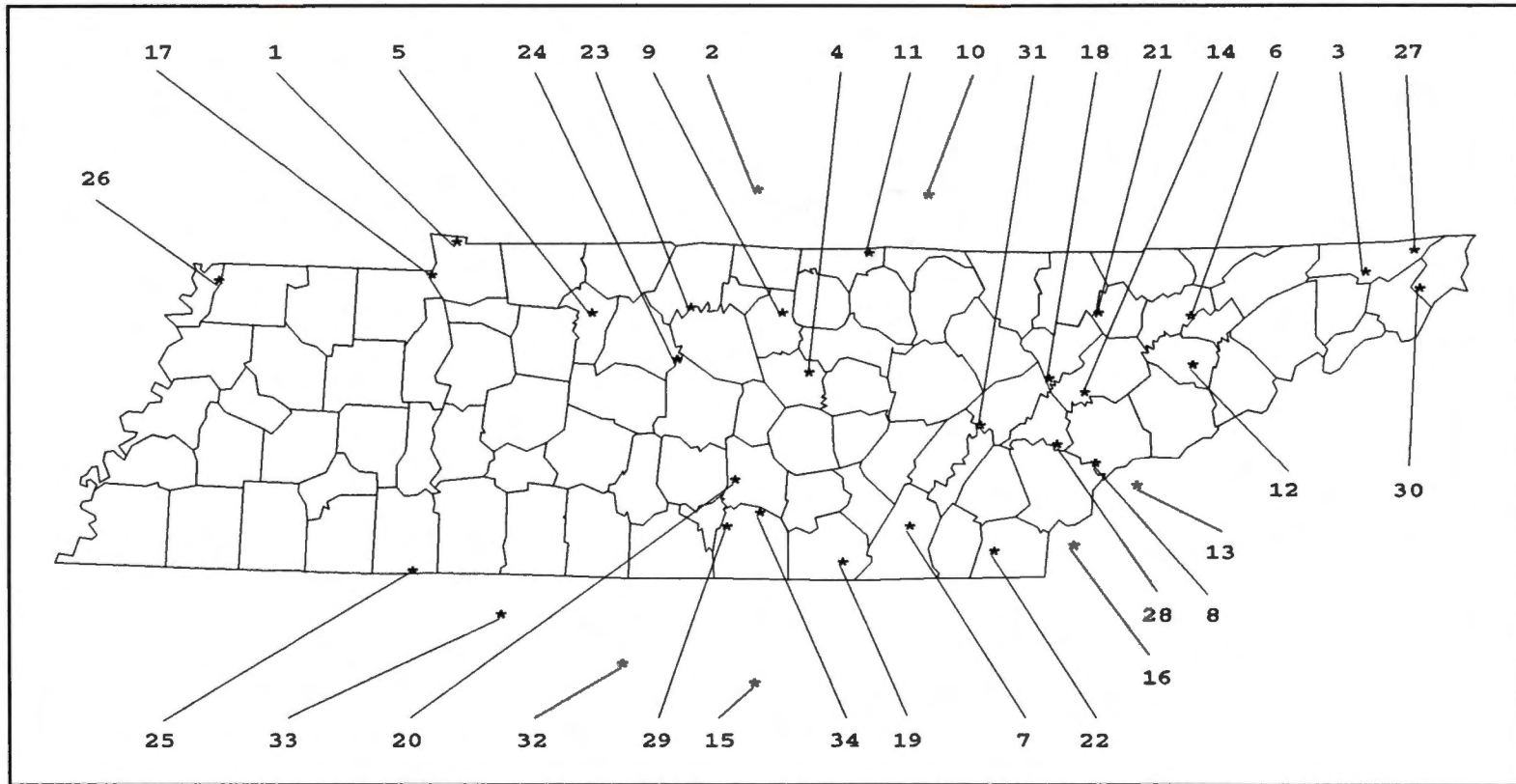


Figure 4.1 All Substitute Sites in the Tennessee Area

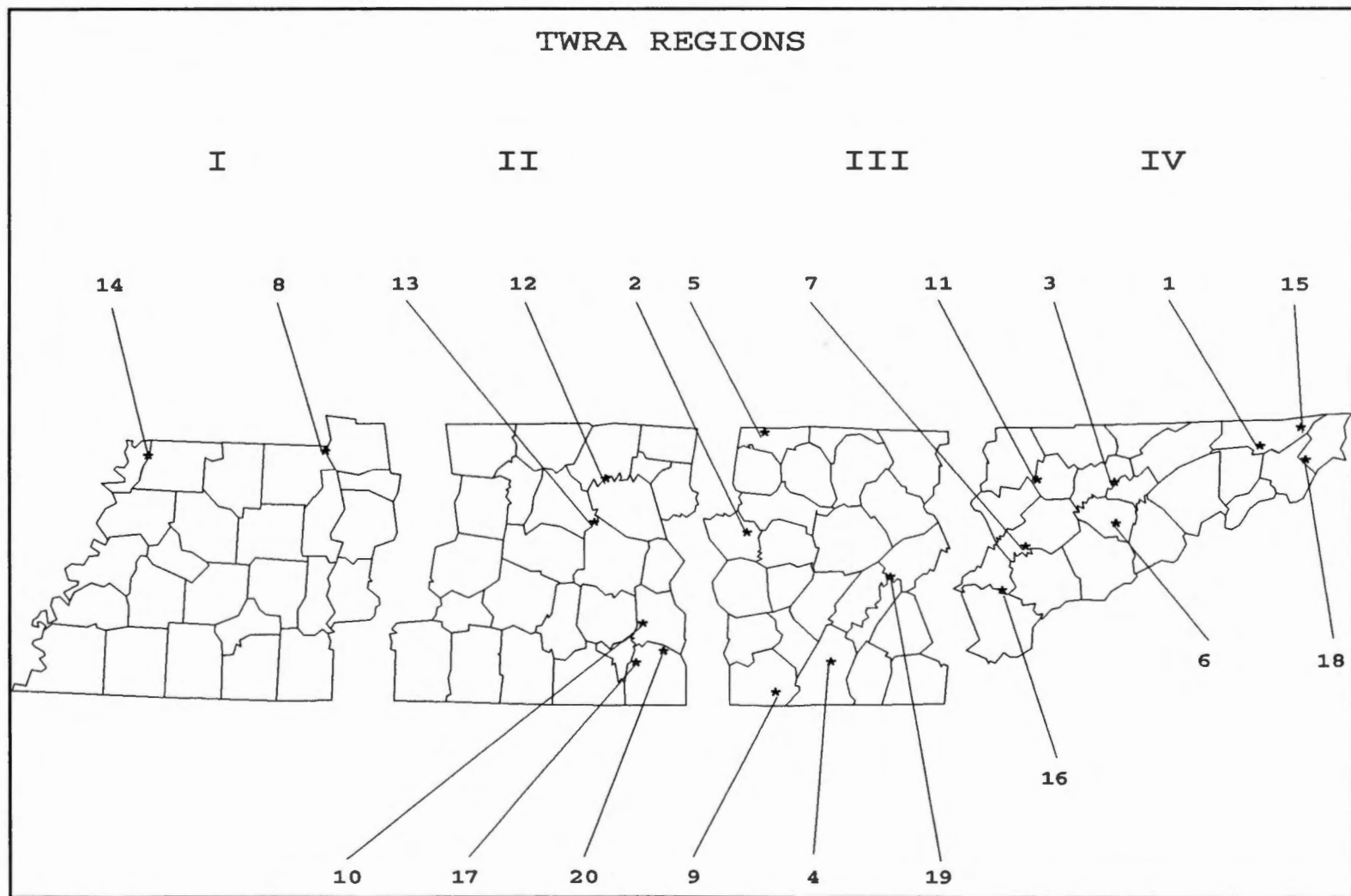


Figure 4.2 All Substitute Sites Used in RUM Estimates: TWRA Regional Strategy

regional boundaries to go fishing. These fishing patterns, however, appeared to show that three "user defined" regions could be established for Tennessee. The western boundary corresponded with the boundary between TWRA regions 1 and 2, while the eastern boundary followed the Cumberland Plateau. The definition of these regions along with the available RUM model reservoir set are displayed in **Figure 4.3** and the corresponding site legend specified in **Table 4.2**. The three User Regions did a better job at defining the set of alternatives visited by anglers, with fewer anglers (6.4%) crossing regional boundaries to go fishing.

