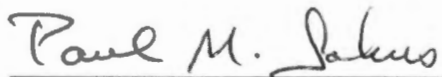


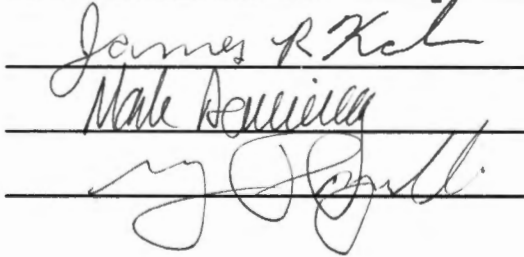
To the Graduate Council:

I am submitting herewith a thesis written by Laurienne Elise Whinstanley entitled "Empirically Estimating the Role of Water Quality on Participation and Visitation in Reservoir Fishing: An Application to the Conservation Reserve Program." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

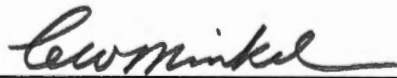


Paul M. Jakus, Major Professor

We have read this thesis  
and recommend its acceptance:



Accepted for the Council:



Associate Vice Chancellor  
and Dean of the Graduate School

# STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a Master of Science degree at the University of Tennessee, Knoxville, I agree that the Library shall make it available to borrowers under the rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of the source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Head of Interlibrary Services when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature Laurenne S. Whistandley  
Date July 28, 1995

**EMPIRICALLY ESTIMATING THE ROLE OF WATER QUALITY  
ON PARTICIPATION AND VISITATION  
IN RESERVOIR FISHING:  
AN APPLICATION TO THE CONSERVATION RESERVE PROGRAM**

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

**Laurienne Elise Whinstanley**

**August 1995**

MS-VET-MED.  
Thesis  
95  
.W352

## DEDICATION

This thesis is dedicated to my parents, Christine and James Lloyd Whinstanley, who have given me love and support throughout the years. This is also dedicated to the memories of Ambrose Henry Evans and Dr. Bruce Ford, who were not able to see this day come to pass. I will be forever grateful for all the energy and compassion that made this achievement possible.

## **ACKNOWLEDGEMENTS**

I would like to thank the following people who gave their time, knowledge and support in helping me complete my graduate work and this thesis.

To Dr. Paul M. Jakus for his time and energy in making sure that I was prepared for the many challenges that lie ahead. His teaching, patience and valuable insight are greatly appreciated and will not be forgotten.

To Dr. James R. Kahn whose great skills as a teacher and advisor had a profound impact on a student who needed encouragement. I will be forever indebted to him because without his guidance I would not have come this far.

To Dr. Gregory K. Pompelli and Dr. Mark Downing for their insight and contribution while serving on my thesis committee.

To Dr. Handy Williamson for his time and interest and to the faculty, staff and colleagues in the Department of Agricultural Economics and Rural Sociology, who gave me advice and support. All their support is greatly appreciated.

To my sister, Toni-Marie McLean and brother-in-law, Norris McLean, who supported me in ways they will never know.

To Dr. Yasmin Hurd and all my family and friends who were there when the road seemed endless.

To Mark Nowak who helped me keep my focus, sense of humor and sanity. Thanks are due to him for helping me keep things

in perspective and for being a best friend and confidant.

Finally, to The University of Tennessee Agricultural Experiment Station for my Research Graduate Assistantship. This helped with my finances and more importantly increased my knowledge and experience in research.

## **ABSTRACT**

This thesis estimates the change in access value resulting from a change in quality of a recreational site. Data on reservoir fishing in east Tennessee are used to evaluate proposed changes in the Conservation Reserve Program (CRP). These changes will result in decreased fishing quality in downstream reservoirs. Demand curves for reservoir fishing are estimated using Heckman Selection models.

The empirical models show that measures of pollution and socioeconomic variables are statistically significant factors in the decision to go fishing. The visitation stage of the Heckman Selection model shows that the number of trips taken is dependent on travel cost to the site, the catch rate, and measures of angler avidity.

Losses to anglers resulting from CRP termination are estimated to be \$9.25 per trip. With extension of CRP to only the most erosive land, angler losses are \$5.60 per trip.

## TABLE OF CONTENTS

| CHAPTER                                                            | PAGE |
|--------------------------------------------------------------------|------|
| CHAPTER 1 . . . . .                                                | 1    |
| Introduction . . . . .                                             | 1    |
| 1.1 Overview . . . . .                                             | 1    |
| 1.2 Objectives and Methodology . . . . .                           | 2    |
| CHAPTER 2 . . . . .                                                | 5    |
| Travel Cost Theory and Measures of Welfare . . . . .               | 5    |
| 2.1 Introduction . . . . .                                         | 5    |
| 2.2 Public Goods . . . . .                                         | 5    |
| 2.3 The Travel Cost Method . . . . .                               | 6    |
| 2.4 Measures of Welfare Change . . . . .                           | 9    |
| 2.5 Econometric Estimation of the Travel Cost<br>Model . . . . .   | 16   |
| CHAPTER 3 . . . . .                                                | 20   |
| Literature Review . . . . .                                        | 20   |
| 3.1 Introduction . . . . .                                         | 20   |
| 3.2 Input/Output Models . . . . .                                  | 21   |
| 3.3 The Physical Linkages . . . . .                                | 24   |
| 3.4 Connecting Pollution To Fish Stocks . . . . .                  | 26   |
| 3.5 Putting Pollution Directly into Behavioral<br>Models . . . . . | 28   |
| 3.6 Summary . . . . .                                              | 33   |
| CHAPTER 4 . . . . .                                                | 35   |
| Reservoir Fishing Data . . . . .                                   | 35   |
| 4.1 Data Collection . . . . .                                      | 35   |
| 4.2 Water Quality Data . . . . .                                   | 38   |
| 4.3 Focusing on East Tennessee . . . . .                           | 40   |
| CHAPTER 5 . . . . .                                                | 46   |
| Results . . . . .                                                  | 46   |
| 5.1 Introduction . . . . .                                         | 46   |
| 5.2 Deriving The Travel Cost and Quality Measures . . . . .        | 46   |
| 5.2.1 Travel Cost Measure . . . . .                                | 47   |
| 5.2.2 Site Quality Indexes . . . . .                               | 48   |
| 5.3 Choice of Variables . . . . .                                  | 49   |
| 5.4 Evaluating the Empirical Models . . . . .                      | 53   |
| 5.4.1 Estimating the Models . . . . .                              | 53   |
| 5.4.2 Participation Models . . . . .                               | 53   |
| 5.4.3 Visitation Models . . . . .                                  | 56   |
| 5.5 Calculating the Welfare Effects of CRP . . . . .               | 62   |
| 5.5.1 Access Value . . . . .                                       | 62   |
| 5.5.2 The Value of CRP Scenarios . . . . .                         | 62   |
| 5.6 Conclusion . . . . .                                           | 66   |

|                                                                                       |    |
|---------------------------------------------------------------------------------------|----|
| CHAPTER 6 . . . . .                                                                   | 68 |
| Conclusions . . . . .                                                                 | 68 |
| 6.1 Summary of Empirical Results . . . . .                                            | 68 |
| 6.2 Evaluating the Benefit Estimates . . . . .                                        | 70 |
| 6.3 Potential Methodological Improvements and<br>Additional Research Issues . . . . . | 71 |
| REFERENCES . . . . .                                                                  | 74 |
| APPENDIX . . . . .                                                                    | 78 |
| VITA . . . . .                                                                        | 97 |

## LIST OF TABLES

| TABLES    |                                                                                                                                                         | PAGE |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Table 4.1 | Response Rates for Fall 1994 Survey . . . . .                                                                                                           | 37   |
| Table 4.2 | Respondent Profile of people sampled . . . . .                                                                                                          | 39   |
| Table 4.3 | 1994 Reservoir Quality Data<br>(Forebay Measurements) . . . . .                                                                                         | 40   |
| Table 4.4 | Code for Substitute Sites in East Tennessee .                                                                                                           | 44   |
| Table 5.1 | Variable Definitions . . . . .                                                                                                                          | 50   |
| Table 5.2 | Selection Stage of Heckman Selection<br>Model--Log(trips), Dependent Variable:<br>1 = Fish in reservoirs, 0 = Do not fish in<br>Reservoirs . . . . .    | 54   |
| Table 5.3 | Selection Stage of Heckman Selection<br>Model--Linear(trips), Dependent Variable:<br>1 = Fish in reservoirs, 0 = Do not fish in<br>Reservoirs . . . . . | 55   |
| Table 5.4 | Visitation Stage of Heckman Selection<br>Model--Log(trips), Dependent Variable:<br>Number of fishing trips taken . . . . .                              | 58   |
| Table 5.5 | Visitation Stage of Heckman Selection<br>Model--Linear(trips), Dependent Variable:<br>Number of fishing trips taken . . . . .                           | 59   |

## LIST OF FIGURES

| FIGURE                                                                                                                            | PAGE |
|-----------------------------------------------------------------------------------------------------------------------------------|------|
| Figure 2.1 Welfare Measurement: Difference Between Marshallian Demand and Hicksian Demand . . .                                   | 11   |
| Figure 2.2 Welfare Measurement: Difference Between Marshallian Demand and Hicksian Demand with a change in site quality . . . . . | 15   |
| Figure 4.1 All Substitute Sites in the East Tennessee Area: User Defined Regions . . . . .                                        | 45   |

## **Chapter 1**

### **Introduction**

#### **1.1 Overview**

The Conservation Reserve Program was first developed in 1984 in an effort to reduce soil erosion and surplus production. A major goal of the CRP is to retire up to 45 million acres of erodible land from agricultural production to control soil erosion, improve water quality, and enhance wildlife habitat. Farmers enter into 10 year contracts to convert highly erodible land into vegetative cover. In return, farmers are given annual payments for participating in this program.

Benefits have accrued on and off the farm. In Tennessee, CRP enrollments have reached more than one half million acres, signifying its importance in the state. These ten year contracts will begin expiring in 1995. The consequences of contract expiration may be substantial. This has quite an implication on the usage of this retired land. Depending on how favorable market conditions are, a large percentage of land will be returned to agricultural production. This has significant implications for all land currently enrolled in CRP. Specifically, there will be noticeable impact on the downstream effects of soil erosion on water quality.

Different policy scenarios have been proposed to deal

with CRP land, once the contracts expire. The first scenario would extend the contract (w/revised stipulations) on the most erodible land. The next scenario would look at the effects of a CRP termination. In this thesis I plan to measure downstream losses to some recreationists under these two scenarios.

Water based recreation activities are important in Tennessee. A survey taken by the Tennessee Wildlife Resources Agency (TWRA) showed that over 1 million people fished in the state of Tennessee between March 1 and August 30, 1994. Of this amount, approximately 650,000 anglers fished in reservoirs, taking on average, 16 trips during the time period (Jakus et al. 1995). This is important because it shows the high demand for use of reservoir fishing facilities in Tennessee.

This thesis focuses on reservoir fishing specifically in East Tennessee. The 34 reservoirs in the state of Tennessee are managed by the Tennessee Wildlife Resources Agency (TWRA), the Tennessee Valley Authority (TVA), and the United States Corp of Engineers (COE). Site specific quality measures were obtained for 15 TVA reservoirs in the East Tennessee regionwe

## **1.2 Objectives and Methodology**

The goal of this thesis is to measure the value of site water quality for reservoir fishing in east Tennessee.

Reservoir fishing was the chosen recreational activity because it is the most popular form of fishing in the state of Tennessee (Jakus et al. 1995). Measuring the value of quality changes in a good such as reservoir fishing is often difficult. Publicly owned water based recreation facilities with zero entrance fees are not commodities which can be marketed, therefore traditional market valuation cannot be used to determine the economic benefits of changes in the quality of these facilities. Several techniques, however, have been developed to estimate the value of quality changes at a recreational site. By observing people's recreational behavior I am able to "indirectly" infer a value for the quality change.

The travel cost method (TCM) is one such technique. By observing the cost of travel that people incur (price) and the number of trips that they take (quantity), a demand curve can be estimated for the recreational site. At any particular site, there will be different travel costs and number of trips taken. This relationship is similar to a demand curve for a marketed commodity. Changes in site quality act as shifters in this demand curve. The difference in consumer surplus (the area under the travel cost demand curve at each quality level) is the value of the change in quality.

Benefits from CRP-induced changes in water quality (pollution index) will be measured by looking at the difference in access values (consumer surplus) at two

different water quality levels. These CRP-induced changes have not previously been measured for Tennessee's reservoirs.

The second chapter of this thesis will present the theory underlying the empirical model. This chapter will focus on the Travel Cost Method and its basic assumptions. Chapter 3 will be a review of literature, focusing on the literature related to the economic impact of CRP, and the benefits associated with changes in recreational site quality. In Chapter 4 I discuss the primary and secondary data used in the analysis, including a description of the survey method and the stratification used in the sampling. Chapter 5 presents the modelling results and the surplus estimates associated with welfare measures from a change in pollution levels. In Chapter 6, I present conclusions, a critical evaluation, and discuss potential future research.

## **Chapter 2**

### **Travel Cost Theory and Measures of Welfare**

#### **2.1 Introduction**

Improvements in soil, water, and air quality, and wildlife resources have been achieved as enrollment in the Conservation Reserve Program (CRP) increased. Benefits created by the CRP have accrued both on and off the farm. Substantial reductions in off-site damages and the expenditures needed to mitigate the impacts of soil erosion have been noted (Ribaudó, 1989a). Recreational activities such as fishing, boating and swimming have improved in quality as erosion and chemical run-off from farmland has fallen. Since use of water-based recreation facilities is not a commodity which can be marketed, traditional market values cannot be used to gauge the economic benefits of quality changes in these resources. Therefore it is difficult to assess the full value of conservation programs.

#### **2.2 Public Goods**

Water-based recreational sites often exhibit characteristics of public goods. Public goods are fully accessible to all and, assuming that congestion does not occur, one person's consumption of a good does not diminish the amount of the good that is available for others. Public

goods are fully accessible because the cost of excluding anyone from the site would be prohibitively high. While this characteristic prevents the good from being traded in a market, consumer theory allows us to determine the relative value of the public good.

Let a rational individual's utility function be defined as  $U = U(X, G)$ , with  $X$  denoting a private good and  $G$  a public good. The relative value of  $G$  and  $X$  to person ( $i$ ) is given by the marginal rate of substitution (MRS) between the public good and the private good,  $MRS_{G,X}^i = U_G^i / U_X^i$ . Because of the non-exclusion characteristic, the amount of  $G$  is equally available to all, so the total value of the public good is the sum of the MRS over all people. This is the Samuelsonian condition for the optimal provision of a public good (Cornes and Sandler, 1986).

### 2.3 The Travel Cost Method

Unfortunately, we cannot observe an individual's value, for the public good (his or her MRS) because we do not observe a market transaction in which relative values are revealed. Consequently, techniques have been developed to overcome this problem. The techniques used to measure the value of a public good are broadly classified as direct and indirect approaches. The direct approach involves an individual assigning a dollar value to the resource. For example, the contingent valuation method asks an individual how much he or she would be willing-

to-pay for its use. The second general approach, collectively known as indirect methods, uses observed market behavior to infer a value for the public good. One example of an indirect method is the travel cost model (TCM). With the TCM, people combine time and marketed goods to produce a recreational trip. It is assumed that the time cost and out-of-pocket cost of travel are a proxy for price of the visit. At any particular site there will be a difference in travel costs and the number of visits for different individuals. The relationship between travel cost and the number of visits is analogous to a demand curve for a marketed commodity, and is a measure of the observed demand for use of the recreational site.