4.1.2 Site Quality Data, Variable Selection Procedures and TCM Results

Table 4.3 identifies the types of data used in the initial TCM models used to identify relevant site quality variables. Partial quality data were obtained for twenty-nine reservoirs. In addition to site quality variables, there are also several variables specific to each angler. Included are four dummy variables indicating whether or not the angler targeted any of four species of fish, the angler's income, the angler's travel cost to the reservoir, the angler's number of trips to the reservoirs, and other angler specific categorical data. Four interaction terms were constructed using the target species dummy variables and the species catch rates. The rationale is that anglers targeting a particular species may be interested in only that species, and the catch rates of other species do not influence behavior. Because anglers

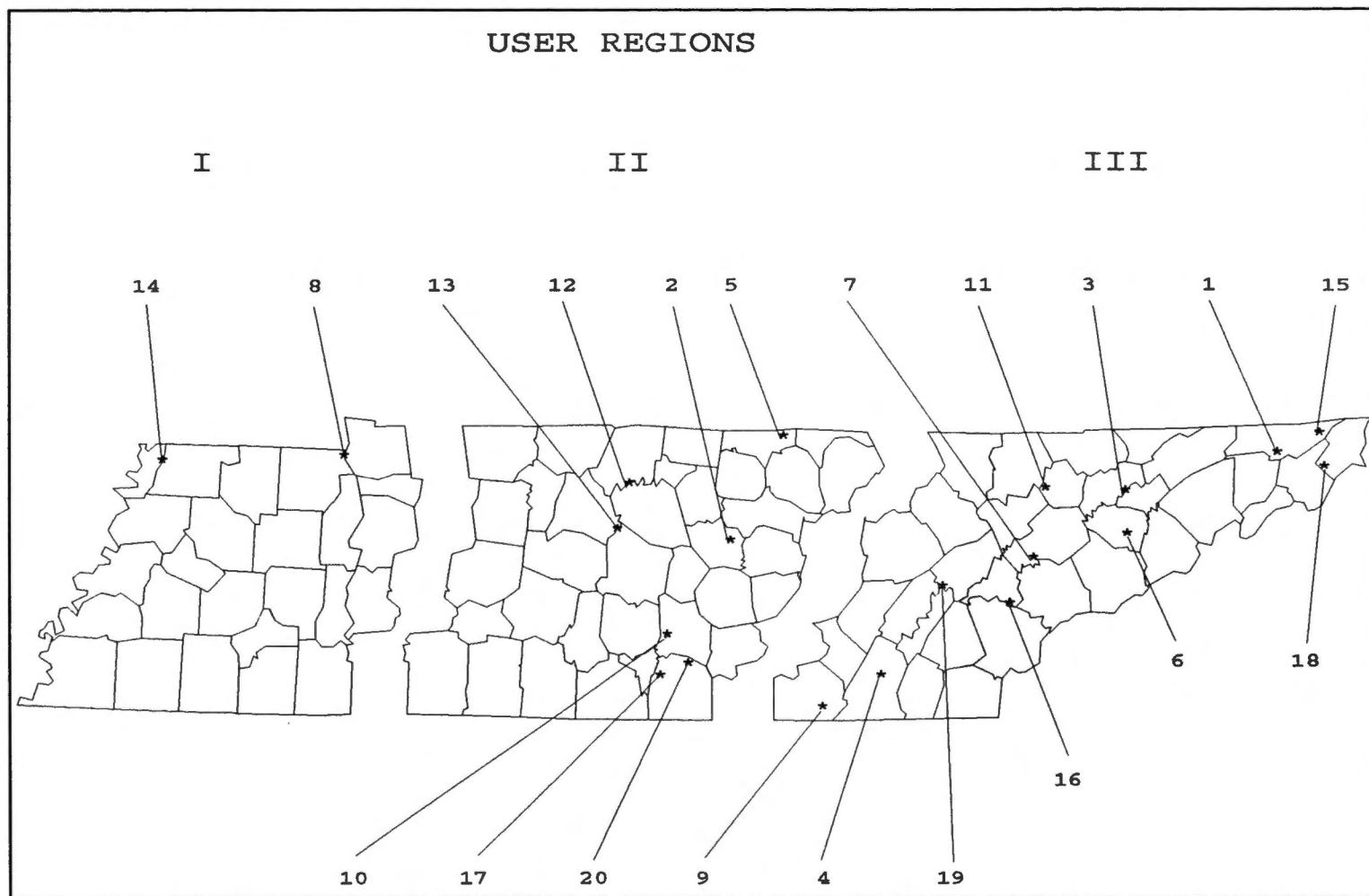


Figure 4.3 All Substitute Sites Used In RUM Estimates: User Defined Regional Strategy

Table 4.3 Independent Variables Used in Stepwise and Backward Regression

- 1) The angler's yearly income
 - 2) Four dummy variables (0,1) for whether or not the angler fished tournaments, owns a boat, subscribes to fishing magazines, or is a member of a fishing club
 - 3) One dummy variable (1,2,3) for how many dollars worth of fishing equipment is owned
 - 4) Four dummy species targeting variables (0,1) for whether or not the angler actively targets crappie, catfish, bass, or striper
 - 5) Each angler's estimated cost of reaching each respective reservoir acquired through multiplying the number of miles to the respective reservoir by two and multiplying by the average cost per mile of operating a vehicle then adding to that the number of miles to each respective reservoir multiplied by two and divided by forty (mph) and multiplying by an hourly wage for each angler
 - 6) Four hourly species catch rates for crappie, catfish, bass, and striper at each reservoir
 - 7) Four interaction variables of the hourly species catch rate multiplied by each respective dummy species targeting variable
 - 8) Ten reservoir quality variables including indices of biotic integrity at the inbay, transition, and forebay zones (available only for TVA managed reservoirs), nitrogen, dissolved oxygen phosphorous, and suspended solids (these five were measured in milligrams per liter), temperature (measured in degrees centigrade), fecal coliform (measured in colonies per liter), and ph (measured in standard units)
 - 9) Five reservoir characteristics for area in acres at full pool, sea level elevation in feet, volume in landacres, length in miles, maximum depth in feet, and number of ramps available at of each respective reservoir
-

could indicate more than one target species, all important species are included. Given the large number of quality measures, preliminary travel cost models were estimated using OLS regression for each regional strategy. This was done to determine the variables affecting anglers' trip decisions, so the RUM estimation could be done in a time efficient manner. The continuous models were run using the number of trips to the reservoir as the dependent variable and reservoir quality variables and angler specific and categorical variables as the set of independent variables. The models were estimated using stepwise regression in the SAS® computer package.

Representative results of the stepwise models for the TWRA regional strategy are shown in **Table 4.4** and the model results for the User regional strategy shown in **Table 4.5**. For most regional specifications, the travel cost variable was negative and statistically significant and will be included in the RUM models. There were other angler specific measures which were also statistically significant with the expected sign across many specifications. However, these angler specific measures which do not change across sites for any one given choice occasion will not be included in the RUM models due to the computational and time limitations of this study. With respect to site quality measures only catch rate interaction terms with the targeting variables and the site characteristics were significant on a consistent basis. The coefficients were usually in agreement with economic theory

Table 4.4 Stepwise Regression of TCM models for State and TWRA Regions, Dependent Variable: Number Fishing Trips to Reservoir, ^aSLE=.15, SLS=.15

VARIABLE	STATE	TWRA 1	TWRA 2	TWRA 3	TWRA 4
Intercept	12.008 ^b (5.422)	16.143 (4.322)	-3.997 (17.954)	-1.667 (10.433)	11.842 (4.842)
Travel Cost	-0.062611 (0.028827)	---	-0.127432 (0.070704)	-0.125470 (0.064718)	---
Tournament	17.743 (6.460)	20.524 (12.224)	---	32.540 (10.561)	17.245 (7.534)
Fisher Club Member	11.681 (5.681)	---	---	17.815 (6.918)	---
Boat Owner	8.586 (5.238)	---	---	---	---
Equip. Owner	---	---	---	13.407 (5.147)	---
Targets	---	---	-44.471 (20.075)	---	---
Catfish	---	---	---	---	---
Striper	83.252 (34.862)	---	---	---	119.832 (27.489)
Inter.	---	---	---	---	---
Crappie	15.076 (6.064)	---	61.240 (19.828)	---	---
Inter.	---	---	---	---	---
Catfish	---	---	---	26.715 (11.108)	---
Inter.	---	---	---	---	---
Length	---	---	0.547800 (0.265451)	---	---
Ramps	---	---	---	---	1.258172 (0.725805)
F-Value	7.16	2.82	4.09	11.54	8.43
R ²	0.1621	0.1136	0.2754	0.4626	0.2426
Step #	6	1	4	5	3

^a The independent variable's corresponding standard error is shown in parentheses

^b The variable's significance level for entering (SLE) and staying (SLS) in the model

Table 4.5 Stepwise Regression of TCM models for State and USER Regions, Dependent Variable: Number Fishing Trips to Reservoir, ^aSLE=.15, SLS=.15

VARIABLE	STATE	USER 1	USER 2	USER 3
Intercept	12.008 b(5.422)	16.143 (4.322)	-19.436 (17.597)	3.001 (6.472)
Travel Cost	-0.062611 (0.028827)	---	-0.089185 (0.059999)	---
Tournament	17.743	20.524	33.266	15.544
Fisher	(6.460)	(12.224)	(12.882)	(7.909)
Club Member	11.681 (5.681)	---	---	12.263 (6.450)
Boat Owner	8.586 (5.238)	---	---	---
Equip. Owner	---	---	---	8.522 (3.693)
Striper	83.252	---	---	79.371
Inter.	(34.862)	---	---	(29.014)
Crappie	15.076	---	35.622	---
Inter.	(6.064)	---	(15.977)	---
Catfish	---	---	---	27.361
Inter.	---	---	---	(11.203)
Ramps	---	---	0.962832 (0.403393)	---
F-Value	7.16	2.82	4.23	8.42
R ²	0.1621	0.1136	0.2145	0.2432
Step #	6	1	4	5

^a The independent variable's corresponding standard error is shown in parentheses

^b The variable's significance level for entering (SLE) and staying (SLS) in the model

where catch rate interactions generally had a positive coefficient. These quality variables are assumed to be important and will also be included in the RUM models.