A household production framework is a useful way to show the relationship between the demand for recreational activities and the derived demand for sites that cater to the activities, i.e. the travel cost demand curve. The household production model assumes that an individual tries to maximize his/her utility from a combination of private goods, public goods and time.

Let the individual's utility function in this case be  $U = U(S_0, S_1)$ , with  $S_0$  denoting non-recreational commodities or service flows, produced using time and market goods, and  $S_1$ , describing the production of recreational service flows. Since  $S_0$  plays no role in this study, it shall generally be ignored. The production function for recreational service

flows is given in equation 2.1:

$$S_r = f_r (X_r; V_1, \dots, V_n; Q_1, \dots, Q_n, t_1, \dots, t_n) \quad (\text{eq. 2.1})$$

where  $S_r$  is produced using  $X_r$ , a vector of market goods purchased as inputs,  $V_j$ , visits to the site  $j$ ,  $Q_j$ , quality of each site and  $t_j$ , time spent at a recreation site per visit (Smith, 1989). Maximization of the utility function subject to the production functions for  $S_o$  and  $S_r$ , and the income and time constraints yields a derived demand curve for recreational visits by person  $i$  to site  $j$ ,  $V_{ij}$ . The travel cost demand model can be expressed in equation 2.2 as:

$$V_{ij} = f (TC_{ij}, S, Q_j, Y_i) \quad (\text{eq. 2.2})$$

where  $V_{ij}$ , visits by person  $i$  to site  $j$  is a function of  $TC_{ij}$ , trip cost for person  $i$  to site  $j$ ,  $S$ , the set of substitute sites available to person  $i$ ,  $Q_j$ , quality of site  $j$  and  $Y_i$ , income of person  $i$ . Since trip expenditures represent a range of travel costs that individuals face, this provides information on how costs or changes in costs affect participation. The assumption is that participants using the site have similar tastes and therefore their responses to differences in the cost of using the site can be viewed as responses along a common demand curve. This information is used to estimate a demand curve for the site.

There are some basic assumptions to the TCM (Freeman, 1993). Individuals respond to changes in travel cost in much the same way they would to a change in a user fee (an out-of-pocket cost). Second, each trip to the site is made only for the purpose of visiting the site. Demand parameters will be biased if an additional purpose of the trip is to visit another site or engage in other activities. Third, the amount of time spent on site is the same across all trips. This allows the number of visits to accurately measure site use and the cost the individuals incurs in order to visit the site. Fourth, there is no pleasure or disutility experienced en route to or from the site. Fifth, the wage rate, or a fraction thereof, can be used as a proxy for the opportunity cost of time.

#### **2.4 Measures of Welfare Change**

In estimating the demand for a particular site, the usual method is to estimate demand functions at the level of the individual and use the demand function to infer the value of the site by observing the value that the individual places on this site. The total value of the site is the sum over all individuals using the site. The travel cost model yields an ordinary Marshallian demand curve, which is the uncompensated demand curve and is a function of prices and income,  $V^m$  (TC, Y), holding S and  $Q_j$  constant and dropping the subscripts for ease of notation. The ordinary demand curve estimates the

number of trips (quantity) by an individual to the site as a function of the cost to access the site (price) and income. On the other hand, Hicksian demand curves include only a substitution effect, making it preferable for welfare measurement. The compensated demand curve shows the relationship between quantity and price on the assumption that other prices and utility are held constant,  $V^h(TC, U)$  (Nicholson, 1992). Unfortunately, the compensated demand curve is not observable, so the practice is to start with an ordinary Marshallian demand curve and evaluate the potential error in welfare measures.

Access value is measured as the difference between what the individual was willing-to-pay and what he or she had to pay. This can be measured as consumer surplus, the area under the Marshallian demand curve between the travel cost paid ( $TC^0$ ) and the travel cost which would drive visits to zero ( $TC^1$ ), i.e. area  $TC^0TC^1b$  in Figure 1. Alternatively, the utility constant measure of access value, compensating variation, is given by the area under the Hicksian demand curve between the travel cost paid ( $TC^0$ ) and the travel cost which would drive visits to zero ( $TC^2$ ), area  $TC^0TC^2b$  in Figure 1.

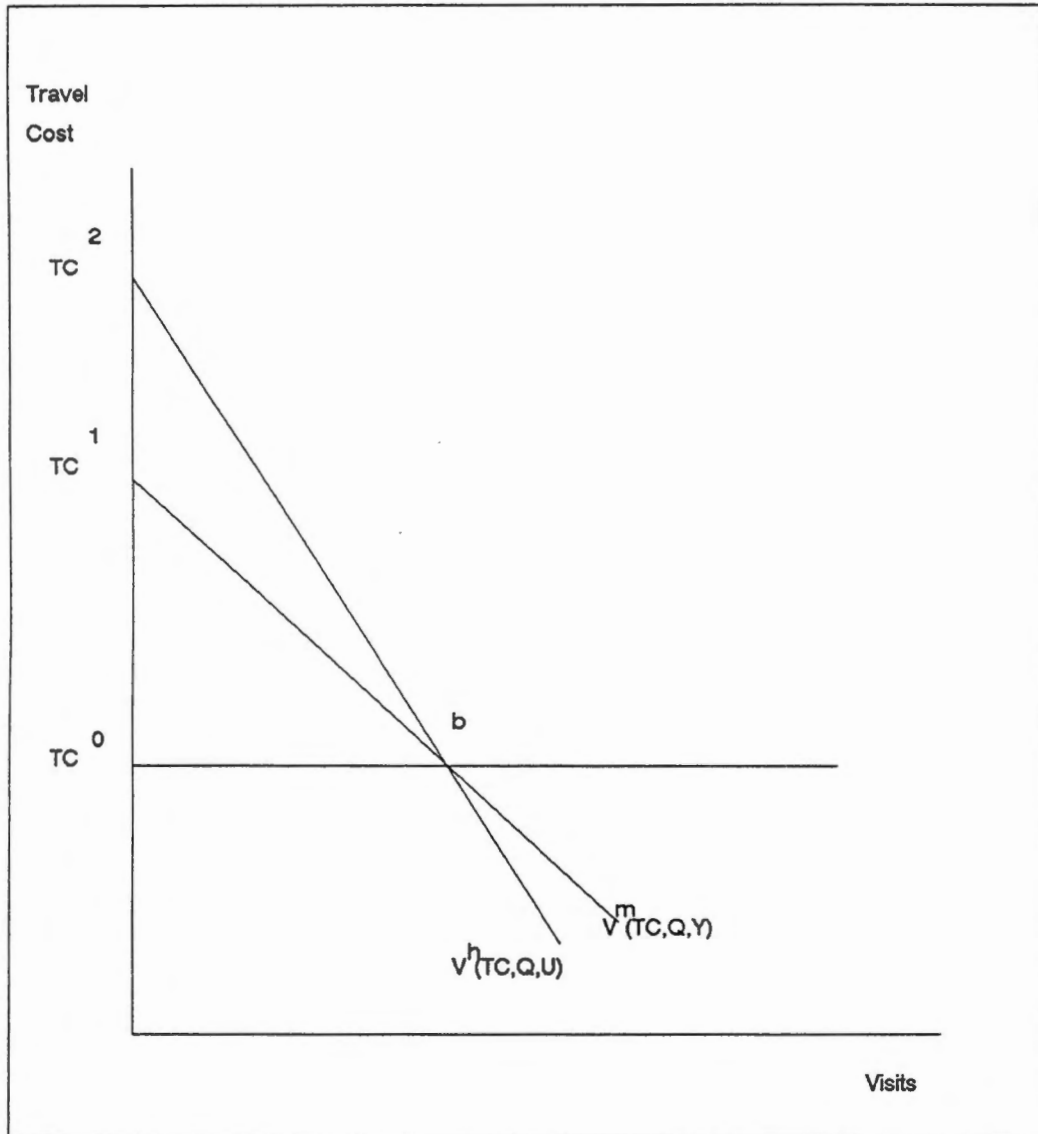


**Figure 2.1. Welfare Measurement: Difference Between Marshallian Demand and Hicksian Demand**

Marshallian consumer surplus can also be written in equation 2.3 as:

$$CS = \int_{TC^0}^{TC^1} V(TC, Y) dTC = \text{Area } TC^0TC^1b \quad (\text{eq. 2.3})$$

while Hicksian compensating variation may be written in equation 2.4 as:

$$CV = \int_{TC^0}^{TC^2} V(TC, U) dTC = \text{Area } TC^0TC^2b \quad (\text{eq. 2.4})$$

Marshallian consumer surplus and Hicksian compensating variation do not, in general, yield the same value. By using the Slutsky equation, however, it is possible to see that when the income effect is small, the Marshallian demand curve provides a good approximation of the Hicksian demand curve. The Slutsky equation may be written in equation 2.5 as:

$$\frac{\partial X^m}{\partial p} = \frac{\partial X^h}{\partial p} \Big|_{\bar{u}} - X^* \frac{\partial X^m}{\partial Y} \quad (\text{eq. 2.5})$$

where  $\partial X^m / \partial p$  is the slope of Marshallian demand function,  $\partial X^h / \partial p$  is the slope of the Hicksian demand function and

$X \cdot \partial X^m / \partial Y$  is the income effect. When the income effect is zero, the two demand curves coincide, and  $CV = CS$ . If the income effect were not zero,  $CV$  would not equal  $CS$ .

Because income compensated access value is measured by integrating the demand curve to the price which drives the number of visits to zero, the TCM implicitly assumes that substitute goods or sites are available to the consumer. This is known as the non-essentiality assumption. This assumption means that the recreation site is not essential to obtain the reference level of utility. If the substitutes were not available, then compensating variation would be infinite since utility could not be held constant.

To measure the value of change in quality of a public good, quality must be "assigned" to the site. By observing the changes in demand for the site when the quality of the site changes, a welfare measure can be calculated. The word "quality" refers to any one or several site characteristics. Measures of water-based recreational site quality can be determined by observing, for example, how resource users react to changes in the concentration of sediments, phosphorus, and nitrogen in waterways, or changes in fish populations. Site characteristics may be affected negatively by pollution or by competing economic activities such as logging, mineral extraction, or agricultural production. Site characteristics may be positively affected by investments (such as the CRP) which enhance the flow of recreation services from a resource

(Freeman, 1993).

In order to estimate changes in site quality we rely on the Marshallian travel cost demand curve,  $V^m (TC, Y, Q^0)$ , where  $Q^0$  represents an initial level of site quality. This curve shifts to the right when there is an improvement in the quality of a site, from  $Q^0$  to  $Q^1$ . Access value has increased due to the quality induced increase in demand for the site. A change in the access value would be computed as the difference in the consumer surpluses obtained at each quality level. The Marshallian consumer surplus for the quality change from  $Q^0$  to  $Q^1$  is  $CS (\Delta Q) = \int V^m (Q^1) - \int V^m (Q^0) = \text{area } TC^0TC^3Z - \text{area } TC^0TC^1X$  (Figure 2). This is simply the difference between access values at each quality level. Similarly, the Hicksian compensating for the quality change from  $Q^0$  to  $Q^1$  is  $CV (\Delta Q) = \int V^h (Q^1) - \int V^h (Q^0) = \text{area } TC^0TC^4Y - \text{area } TC^0TC^2X$ .

Figure 2 also illustrates the error in using consumer surplus rather than compensating variation as the value of site quality improvements. Where consumer surplus for a change in quality is the difference in the areas under the Marshallian demand curves,  $V^m(TC, Q, Y)$ , the compensating variation for a change in quality is the difference in the areas under the Hicksian demand curves,  $V^h (TC, Q, U)$ . As noted above, the error in using CS instead of CV is related to the size of the income effect. In Figure 2, the error is the difference in value erroneously included in the consumer

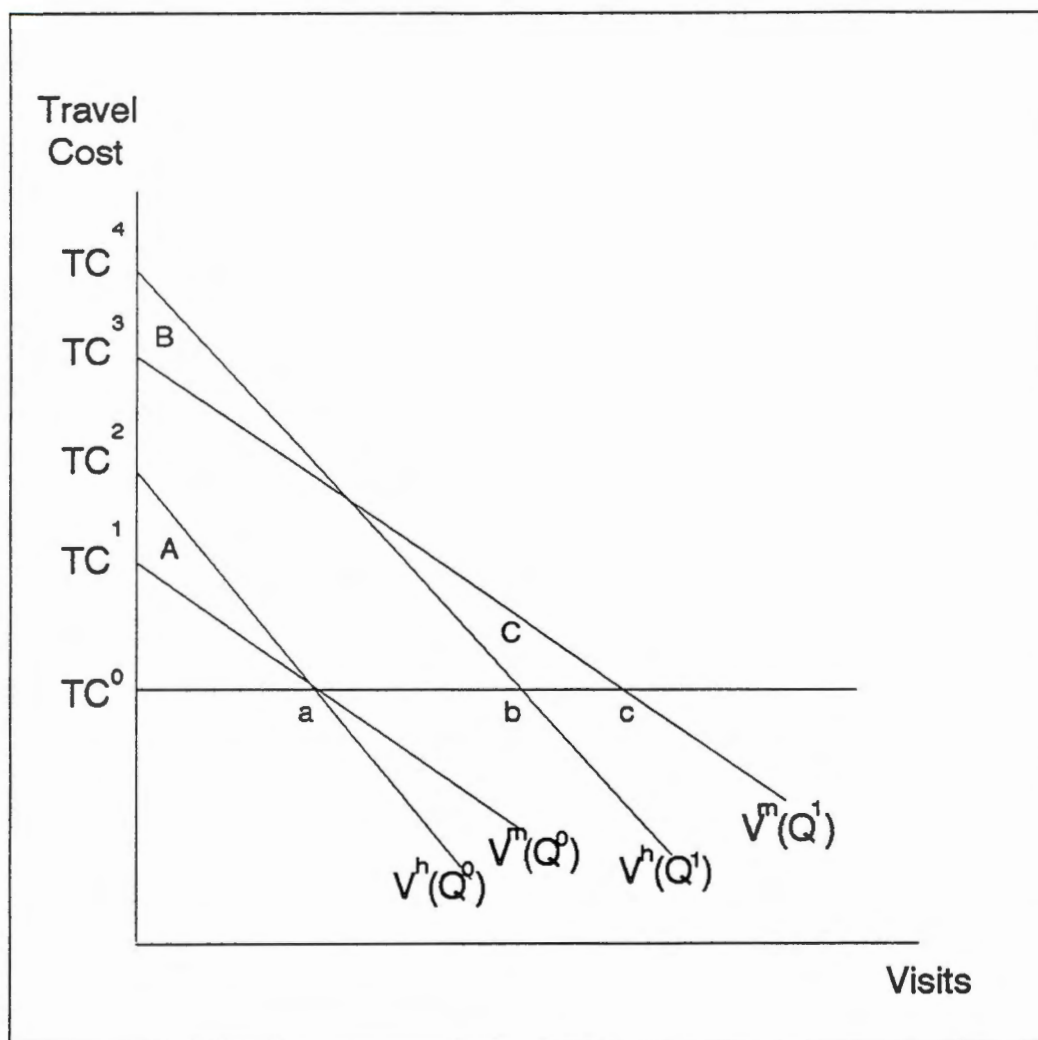


Figure 2.2

Welfare Measurement: Difference Between Marshallian Demand and Hicksian Demand with a Change in site quality

surplus calculation (area A + C) less that erroneously excluded (area B). In using the difference in access values as a measure of the value of a quality change, the TCM makes use of the notion of weak complementarity. The model assumes that site quality contributes to utility only when it is used as part of a recreational trip, i.e., site quality and recreational trips are weak complements. Weak complementarity implies that when the quantity of trips is zero, the marginal utility of quality will also be zero,  $\partial U / \partial Q|_{V=0} = 0$ . This feature of the model implies that only users of the resource obtain value from a change in site quality.