This narrow set of explanatory variables seem to best determine angler fishing behavior. It was not readily apparent that any other site quality variables or reservoir characteristics were significant on a consistent basis, so it was assumed that other quality variables did not have coefficients different from zero. Income was not a determinant of the number of trips a recreationist demands (the income coefficient not being significantly different from zero) and may only be a factor in determining participation in reservoir fishing (Bockstael, McConnell, and Strand, 1991).

The continuous travel cost models, estimated by stepwise regression, ascertained the measures which influence an angler's reservoir trip demand. It is presumed that these are the measures which influence the site selection on any given trip also. RUM models estimated with these quality variables can be used to determine the value that anglers place on reservoir quality. The set of variables chosen for RUM estimation were the four individual catch rates, travel cost, the reservoir's realized catch rates for an angler (the interaction variables) and reservoir area. The data for these variables were complete for only twenty reservoirs, thus this will be the number of substitute sites in the RUM model.

4.2 Random Utility Model Results

Random utility models were estimated using the multinomial logit procedure in LIMDEP[®]. In contrast with continuous travel cost models, RUM models focus on the determinants of a single choice occasion. The dependent variable was a discrete (0,1) variable, where the value one was assigned to indicate the reservoir chosen most frequently, and zero assigned to all other reservoir choices. Strictly interpreted, the RUM analysis which is presented here is not for a single observed choice occasion, but for the modal choice made over the course of a season (i.e. the reservoir the angler chose to visit most often).

With no clear economic theory guiding which specific quality variables should modeled, only that quality variables should be included in the models, a variety of model specifications for the RUM models were explored with the quality variables chosen in **Section 4.1.2**. The variables which were statistically significant on at least a somewhat consistent basis are travel cost, the bass catch rate, the catfish catch rate, the crappie catch rate, the striper catch rate, and reservoir area. The catfish coefficient frequently changed sign, however, and a consistent determination of its effect could not be established. A positive sign would be predicted by economic theory, if the species was valued and not considered a nuisance. Reservoir area showed up as a significant determinant and its positive coefficient seemed to

agree with economic theory because water fluctuation on smaller reservoirs has a negative impact on fishing quality. Larger reservoirs also provide a greater number of boat launching points, possibly making the reservoir more accessible to anglers. The signs of the coefficients of the crappie and striper variables were not consistent with economic theory, were statistically insignificant, and were dropped from the analysis.

The final specification included travel cost, bass catch rate, catfish catch rate, and reservoir area. The signs of the coefficients of all of the variables, with the exception of the catfish catch rate, were consistent with economic theory, with the bass catch rate showing up negative only three times. The catfish catch rate, however, showed up negative in all but two specifications which would imply that in these models the catfish species is considered an annoyance. This logically appears to be so, since only 15-20% of anglers target catfish, whereas 65-70% of anglers target bass. Models were estimated for each regional strategy outlined in **Section 4.2**. Due to the availability of only two sites in TWRA and User Region 1 no individual estimates were made for this region. **Table 4.6** shows statewide and TWRA regional specifications where reservoirs are grouped by different combinations of regions. **Table 4.7** shows statewide and user-defined regional models.

The travel cost variable incorporated into the data and

Table 4.6 RUM Models for State and TWRA Regions, Dependent Variable: 1=Site Chosen, 0=All Sites Not Chosen

Variable	Statewide ^a	TWRA 234 ^b	TWRA 23 ^c	TWRA 34 ^c	TWRA 2 ^d	TWRA 3 ^d	TWRA 4 ^d
Travel Cost	-.0271 ^e (-14.7)	-.0281 (-13.72)	-.0277 (-10.363)	-.0320 (-11.250)	-.0319 (-4.960)	-.02873 (-6.460)	-.03073 (-6.759)
Bass Catch	.6772 (1.17)	.3432 (.566)	-1.5489 (-1.438)	.4131 (.554)	4.8806 (2.129)	-6.6905 (-2.396)	.6507 (.458)
Catfish Catch	-.2985 (-.834)	-.3495 (-.963)	-.0353 (-.060)	-.1164 (-.278)	-4.3127 (-2.945)	2.2112 (1.949)	-.59302 (-.510)
Reservoir Area	.225*10 ⁻⁴ (6.835)	.450*10 ⁻⁴ (4.865)	.341*10 ⁻⁴ (2.581)	.491*10 ⁻⁴ (4.258)	.672*10 ⁻⁴ (1.162)	.747*10 ⁻⁴ (2.527)	.495*10 ⁻⁴ (2.829)
# Obs.	238	212	129	156	56	73	83
# Sites	20	18	10	13	5	5	8
χ^2 (4)	796.2	669.8	318.94	437.8	82.132	142.81	136.19

^a Statewide model includes 20 reservoirs in all 4 TWRA regions

^b Model includes reservoirs in TWRA regions 2, 3, and 4

^c Model includes reservoirs in TWRA regions 2 and 3, or 3 and 4

^d Model includes only those reservoirs in the designated TWRA region

^e The independent variable's corresponding t-statistic is shown in parentheses

Table 4.7 RUM Models for State and User Regions, Dependent Variable: 1=Site Chosen, 0=All Sites Not Chosen

Variable	Statewide ^a	USER 23 ^b	USER 2 ^c	USER 3 ^c
Travel Cost	-.0271 d(-14.7)	-.0281 (-13.72)	-.02745 (-7.331)	-.03226 (-9.894)
Bass Catch	.6772 (1.17)	.3432 (.566)	-2.7287 (-2.209)	.8387 (1.041)
Catfish Catch	-.2985 (-.834)	-.3495 (-.963)	.4178 (.645)	-.5385 (-1.135)
Reservoir Area	.225*10 ⁻⁴ (6.835)	.450*10 ⁻⁴ (4.865)	-.912*10 ⁻⁵ (-.372)	.590*10 ⁻⁴ (4.717)
# Obs.	238	212	75	137
# Sites	20	18	7	11
χ^2 (4)	796.2	669.8	121.55	350.47

^a Statewide model includes 20 reservoirs in all 3 User regions

^b Model includes reservoirs in User regions 2 and 3

^c Model includes only those reservoirs in the designated User region

^d The independent variable's corresponding t-statistic is shown in parentheses

specified in these models performed well. This variable showed up in all the regional strategy specifications with statistical significance and a relatively constant coefficient. Reservoir area tended to show up statistically significant with a somewhat constant coefficient, however, it did not perform as well as the travel cost variable. As for the bass and catfish catch rate variables, the bass catch rate performed better, but neither performed as well as expected. Neither showed up statistically significant or with a relatively constant coefficient on a steady basis. Due to this poor performance of the catch rate variables and the high standard error associated with them, their benefit estimates may not be reliable. This leaves the conclusion that these models may not be adequate to base policy decisions upon.

4.3 IIA and Regionality Test Results

RUM models are sensitive to the specification of the choice set. A key assumption of the multinomial logit (MNL) model is the Independence of Irrelevant Alternatives (IIA). This feature of the MNL approach implies that the ratio of the probabilities of choosing any two reservoirs will stay the same if an irrelevant choice is added to the choice set. If the choice is not actually irrelevant, the ratios will change. If a regional MNL model is appropriate, similar parameter estimates will be obtained from a restricted choice set model (estimated with only that region's sites) and from a full choice set model (which includes all other alternatives in the

state). An IIA test is a formal test of the reservoir groupings (regions) used to specify the model.

This test, when performed according to the specifications set forth by Greene, gives a chi-square statistic which tests the null hypothesis that the full choice set parameter estimates and the restricted choice set parameter estimates are equal. This test's specifications are given in **Equation 4.1**.

$$\chi^2 = (\beta_R - \beta_U)' [\hat{V}_R - \hat{V}_U]^{-1} (\beta_R - \beta_U) \quad \text{Eq. 4.1}$$

This test specification represents $\hat{\beta}_i$ as the parameter vector and $\hat{V}_i$ as the variance-covariance matrix. R and U subscripts denote the restricted and unrestricted choice sets. The test was conducted by first estimating a RUM model in LIMDEP® for each unrestricted model (including all observations and all substitute sites in the unrestricted set) to obtain the estimated beta and variance-covariance matrix. Second, a restricted model was estimated (including all observations in the unrestricted set but containing only the substitute sites present in the subset) and the beta vector and variance-covariance matrices obtained. **Equation 4.1** was applied, yielding a chi-square test statistic. The results from this test (with 4 degrees of freedom, the number of model parameters) are given in **Table 4.8**.

With these hypothesis tests, several conclusions can be made about these models. First, it appears that TWRA Region 4 dominates the TWRA regional strategy, since TWRA Regions 2

Table 4.8 Results of IIA Tests of Regionality

Formal Hypothesis		$H_0: \beta_r = \beta_u$	
Chi-Square (4)		α of .05 = critical value of 9.49	
UNRESTRICTED	RESTRICTED	STATISTIC	TEST RESULT
TWRA 234	TWRA 2	10.40	Reject H_0 :
TWRA 234	TWRA 3	10.83	Reject H_0 :
TWRA 234	TWRA 4	1.71	Do Not Reject H_0 :
TWRA 23	TWRA 2	7.54	Do Not Reject H_0 :
TWRA 23	TWRA 3	13.25	Reject H_0 :
TWRA 34	TWRA 3	3.50	Do Not Reject H_0 :
TWRA 34	TWRA 4	11.88	Reject H_0 :
USER 23	USER 2	10.59	Reject H_0 :
USER 23	USER 3	7.56	Do Not Reject H_0 :

and 3 are significantly different from the state model and TWRA Region 4 is not. This result suggests that alternatives in TWRA Regions 2 and 3 are irrelevant to anglers in TWRA Region 4. This may be due to the greater number of substitute sites available in Region 4. Nevertheless, when observing the fishing patterns that the user-defined regions were based on, this is somewhat of a surprise and does not seem entirely reasonable (due to the number of anglers from TWRA Region 4 who visit TWRA Region 3). However, when narrowing the unrestricted set of choices into TWRA Regions 2 and 3 or TWRA Regions 3 and 4, some apparently contradictory results are obtained.