## 2.5 Econometric Estimation of the Travel Cost Model

When estimating travel cost models, methods have been developed to include both users and non-users demand for recreation sites. This is important because changes in water quality may induce greater participation. When estimating a TCM regression using only participants, truncation effects arise because there are no data available for non-participants. In a truncated distribution, the sample is incomplete since no observations are drawn below a certain level, i.e.,  $V < 1$ . The model in equation 2.6:

$$E(V_{ij} | V_{ij} > 0) = f(TC_{ij}, Q_j, Y_i) \quad (\text{eq. 2.6})$$

is an example of a truncated model. Only a subset of all

possible observations is observed, because it focuses only on those individuals who are already involved in that recreation, ( $V_{ij} > 0$ ). The characteristics of non-users and how they value changes in quality are not observed (those for whom  $V_{ij} = 0$ ). If the CRP results in a noticeable increase in quality, this might be enough to get non-users involved in recreation and these "new" users need to be included in the regression equation. OLS regressions using only current users (a truncated sample) would estimate the value of the change in water quality to current anglers, without including quality effects on non-anglers. Further, the OLS parameter estimates of a truncated sample are biased and inconsistent (Greene, 1992). If we wish to draw inferences about the effect of water quality improvements for the full population, we must sample both users and non-users, and employ econometric methods which use all observations. Such a sample is considered censored, where the independent and dependent variables are observed for all observations, but many of the dependent variables take a value of zero (no trips).

Selection models include the decision to become involved in a recreational activity and, with the decision to participate, how many visits to make. The truncated model is likely to predict greater values than the selection model, simply because the truncated model disregards zero values (non-users), whereas the selection model includes both users and non-users.

In a selection model, a probit model is estimated at the selection stage, and the parameters are used to calculate the inverse Mill's ratio (IMR). The arguments of the probit model (and the IMR) include those variables believed to influence the participation decision, e.g. income, pollution, and socio-demographic variables. The IMR "re-scales" the density function used in the visitation model to adjust for truncation. The IMR ( $\lambda$ ) is the value of the density function for the standard normal divided by the probability that a person will go fishing (equation 2.7),

$$\lambda^i = \frac{-\phi(Z^i\alpha)}{\Phi(Z^i\alpha)} \quad (\text{eq. 2.7})$$

where  $\phi$  is the density function for the standard normal,  $\Phi$  is its cumulative density function,  $Z^i$  are independent variables for person  $i$ , and  $\alpha$  are parameters estimated from the probit equation. Using the IMR on the right hand side of the visitation model corrects for the truncation effects. By including the IMR in the visitation model, people who might decide to go fishing in the future will be accounted for. The empirical model is now  $V_{ij} = \omega + \beta TC_{ij} + \gamma Y_i + \delta Q_j + \sigma \lambda_i$ . Using the IMR in the visitation model implies the factors which affect participation (e.g. pollution) are also expected to influence the visitation stage. In this way, users and non-users (potential "new" users) are linked. Most censored regression-studies have employed the Tobit model. The Tobit model is

very restrictive because the same variables are used in both the participation and visitation models. Further, the coefficients of the independent variables are identical across the participation and visitation stages.

In this thesis the Heckman selection model will be used instead of the Tobit model. The Heckman selection model is less restrictive. The variables which explain participation in reservoir fishing (the probit model) are not necessarily the same as the variables used in the visitation model. The Heckman selection model therefore leads to more flexibility because the parameter vectors are allowed to be different. The participation and visitation models will be estimated simultaneously using the method of maximum likelihood to derive parameter estimates which are unbiased, consistent, and efficient.

These models will be used to estimate the demand for a site once the quality of the site improves. By improving upon work done by Ribaud and others in the area of CRP induced water quality benefits, the available data will allow us to measure how an angler values a site by estimating the consumer surplus from an improvement in the quality of that site.

## **Chapter 3**

### **Literature Review**

#### **3.1 Introduction**

Many studies have examined the impact that farm programs such as the Conservation Reserve Program (CRP) have had on water quality. CRP has generated improvements in water quality, improved soil productivity, wildlife habitats and reduced agricultural surpluses. Most studies measuring the impact of CRP on downstream recreation have been conducted at highly aggregated levels. In contrast, this research examines the water quality benefits of CRP at the disaggregated level: using individual level data I examine CRP benefits accruing to reservoirs anglers in East Tennessee. First, however, the literature is reviewed with regard to the methods used to model the economic impact of CRP, the physical downstream impacts of farm programs, and the associated recreational fishing benefits.

Two different approaches have been used to examine CRP and its economic impact. The benefits of recreation are measured differently by each method. The first approach uses the Input-Output (I/O) method by calculating the economic impacts that occur as a result of implementation of the CRP. The second approach concentrates on forging the linkages between erosion and changes in Marshallian consumer surplus

derived from improvements in recreation quality.

This chapter first reviews the I/O modelling approach by showing the economic impacts of CRP with and without adjustments for quality induced changes in the recreation sector. The linkages between agricultural pollutants, conservation programs (such as CRP), and the behavior of recreationists are examined by Kahn and Kemp, and Ribaudo (1989a, 1989b). I differentiate between the methods used by these authors and the methods which will be used in this study.

### **3.2 Input/output models**

Input-Output models use data that analyze the relationship between a particular industry and all other industries in an economy by connecting the output produced in one industry to the required inputs from all other industries. The method can be used to examine how a change in one or more industries affect other industries in that economy. Three examples in the literature are presented in this review. Broomhall and Johnson (1990), Hyberg et al. (1991), and Siegel and Johnson (1991), all used the I/O model to determine what effect CRP had on local economies.

Broomhall and Johnson (1990) used an I/O model to analyze the impact of the CRP on a local economy of a region dependent on agriculture. The analysis concerned an area where land was converted almost exclusively to timber which could be

harvested in 20-25 years. The net effect of the CRP on sectoral employment and income was negative in all years except those when timber harvest occurred. This research showed that CRP has significant economic impacts on the local community. The authors recognized, however, that non-market benefits were excluded from their analysis. With a reduction in run-off, an increase in the quality of recreational fishing both locally and downstream could occur.

Hyberg et al. (1991) used an I/O model to examine the impacts of the CRP on five industrial sectors at national, regional and local levels. This analysis studied three stages of CRP, which reflected changes in program requirements over time. In all three stages, the results showed that CRP reduced regional and national economic activity, due to decreases in agricultural production and the resulting decrease in the use of agricultural inputs. Although there was only a small impact on the national economy in terms of employment and income, CRP was shown to have a major impact on agriculturally dependent regions. Again the downstream impacts of CRP were excluded from the analysis.

Siegel and Johnson (1991) examined the economic trade-offs between resource based activities (such as recreation) and agricultural production in Virginia. With erodible cropland being taken out of agricultural production, improvements in water quality should occur, resulting in an increase in water-based recreational use, and the money spent

on these activities. While the land is in retirement, farmers may be able to supplement their income by renting this land for recreational purposes, such as hunting, fishing, swimming, hiking and other types of recreation.

With the demand for water-based recreational activities growing at a faster rate than the demand for agricultural products, decreases in crop production and farm income may possibly be off-set by increases in recreational activity. A break-even approach was used to develop a basis for farmer compensation to determine the level of recreational activity necessary to offset the negative economic effects associated with decreased agricultural production.

Siegel and Johnson examined a broader range of CRP related impacts than the two previous studies. These included not only reduced crop production and input purchases, vegetative cover maintenance expenditures and CRP payments, but also the rental payments by recreationists to farmers and the goods and services purchased by recreationists. The authors estimated the increase in recreational activity needed to offset the otherwise negative economic effect that CRP has within a region. Any combination of CRP rental payments and increased recreation expenditures which totaled \$75 per acre would be sufficient to offset negative CRP effects.

In all three papers, the I/O models showed that employment and total income decreased when offsite effects were ignored. The Siegel and Johnson paper suggests that CRP

induced increases in recreation activity are important to minimize the negative effect of CRP. I/O models are not well-suited to gauge the magnitude of changes in recreation activity (or calculate the surplus measures) associated with quality changes. The travel cost model estimated with a selection model is an appropriate method. Not only can surplus measures be determined, but the change in the number of fishing trips can be estimated as well. When combined with expenditure data, a selection model can provide the information required for a Siegel/Johnson-type break-even analysis.

### **3.3 The Physical Linkages**

Agricultural production is a source of pollution in many waterways. This occurs when inputs used in agriculture are washed into the water-stream. Once in the water-stream, these pollutants are responsible for damage to plants, animals and humans who use the water. Agricultural non-point source pollution causes more damage to waterways than any other type of pollutant (Ribaudó, 1989a).

Some damage can be averted by using effective conservation practices which lead to a reduction in the discharge of pollutants such as sediments and pesticides. With this reduction in the amount of discharge, the quality of downstream waterways (such as reservoirs, lakes or rivers) are improved because of the decrease in pollutant loadings. The

improvement in quality may lead to an increase in the use of these sites for recreation.

To make the connection to travel cost models, it is first necessary to understand the linkages between a conservation program and subsequent changes in the behavior of recreationists. The links between soil erosion and water quality are important in understanding the source of downstream benefits of conservation programs like the CRP. The first step occurs when soil is washed to the edge of the field by rainfall or melted snow. Attached to these soil particles are nutrients and pesticides. The amount of pollutant washed to the edge of the field depends on factors such as slope characteristics, the erodibility of the land, crop management and whether or not there are conservation practices installed (Ribaudó, 1989a).

In the second stage, soil particles and the attached pollutants are carried from the edge of the field into the waterways. The concentration of these particles is dependent on slope, the type of crop management involved and the distance to the waterway.

The change in water quality due to agricultural pollutant loading constitutes the third link. An increase in the level of pollutants results in physical and biological impacts on the waterway. Physical impacts are the changes in dissolved oxygen content, nutrient concentrations, temperature, odor and pH. Biological impacts are the changes that occur in fish

populations due to increased pollution deposits. Accumulation of nutrients in the waterway promotes the growth of algae and weeds. This not only hinders swimmers and boaters, but it also changes the composition of fish population, for example, cold water fish being replaced by warm water species (Silvander and Drake, 1991). The fourth link between soil erosion and offsite damage examines the relationship between the change in the quality (i.e. physical and biological impacts) of water and the use of this water. This fourth link measures the impacts of declining water quality on the different users of the resource. Increased nutrient loadings, or reduction in dissolved oxygen, may change fishstocks, making the water body less suitable for fishing. The final link is the perceived quality changes of the water-stream and the resulting changes in derived demand for the site by recreationists.

#### **3.4 Connecting Pollution to Fish Stocks**

Silvander and Drake (1991) examined the economic effects that nitrogen loss (from agricultural production) have on fisheries in Sweden. The leaching of nitrates is a cause of eutrophication of water ways, resulting in a loss of fish populations. The connection between agricultural practices and the impact on anglers was asserted in a contingent valuation scenario, and not measured using actual pollution data and observed behavior.

Silvander and Drake found that approximately 97% of anglers would fish less if a popular species disappeared, due to the nitrate pollution. A substantial number of respondents (63.5%) stated that they would be willing to pay some amount to preserve fish populations. The authors proposed different scenarios, such as the action that anglers would take if a popular species disappeared. They were then able to determine an angler's willingness to pay (WTP) to preserve present fish populations. Although the authors examined the effects that nitrate loadings into the water-stream had on an angler, the CVM method was not able to calculate welfare benefits/losses associated with changes in the levels of this pollutant.

Kahn and Kemp (1985) looked at the way in which the run-off of agricultural chemicals and soil erosion contributed to the reduction of submerged aquatic vegetation (SAV) in Chesapeake Bay. SAV in the Chesapeake Bay had been a significant component in the ecology of the estuary, but with increased deposits of suspended solids, herbicides and plant nutrients, the plant population has declined.

The standard Shaeffer model was used to show the relationship between fish stocks and catch rates. This equilibrium catch equation maps the catch rate which sustains fishstocks at a constant level. An increase in pollution leads to a reduction in SAV, and a downward shift in the equilibrium catch function. The carrying capacity of the environment in this situation is reduced, so the catch rate

associated with a given level of the fish stock declines as well.

The relationship between fish populations, pollution, and social welfare was measured by mapping the equilibrium catch equation in price-quantity space. Supply curves were drawn for each level of fishstock, while demand was constant. This mapping makes it possible to derive the relationship between the reductions in SAV and the welfare losses of the fisheries (producer and consumer surplus).

Thus, Kahn and Kemp modeled the impacts of pollution on fisheries by indirectly connecting pollution levels to SAV, then SAV to fish populations. These relationships were estimated empirically using biological time-series data. Demand and supply curves for recreational fishing were theoretically developed and empirically estimated. The interaction of the equilibrium catch equation, the demand equation and the supply equation were then used to develop total and marginal damage functions, from which welfare losses were calculated.

### **3.5 Putting Pollution Directly into Behavioral Models**

An alternative formulation is to put the pollution measures directly into the behavioral model, bypassing the connection between fishstock (or catch) and pollution. This assumes that anglers can perceive the measures of pollution and respond accordingly.

For example, Ribaudó (1989a, 1989b) examined the impact of soil erosion and the damages off-site. Benefits of reduced erosion were estimated for nine impact categories, including recreational fishing. The first two links connecting CRP and angler behavior were modelled by projecting the amount of soil erosion averted for CRP enrollments of 23 million acres (actual enrollment) and 45 million acres (the program goal). Materials discharged (total suspended sediment (TSS), nitrogen (TKN), and phosphorous (TP)) were estimated for the reduced soil erosion levels. Thus CRP was shown to reduce the levels of discharge in TKN, TSS and TP.

Three equations were estimated to quantify the relationship between material concentration in waterbodies and the explanatory variables, material discharge (weight/yr), stream flow (volume/day) and water storage (volume) in equation 3.1:

(eq. 3.1)

$$\text{TSS} = \alpha_s + \beta_s \text{ materials discharged} + \gamma_s \text{ storage} + \delta_s \text{ flow}$$

$$\text{TKN} = \alpha_n + \beta_n \text{ materials discharged} + \gamma_n \text{ storage} + \delta_n \text{ flow}$$

$$\text{TP} = \alpha_p + \beta_p \text{ materials discharged} + \gamma_p \text{ storage} + \delta_p \text{ flow}$$

Flow and storage were expected to affect concentration negatively, while discharge was expected to affect concentration positively. The results showed that except for storage, the explanatory variables were significant at the 99 percent level. These models linked on-farm conservation

practices to the quality of downstream water bodies.