From these tests, choices in TWRA Region 3 are irrelevant to anglers in TWRA Region 2, while choices in TWRA Region 2 are relevant to those in TWRA Region 3. With respect to TWRA

Regions 3 and 4, choices in TWRA Region 4 are irrelevant to anglers in TWRA Region 3, but choices in TWRA Region 3 are relevant to those in TWRA Region 4. This is contrary to results described in the previous paragraph.

This contradiction can be partially examined by looking at the test results for the user-defined regions. Some TWRA Region 3 reservoirs were combined with those in TWRA Region 4 to create User Region 3. The test results show that the reservoir choices located in the central portion of the state are irrelevant to Eastern Tennessee anglers. Here again, this may be due to the greater number of substitute sites from which an angler can select in the eastern portion of the state. This leads to the reasonable conclusion that, where more substitute sites are available in a given region, the less influence reservoirs in other regions will have.

In summary, these results give validity to the notion that, as far as site selection goes, there are regionality issues that must be addressed in Tennessee. In other words, we should not treat the state as a whole. Another result from these tests also suggests that the administrative nature of the TWRA regional strategy does not adequately reflect angler's fishing patterns, and a User-defined regional strategy would make more sense based on the observed angling patterns.

4.4 Benefit Estimates

4.4.1 Compensating Variation Measures

Compensating variation measures for quality changes were calculated by type of regional specification. The calculation followed **Equation 2.15 in Chapter 2**. Benefit measures were calculated in two separate ways and for three different magnitudes of quality change. The two ways in which these were calculated were, first, the value of a quality change at each reservoir individually, and second, the value of a simultaneous quality change at all reservoirs in a region. The different levels of the quality change were increases of 10%, 25%, and 50% in each species catch rate. These three different levels were selected so that they might reflect some reasonable increases in catch rates and also be able to show the non-linearity of the welfare function.

4.4.2 Per Trip Benefit Estimates

The signs of the coefficients of the RUM models determine whether compensating variation is positive or negative and, as previously noted, some signs were negative. The values for the bass variable however showed up positive in nearly all cases. The benefit estimates are presented in **Table 4.9** through **Table 4.14**.

The benefit measures also tended, to a large degree, to agree with economic theory, in that they grew smaller for any given reservoir as the set of reservoir alternatives widened from regional to sub-statewide to statewide (left to right in

Table 4.9 **Benefit Estimates for a Given Percentage Increase in Bass Catch Rate at Individual Reservoirs, TWRA Regional Strategy (Dollars Per Trip)**

	10%			25%			50%		
	OWN ^a	TWRA234	STATE	OWN ^a	TWRA234	STATE	OWN ^a	TWRA234	STATE
REGION 1									
KENTUCKY	---	---	0.029	---	---	0.075	---	---	0.157
REELFOOT	---	---	0.000	---	---	0.000	---	---	0.000
REGION 2									
NORMANDY	0.467	0.008	0.046	1.386	0.019	0.117	3.733	0.040	0.244
OLD HICKORY	1.533	0.006	0.037	4.262	0.015	0.095	10.099	0.031	0.196
PERCY PRIEST	3.090	0.006	0.037	8.078	0.014	0.093	17.250	0.029	0.191
TIMS FORD	0.968	0.012	0.064	3.100	0.031	0.165	9.365	0.063	0.349
WOODS	0.411	0.011	0.069	1.308	0.028	0.179	3.988	0.058	0.378
REGION 3									
CENTER HILL	^b (0.29)	0.010	0.036	(0.653)	0.025	0.092	(1.106)	0.050	0.187
CHICKAMAUGA	(6.384)	0.105	0.175	(14.02)	0.264	0.447	(22.15)	0.538	0.927
DALE HOLLOW	(0.052)	0.011	0.030	(0.111)	0.028	0.076	(0.176)	0.057	0.157
NICKAJACK	(0.336)	0.013	0.052	(0.684)	0.034	0.132	(1.008)	0.069	0.275
WATTS BARR	(3.678)	0.214	0.309	(7.590)	0.540	0.789	(11.15)	1.096	1.634
REGION 4									
BOONE	0.022	0.000	0.001	0.057	0.001	0.003	0.120	0.002	0.006
CHEROKEE	0.105	0.007	0.009	0.263	0.018	0.022	0.530	0.037	0.045
DOUGLAS	0.217	0.027	0.036	0.549	0.068	0.092	1.119	0.138	0.189
FORT LOUDON	0.007	0.008	0.017	0.017	0.021	0.042	0.035	0.042	0.084
NORRIS	0.167	0.046	0.061	0.424	0.117	0.155	0.869	0.237	0.320
SOUTH HOLSTON	0.019	0.000	0.001	0.048	0.001	0.003	0.099	0.002	0.006
TELLICO	0.007	0.010	0.018	0.017	0.024	0.045	0.035	0.048	0.091
WATAUGA	0.008	0.000	0.000	0.021	0.000	0.001	0.042	0.001	0.002

^a Quality change using the most restricted set of substitutes sites (the 'own' region)

^b Negative benefit estimates are shown in parentheses

Table 4.10 **Benefit Estimates for a Given Percentage Increase in Catfish Catch Rate at Individual Reservoirs, TWRA Regional Strategy (Dollars Per Trip)**

	10%			25%			50%		
	OWN ^a	TWRA234	STATE	OWN ^a	TWRA234	STATE	OWN ^a	TWRA234	STATE
REGION 1									
KENTUCKY	---	---	^b (0.02)	---	---	(0.058)	---	---	(0.113)
REELFOOT	---	---	0.000	---	---	0.000	---	---	0.000
REGION 2									
NORMANDY	(0.203)	(0.004)	(0.012)	(0.467)	(0.011)	(0.029)	(0.818)	(0.022)	(0.057)
OLD HICKORY	(1.405)	(0.007)	(0.019)	(3.129)	(0.018)	(0.048)	(5.176)	(0.036)	(0.094)
PERCY PRIEST	(0.637)	(0.001)	(0.004)	(1.574)	(0.004)	(0.010)	(3.091)	(0.007)	(0.019)
TIMS FORD	(0.429)	(0.008)	(0.018)	(0.942)	(0.019)	(0.043)	(1.537)	(0.037)	(0.085)
WOODS	(0.239)	(0.010)	(0.026)	(0.509)	(0.024)	(0.063)	(0.794)	(0.046)	(0.124)
REGION 3									
CENTER HILL	0.298	(0.028)	(0.044)	0.824	(0.068)	(0.110)	1.952	(0.132)	(0.215)
CHICKAMAUGA	3.793	(0.173)	(0.125)	9.998	(0.426)	(0.307)	21.586	(0.827)	(0.597)
DALE HOLLOW	0.004	(0.003)	(0.003)	0.011	(0.006)	(0.007)	0.021	(0.013)	(0.015)
NICKAJACK	0.215	(0.022)	(0.036)	0.605	(0.053)	(0.089)	1.481	(0.103)	(0.173)
WATTS BARR	2.184	(0.332)	(0.206)	5.963	(0.818)	(0.508)	13.666	(1.596)	(0.992)
REGION 4									
BOONE	(0.015)	(0.000)	(0.000)	(0.038)	(0.001)	(0.001)	(0.074)	(0.002)	(0.002)
CHEROKEE	(0.327)	(0.025)	(0.013)	(0.808)	(0.062)	(0.033)	(1.583)	(0.123)	(0.065)
DOUGLAS	(0.089)	(0.012)	(0.007)	(0.222)	(0.031)	(0.018)	(0.440)	(0.061)	(0.036)
FORT LOUDON	(0.036)	(0.049)	(0.042)	(0.087)	(0.121)	(0.104)	(0.168)	(0.236)	(0.203)
NORRIS	(0.023)	(0.007)	(0.004)	(0.058)	(0.018)	(0.010)	(0.115)	(0.036)	(0.020)
SOUTH HOLSTON	(0.013)	(0.000)	(0.000)	(0.032)	(0.001)	(0.001)	(0.062)	(0.002)	(0.002)
TELLICO	(0.006)	(0.009)	(0.008)	(0.015)	(0.024)	(0.019)	(0.030)	(0.047)	(0.038)
WATAUGA	(0.007)	(0.000)	(0.000)	(0.016)	(0.000)	(0.000)	(0.032)	(0.001)	(0.001)

^a Quality change using the most restricted set of substitutes sites (the 'own' region)

^b Negative benefit estimates are shown in parentheses

Table 4.11 **Benefit Estimates for a Given Percentage Increase in Bass Catch Rate at Individual Reservoirs, USER Regional Strategy (Dollars Per Trip)**