To measure the benefits of a water quality improvement, a model was needed to link changes in water quality to changes in recreational activity (and thus, consumer surplus). Ribaudo developed a sequential participation-visitation model for recreational fishing using the 1985 National Survey of Fishing and Hunting. Ribaudo (1989a, 1989b) was able to measure the benefits of an improvement in quality by bypassing the connection between the level of pollutants and fishstocks. The first part of the sequential model looked at the decision to participate in the fishing activity, i.e., the probability that a person would go fishing during a given year. Socioeconomic factors such as household income, urban or rural residence, whether one grew up in an urban or rural area, age, and sex were explanatory variables. TSS, TKN and TP were also used in the participation model because they linked non-point pollution in waterways to recreational participation. The visitation part of the model determined how often the person would fish, once the decision to fish was made. The number of days spent fishing was a function of the socioeconomic factors mentioned above, water quality (TSS, TKN and TP), and distance travelled to the recreation site, where distance was a proxy for travel costs<sup>1</sup>. The sequential model was then used to estimate changes in fishing days by looking at changes in the

---

<sup>1</sup>. The data available to Ribaudo was not suitable for travel cost modeling.

quality of water.

The sequential model predicted near zero benefits from recreational fishing. Although the participation model showed that a decrease in materials discharged led to increased participation, the water quality variables were insignificant in the visitation model. This implies that although the decision to fish is a function of water quality, other factors dictate how often to fish.

In a related study, Ribaudó and Piper (1991) sought to link water quality to recreational usage at the national level. Using the same data, a two step sequential model was again used, where the probability of participation was determined by a logit model. Then, depending on participation, a visitation equation was estimated to determine the quantity demanded for this activity (visitation model).

The primary difference with Ribaudó's earlier work was the transformation of pollutant concentrations to a 0-1 "threshold" index. The three pollutant concentrations used were again TSS, TKN, and TP. Concentration thresholds at which water quality was impaired were identified. For TSS, TKN and TP, the levels were 90 mg/l, 0.9 mg/l and 0.1 mg/l respectively. It was assumed that if any one of the pollutants exceeded its threshold value, water quality was impaired, and concentrations of other pollutants were disregarded. A 0-1 water quality index (a dummy variable)

took the value 1 if one pollutant exceeded its threshold, or the value 0 if no pollutant exceeded its threshold. Indices were created for water quality in a respondents' home region and regions adjacent to their home.

Socioeconomic factors, such as income, rural residency and younger age were expected to affect fishing participation positively. Other influences on participation were proximity to water and water quality. In the visitation model, how often a person went fishing was a function of socioeconomic factors, travel costs and water quality. In determining which site to visit, the person also makes a decision on how far to travel. In this model, the angler faces two choices, how often to fish, and how far to travel. This can be shown in equation 3.3 as:

$$V_i = V(Q_j, D, Y_i, SE_i) \quad (\text{eq. 3.3})$$

$$D = D(Q_j, Y_i)$$

where  $V_i$  is the number of fishing trips per year by individual (i),  $Q_j$  is the water quality of regions (j) where j indexes home and adjacent regions,  $D$  is the average distance to visited sites,  $Y_i$  is the income of individual (i) and  $SE_i$  are other socioeconomic variables. The distance equation was significant at the 1 percent level. While distance travelled was positively related to income, distance and water quality were not related. The total trips equation was significant

at the 1 percent level, although water quality was again not a significant factor in determining the number of fishing trips made. When the quality of water improves, it is expected that the total trips to recreation sites should increase, either through increased visits to a particular site or increased visits to substitute sites. The results showed that when quality of all sites improve, it was more difficult to determine the effect on the number of trips taken.

With respect to the Conservation Reserve Program, reduction in the erosion of soil and subsequent decrease in pollutant levels in waterways were not adequate to show increased use, due to a perceived increase in water quality. Therefore the conclusion was that the effects of the CRP at that time was not enough to improve the water quality or, alternatively, the initial water quality was already considered to be good.

### **3.6 Summary**

While I/O models have often been used to measure the economic impacts of conservation programs, they are not well suited to quantify the changes in recreation behavior due to changes in water quality. Instead, a travel cost model may be better suited to measure these impacts, by measuring benefits and to provide information to I/O modeling efforts.

In the travel cost literature, two methods of connecting conservation programs, pollution, and angler behavior are

reviewed. The works of Kahn and Kemp and Silvander and Drake asserted a connection between pollution and fishstocks. The Silvander and Drake connection was not "formal" while Kahn and Kemp reported a structural model relating aquatic vegetation to fishstocks. In both cases, anglers were presumed to respond to fish stocks.

Ribaudo et al., skipped the connections that Kahn and Kemp made, by connecting soil erosion programs to changes in pollutant levels of water. They were then able to examine the changes in behavior and measure welfare effects incurred by recreationists.

Many travel cost demand models are similar to Ribaudo's work, because the pollution measures are included in behavioral models. This thesis will follow this route. Pollution measures will be used to determine the effect these indexes have on the decision to participate. The significance to the visitation model of travel cost, water quality (fish catch) and income will be analyzed. Further, the significance of the participation variables to the behavioral model will also be examined.

## **Chapter 4**

### **Reservoir Fishing Data**

#### **4.1 Data Collection**

Primary data were collected in the fall of 1994, using a random digit telephone survey of 10,000 phone numbers from all over Tennessee. The survey asked questions pertaining to outdoor recreational activities in the state of Tennessee taken between March 1 and August 31 of 1994 (see survey in **Appendix**). The sample was stratified so that 30 percent of the ten thousand households called came from four primarily "urban" counties (Knox, Davidson, Hamilton, and Shelby). This was done because past surveys have shown rural populations engage in more outdoor recreational activities, and the stratification would therefore create a larger sample of detailed behavioral data (Jakus et al., 1994). The remaining 70 percent of the telephone numbers were taken from 91 "rural" counties.

Of the ten thousand telephone numbers called, about 29 percent were ineligible (due to disconnects and hearing/language problems, or businesses). Of the 7100 remaining eligible numbers, there was no contact with 1460 (37 percent of eligible numbers). Only thirty three calls (<1 percent) were terminated in mid-interview, but nearly 3000 persons refused to even begin the survey (41.9 percent of

eligible numbers). Completed surveys were obtained from 2631 Tennessee residents (37 percent of eligible). The final response rate for the sample was 46.7 percent, which was calculated as the number of completed interviews divided by the total number of eligible numbers, less the no contact calls (see Table 4.1).

Because the survey was stratified by urban/rural county of residence, rural residents were assigned greater weights to accurately reflect Tennessee's population. Also, because females answered the phone most often, females were given greater weights.

Once weighted by county type and gender, the respondent profile showed that the average age was 42.6 years of age (with the minimum age for respondents being sixteen years old). The average years of education was 13, or through the first year of college. The average income of those surveyed was \$37,500, the percentage of farmers participating in the survey was 9.5, with males constituting 48.2 percent of the weighted sample.

Of the people who responded, 26.6 percent stated that they went fishing between March and August of 1994. Those who reported fishing activity in the sample period were asked what kind of water bodies were fished. Thirty-four percent stated that they fished in private ponds, 30.6 percent stated that they fished in private lakes, 18.8 percent reported fishing in small public lakes, 24.2 percent in warm water streams,

**Table 4.1****Response Rates for Fall 1994 Survey**

| Category                                                                | Number | %      |
|-------------------------------------------------------------------------|--------|--------|
| Total Phone Numbers                                                     | 10,000 | 100.0% |
| Ineligible                                                              |        |        |
| Hearing/Language Problems                                               | 94     | 0.9%   |
| Disconnects                                                             | 1997   | 20.0%  |
| Business/Government                                                     | 811    | 8.1%   |
| Eligible                                                                |        |        |
| No Contact                                                              | 1460   | 14.6%  |
| Terminate                                                               | 33     | 0.3%   |
| Refused                                                                 | 2974   | 29.7%  |
| Completions                                                             | 2631   | 26.3%  |
|                                                                         |        |        |
| Effective Response rate =<br>Completions/(Total<br>Eligible-no contact) |        | 46.7%  |

16.1 percent in trout streams and approximately 60.2 percent stated that they had fished in reservoirs. Anglers were also asked how many trips they took to each reservoir visited, the distance they had to drive to access the reservoir, and how many fish were caught and released on an average trip to that reservoir.

Other angler data were also collected, including the type of license that was bought, whether or not they owned a boat, if they fished from a boat, if they belonged to a fishing club, whether they participated in fishing tournaments, and the number of years they had fished. In order to avoid the problem of truncation effects (see Chapter 2), data were also collected from non-participants. Data collected from all survey participants included socio-demographic variables such as income, age, education, and whether or not the respondent's parents fished or hunted. Table 4.2 reports some statistical data on the people who were sampled. These results appear to be similar to the results of a survey taken by Jakus et al. (1994). For example, census data reveal a mean age of 40.9 years, which is very close to the mean age of 43.3 in this survey.

#### **4.2 Water Quality Data**

Obtaining reservoir quality data is important because it is hypothesized that these characteristics are influenced by

**Table 4.2          Respondent Profile of people sampled**

| <b>Variable</b>    | <b>Mean</b> | <b>Minimum</b> | <b>Maximum</b> |
|--------------------|-------------|----------------|----------------|
| Age                | 43.38       | 16.00          | 1.00           |
| Urban Residence    | 0.39        | 0.00           | 91.00          |
| Income             | 37.15       | 7.50           | 1.00           |
| Gender             | 0.44        | 0.00           | 100.00         |
| Education level    | 13.41       | 8.00           | 1.00           |
| Race               | 0.12        | 0.00           | 18.00          |
| Parents Hunt/Fish  | 0.56        | 0.00           | 1.00           |
| Percent of Water   | 3.83        | 0.00           | 1.00           |
| Travel Cost        | 29.77       | 0.00           | 193.20         |
| Fish Catch         | 14.06       | 0.00           | 420.00         |
| Dissolved Oxygen   | 6.52        | 5.78           | 8.04           |
| Nitrogen           | 0.58        | 0.38           | 0.72           |
| Phosphorous        | 0.29E-01    | 0.12E-01       | 0.44E-01       |
| Suspended Sediment | 6.89        | 0.73           | 17.96          |

CRP and have an effect on angler behavior. Reservoir quality data were obtained from secondary sources. Of the 34 reservoirs in Tennessee, 19 are managed by the Tennessee Valley Authority (TVA), while the rest are under the supervision of the Corps of Engineers (COE) and Tennessee Wildlife Resources Agency (TWRA). Reservoir quality measures were obtained for fifteen TVA managed reservoirs. The measures included concentration levels of dissolved oxygen (DO), total nitrogen (TN), total phosphorous (TP) and total suspended sediment (TSS) (see Table 4.3).

The TVA data represent mean monthly levels of dissolved oxygen, nitrogen, phosphorous and total suspended sediment over the course of the monitoring period (Feb-Oct. 1994). Chemical characteristics were measured at reservoir forebays, in the vicinity of the reservoir dam. While some reservoirs also had measurements taken in the transition zone (middle) and embayment zones (major reservoir 'arms'), forebay measurements were available for the maximum of reservoirs (Meinert, personal communication, 1995).

#### **4.3 Focusing on East Tennessee**

While the data were collected from the entire state of Tennessee, this thesis will focus on reservoir fishing in east Tennessee. There are two major reasons for doing so. First, Tennessee is geographically and agriculturally diverse from

east to west. To reduce the number of assumptions necessary to model the impact of conservation programs, it is desirable to have relatively homogeneous geographic and agricultural characteristics within the study site. Relevant homogeneous characteristics include types of soil, average slopes, and types of agricultural management practices. If these factors are more alike within a region, the downstream effects of the CRP program are easier to predict. The east Tennessee region is in the Tennessee river valley and is located between the Appalachian mountains and the Cumberland plateau. Compared to middle and western Tennessee, this region seems to be geographically homogeneous. A second reason to focus on east Tennessee is that the majority of TVA reservoirs are located in this region, with few reservoirs to the TVA reservoirs. In middle and west Tennessee, anglers have available other substitute sites--primarily U.S. Army Corps of Engineers reservoirs. Because no pollution data are available for these reservoirs, they would have to be dropped from the analysis, resulting in a data set which does not reflect the full range of alternative fishing sites.

Since I did not want to exclude relevant substitutes, I looked to see if the geographic division (east Tennessee) corresponded to the sites actually visited by east Tennessee anglers. I examined the "extent of the market" for east Tennessee reservoirs in two distinct ways. First, I looked

**Table 4.3      1994 Reservoir Quality Data (Forebay  
Measurements)**

| Reservoir     | DO<br>(mg/l) | TN<br>(mg/l) | TP<br>(mg/l) | TSS<br>(mg/l) |
|---------------|--------------|--------------|--------------|---------------|
| Boone         | 6.736        | 0.600        | 0.015        | n/a           |
| Cherokee      | 5.598        | 0.730        | 0.015        | n/a           |
| Chickamauga   | 7.264        | 0.538        | 0.036        | 7.917         |
| Douglas       | 4.380        | 0.660        | 0.054        | n/a           |
| Ft. Loudon    | 6.237        | 0.684        | 0.044        | 7.417         |
| Ft. Pat Henry | 8.357        | 0.845        | 0.030        | n/a           |
| Guntersville  | 7.463        | 0.514        | 0.031        | 5.333         |
| Melton Hill   | 8.039        | 0.717        | 0.015        | 4.583         |
| Nickajack     | 6.968        | 0.566        | 0.037        | 6.583         |
| Norris        | 6.742        | 0.550        | 0.007        | n/a           |
| Parkesville   | 7.475        | 0.240        | 0.0230       | n/a           |
| South Holston | 6.160        | 0.710        | 0.007        | n/a           |
| Tellico       | 6.246        | 0.378        | 0.022        | 6.25          |
| Watauga       | 7.219        | 0.500        | 0.014        | n/a           |
| Watts Bar     | 6.333        | 0.517        | 0.031        | 5.667         |

at each reservoir and examined how far away anglers travelled to that particular site. I found that nearly all visitors to east Tennessee reservoirs drove less than 75 miles, so angler origins were within the east Tennessee area. The second procedure examined the reservoirs visited by east Tennessee anglers. Most (>95%) of reservoir trips by east Tennessee anglers were made to east Tennessee reservoirs, with very few visits to reservoirs outside the region. The set of reservoirs used in the estimation are shown in **Table 4.4**. A study done by Bates (1994) using 1992 data reached the same conclusion: east Tennessee anglers primarily visit east Tennessee reservoirs, and east Tennessee reservoirs attract primarily east Tennessee anglers. Therefore, I was able to focus on a region that is both geographically homogeneous and includes all of the relevant substitutes sites for anglers (see **Figure 4.1**).

With the information provided from primary and secondary data sources, the Heckman selection travel cost model developed in Chapter 2 will be estimated. I adopt the Ribaud approach by including pollution data in the behavioral models. Models will be estimated for the east Tennessee region. The benefits that a program such as CRP has on downstream recreational activity of reservoir fishing will be calculated.