	10%			25%			50%		
	OWN ^a	USER23	STATE	OWN ^a	USER23	STATE	OWN ^a	USER23	STATE
REGION 1									
KENTUCKY	---	---	0.029	---	---	0.075	---	---	0.157
REELFOOT	---	---	0.000	---	---	0.000	---	---	0.000
REGION 2									
CENTER HILL	^b (0.40)	0.010	0.036	(0.970)	0.025	0.092	(1.825)	0.050	0.187
DALE HOLLOW	(0.049)	0.011	0.030	(0.116)	0.028	0.076	(0.211)	0.057	0.157
NORMANDY	(0.464)	0.008	0.046	(1.064)	0.019	0.117	(1.851)	0.040	0.244
OLD HICKORY	(0.965)	0.006	0.037	(2.274)	0.015	0.095	(4.118)	0.031	0.196
PERCY PRIEST	(1.046)	0.006	0.037	(2.498)	0.014	0.093	(4.624)	0.029	0.191
TIMS FORD	(0.220)	0.012	0.064	(0.481)	0.031	0.165	(0.783)	0.063	0.349
WOODS	(0.407)	0.011	0.069	(0.906)	0.028	0.179	(1.503)	0.058	0.378
REGION 3									
BOONE	0.002	0.000	0.001	0.005	0.001	0.003	0.011	0.002	0.006
CHEROKEE	0.038	0.007	0.009	0.097	0.018	0.022	0.196	0.037	0.045
CHICKAMAUGA	0.105	0.105	0.175	0.269	0.264	0.447	0.566	0.538	0.927
DOUGLAS	0.134	0.027	0.036	0.342	0.068	0.092	0.704	0.138	0.189
FORT LOUDON	0.017	0.008	0.017	0.042	0.021	0.042	0.084	0.042	0.084
NICKAJACK	0.002	0.013	0.052	0.006	0.034	0.132	0.012	0.069	0.275
NORRIS	0.198	0.046	0.061	0.505	0.117	0.155	1.044	0.237	0.320
SOUTH HOLSTON	0.002	0.000	0.001	0.005	0.001	0.003	0.011	0.002	0.006
TELLICO	0.022	0.010	0.018	0.055	0.024	0.045	0.112	0.048	0.091
WATAUGA	0.001	0.000	0.000	0.002	0.000	0.001	0.004	0.001	0.002
WATTS BARR	0.448	0.214	0.309	1.146	0.540	0.789	2.379	1.096	1.634

^a Quality change using the most restricted set of substitutes sites (the 'own' region)

^b Negative benefit estimates are shown in parentheses

Table 4.12 **Benefit Estimates for a Given Percentage Increase in Catfish Catch Rate at Individual Reservoirs, USER Regional Strategy (Dollars Per Trip)**

	10%			25%			50%		
	OWN ^a	USER23	STATE	OWN ^a	USER23	STATE	OWN ^a	USER23	STATE
REGION 1									
KENTUCKY	---	---	^b (0.02)	---	---	(0.058)	---	---	(0.113)
REELFOOT	---	---	0.000	---	---	0.000	---	---	0.000
REGION 2									
CENTER HILL	0.180	(0.028)	(0.044)	0.456	(0.068)	(0.110)	0.937	(0.132)	(0.215)
DALE HOLLOW	0.002	(0.003)	(0.003)	0.004	(0.006)	(0.007)	0.009	(0.013)	(0.015)
NORMANDY	0.044	(0.004)	(0.012)	0.111	(0.011)	(0.029)	0.226	(0.022)	(0.057)
OLD HICKORY	0.187	(0.007)	(0.019)	0.472	(0.018)	(0.048)	0.961	(0.036)	(0.094)
PERCY PRIEST	0.040	(0.001)	(0.004)	0.100	(0.004)	(0.010)	0.201	(0.007)	(0.019)
TIMS FORD	0.024	(0.008)	(0.018)	0.061	(0.019)	(0.043)	0.124	(0.037)	(0.085)
WOODS	0.059	(0.010)	(0.026)	0.149	(0.024)	(0.063)	0.307	(0.046)	(0.124)
REGION 3									
BOONE	(0.001)	(0.000)	(0.000)	(0.002)	(0.001)	(0.001)	(0.005)	(0.002)	(0.002)
CHEROKEE	(0.084)	(0.025)	(0.013)	(0.207)	(0.062)	(0.033)	(0.402)	(0.123)	(0.065)
CHICKAMAUGA	(0.107)	(0.173)	(0.125)	(0.260)	(0.426)	(0.307)	(0.494)	(0.827)	(0.597)
DOUGLAS	(0.039)	(0.012)	(0.007)	(0.096)	(0.031)	(0.018)	(0.190)	(0.061)	(0.036)
FORT LOUDON	(0.060)	(0.049)	(0.042)	(0.148)	(0.121)	(0.104)	(0.285)	(0.236)	(0.203)
NICKAJACK	(0.002)	(0.022)	(0.036)	(0.006)	(0.053)	(0.089)	(0.011)	(0.103)	(0.173)
NORRIS	(0.019)	(0.007)	(0.004)	(0.048)	(0.018)	(0.010)	(0.096)	(0.036)	(0.020)
SOUTH HOLSTON	(0.001)	(0.000)	(0.000)	(0.002)	(0.001)	(0.001)	(0.005)	(0.002)	(0.002)
TELLICO	(0.014)	(0.009)	(0.008)	(0.034)	(0.024)	(0.019)	(0.068)	(0.047)	(0.038)
WATAUGA	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.002)	(0.001)	(0.001)
WATTS BARR	(0.432)	(0.332)	(0.206)	(1.056)	(0.818)	(0.508)	(2.034)	(1.596)	(0.992)

^a Quality change using the most restricted set of substitutes sites (the 'own' region)

^b Negative benefit estimates are shown in parentheses

Table 4.13

**Benefit Estimates for a Simultaneous Given Percentage Increase in
Species Catch Rate at All Reservoirs in the Region, TWRA Regional
Strategy (Dollars Per Trip)**

	BASS			CATFISH		
	10%	25%	50%	10%	25%	50%
STATE	1.015	2.547	5.122	(0.595)	(1.482)	(2.945)
TWRA234	0.493	1.234	2.474	(0.697)	(1.733)	(3.440)
TWRA2	6.060	15.345	31.426	(3.011)	(7.171)	(13.246)
TWRA3	^a (11.785)	(29.267)	(57.731)	6.196	15.509	31.074
TWRA4	0.549	1.376	2.765	(0.519)	(1.291)	(2.560)

^a Negative benefit estimates are shown in parentheses

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Table 4.14

**Benefit Estimates for a Simultaneous Given Percentage Increase in
Species Catch Rates at All Reservoirs in the Region, User Regional
Strategy (Dollars Per Trip)**

	BASS			CATFISH		
	10%	25%	50%	10%	25%	50%
STATE	1.015	2.547	5.122	(0.595)	(1.482)	(2.945)
USER 23	0.493	1.234	2.474	(0.697)	(1.733)	(3.440)
USER 2	^a (3.701)	(9.178)	(18.124)	0.532	1.336	2.690
USER 3	0.959	2.407	4.849	(0.766)	(1.897)	(3.733)

^a Negative benefit estimates are shown in parentheses

Table 4.9 through **Table 4.12**). This tends to agree with theory because, as the range of substitutes and qualities available for an individual is restricted, that individual will value a quality change at the chosen reservoir more. This increase in value occurs because the individual will have a higher probability of choosing any one specific reservoir in the more restricted model.

The compensating variation calculated from these models can and should be compared to similar studies. A compensating variation range (in dollars) for species catch rate change for the TWRA regional strategy is given in **Table 4.15** and for the user-defined regional strategy is given in **Table 4.16**. For the most part, majority of these compensating variations (overlooking extreme values) appear to be reasonable welfare estimates on a per trip basis when compared to some recent literature.

There have been several studies of this type, some deviating in one form or another from the particular form taken in this research, so their benefit estimates are not comparable (Morey, Rowe, and Watson, 1993, and Parsons and Needelman, 1992). However, studies that are largely of a similar type do provide comparable welfare estimates. Kaoru estimated a RUM model for fishing quality on the North Carolina coast. He found per trip benefit estimates ranging from \$.34 to \$5.79 for an overall catch rate increase of 10%, 25%, or 50% over three different aggregation levels. Parsons

Table 4.15 **Range of Compensating Variations Over All Reservoirs for Bass and Catfish Catch Rate Increases for the TWRA Regional Strategy**

	BASS		CATFISH	
	LOW	HIGH	LOW	HIGH
10%	^a (6.38)	3.09	(1.41)	3.79
25%	(14.02)	8.08	(3.13)	10.00
50%	(22.15)	17.25	(5.18)	21.59

^a Negative benefit estimates are shown in parentheses

Table 4.16 **Range of Compensating Variations Over All Reservoirs for Bass and Catfish Catch Rate Increases for the User Regional Strategy**

	BASS		CATFISH	
	LOW	HIGH	LOW	HIGH
10%	^a (1.05)	.45	(.43)	.19
25%	(2.50)	1.15	(1.06)	.47
50%	(4.62)	2.38	(2.03)	.96

^a Negative benefit estimates are shown in parentheses

and Kealy examined angler willingness to pay measures for improvements in dissolved oxygen availability for fish habitat. The proposed improvement would take place at between 25% and 95% of the given sites (either improving only the lowest quality sites to a moderate level or require all sites to conform to a high standard level, respectively), and would improve fish habitat and activity in an effort to improve catch rate. Using an equivalent variation measure, anglers were willing to pay between \$.65 to \$1.76 per trip, depending on the choice set specified. The equivalent variation specified leaves an angler at the point of indifference in lieu of the proposed quality change, whereas the compensating variation returns the angler to the point of indifference after the quality change has already taken place. In a quality improvement such as this, which places an individual at a higher level of utility, the equivalent variation would be greater than, but comparable to, the compensating variation.