**Table 4.4                      Code for Substitute Sites in East Tennessee**  
**(Figure 4.1)**

|   |             |    |               |    |               |
|---|-------------|----|---------------|----|---------------|
| 1 | Boone       | 6  | Ft. Pat Henry | 11 | Parkesville   |
| 2 | Cherokee    | 7  | Guntersville  | 12 | South Holston |
| 3 | Chickamauga | 8  | Melton Hill   | 13 | Tellico       |
| 4 | Douglas     | 9  | Nickajack     | 14 | Watauga       |
| 5 | Ft. Loudon  | 10 | Norris        | 15 | Watts Bar     |

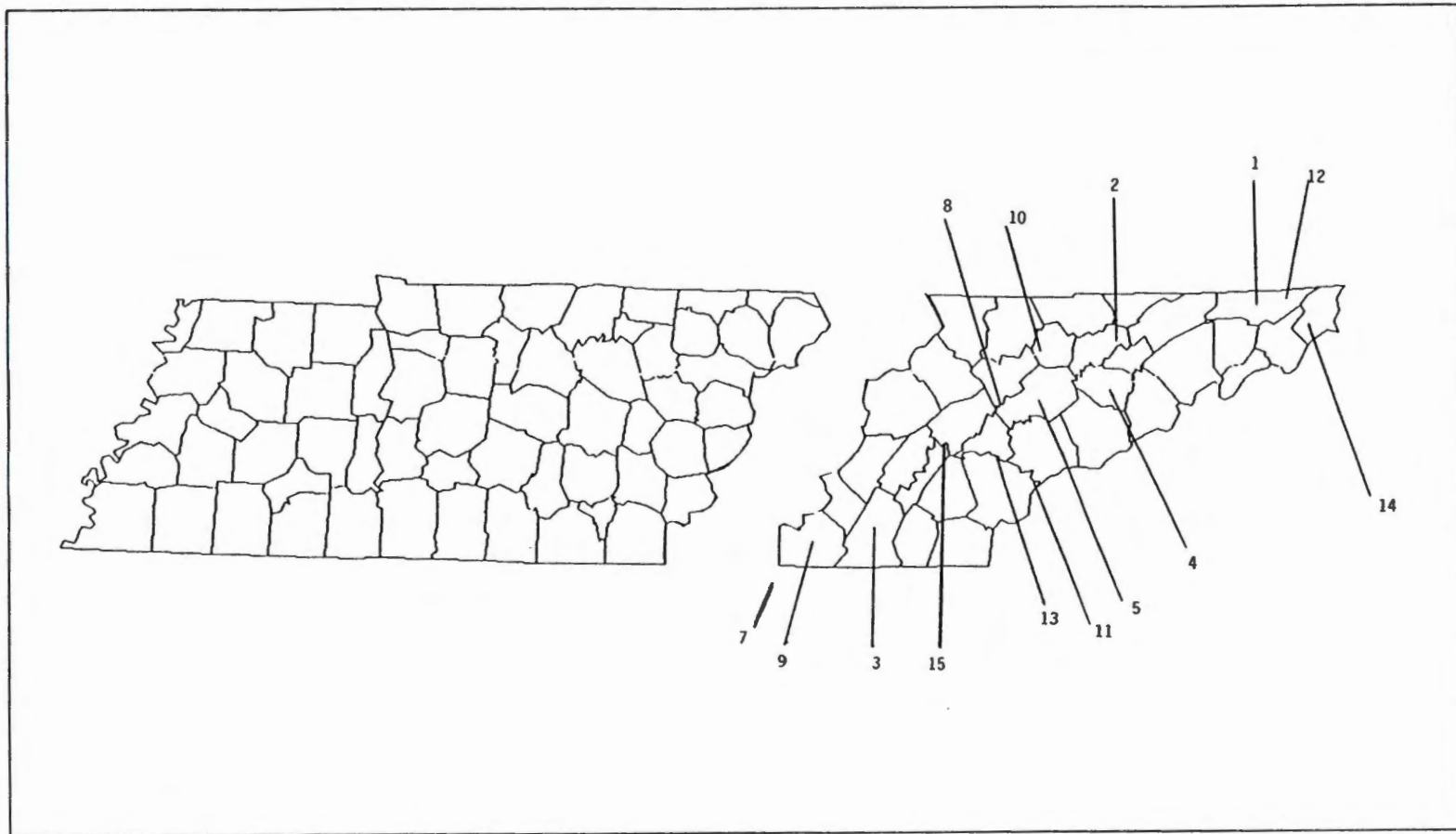


**Figure 4.1**      **All Substitute Sites in the East Tennessee Area:**  
**User Defined Regions**

## **Chapter 5**

### **Results**

#### **5.1 Introduction**

This study estimates travel cost models and the demand for reservoir fishing in East Tennessee. Site quality measures were available for 15 reservoirs in East Tennessee, making it possible to determine what measures had an impact on the behavior of recreationists.

The Heckman selection model was used to estimate the demand for reservoir fishing (see Chapter 2). The water quality variables discussed in Chapter 4 are included in these models to determine if pollution levels played a role in the decision to go fishing. The travel cost models will be analyzed according to their statistical significance and how they conform to economic theory. Models will be presented specifically for the East Tennessee region. The results were used to estimate projected benefits of CRP extending into the year 2000, or terminating the program.

#### **5.2 Deriving the Travel Cost and Quality Measures**

In order to estimate the fishing models, measures of travel cost, fishing quality, and water quality must be constructed. Indexes for each of these measures were required to collapse the multivariate censored demand model (for 15

reservoirs) into a more tractable univariate model.

### 5.2.1 Travel Cost Measure

The travel cost measure was derived by calculating the opportunity cost of time and the out of pocket cost of taking a trip. The hourly opportunity cost of time was assumed to be the wage rate (annual income divided by 2000 hours) multiplied by one-third. While not a perfect measure of the opportunity cost of time, it is a fairly standard approximation (Freeman, 1993). All respondents were asked the travel time to any given reservoir, so the round trip opportunity cost of time to visit the reservoir was calculated as just (travel time \* 2 \* opportunity cost).

The per mile out of pocket cost was \$0.4577 (Statistical Abstract of the United States, 1994). This cost represents not only expenses associated with gasoline, but also includes costs for oil, tires and insurance. Because anglers also were asked the distance traveled to each reservoir visited, round trip out of pocket costs were (miles \* 2 \* 0.4577). The total travel cost to any given reservoir was the sum of opportunity costs and out-of-pocket costs. Because a univariate modeling approach was used, an index for travel cost which reflected the cost of travel to the reservoirs selected was constructed. The share of visits to any one reservoir was calculated as the number of visits to that reservoir, divided by the number of visits to all east Tennessee reservoirs. Denoting the share

and travel cost to any reservoir  $j$  as  $S_j$  and  $TC_j$  respectively, the travel cost index was constructed as the share weighted sum of the travel costs,

$$TCINDEX = \sum S_j TC_j$$

where  $\sum S_j = 1$ .

### 5.2.2 Site Quality Indexes

Quality indices were also constructed as share weighted sums. For fishing quality, each angler was asked how many fish he or she caught (on an average trip) at each reservoir. The fishing quality index (CATCH) was,

$$CATCH = \sum S_j CATCH_j$$

The indices for the pollutant levels (DO, TN, TP, TSS) experienced by anglers were also constructed according to a share weighted sum.

To model the effect of pollutant loading on participation in reservoir fishing, it was necessary to construct pollutant measures for non-anglers. Because these people did not fish, a share weighted index could not be constructed. Instead, it was assumed that non-anglers in a county would likely visit the same reservoirs visited by anglers from the same county. The mean of the pollutant levels for reservoirs visited by anglers from a county was then "assigned" to non-anglers from

that county. This assumes that non-anglers can somehow perceive the water quality of reservoirs, make choices about participation based on that perception, and that this measure is an adequate proxy for perceptions.

### **5.3 Choice of Variables**

The variables used in this analysis are reported in **Table 5.1**. Variables are divided into three categories: those always used in the participation model, those always used in the visitation model, and water quality variables (which are used in both stages). Income is also used at both stages.

Participation in reservoir fishing was assumed to be a function of socio-demographic attributes of the potential angler, the supply of reservoir fishing and the water quality of available reservoir fishing sites. The socio-demographic variables were AGE, GENDER, EDUCATION, RACE, INCSCALE, URBAN and PARHF. The first six of these variables attempt to capture "current" attributes of the angler. Based on past research, it was expected that males would be more likely to fish than females (Jakus et al., 1994).

**Table 5.1            Variable definitions**

|                                   |                                                                      |
|-----------------------------------|----------------------------------------------------------------------|
| <b>Selection Model Variables</b>  |                                                                      |
| AGE                               | Age (years)                                                          |
| URBAN                             | 0 = urban county, 1 = rural                                          |
| INCSCALE                          | Annual household income (\$1000)                                     |
| GENDER                            | 1 = male, 0 = female                                                 |
| EDUC                              | Years of schooling                                                   |
| RACE                              | 1 = non-white, 0 = white                                             |
| PARHF                             | Did parents hunt or fish?<br>1 = yes, 0 = no                         |
| WTRPRCT                           | % area of county covered by water                                    |
|                                   |                                                                      |
| <b>Visitation Model Variables</b> |                                                                      |
|                                   |                                                                      |
| TOTRES                            | Number of reservoir fishing trips<br>March 1, 1994- August 31, 1994  |
| LNTOTRES                          | Natural log of res. fishing trips                                    |
| TCINDEX                           | Travel cost index (section 5.2)                                      |
| CATCH                             | Catch per trip (see section 5.2)                                     |
| CLUB                              | Belongs to fishing club<br>1 = yes, 0 = no                           |
| BOAT                              | Owns a boat 1 = yes, 0 = no                                          |
|                                   |                                                                      |
| <b>Water Quality Variables</b>    |                                                                      |
|                                   |                                                                      |
| DOINDEX                           | Index of dissolved oxygen<br>concentration (see section 5.2)         |
| TNINDEX                           | Index of total nitrogen<br>concentration (see section 5.2)           |
| TPINDEX                           | Index of total phosphorous<br>concentration (see section 5.2)        |
| TSSINDEX                          | Index of total suspended sediment<br>concentration (see section 5.2) |

Older anglers would be less likely to fish than younger anglers. Whites were expected to be more likely to fish than non-whites, while higher income persons were expected to be less likely to fish in reservoirs. The more educated the person, the less likely they were expected to fish in reservoirs. Residents of rural Tennessee counties fish in greater percentages than residents of urban counties, and so they were expected to fish more than urban residents.

PARHF was a variable designed to capture past fishing experience. Anglers whose parents hunted or fished were likely to have taken up the sport as children, and thus be more likely to fish than adults who did not fish as children.

WTRPRCT attempts to capture the availability of reservoirs, or the "supply" of reservoir fishing opportunities. The greater the percentage of water in a county, the more likely residents of that county would fish in reservoirs.

Finally, measures of water quality were also believed to influence participation. As the level of dissolved oxygen increases, greater fish populations are sustained, and participation is expected to increase. As levels of nitrogen increase, eutrophication occurs, damaging fish populations, so participation is expected to decrease. As levels of suspended sediment increase, water clarity decreases, and participation is expected to decrease. As levels of phosphorous increase,

fishing quality is expected to decrease, making participation less likely.

Visitation to reservoirs was assumed to be a function of travel cost index (TCINDEX), the number of fish caught per trip (CATCH), the "avidity" of the angler (CLUB, BOAT) and the water quality of the site. These variables were selected in an effort to explain what factors led to increased trips to the reservoir site.

It was expected that the travel cost measure would have an inverse relationship to the amount of trips taken. As the trip cost to a site increases, it is expected that fewer trips will be taken. The more fish that are caught on an average trip, the more likely that more trips will be taken to that site.

CLUB was included to control for angler avidity. Membership in a club, was therefore expected to have a positive influence on trips to a reservoir. This was also expected of those who owned a boat (BOAT), since a boat owner would be expected to take more trips to the reservoir.

The water quality measures were also expected to affect visitation. The dissolved oxygen measure, DOINDEX, was expected to have a positive relationship to trips taken. As the dissolved oxygen level increased, it was assumed that there would be a greater fish population which would lead to increased visits. The nitrogen measure, TNINDEX, and trips were expected to have an inverse relationship. An increase in

nitrogen leads to a decrease in the fish populations (due to eutrophication), therefore implying less trips taken. TPINDEX, the phosphorous measure, was expected to be negatively related to visitation. Total suspended sediment, TSSINDEX, was also expected to be inversely related to trips. As sediment levels increase, the clarity of water decreases, leading to a reduction in visits.

## **5.4 Evaluating the Empirical models**

### **5.4.1 Estimating the models**

The models were estimated using a Heckman selection model. As discussed in Chapter 2, the Heckman selection model simultaneously estimated the participation and visitation models. Maximum likelihood estimates were used to derive the likelihood ratio statistics, which were then used to evaluate the overall suitability of the models. The significance of the individual variables can be examined by looking at the t-ratios.

### **5.4.2 Participation models**

The results of the participation equation were consistent in all of the modelling for both the linear and the semi-log forms (see Tables 5.2 and 5.3). The coefficient for AGE was shown to be significant and negative. The variable URBAN was also significant at the 95% level and its coefficient had a

**Table 5.2 Selection Stage of Heckman Selection Model--  
Log(trips)  
Selection Model (n= 472) Dependent variable: 1 = fish in  
reservoirs, 0 = do not fish in reservoirs**

| Variable  | Model #1                    | Model #2             | Model #3             | Model #4              |
|-----------|-----------------------------|----------------------|----------------------|-----------------------|
| ONE       | -.68<br>(-.27) <sup>1</sup> | -.74<br>(-.30)       | -.87<br>(-.34)       | .12<br>(.034)         |
| AGE       | -.202E-01*<br>(-2.18)       | -.20E-01*<br>(-2.17) | -.20E-01*<br>(-2.18) | -.212E-01*<br>(-2.14) |
| URBAN     | 1.02*<br>(2.26)             | 1.07*<br>(2.33)      | 1.06*<br>(2.28)      | 1.04*<br>(1.80)       |
| INCOME    | .84E-02<br>(1.15)           | .86E-02<br>(1.17)    | .85E-02<br>(1.14)    | .83E-02<br>(1.10)     |
| GENDER    | .704*<br>(2.37)             | .69*<br>(2.20)       | .69*<br>(2.2)        | .65*<br>(1.97)        |
| EDUCATION | -.17E-01<br>(-.26)          | -.17E-01<br>(-.25)   | -.19E-01<br>(-.27)   | -.21<br>(-.29)        |
| RACE      | -.16<br>(-.32)              | -.14<br>(-.273)      | -.12<br>(-.25)       | -.13<br>(-.26)        |
| PARHF     | .17<br>(.59)                | .17<br>(.57)         | .19<br>(.65)         | .21<br>(.71)          |
| WTRPRCT   | .32E-01<br>(.99)            | .30E-01<br>(.93)     | .30E-01<br>(.93)     | .35E-01<br>(1.10)     |
| DOINDEX   | 1.03*<br>(2.50)             | 1.03*<br>(2.50)      | 1.05*<br>(2.43)      | .91*<br>(1.80)        |
| TNINDEX   | -11.18*<br>(-3.83)          | -11.16*<br>(-3.77)   | -11.00*<br>(-3.52)   | -11.39*<br>(-3.57)    |
| TPINDEX   | 292.75*<br>(5.74)           | 294.36*<br>(5.72)    | 296.4*<br>(5.50)     | 293.08*<br>(5.18)     |
| TSSINDEX  | -1.60*<br>(-5.35)           | -1.60*<br>(-5.33)    | -1.62*<br>(-5.02)    | -1.57*<br>(-4.69)     |

\* indicates significance at the 5% level.

---

<sup>1</sup> t-statistic in parenthesis

**Table 5.3          Selection Stage of Heckman Selection Model--  
Linear (trips)  
Selection Model (n= 472) Dependent variable: 1 = fish in  
reservoirs, 0 = do not fish in reservoirs**

| Variable  | Model #1                      | Model #2             | Model #3              | Model #4             |
|-----------|-------------------------------|----------------------|-----------------------|----------------------|
| ONE       | -2.55<br>(-1.11) <sup>2</sup> | -2.61<br>(-1.15)     | -2.73<br>(-1.2)       | -2.24<br>(-.792)     |
| AGE       | -.21E-01*<br>(-2.47)          | -.21E-01*<br>(-2.46) | -.213E-01*<br>(-2.48) | -.23E-01*<br>(-2.57) |
| URBAN     | 1.024*<br>(2.275)             | 1.04*<br>(2.31)      | 1.03*<br>(2.23)       | 1.05*<br>(2.09)      |
| INCOME    | .78E-02<br>(1.09)             | .79E-02<br>(1.11)    | .77E-02<br>(1.09)     | .73E-02<br>(1.02)    |
| GENDER    | .794*<br>(2.93)               | .79*<br>(2.79)       | .79*<br>(2.79)        | .73*<br>(2.4)        |
| EDUCATION | -.28E-01<br>(-0.451)          | -.27E-01<br>(-.428)  | -.28E-01<br>(-.434)   | -.35E-01<br>(-.49)   |
| RACE      | -.136<br>(-.298)              | -.12<br>(-.266)      | -.11<br>(-.25)        | -.13<br>(-.28)       |
| PARHF     | .119<br>(.466)                | .114<br>(.445)       | .13<br>(.49)          | .19<br>(.69)         |
| WTRPRCT   | .19E-01<br>(.58)              | .178E-01<br>(.54)    | .18E-01<br>(.53)      | .23E-01<br>(.71)     |
| DOINDEX   | 1.23*<br>(3.22)               | 1.23*<br>(3.23)      | 1.24*<br>(3.23)       | 1.20*<br>(2.75)      |
| TNINDEX   | -9.51*<br>(-3.86)             | -9.53*<br>(-3.87)    | -9.40*<br>(-3.81)     | -9.68*<br>(-3.04)    |
| TPINDEX   | 282.24*<br>(6.04)             | 284.1*<br>(6.06)     | 284.25*<br>(6.04)     | 285.94*<br>(5.39)    |
| TSSINDEX  | -1.56*<br>(-5.78)             | -1.56*<br>(-5.82)    | -1.56*<br>(-5.75)     | -1.55*<br>(-5.30)    |

\* indicates significance at the 5% level.

---

<sup>2</sup> t-statistic in parenthesis

positive sign. Income (INCSCALE) was positive as expected, however its coefficient was not significantly different from zero. Education (EDUC), was inversely related implying that more highly educated individuals are less likely to fish in reservoirs. RACE was also inversely related but statistically insignificant. The variable PARHF showed a positive relationship (capturing upbringing experience) but was statistically insignificant. The supply of water in the region, WTRPRCT, showed a direct relationship to the person's decision to fish, however it was not statistically different from zero.

Dissolved oxygen (DOINDEX), was positive and statistically significant at the 95% level, as expected. Nitrogen (TNINDEX), was negative and significant at the 95% level, as was suspended sediment (TSSINDEX). Phosphorous was also statistically significant at the 95% level, however the coefficient carried a positive value in all model specifications.

The results imply that water quality is an important determinant of the decision to fish. Therefore, if the water quality improves, with dissolved oxygen increasing and nitrogen and suspended sediment decreasing, this will entice new anglers to go fishing. A decrease in water quality will lower the number of anglers who will go reservoir fishing.

#### **5.4.3 Visitation models**

Two common specifications of the visitation models (eq. 2.2) were estimated. The first used the natural log of trips as the dependent variable (the semi-log model), while the second used trips as the dependent variable (the linear model) (see Tables 5.4 and 5.5). The base model for all the specifications used the travel cost (TCINDEX) and fish catch (CATCH) variables on the right hand side of the equation. Subsequent additions to these models included variables showing the angler's avidity (CLUB, BOAT) and pollution indexes. Likelihood ratio tests were used to jointly test the relationship between right hand side variables and the number of trips taken.

Overall, the semi-log models performed better than the linear models. The visitation models showed that travel cost and fish catch variables were very important in determining the number of visits. Measures of angler avidity (CLUB, BOAT) were also important determinants of visitation. The pollution measures performed poorly in the visitation models. These variables were either insignificant or had the wrong sign.

In the semi-log model, the joint restriction that travel cost and catch have coefficients equal to zero is rejected at the 0.06 level. After adding CLUB to the model, the joint restriction that all right hand side coefficients equal zero is rejected at the 0.01 level. After adding BOAT, the joint restriction is rejected at the 0.01 level again.

When adding the four pollution indexes to the model, the

**Table 5.4 Visitation Stage of Heckman Selection Model--  
Log(trips)  
Selection Model (n= 58) Dependent variable: Number of fishing  
trips taken.**

| Variable          | Model #1                       | Model #2                         | Model #3                        | Model #4                      |
|-------------------|--------------------------------|----------------------------------|---------------------------------|-------------------------------|
| ONE               | 3.0<br>(9.7) <sup>3</sup>      | 2.89*<br>(10.3)                  | 2.62<br>(.91)                   | .58<br>(.17)                  |
| TCINDEX           | -.13E-01<br>(-1.53)            | -.15E-01*<br>(-1.84)             | -.15E-01*<br>(-1.99)            | -.13E-01<br>(-1.40)           |
| CATCH             | .403E-01*<br>(1.77)            | .45E-01*<br>(2.10)               | .42E-01*<br>(2.12)              | .38E-01*<br>(1.92)            |
| CLUB              |                                | 1.56<br>(.97)                    | 1.50<br>(1.07)                  | 1.53<br>(.94)                 |
| BOAT              |                                |                                  | .52<br>(1.6)                    | .52<br>(1.58)                 |
| DOINDEX           |                                |                                  |                                 | .84E-01<br>(.15)              |
| TNINDEX           |                                |                                  |                                 | 4.40<br>(.97)                 |
| TPINDEX           |                                |                                  |                                 | -62.19<br>(-.693)             |
| TSSINDEX          |                                |                                  |                                 | .19<br>(.49)                  |
| Sigma             | 1.15*<br>(5.7)                 | 1.08*<br>(6.3)                   | 1.05*<br>(6.54)                 | 1.08*<br>(6.02)               |
| Log<br>likelihood | -180.9                         | -177.8                           | -175.9                          | -174.32                       |
| $\chi^2$          | 5.96 <sup>a</sup><br>(p = .06) | 12.28 <sup>a</sup><br>(p = .008) | 16.08 <sup>a</sup><br>(p = .01) | 3.16 <sup>b</sup><br>(p = .5) |

\* indicates significance at the 5% level

(a) tests the restriction that visitation model parameters are jointly equal to zero.

(b) tests the restriction that the pollution variables in the visitation model are jointly equal to zero.

---

<sup>3</sup> t-statistic in parenthesis

**Table 5.5          Visitation Stage of Heckman Selection Model--  
Linear(trips)  
Selection Model (n= 58) Dependent variable: Number of fishing  
trips taken.**

| Variable          | Model #1                       | Model #2                        | Model #3                        | Model #4                       |
|-------------------|--------------------------------|---------------------------------|---------------------------------|--------------------------------|
| ONE               | 28.8<br>(3.6) <sup>4</sup>     | 26.6*<br>(3.45)                 | 21.26*<br>(2.4)                 | 37.90<br>(.32)                 |
| TCINDEX           | -.25E-01<br>(-1.03)            | -.29<br>(-1.37)                 | -.303<br>(-1.42)                | -.23<br>(-.86)                 |
| CATCH             | .826<br>(1.33)                 | .92<br>(1.6)                    | .84<br>(1.5)                    | .78<br>(1.2)                   |
| CLUB              |                                | 36.1*<br>(2.4)                  | 34.0*<br>(2.2)                  | 34.78*<br>(2.13)               |
| BOAT              |                                |                                 | 12.00<br>(1.5)                  | 14.28<br>(1.5)                 |
| DOINDEX           |                                |                                 |                                 | -11.62<br>(-.59)               |
| TNINDEX           |                                |                                 |                                 | 151.49<br>(1.60)               |
| TPINDEX           |                                |                                 |                                 | -2951.93<br>(-1.17)            |
| TSSINDEX          |                                |                                 |                                 | 12.18<br>(.93)                 |
| SIGMA             | 25.6*<br>(6.48)                | 24.3*<br>(6.81)                 | 23.5*<br>(7.4)                  | 24.6*<br>(6.25)                |
| Log<br>Likelihood | -395.22                        | -392.14                         | -390.15                         | -387.54                        |
| $\chi^2$          | 4.72 <sup>a</sup><br>(p = .10) | 10.88 <sup>a</sup><br>(p =.018) | 14.86 <sup>a</sup><br>(p =.005) | 5.22 <sup>b</sup><br>(p = .25) |

\* indicates significance at the 5% level

(a) tests the restriction that visitation model parameters are jointly equal to zero.

(b) test the restriction that the pollution variables in the visitation model are jointly equal to zero.

---

<sup>4</sup> t-statistic in parenthesis

test relevant to this thesis is if the coefficients are jointly equal to zero. The chi-square test statistic for this restriction is 3.14 ( $p = 0.53$ ), suggesting that this restriction cannot be rejected. Thus, in the semi-log model, measures of pollution do not affect the number of visits.

In the linear model, the joint restriction that travel cost and catch have coefficients equal to zero was rejected with a chi-square test statistic of 4.72 ( $p = .10$ ). After adding CLUB to the model, the hypothesis that the right hand side coefficients jointly equal zero was rejected with  $p = 0.018$ . After adding BOAT, the null hypothesis was again rejected with  $p = .005$ .

When adding the four pollution indexes to the model to test whether the pollution variables are equal to zero, we found that the chi-square statistic is 5.22. This implies that this restriction cannot be rejected ( $p = .25$ ). Again we conclude that pollution indexes are not a factor in determining the number of visits that are taken.

The chosen specification for welfare analysis was a semi-log model. Following work done by Bockstael et al., the semi-log model was selected to be studied in the welfare analysis. This semi-log model included travel cost, fish catch, and variables measuring an angler's avidity, such as CLUB and BOAT (model #3). The travel cost variable carried the correct sign and was statistically significant at the 95% level with a t-ratio of -1.996. This corresponds to demand theory because as

the price increases the amount of trips taken will decrease (the substitution effect). Although not reported in this thesis, other specifications included income in the visitation model. Income was never statistically significant, suggesting visitation is independent of income. The implication is that visitation is driven primarily by travel costs, and that the Marshallian demand curve is an adequate proxy for the Hicksian demand curve.

The fish catch variable also met expectations because there was a positive relationship between fish catch and the amount of trips taken. CATCH was statistically significant with a t-ratio of 2.12. The water pollution measures at the visitation stage will be ignored since the likelihood ratio test showed these variables did not affect visitation. Similar to Ribaudó's models, the number of trips taken is dictated by other factors than water pollution. While this model was appealing for the reasons outlined above, the model was not an accurate predictor of participation rates or the number of reservoir trips taken. Evaluated at mean levels, the participation model predicts less than 1 percent participation in reservoir fishing, while many surveys, including the one on which these models are based, suggest participation rates around 20 percent. Using the model coefficient, the expected number of trips taken (given a trip was made), is 5.7 trips per year. The raw data indicate that reservoir anglers take on average 16 trips per year. Per trip

welfare measures will be evaluated using both estimates of the mean number of trips taken.

## **5.5 Calculating the Welfare Effects of CRP**

### **5.5.1 Access Value**

Before discussing the consumer surplus of a change in quality, we will evaluate the consumer surplus per trip for the baseline situation. By integrating under the demand curve at base line quality, a total consumer surplus of \$90.59 was estimated. Using the mean number of trips for the raw data (16 trips) yields a consumer surplus of \$5.66 per trip, or using the predicted number of trips (5.72 trips), the estimated consumer surplus is \$15.84 per trip. These consumer surplus measures of access value are quite comparable to previous studies that have been done. Smith and Kaoru (1990) report a consumer surplus range from \$0.11 to \$327.22, with most values falling in the range. They do not differentiate, however, between reservoir fishing and other water-based recreation activities.

### **5.5.2 The Value of CRP Scenarios**

By changing the quality at the site, we will be able to find the welfare impacts of the change in quality between the original level of quality and the subsequent level of quality.

The travel cost demand models of section 5.5 can be used

to determine the welfare impacts of proposed changes in the Conservation Reserve Program. Because the Conservation Reserve Program primarily focuses on soil erosion, this paper will make the connection between total suspended sediment (TSS) and CRP scenarios. Using the best travel cost model (semi-log specification #3), changes in consumer surplus will be calculated for changes in concentrations of TSS in reservoirs.

Analysis by English (1995, personal communication) has determined estimates of the physical effects for proposed changes in CRP. Two policy scenarios were set up to see the effect that a termination or an extension of CRP into the year 2000 would have on erosion rates. Using 1992 as the base year, total baseline erosion (in tons) was defined as the acres enrolled in CRP (by crop) multiplied by the average gross erosion for enrolled land. Baseline total sediment delivered to water bodies was derived by multiplying total erosion by the sediment delivery ratio. A simulation model (POLYSIS), applied to the agricultural economy was used to determine the land use impacts for proposed changes in CRP. English showed that if CRP was discontinued, 60% or more of the land would be returned to crop production and there would be a 15% percent increase in total erosion by the year 2000. This measure was derived by subtracting the 1992 level of total sediment deposited into waterways from the total sediment delivered if CRP was discontinued, divided by the

1992 level of total sediment.

The second scenario involved a new version of CRP, which targets the most erosive land. Extending CRP to the year 2000 resulted in a 7.5% increase in total erosion per year, using 1992 erosion levels as the base year. Erosion increases because some current CRP land is released for production.

The analysis by English measures the change in total tons of sediment delivered to water bodies: the TCM models use a TSS concentration level as a measure of pollution (mg/l). A connection between these two measures must be made. Given the available data, the best assumption that can be made is to assert that a given percentage change in sediment delivered corresponds to the same percentage change in TSS concentration. This assumption is tantamount to assuming that all sediment in waterways has an agricultural source. If other sources were present (eg., construction work), then a given percentage change in "agriculture sediment" would correspond to a smaller percentage change in TSS concentration. Because we lack the information needed to make this adjustment, this thesis will make the assumption of a 1-1 correspondence, which biases the benefit measures upward.

Second, sediment carried to the waterway often has nutrient and pesticide residues attached. Increased sediment delivery, then, also increases nutrient delivery. We have no information on changes in nutrient delivery for either policy scenario. The benefit estimates thus ignore the other

pollution impacts (nitrogen and phosphorous) which are likely to occur simultaneously with sediment delivery.