4.4.3 Aggregate Benefits.

The benefit estimates for improving the bass and catfish catch rates (presented in Table 4.9 through Table 4.12) represent per trip estimates for a single angler. In considering a proposed project to improve fishing quality, however, a policy maker must determine the total benefit of the project. Only then can a comparison of benefits and costs be made (where total costs of a project are usually well

defined).

To obtain aggregate measures from the per trip benefit estimates, the appropriate fishing population (in each region) must be enumerated, and the mean number of visits per angler must be known. Then an estimate of the total number of trips taken by all anglers may be calculated. Since the data set on which the RUM analysis is based did not have a measure of fishing population by region, data from a 1993 survey of Tennessee residents over age 16 was used to obtain estimates of the fishing population and the mean number of fishing trips.

The total benefit for region j (TB_j) was calculated by using **Equation 4.2**.

$$\hat{TB}_j = CV_j * \bar{T}_j * A_j * P_j \quad \text{Eq. 4.2}$$

In this equation, CV_j = the regional compensating variation measure, $\bar{T}_j$ = the mean visits per region per angler over age 16, A_j = the percent of the population over age 16 which fishes in reservoirs in the region, and P_j = the total population over age 16 per region.

Aggregate benefit estimates are presented in **Table 4.17** and **Table 4.18**. The aggregate estimates, however, contain some known error. Because participation rates were based on the angler's region of origin, the calculation assumes anglers do not fish outside their home region. To the extent that this assumption is violated, aggregate estimates are in error. As noted in **Section 4.2.a.**, more cross region reservoir

Table 4.17 ^aAggregate Benefit Estimates for a Simultaneous Given Percentage Increase in Species Catch Rate at All Reservoirs in the Region, TWRA Regional Strategy (Thousands of Dollars Per Season)

	BASS			CATFISH		
	10%	25%	50%	10%	25%	50%
STATE	8,667	21,739	43,719	(5,078)	(13,000)	(25,000)
TWRA234	3,440	8,614	17,276	(4,864)	(12,000)	(24,000)
TWRA2	14,951	37,856	77,529	(7,429)	(18,000)	(33,000)
TWRA3	^b (20,000)	(51,000)	(100,000)	10,772	26,964	54,027
TWRA4	1,525	3,822	7,679	(1,441)	(3,585)	(7,111)

^a A required assumption with these estimates is that every trip which an angler makes must be made within that anglers own region. Any trip(s) taken by an angler outside their own region would be accruing benefits (or losses) to the other region and negating the impact of the benefit (or loss) to their own region.

^b Negative benefit estimates are shown in parentheses

Table 4.18 ^aAggregate Benefit Estimates for a Simultaneous Given Percentage Increase in Species Catch Rate at All Reservoirs in the Region, TWRA Regional Strategy (Thousands of Dollars Per Season)

	BASS			CATFISH		
	10%	25%	50%	10%	25%	50%
STATE	8,667	21,739	43,719	(5,078)	(13,000)	(25,000)
USER 23	3,440	8,614	17,276	(4,864)	(12,000)	(24,000)
USER 2	^b (11,000)	(27,000)	(54,000)	1,576	3,956	7,966
USER 3	3,859	9,689	19,516	(3,083)	(7,634)	(15,000)

^a A required assumption with these estimates is that every trip which an angler makes must be made within that anglers own region. Any trip(s) taken by an angler outside their own region would be accruing benefits (or losses) to the other region and negating the impact of the benefit (or loss) to their own region.

^b Negative benefit estimates are shown in parentheses

visitation was observed for TWRA regional strategy than the User-Defined regional strategy. Aggregate benefits based on the User regions is thus less subject to this source of error.

Under close scrutiny, however, it is obvious that for several reasons these measures are poor estimates on which to base policy decisions. First, these measures are subject to the restriction that anglers fish only in their home region. Second, they are also constrained by the data on substitute reservoirs and fail to take into account any anglers other than the in-state and yearly licensed ones. Third, the bass and catfish catch rate coefficients are seldomly significant which means there will be a high degree of error associated with the estimated benefits. Lastly, depending upon the regional strategy specified for the estimated models, the associated benefit estimates have a large range. Under actual circumstances this degree of variability from region to region would not be expected (especially for the TWRA regional strategy) due to the number of anglers who cross regional boundaries.

4.5 Results Discussion and Conclusion

Given that the focus of this study is on the value of reservoir fishing quality, the empirical results have been disappointing. Few site quality variables were statistically significant, and many were in conflict with theoretical expectations. It is possible the data gathered for quality measures are not the appropriate measures for which to

estimate the models.

Possible rationale for the empirical results can be given. First, quality measures for some reservoirs were unavailable, which meant that those reservoirs were removed from the data and the set of relative substitute sites. If these reservoirs were important and relevant substitutes for the sites which were included, the empirical results are biased. Second, the quality data were obtained through three separate agencies, (TVA, COE, and TWRA) and there may have been deviations in measurement across agencies, affecting the quality measures. For example, some catch-rate data were measured from electrofishing and others from general creel data. Another possibility is reservoir quality changed from the time at which the quality data were gathered (mid to late 1980's) to the year in which the survey was taken (1992). Fourth, the site quality measures used (the catch rates) may not correspond closely to the actual site quality experienced by the anglers in the sample. The sample was composed of annual license holders - the most experienced and active anglers in the state. It is possible that the catch rate is angler specific, such that the mean catch rates used in the empirical modeling were poor measures of the relevant site quality.

CHAPTER FIVE

Conclusions

5.1 Introduction

The goal of this research was to estimate the value of changing the quality of fishing in Tennessee's reservoir resources. The validity and reliability of the benefit estimates depend on the analyst's ability to adequately model the factors determining angler site selection. The modeling effort described in **Chapter 4** relied on a set of assumptions imposed by the methodology chosen, and on the quality of the data. Issues associated with the data and the maintained assumptions are evaluated below. The chapter concludes with a discussion of future research issues.

5.2 Quality of the Data

There were a number of problems associated with the data which were used in this analysis. One of the primary characteristics of the sample is that it represents people who fish more actively than does the entire Tennessee angling population. The true population of Tennessee anglers is composed of people who are both residents and non-residents of Tennessee, people under age 14 and over age 65 who do not need a license, and other people, who, due to various reasons, do not need a license. There are also those people who purchase daily or weekly permits, and illegal anglers, those people who do not purchase a license as required by law. The sample of

anglers used in this study reflects only that portion of the total population which hold either yearly combination licenses or yearly sportsman's licenses and who are residents of the state of Tennessee. Members of this sample fish more often and across a broader spectrum of fishing resources than does the population at large.

Accordingly, the site quality data used for this study may not have accurately reflected the actual quality realized by the sample of experienced anglers. The proper catch rate data would reflect what a more acclimated and experienced Tennessee reservoir angler would catch. The quality data actually used reflect what an average angler would catch. This could explain why the catch rates performed relatively poorly in the empirical models. A further issue is the way in which the dependent variable for the RUM models was formed. RUM models are generally based on intercept surveys, where the respondent is interviewed at the fishing site. By postulating the set of relevant substitute sites, the researcher can then estimate the RUM model using the interview site as the chosen site. The data on which this research was based was a telephone survey. The respondent stated which reservoir he or she fished at most often, and this site was designated as the chosen site. The RUM models were also estimated using catch rates averaged across anglers and seasons. If angler visits to individual reservoirs change in accordance with seasonal pattern in fish catch, the dependent variable may not

accurately reflect any given choice occasion.

5.3 Regionality and Relevant Site Ranges

An important maintained assumption of the multinomial logit model is the independence of irrelevant alternatives assumption. The analyst must be careful to specify the correct set of alternative sites. The angling population in Tennessee, has numerous sites from which to choose across the state, without any intrastate boundaries to limit their selection. It is unlikely, however, that an angler considers all sites for a given trip. To evaluate the IIA assumption, the appropriate regional strategy must be addressed.

The Tennessee Wildlife Resources Agency breaks its management down into four administrative regions within the state. Although this breakdown may not be entirely correct with respect to Tennessee angling patterns, it does provide an initial strategy with which to begin. The TWRA regions, however, did not appear to reflect observed reservoir use patterns. With this in mind, the User regions were established, to better reflect the intrastate "boundaries" to which anglers seem to adhere when selecting a reservoir. These boundaries roughly correspond to traditional West, Middle, and East Tennessee breakdowns, with dividing lines at the western half of the Tennessee river and the eastern side of the Cumberland Plateau. These dividing lines tend to depict the actual relevant range of site choices available to an angler.

The results suggest preliminary support for the notion of regionality. The IIA tests, in many cases (generally more so the case in TWRA region four and User region three), show that introduction of sites from outside the region does not significantly affect the parameter estimates. The probability ratio for any two sites within the region stays constant with the new choice set, implying that anglers do not consider sites from outside the region. The IIA tests show that at least in part this regionality must be true with the null hypothesis not being rejected (regional models and state models are no different) in several cases.

5.4 Benefit Estimates

The compensating variation measures were, for the most part, of reasonable magnitude. In many cases, however, benefits of an increase in catch were negative because of a negative coefficient in the RUM model. Aggregate benefits were calculated by scaling the per trip benefits for a quality increase for all reservoirs in a region by the predicted number of total angler trips in the region. **Chapter 4** notes some of the shortcomings of this method, but the aggregate estimates also appear reasonable relative to the utilization of reservoir resources and the method of calculation.