As discussed previously in Chapter 2, the inverse Mill's ratio was calculated by dividing the cumulative density by the normal distribution function, each evaluated at given right hand side variables and coefficients. The cost of CRP termination or extension was modeled by letting the IMR shift the demand function. For both scenarios, there was a negative consumer surplus with the increase in TSS levels so the demand function would shift to the left. Using semi-log specification #3 and increasing the levels of TSS by 15%, (CRP cancellation) it was possible to derive the loss in consumer surplus. For an increase in TSS by 15%, the loss in consumer surplus of a change in quality was \$9.25 per trip using the predicted number of trips (or \$3.31 using the mean number of trips for the raw data). For an increase in TSS by 7.5%, the loss consumer surplus from a change in quality was \$5.60 per trip using the predicted number of trips (or \$2.00 using the mean number of trips for the raw data).

These results conform to economic theory and compare favorably with other estimates of water quality benefits. As the amount of sediment in the water increases, the expectation is that there will be a decrease in the amount of consumer surplus. By comparing the consumer surplus of this study to other related studies, we can get an idea of the similarities or differences that exist in the consumer welfare derived.

Other studies, such as that done by Kahn and Kemp, found the fish catch variable to be statistically insignificant. As a result of a reduction in SAV and subsequently in fish population, they asserted that fish population was very important to the individual angler, however on the broad scale, angler ability was more important when determining fish catch across anglers. Therefore, assuming that skilled anglers will take more trips and catch more than lower skilled anglers. The Silvander and Drake study determined that people reacted negatively to pollution in the water. If eutrophication were to occur, angling days would reduce from an average number of 7.2 days to 2.3 days per year, meaning that there would be significant implications for recreationists.

## **5.6 Conclusions**

The goal of this research was to estimate the change in demand for reservoir fishing in east Tennessee given changes in water quality. The models for the most part performed well. The water pollution indices seemed to be a significant factor in the decision to go fishing. Other variables that seemed to affect this decision were AGE, URBAN and GENDER. These showed that the younger a person was the more likely it was for that person to go fishing. Also, the results showed that there was a higher likelihood that a male and a rural person would fish. While the pollution indexes performed as expected in the

participation equation, their insignificance in the visitation equation indicate that pollution levels were not a factor in the number of trips taken. Ongoing research by English (1995) has showed that soil erosion reduction programs such as the CRP can exhibit significant positive impacts on water quality and hence increase the quality of the fishing experience.

## **Chapter 6**

### **Conclusions**

#### **6.1 Summary of Empirical Results**

The focus of this research was to estimate the change in demand for reservoir fishing given a CRP induced change in the quality of east Tennessee reservoirs. In Chapter 5, a participation model was estimated simultaneously with a visitation model. The participation model included the factors believed to influence the decision to go reservoir fishing, while the visitation model included the factors influencing the number of trips taken. The simultaneous participation-visitation model represents an improvement upon past research (e.g., that by Ribaud) which employed two-stage modeling methods. Further, the available data permitted estimation of a standard TCM, thus avoiding problems encountered by Ribaud.

The results of the modelling showed that the majority of the variables corresponded with economic theory. Pollution indices and socioeconomic variables were shown to play a significant role in the decision to go fishing. In particular, as dissolved oxygen level decreased, or suspended sediment or nitrogen concentrations increased, people were less likely to go reservoir fishing. When the pollution indices were measured to see the affect on visitation to the

site, I was quite disappointed, since these variables were not significant and the variable phosphorous (TPINDEX) even showed a different sign than expected. The overall results of the water quality measures in the visitation stage mean that pollution indices were not a factor in the number of trips taken, once the decision to fish was made. TCINDEX and CATCH, performed as expected. TCINDEX was statistically significant and inversely related to the amount of trips taken. CATCH was also significant and positive, showing that the more fish an angler can catch on an average trip, the more trips will be taken to that site. These results suggest reservoir fishing exhibits characteristics near those of a normal good. As income increases, people are more likely to participate in reservoir fishing. After the participation decision has been made, however, income was shown to have no statistically significant effect on visitation. As prices (travel costs) increase, less of the good (visits to the site) will be consumed (the substitution effect). As quality of the good increases, a greater amount of the good (trips) will be consumed. Because income effect was insignificant in the visitation stage, by using the Slutsky equation (eq. 2.5), I was able to show that the Marshallian consumer surplus was an adequate proxy for Hicksian compensating variation.

Under the CRP extension scenario, per trip losses in consumer surplus were estimated to be \$5.60 (using the predicted number of trips), while under the CRP termination

scenario per trip losses were estimated to be \$9.25. The negative benefits were expected because there was a projected increase in the amount of total suspended sediment into the waterway under both scenarios.

## **6.2 Evaluating the Benefit Estimates**

Are the benefit estimates from this research adequate for policy analysis? The benefit estimates should be interpreted with caution. First, the "physical effects" model of the two CRP scenarios, measured CRP effects in gross tons of sediment delivered to waterbodies. The benefit estimates assumed to be a one-to-one correspondence between sediment delivery and sediment concentration -- the actual measure used in the TCM model (see Chapter 5 for more detail). Second, the benefit estimates excluded additional benefit losses associated with the probable increase in nutrient delivery (and concentration). Finally, I measured only the benefits associated with reservoir fishing -- to the exclusion of other downstream water-based activities such as other modes of fishing (trout stream, ponds, warm water streams), boating or swimming. If sediment delivery impacted these activities then surplus losses were likely to be even greater. Although there were improvements in the methodology applied, a few compromises were made, nonetheless I believe that the results are reasonable.

### **6.3 Potential Methodological Improvements and Additional Research Issues**

A critical evaluation of the methodology used in this thesis reveals several ways in which the methodology may be improved. One assumption made very early in this research was that a univariate demand equation would be adequate to model reservoir fishing. For each person in the sample, 15 reservoirs were available for fishing. In collapsing the 15 reservoir system into a univariate model, indices were created for travel cost, fish catch, and water quality. These indices were then used to represent all reservoirs. This is an assumption that can easily be disputed. A possible improvement in this research would retreat from the univariate demand equation to a multivariate system of demand equations--one equation for each reservoir.

A further improvement would acknowledge the discrete nature of the dependent variable in the visitation model. Because the variable takes on only integer values, the assumption of a normally distributed error is technically incorrect. To account for sample selection, a hurdle count data model could have been used instead of the Heckman Selection model (Ozuna et al. 1993). Count data models have the advantage of increased statistical efficiency. A point of further research would be to compare the Heckman Selection model used in this thesis with other types of selection models, i.e. truncated models.

Additionally, when determining the opportunity cost of time, a method such as a grid search (starting with a small fraction of the wage and continuing to the full wage) could have been used to determine which fraction of the wage was appropriate. Another procedure would have been to decompose the opportunity cost into money cost and time cost, isolating the effect of each on the demand for reservoir fishing.

Also important for further evaluation would be to determine the interaction between the pollution indices and angler avidity (CLUB, BOAT) to see what relationship exists. The final methodological improvement involves the physical effects model. The benefit estimates reported in this thesis were based on a simple 1-1 correspondence between sediment concentration and sediment delivery. A more sophisticated structural model of this relationship is desirable. Ribaud established this link with a simple OLS model, but the available data were not amenable to such an approach.

Using the model employed in this thesis could further contribute to literature by extension to other forms of fishing. The research methodology could be applied to warm water fishing, trout fishing and small lake fishing. There is also the potential for this research to be linked with other areas that focus on the effects of CRP. As noted in chapter 3, I/O models have often been used to measure the economic impacts of conservation programs. In the past they have not looked at the changes in consumer recreational behavior. By

linking the information derived in this research I can make a connection between changes in recreation activity and the subsequent economic impacts of CRP.

To make this study fully policy relevant, the CRP scenarios should have been based on east Tennessee CRP enrollments, crop mixes, cropping patterns, and management techniques. Only then could the estimates of offsite benefits be included in the benefit cost analysis of CRP extension/termination. This thesis does, however provide strong evidence that downstream benefits of conservation programs are substantial. Most benefit cost analyses ignore these offsite benefits to downstream recreationists, but these benefits should be included in the decision making process. Ignoring these benefits may lead to ill-informed policy decisions.

## **REFERENCES**

## References

- Bates, Michael. "Analyzing the Effect of Site Quality on Tennessee Reservoir Fishing Site Selection Using a Random Utility Model". The University of Tennessee Department of Agricultural Economics and Rural Sociology: 1994.
- Bockstael, Nancy, W. Michael Hanemann and Ivar E. Strand, Jr. 1987. "Measuring the Benefits of Water Quality Improvements Using Recreation Demand Models". Volume II. U.S. Environmental Protection Agency. Washington, D.C. 1984.
- Broomhall, David, and Thomas Johnson. 1990. "Regional Impacts of the Conservation Reserve Program in the Southeast with Conversion to Trees: An Application of Input-Output Analysis". The Review of Regional Studies. 20 (2): 76-85.
- Cornes, Richard and Todd Sandler. The Theory of Externalities, Public Goods, and Club Goods. First Edition. New York: Cambridge University Press. 1986.
- English, Burton. Personal Communication. 1995.
- Freeman, A. Myrick, III. The Measurement of Environmental and Resource Values: Theory and Methods. 1993.
- Greene, William H. Econometric Analysis. Second Edition. New York: Macmillan Publishing Company, 1993.
- Hyberg, Bengt T., M.R. Dicks, and Thomas Hebert. 1991. "Economic Impacts of the Conservation Reserve Program on Rural Economies". The Review of Regional Studies. 21 (2): 91-105.
- Jakus, Paul M., Laurienne Whinstanley and J. Mark Fly. Fishing and Hunting by Tennessee Residents: A Report on Activities and Attitudes--March-August 1993. Research Report 94-18. The University of Tennessee Agricultural Experiment Station; Knoxville, Tennessee: 1994.
- Kahn, James R. and W. Michael Kemp. 1985. "Economic Losses Associated with the Degradation of an Ecosystem: The Case of Submerged Aquatic Vegetation in Chesapeake Bay". Journal of Environmental Economics and Management. 12: 246-263.
- Meinert, Dennis L. Personal Communication. 1995.

- Nicholson, Walter. Microeconomic Theory: Basic Principles and Extensions. Fifth Edition. Fort Worth: The Dryden Press, 1992.
- Ozuna, Teofilo, Jr., Lonnie L. Jones and Oral Capps, Jr. "Functional Form and Welfare Measures in Truncated Recreation Demand Models". American Journal of Agricultural Economics. 75 (4): 1030-1035.
- Randall, Alan. Resource Economics: An Economic Approach to Natural Resource and Environmental Policy. Second Edition. New York: John Wiley and Sons, Incorporated, 1987.
- Ribaudo, Marc O. Water Quality Benefits from the Conservation Reserve Program. Agricultural Economic Report 606. United States Department of Agriculture: 1989a.
- Ribaudo, Marc O. 1989b. "Targeting the Conservation Reserve Program to Maximize Water Quality Benefits". Land Economics. 65 (4): 320-332.
- Ribaudo, Marc O., C. Tim Osborn and Kazim Konyar. 1994. "Land Retirement as a Tool for Reducing Agricultural Nonpoint Source Pollution". Land Economics. 70 (1): 77-87.
- Ribaudo, Marc O., and Steven L. Piper. Estimating Changes in Recreational Fishing Participation from National Water Quality Policies. Water Resources Research Vol 27 (7): 1757-1763. Economic Research Service; United States Department of Agriculture: 1991.
- Siegel, Paul B., and Thomas G. Johnson. 1991. "Break-Even Analysis of the Conservation Reserve Program: The Virginia Case". Land Economics. 67 (4): 447-461.
- Silvander, Ulf and Lars Drake. 1991. "Chapter IV, Nitrate Pollution and Fisheries Protection in Sweden." Farming and the Countryside: An Economic Analysis of External Costs and Benefits. ed. Nick Hanley. London: C.A.B. International.
- Smith, V. Kerry. 1989. "Taking Stock of Progress with Travel Cost Recreation Demand Methods: Theory and Implementation". Marine Resource Economics. 6 (4): 297-310.
- Smith, V. Kerry and Yoshiaki Kaoru. 1990. "Signals or Noise? Explaining the Variation in Recreation Benefits Estimates". American Journal of Agricultural Economics. 72 (2): 419-433.

Statistical Abstract of the United States. 1994. The  
National Data Book.

## **APPENDIX**

Survey # \_\_\_\_\_

**Hunting, Fishing, and Wildlife Management Survey  
September 1994**

Hello, my name is \_\_\_\_\_ and I am calling for the University of Tennessee - Knoxville. We are contacting people throughout the state to ask questions about outdoor recreation activities.

For this survey to be representative, I need to randomly select a person from your household to interview. Could you please tell me how many people there are living in your household 16 years of age or older? \_\_\_\_\_

Out of those \_\_\_\_\_ people, may I speak with the person who had the most recent birthday?

\_\_\_\_\_ **Self**                      \_\_\_\_\_ **Someone Else**

**IF IT'S THE PERSON ON THE PHONE: CONTINUE.**

**WHEN CORRECT PERSON ANSWERS, REPEAT FIRST PARAGRAPH AND CONTINUE BELOW. IF PERSON IS NOT THERE AT THE TIME, FIND OUT WHEN TO CALL BACK.**

Is this a good time to ask you some questions or would another time be better for you? When would be a good time? And what is your first name so I'll know who to ask for?

Callback: \_\_\_\_\_ First Name: \_\_\_\_\_

Phone Number: \_\_\_\_\_ Eastern/Central  
Rural/Metro

| ID #    | CODES |       | FOR CALLBACKS |    |       |       |
|---------|-------|-------|---------------|----|-------|-------|
|         | Date  | Time  | Results       |    | Date  | Time  |
| ____ #1 | _____ | _____ | _____         | #1 | _____ | _____ |
| ____ #2 | _____ | _____ | _____         | #2 | _____ | _____ |
| ____ #3 | _____ | _____ | _____         | #3 | _____ | _____ |
| ____ #4 | _____ | _____ | _____         | #4 | _____ | _____ |
| ____ #5 | _____ | _____ | _____         | #5 | _____ | _____ |

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.

First, I would like to ask you some questions about the kinds of hunting and fishing you might have done in Tennessee during March 1, 1994 through August 31, 1994.

1. Did you hunt in Tennessee between March 1 and August 31, 1994? Please do not include as hunting occasions when you only observed others hunt.