The validity and reliability of the benefit estimates is in doubt, however. The nature of the sample - most active anglers - and the question of appropriate site quality measures may lead to a biased (invalid) benefit estimate. If

the quality measures used in this study deviate systematically from those actually experienced by the sample anglers, the site quality parameters may be biased. Further, the high standard errors associated with all estimated parameters implies that the compensating variation and aggregate measures have a relatively high variance. These issues make the benefit estimates potentially unsuitable for policy analysis.

5.5 Future Research

Although not satisfying in its empirical quality, this research can still prove useful. Future research efforts can be modified in light of the problems encountered in this research.

When looking at future research possibilities there are several different actions that can be employed to have more satisfying results. One major action deals with the collection of appropriate quality data. A more optimal way for the collection of this data is for all of it to be collected by the same agency with the same procedure in the same year and be available for all sites. This action could eliminate nearly all data problems. A second action that is feasible is to collect a sample that reflects the entire and true angling population in Tennessee. With both these actions being taken, a set of observations may be obtained which is more truly reflective of the actual incurred angling situations.

There are also some other procedures or methods that may

be taken with regard to the estimation of the random utility models. It could be possible to utilize a nested model in conjunction with specific targeting variables, or even models which use site aggregation (Parsons and Needelman, 1992) or randomly drawn opportunity sets (Parsons and Kealy, 1992). There are also other options available than the random utility model using the multinomial logit model, such as using a specific discrete choice model in place of the multinomial logit model. Other models such as the varying parameters model (Agnello and Han, 1993) or the alternative travel cost model (Caulkins, Bishop, and Bouwes, 1986) could possibly be used as substitutes for the random utility model. With the possibilities that are available here to adjust for data, sample, and even model structure imperfections, it is almost assured that through some combination of these adjustments, future studies can be complete and thorough successes.

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APPENDIX

OBS.ID. _____ (V1)

Result of Phone Call (V2)

First of all, this survey is strictly confidential. Your responses will not be associated with your name. You also have the right to refuse to answer any of the questions. All questions refer to fishing activities and management in Tennessee.

1. Have you fished in Tennessee during 1992? (V3)

01 Yes -----> 1a. Do you have a current license to fish in Tennessee?

(V4)

01 Yes ----> GO TO Q1b, THEN Q2.

02 No -----> GO TO Q1c, THEN Q2.

02 No -----> 1a. Do you have a current license to fish in Tennessee?

01 Yes ----> GO TO Q1b, THEN Q7, p. 8.

02 No -----> GO TO Q1c, THEN TERMINATE.

1b. What type of fishing license do you have or use, if any?
READ LIST.

01 Combination fishing/hunting (V5)

02 Sportsman license

03 Daily permit

04 Combination fishing/hunting with trout supplement/stamp

05 Sportsman license with trout supplement/stamp

06 Senior citizen license/disabled vet

55 Skipped

98 Don't know

77 Refused

1c. Is there a particular reason why you did not purchase a license in 1992? **OPEN-ENDED AND CODE.**

01 Have reached age 65 (V6)

02 Too expensive

03 Did not have enough time

04 No reason

05 No longer interested in fishing

55 Skipped
97 Other (SPECIFY)

98 Don't know
77 Refused

2. Have you fished in Tennessee farm ponds in 1992?

01 Yes -----> GO TO Q2a. (V7)
02 No -----> GO TO Q3.
55 Skipped
77 Refused

2a. About how many times have you fished in farm ponds so far this year? _____

IF RESPONDENT GIVES YOU A RANGE, ASK FOR JUST ONE NUMBER.

55 Skipped (V8)
98 Don't know
77 Refused

2b. What kinds of fish did you catch?

SEE FISH CODES.

(V9) (V10) (V11) (V12) (V13) (V14) (V15)

55 Skipped
98 Don't know
77 Refused

2c. Who owns the farm pond where you fish most often? Does that land belong to (READ LIST)?

01 Yourself (V16)
02 A relative
03 A friend or neighbor
04 A commercial business
55 Skipped
97 Other (SPECIFY)

98 Don't know
77 Refused

3. Have you fished in warm water streams in Tennessee in 1992? These are streams which are not impounded by dams, where you usually catch bass, blue gill, and catfish?

01 Yes -----> GO TO Q3a. (V17)

02 No -----> GO TO Q4.
55 Skipped
77 Refused

3a. About how many times have you fished in warm water streams
in 1992? _____

55 Skipped (V18)
98 Don't know
77 Refused

3b. What kinds of fish did you catch?

SEE FISH CODES.

(V19) (V20) (V21) (V22) (V23) (V24) (V25)

55 Skipped
98 Don't know
77 Refused

3c. What is the warm water stream you fish most often?

(V26)

3d. When fishing there, do you ever fish from privately owned
land?

01 Yes -----> GO TO Q3e. (V27)
02 No -----> GO TO Q4.
55 Skipped
98 Don't know > GO TO Q4.
77 Refused ---> GO TO Q4.

3e. Does that land belong to (READ LIST)?

01 Yourself (V28)
02 A relative
03 A friend or neighbor
55 Skipped
97 Other (SPECIFY)

98 Don't know
77 Refused

4. Have you fished in trout streams in Tennessee in 1992?

01 Yes -----> GO TO Q4a. (V29)

02 No -----> GO TO Q5.
55 Skipped
98 Don't know
77 Refused

4a. About how many times have you fished in trout streams so far this year? _____

55 Skipped (V30)
98 Don't know
77 Refused

4b. What kinds of trout did you catch? **SEE FISH CODES.**

4c. On average, how many (**FISH NAMED**) did you catch?

4d. On average, how many did you release?

Fish	4b.	4c.	4d.	
_____	_____	_____	_____	(V31 V32 V33)
_____	_____	_____	_____	(V34 V35 V36)
_____	_____	_____	_____	(V37 V38 V39)
_____	_____	_____	_____	(V40 V41 V42)

55 Skipped
98 Don't know
77 Refused

4e. In general, would you support or oppose a program of size limits and bait restrictions on trout?

01 Support (V43)
02 Oppose
55 Skipped
97 Other (**SPECIFY**)

98 Have no opinion/don't know
77 Refused

4f. What size in inches do you consider to be a quality trout?

_____ inches -----> GO TO Q4g. (V44)

55 Skipped
98 Don't know -----> GO TO Q4h. (**LEAVE OUT "INCHES" IN Q4h.**)
77 Refused

4g. Would you support or oppose that length as a size limit for a quality trout regulation?

- 01 Support (V45)
- 02 Oppose
- 55 Skipped
- 98 Don't know (LEAVE OUT "INCHES" IN Q4h.)
- 77 Refused

4h. As part of a quality trout regulation, how many (SIZE NAMED) inch trout should people be able to keep? _____ (V46)

4i. What is the trout stream you fish most often?
_____ (V47)

4j. How many miles do you drive to this stream? IF NECESSARY, ASK: Do you know how long it takes you to get there?

_____ miles (V48)

_____ hour(s) _____ minutes (V49 V50)

- 55 Skipped
- 98 Don't know
- 77 Refused

4k. When fishing there, do you ever fish from privately owned land?

- 01 Yes -----> GO TO Q41. (V51)
- 02 No -----> GO TO Q5.
- 55 Skipped
- 98 Don't know --> GO TO Q5.
- 77 Refused

4l. Does that land belong to (READ LIST)?

- 01 Yourself (V52)
 - 02 Relative
 - 03 Friend or neighbor
 - 55 Skipped
 - 97 Other (SPECIFY)
-
- 98 Don't know
 - 77 Refused

5. Have you fished in Tennessee reservoirs in 1992?

01 Yes -----> GO TO Q5a. (V53)
02 No -----> GO TO Q6.
55 Skipped
98 Don't know
77 Refused

5a. About how many times have you fished in reservoirs so far this year? _____

55 Skipped (V54)
98 Don't know
77 Refused

5b. When you fish in reservoirs, is there a particular kind you fish for?

01 Yes -----> GO TO Q5d. (V55)
02 No -----> GO TO Q5c.
55 Skipped
98 Don't know
77 Refused

5c. What kinds of fish do you fish for in reservoirs?

(V56) (V57) (V58) (V59) (V60) (V61) (V62) (V63) SKIP TO Q5j.

5d. What kind is that? _____ (V64)

5e. If (FISH NAMED IN 5d) are not biting, what is your next preferred kind? _____ (V65)

5f. If (FISH NAMED IN 5e) are not biting, what is your next preferred kind? _____ (V66)

5g. For every ten times that you fish, how many times do you fish for (FISH NAMED IN 5d)? _____ (V67)

5h. For every ten that you catch, about how many do you keep? _____ (V68)

5i. When fishing for (FISH NAMED IN 5d), do you prefer to use live or artificial bait?

- 01 Live (V69)
- 02 Artificial
- 03 Both
- 55 Skipped
- 98 Don't know
- 77 Refused

5j. Do you ever fish for striped bass, rock fish, or hybrid bass in reservoirs or tail waters?

- 01 Yes (V70)
- 02 No
- 98 Don't know

5k. What is the reservoir that you fish most often?

(V71)
No preference -----> GO TO Q6.

5l. How many trips did you take to this reservoir in 1992?

(V72)

5m. How many miles do you drive to this reservoir? **IF NECESSARY, ASK:** Do you know how long it takes you to get there?

_____ miles (V73)

_____ hour(s) _____ minutes (V74 V75)

- 55 Skipped
- 98 Don't know
- 77 Refused

5n. If you don't go to (RESERVOIR NAMED IN 5k), what reservoir do you go to?

(V76)

No preference -----> GO TO Q6.

- 55 Skipped

77 Refused

5o. How many trips did you take to this reservoir in 1992?

(V77)

5p. How many miles do you drive to this reservoir? **IF NECESSARY, ASK:** Do you know how long it takes you to get there?

_____ miles

(V78)

_____ hour(s) _____ minutes

(V79 V80)

55 Skipped

98 Don't know

77 Refused

6. How many days was the longest fishing vacation that you took in 1992, if any? _____

(V81)

55 Skipped

98 Don't know

77 Refused

7. How many fishing clubs do you belong to, if any?

(V82)

98 Don't know

77 Refused

8. How many fishing magazines do you subscribe to, if any?

(V83)

98 Don't know

77 Refused

9. Have you fished in any tournaments in 1992?

01 Yes

(V84)

02 No

10. Do you own a boat?

- 01 Yes (V85)
- 02 No

11. About how much money would you say you have invested in fishing equipment, not including a boat? Would you say (READ LIST)

- 01 Less than \$500 (V86)
- 02 \$500 to \$2,000
- 03 More than \$2,000
- 98 Don't know
- 77 Refused

12. As you may know, the Tennessee Wildlife Resources Agency, TWRA, has established separate fish management regulations for individual reservoirs across the state. Should regulations be the same for all reservoirs in the state or should regulations be established for each individual reservoir?

- 01 Same for all reservoirs (V87)
- 02 Established for individual reservoirs
- 97 Other (SPECIFY)

-
- 98 Don't know
 - 77 Refused

12a. Why do you think TWRA established regulations for individual reservoirs? OPEN-ENDED AND CODE.

- 01 Because each reservoir (V88)
is (biologically) different.
- 02 Because TWRA responds to the fishing public's wishes.
- 03 To protect the fish population
- 97 Other (SPECIFY)

-
- 98 Don't know
 - 77 Refused

13. Do you think the current number of black bass you can keep per day should (READ LIST)? (IF ASKED: Black bass includes largemouth, smallmouth, and spotted bass)

- 01 Increase (V89)
- 02 Decrease
- 03 Remain the same

98 No opinion/don't know
77 Refused

14. Size limit regulations can be established which will probably increase the number of fish you catch, but will lower the number you can legally keep.

14a. Would you support or oppose a size limit on black bass in Tennessee reservoirs?
(V90)

01 Support the limit -----> 14b. What is the size limit in inches you would support? _____ inches
(V91)

02 Oppose the limit
97 Other (SPECIFY)

98 Have no opinion/don't know
77 Refused

14c. Would you support or oppose a size limit on crappie in Tennessee reservoirs?

01 Support the limit (V92)
02 Oppose the limit
97 Other (SPECIFY)

98 Have no opinion/don't know
77 Refused

15. If the public believes that a regulation would be beneficial to a fishery but TWRA believes it would not be a benefit, should the regulation be imposed by TWRA anyway?
(ANY ADDITIONAL EXPLAINS THAT GO WITH "YES" OR "NO" SHOULD BE WRITTEN OUT BELOW THE QUESTION.)

01 Yes (V93)
02 No
97 Other (SPECIFY)

98 No opinion/don't know
77 Refused

16. Is there anyone under age 14 living in your household?

01 Yes -----> GO TO Q16a. (V94)
02 No -----> GO TO Q17.
77 Refused

16a. How many persons in your household under age 14 fished in 1992? _____

00 None -----> GO TO Q17. (V95)
55 Skipped
77 Refused

16b. Overall, would you say that in 1992 they/this person fished (READ LIST)?

01 Frequently (V96)
02 Occasionally
03 Once or twice
55 Skipped
98 Don't know
77 Refused

17. Other than yourself, is there anyone 65 years of age or older living in your household?

01 Yes -----> GO TO Q17a. (V97)
02 No -----> GO TO Q18.
77 Refused

17a. Other than yourself, how many persons in your household 65 years of age or over fished in 1992? _____

00 None -----> GO TO Q18. (V98)
55 Skipped
77 Refused

17b. Overall, would you say that in 1992 they/this person fished (READ LIST)?

01 Frequently (V99)
02 Occasionally
03 Once or twice
55 Skipped
98 Don't know
77 Refused

18. Do you think that Tennessee fishing regulations are (READ LIST)?

01 Very complicated (V100)
02 Somewhat complicated

03 Neither complicated nor simple
04 Somewhat simple
05 Very simple
98 Don't know
77 Refused

19. If there were no regulations, what is the smallest size fish, in inches, that you would keep of the following?

Black bass _____ inches 00 None 98 Don't know
77 Refused
(V101)

Crappie _____ inches 00 None 98 Don't know 77
Refused
(V102)

Sauger _____ inches 00 None 98 Don't know 77
Refused
(V103)

20. Do you support or oppose the sauger regulations currently in effect?

01 Support (V104)
02 Oppose
03 Not familiar with regulations
04 No opinion
77 Refused

21. Do you support or oppose the regulations currently in effect for smallmouth bass in Dale Hollow Reservoir?

01 Support (V105)
02 Oppose
03 Not familiar with regulations
04 No opinion
77 Refused

22. Overall, how satisfied are you with how TWRA manages the fishery resources in Tennessee? (READ LIST)

01 Very dissatisfied (V106)
02 Somewhat dissatisfied
03 Neither dissatisfied nor satisfied
04 Somewhat satisfied
05 Very satisfied
98 Don't know

23. Are there other comments that you would like to make about TWRA or the fishery resources in Tennessee?

24. Would you be willing to answer additional questions in the future for a mail survey?

- 01 Yes (V107)
02 No

To conclude the interview, we have a few background questions to help us understand more about the people TWRA serves across that state who fish. Again, these responses are confidential and will not be associated with your name.

25. What is your zipcode? _____ RECORD 5 DIGITS.
(V108)

26. How many people live in your household? _____ RECORD
NUMBER.
(V109)

27. Do you own your home or rent?

- 01 Own (V110)
02 Rent
77 Refused

28. Are you a full-time or part-time farmer?

- 01 No -----> GO TO Q29. (V111)
02 Full-time ----> GO TO Q29.
03 Part-time ----> GO TO Q28a.
77 Refused

28a. Did you have an agricultural income of \$1,000 or more in 1991?

- 01 Yes (V112)

02 No
55 Skipped
98 Don't know
77 Refused

29. What is your age? _____ RECORD YEARS. (V113)

30. What is the highest grade of school you completed? (READ LIST)

01 Less than high school (V114)
02 High school graduate (12)
03 Some college (13-15)
04 College graduate (16)
05 Post-graduate (17+)
77 Refused

31. I am going to read a list of income categories for household income from all sources before taxes during 1991. Please stop me when I get to yours.

01 \$5,000 or less (V115)
02 \$5,001 - \$15,000
03 \$15,001 - \$25,000
04 \$25,001 - \$35,000
05 \$35,001 - \$50,000
06 \$50,001 - \$65,000
07 \$65,001 - \$80,000
08 Over \$80,000
98 Don't know
77 Refused

Thank you very much for your cooperation. Your answers will be most helpful in this study.

GENDER

01 Male (V116)
02 Female

DAY OF INTERVIEW

01 Mon., Nov. 9 (V117)
02 Tues., Nov. 10
03 Wed., Nov. 11
04 Thurs., Nov 12
10 Wed., Nov. 18
11 Thurs., Nov. 19
12 Fri., Nov. 20

05 Fri., Nov. 13
06 Sat., Nov. 14
07 Sun., Nov. 15
08 Mon., Nov. 16
09 Tues., Nov. 17

13 Sat., Nov. 21
14 Sun., Nov. 22
15 Fri., Nov. 27
16 Sat., Nov. 28
17 Sun., Nov. 29

INTERVIEWER

01 Sonya
03 Pam
04 Graff
05 Shannon
06 Christi
08 Stephanie
09 Anne
10 Robin
11 Karen

14 Jill
15 Bill
17 Tanya
20 Cathy
21 Meredith
22 Coriya
23 John
24 Kathleen
25 Monica
27 Chad

(V118)

VITA

Michael Wayne Bates was born in Pulaski, Tennessee on October 14, 1969. He is the son of Forrest and Betty Bates of Elkton, Tennessee. After attending Elkton Elementary School for Kindergarten through Sixth grades, he attended Athens Bible School in Athens, Alabama for Seventh through Tenth grades. He attended Eleventh and Twelfth grades and subsequently graduated from Giles County High School in Pulaski, Tennessee in May of 1987. The following August he enrolled in Martin Methodist College, a junior college in Pulaski, and after transferring to The University of Alabama in Huntsville, eventually transferred to and graduated from The University of Tennessee, Martin in May of 1992 with a Bachelor's Degree majoring in Economics. On August 19, 1992 he accepted an Agricultural Experiment Station graduate research assistantship from The University of Tennessee, Knoxville in the Department of Agricultural Economics and Rural Sociology. In December of 1994, he received a Master of Science Degree in Agricultural Economics from The University of Tennessee, Knoxville. He is presently living in Elkton, Tennessee and working for the family business.

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