01 Yes  
00 No

- 1a. (If yes), On how many different days did you actually hunt \_\_\_\_\_ from March 1 through August 31, 1994? **FOR SQUIRREL ONLY:** Please remember that squirrel season was open only **five** days during this time period.

|           | <u>Yes</u> | <u>No</u> | <u>Days</u> |
|-----------|------------|-----------|-------------|
| Squirrel  | 01         | 00        | _____       |
| Turkey    | 01         | 00        | _____       |
| Coyote    | 01         | 00        | _____       |
| Groundhog | 01         | 00        | _____       |
| Crow      | 01         | 00        | _____       |

2. How many years have you been hunting wild turkeys? \_\_\_\_\_
3. Approximately how many wild turkeys have you harvested since you started hunting them? \_\_\_\_\_
4. How many turkeys did you kill during the spring turkey season? \_\_\_\_\_
5. On what two wildlife management or public hunting areas did you hunt turkey most often?  
**[IF HUNTED ON AREA OTHER THAN WMA, CODE "0" FOR NONE.]**

WMA #1 \_\_\_\_\_ WMA #2 \_\_\_\_\_

6. In what two counties did you hunt turkey most often?

County #1 \_\_\_\_\_ County #2 \_\_\_\_\_

7. Did you flush any hen turkeys off a nest this spring?

01 Yes  
00 No  
03 Don't Know

8. How many turkeys did you shoot at in Tennessee in 1994? \_\_\_\_\_

9. How many turkeys were hit and lost? \_\_\_\_\_
10. Do you turkey hunt all day long, or just in the morning?
- 01 All Day  
02 Morning Only  
03 Other (Specify) \_\_\_\_\_
11. Would you support or oppose a noon closure for turkey hunting?
- 01 Support  
02 Oppose  
03 No opinion (Do not read)  
04 Other (Specify) \_\_\_\_\_
12. Is the current spring turkey season **[READ LIST]**.....?
- 01 Too long  
02 Too short  
03 About right  
04 No opinion (Do not read)  
05 Other (Specify) \_\_\_\_\_
13. Does the turkey season **[READ LIST]**.....?
- 01 Open too early  
02 Close too late  
03 Or is it about right  
04 No opinion (Do not read)  
05 Other (Specify) \_\_\_\_\_
14. Would you prefer that turkey season open on a fixed date (such as April 1) or continue to open on a Saturday?
- 01 Fixed date  
02 Saturday  
03 No opinion (Do not read)  
04 Other (Specify) \_\_\_\_\_
15. Would you support or oppose designated walk-in areas on wildlife management areas for turkey hunting?
- 01 Support  
02 Oppose  
03 No opinion (Do not read)  
04 Other (Specify) \_\_\_\_\_

16. Would you support or oppose designating a Fall season for turkey hunting?

- 01 Support
- 02 Oppose
- 03 No opinion (Do not read)
- 04 Other (Specify) \_\_\_\_\_

17. Overall, how satisfied are you with how the Tennessee Wildlife Resources Agency manages the wild turkey program? Would you say: **[READ LIST]**

- 01 Very dissatisfied
- 02 Somewhat dissatisfied
- 03 Neither satisfied, nor dissatisfied
- 04 Somewhat satisfied
- 05 Very satisfied
- 06 Don't know (Do not read)

18. Did you hunt in Tennessee between September 1, 1993 and February 28, 1994, that is, last Fall or Winter?

- 01 Yes
- 00 No

19. If you hunt any animals, how many years have you been hunting? \_\_\_\_\_

**IF NEVER HUNTED, CODE AS ZERO YEARS. IF 0 YEARS, GO TO Q23 ON PAGE 5.  
IF INACTIVE HUNTER CODE AS 97 —> GO TO 19a.**

19a. Why do you no longer hunt?

- 01 Not enough time
- 02 Too expensive
- 03 Health reasons
- 04 Getting too old
- 05 No longer interested
- 06 No place to go
- 07 Poor quality of hunting
- 08 Changed family circumstances
- 09 Changed attitude towards hunting
- 10 Other (Specify) \_\_\_\_\_

20. What person had the most influence in terms of introducing you to the sport of hunting?  
**IF GIVEN A SPECIFIC NAME, ASK THEM TO:** Describe their relationship to you.

- 01 Father
- 02 Mother
- 03 Sibling
- 04 Uncle or Aunt
- 05 Friend
- 06 Hunter Safety Teacher
- 07 Grandparent
- 08 No one/myself
- 09 Other (Specify) \_\_\_\_\_

**IF INACTIVE HUNTER, SKIP Q21 AND GO TO Q22.**

21. Do you lease any land from someone else for hunting?

- 01 Yes
- 00 No

22. Overall, how satisfied are you with how the Tennessee Wildlife Resources Agency manages the wildlife resources in Tennessee? Would you say: **[READ LIST]**

- 01 Very dissatisfied
- 02 Somewhat dissatisfied
- 03 Neither dissatisfied, nor satisfied
- 04 Somewhat satisfied
- 05 Very satisfied
- 06 Don't know (Do not read)

---

**SKIP Q23 IF THE RESPONDENT IS AN ACTIVE HUNTER ———> GO TO Q24**

---

23. As a person who does not currently hunt, do you support or oppose legal hunting by other people?

- 01 Support
- 02 Oppose
- 03 No Opinion (Do not read)
- 04 Other (Specify) \_\_\_\_\_

24. Did you do any fishing in Tennessee between March 1 and August 31, 1994? Please do not include as fishing occasions when you only observed others fish.

01 Yes  
00 No -----> GO TO Q34 ON PAGE 15

25. Did you fish in farm ponds or small lakes on privately owned lands in Tennessee during that time period? **IF YES, CLARIFY:** Was that farm ponds, small lakes, or both?

|             | <u>Yes</u> | <u>No</u> | <u>DK</u> |
|-------------|------------|-----------|-----------|
| Farm Ponds  | 01         | 00        | 03        |
| Small Lakes | 01         | 00        | 03        |

**IF NO OR DON'T KNOW FOR BOTH —> GO TO Q26 ON PAGE 7.**

- 25a. About how many times did you fish farm ponds or small lakes on privately owned lands from March 1 through August 31, 1994? \_\_\_\_\_

How many miles do you drive (one way) to this spot? \_\_\_\_\_

How long does the drive take? \_\_\_\_\_ Hrs. \_\_\_\_\_ Min.

- 25b. On an average trip to private ponds or lakes, how many fish do you catch?  
\_\_\_\_\_

- 25c. On an average trip to private ponds or lakes, how many fish do you release?  
\_\_\_\_\_

- 25d. Who owns the farm pond or small lake where you fish most often? Does that land belong to: **[READ LIST]**

01 Yourself  
02 A relative  
03 A friend or neighbor  
04 Other (Specify) \_\_\_\_\_  
05 Don't know

- 25e. Did you fish in small lakes or ponds which are publicly owned?

01 Yes  
00 No

Which ones? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

26. I would now like to ask you some questions about fishing in warm water streams, that is, stream areas which are not closed off by dams. For instance, almost all of the Tennessee River would be reservoirs and not a warm water stream since most of it is closed off by dams.

Did you fish in warm water streams in Tennessee between March 1 and August 31, 1994?

- 01 Yes -----> **GO TO Q26a.**  
00 No -----> **GO TO Q27 ON PAGE 9.**  
98 Don't Know -----> **GO TO Q27 ON PAGE 9.**

26a. About how many times did you fish warm water streams from March 1 through August 31, 1994? \_\_\_\_\_

26b. What kinds of fish did you catch? (**CIRCLE ALL MENTIONED**) **PROBE:** Any others?

| <u>Kinds</u>                              | <u>Yes</u> | <u>No</u> |
|-------------------------------------------|------------|-----------|
| <b><u>BASS</u></b>                        |            |           |
| Largemouth bass                           | 01         | 00        |
| Smallmouth bass                           | 01         | 00        |
| Spotted bass                              | 01         | 00        |
| Striped bass, hybrid bass,<br>or rockfish | 01         | 00        |
| Rock bass (Redeye)                        | 01         | 00        |
| White bass                                | 01         | 00        |
| Other bass (generic)                      | 01         | 00        |

| <u>Kinds</u>           | <u>Yes</u> | <u>No</u> |
|------------------------|------------|-----------|
| <b><u>OTHER</u></b>    |            |           |
| Bluegill/sunfish/bream | 01         | 00        |
| Carp                   | 01         | 00        |
| Catfish                | 01         | 00        |
| Crappie                | 01         | 00        |
| Sauger                 | 01         | 00        |
| Trout                  | 01         | 00        |
| Walleye                | 01         | 00        |
| Other                  | 01         | 00        |

(Specify) \_\_\_\_\_

26c. What warm water stream did you fish most often? \_\_\_\_\_

26d. On an average trip to that stream, how many fish did you usually catch?  
\_\_\_\_\_

26e. On an average trip to that stream, how many fish did you usually release?

\_\_\_\_\_

26f. What is the closest town to where you fished that stream?

\_\_\_\_\_

How many miles do you drive (one way) to this spot? \_\_\_\_\_

How long does the drive take? \_\_\_\_\_ Hrs. \_\_\_\_\_ Min.

26g. When fishing there, do you ever fish from privately owned land?

01 Yes -----> **GO TO Q26h.**

00 No -----> **GO TO Q27 ON PAGE 9.**

98 Don't know ----> **GO TO Q27 ON PAGE 9.**

26h. Does that land belong to? **[READ LIST]**

01 Yourself

02 A relative

03 A friend or neighbor

04 Other (Specify) \_\_\_\_\_

98 Don't know

27. Did you fish in trout streams in Tennessee between March 1 and August 31, 1994?

- 01 Yes -----> **GO TO Q27a.**  
00 No -----> **GO TO Q28 ON PAGE 11.**  
98 Don't know -----> **GO TO Q28 ON PAGE 11.**

27a. About how many times did you fish trout streams from March 1 through August 31, 1994? \_\_\_\_\_

27b. What kinds of trout did you catch? **(CIRCLE ALL MENTIONED).**

27c. On average, how many (kinds named in Q28b) did you catch on each trip?

27d. On average, how many (kinds named in Q28b) did you release on each trip?

| <u>Kinds</u>  | <u>Yes</u> | <u>No</u> | <u>Average Caught</u> | <u>Average Released</u> |
|---------------|------------|-----------|-----------------------|-------------------------|
| Brown trout   | 01         | 00        | _____                 | _____                   |
| Brook trout   | 01         | 00        | _____                 | _____                   |
| Rainbow trout | 01         | 00        | _____                 | _____                   |
| Other _____   | 01         | 00        | _____                 | _____                   |

27e. What is the trout stream you fished most often? \_\_\_\_\_

27f. What is the closest town to where you fished that stream?  
\_\_\_\_\_

How many miles do you drive (one way) to this spot? \_\_\_\_\_

How long does the drive take? \_\_\_\_\_ Hrs. \_\_\_\_\_ Min.

27g. When fishing there, do you ever fish from privately owned land?

- 01 Yes -----> **GO TO Q27h.**  
00 No -----> **GO TO Q27i.**  
98 Don't know -----> **GO TO Q27i.**

27h. Does that land belong to: **[READ LIST]**

- 01 Yourself  
02 Relative  
03 Friend or neighbor  
04 Other (Specify) \_\_\_\_\_  
98 Don't know

27i. Do you support or oppose the harvest restrictions on small portions of small tailwater sections (rivers below dams, such as the Clinch, South Holston, and Hiwassee Rivers)?

- 01 Support
- 02 Oppose
- 03 No opinion (Do not read)
- 04 Other (Specify) \_\_\_\_\_

27j. Do you support or oppose the management technique of placing bait restrictions and size limits on small portions of tailwater sections (rivers below dams, such as the Clinch, South Holston and Hiwassee Rivers)?

- 01 Support
- 02 Oppose
- 03 No opinion (Do not read)
- 04 Other (Specify) \_\_\_\_\_

27k. Reducing the daily trout creel limit would reduce stocking costs and extend the catch of a limited number of fish. Would you support or oppose reducing the trout creel limit from 7 fish to 5 fish per day?

- 01 Support
- 02 Oppose
- 03 No opinion (Do not read)
- 04 Other (Specify) \_\_\_\_\_

27l. Because of the difficulty in rearing, brown trout are produced in limited numbers in TWRA hatcheries. Brown trout are stocked as fingerlings in several tailwaters on which there are no minimum size limits or bait restrictions. Would you prefer the current "no size limit" regulations or do you think a 14" limit should be imposed?

- 01 No size limit
- 02 14"
- 03 No opinion (Do not read)
- 04 Other (Specify) \_\_\_\_\_

28. Did you fish in reservoirs in Tennessee, which includes most of the Tennessee and Cumberland Rivers, between March 1 and August 31, 1994?

01 Yes -----> **GO TO Q28a.**  
00 No -----> **GO TO Q28o ON PAGE 14.**  
98 Don't know -----> **GO TO Q28o ON PAGE 14.**

- 28a. About how many times did you fish in Tennessee reservoirs from March 1 through August 31, 1994? \_\_\_\_\_

- 28b. What kinds of fish did you catch? (**CIRCLE ALL MENTIONED**) **PROBE:** Any others?

- 28c. On average, how many (bass named in Q28b) did you catch on each trip?

- 28d. On average, how many (bass named in Q28b) did you release on each trip?

| <u>Kinds</u>                           | <u>Yes</u> | <u>No</u> | <u>Average Caught</u> | <u>Average Released</u> |
|----------------------------------------|------------|-----------|-----------------------|-------------------------|
| <b><u>BASS</u></b>                     |            |           |                       |                         |
| Largemouth bass                        | 01         | 00        | _____                 | _____                   |
| Smallmouth bass                        | 01         | 00        | _____                 | _____                   |
| Spotted bass                           | 01         | 00        | _____                 | _____                   |
| Striped bass, hybrid bass, or rockfish | 01         | 00        | _____                 | _____                   |
| Rock bass (Redeye)                     | 01         | 00        | _____                 | _____                   |
| White bass                             | 01         | 00        | _____                 | _____                   |
| Other bass (generic)                   | 01         | 00        | _____                 | _____                   |

**OTHER**

|                        |    |    |
|------------------------|----|----|
| Bluegill/sunfish/bream | 01 | 00 |
| Carp                   | 01 | 00 |
| Catfish                | 01 | 00 |
| Crappie                | 01 | 00 |
| Sauger                 | 01 | 00 |
| Trout                  | 01 | 00 |
| Walleye                | 01 | 00 |
| Other                  | 01 | 00 |

(Specify) \_\_\_\_\_

- 28e. What reservoir did you fish most often?  
28f. How many trips did you take to this reservoir from March 1 through August 31, 1994?  
28g. How many miles do you drive (one way) to this reservoir?  
28h. How long does the drive take?  
28i. On average, how many fish did you catch on each trip to this reservoir?  
28j. On average how many fish did you release on each trip?  
28k. Were there any other reservoirs you visited March 1 through August 31, 1994?
-

**(West Tenn.)**

|          | <u>Yes</u> | <u>No</u> | <u>Trips</u> | <u>Miles</u> | <u>Hrs.</u> | <u>Min.</u> | <u>Catch</u> | <u>Release</u> |
|----------|------------|-----------|--------------|--------------|-------------|-------------|--------------|----------------|
| Barkley  | 1          | 0         |              |              |             |             |              |                |
| Kentucky | 1          | 0         |              |              |             |             |              |                |
| Pickwick | 1          | 0         |              |              |             |             |              |                |
| Reelfoot | 1          | 0         |              |              |             |             |              |                |

**(Middle Tenn.)**

|              | <u>Yes</u> | <u>No</u> | <u>Trips</u> | <u>Miles</u> | <u>Hrs.</u> | <u>Min.</u> | <u>Catch</u> | <u>Release</u> |
|--------------|------------|-----------|--------------|--------------|-------------|-------------|--------------|----------------|
| Center Hill  | 1          | 0         |              |              |             |             |              |                |
| Cheatham     | 1          | 0         |              |              |             |             |              |                |
| Cordell Hull | 1          | 0         |              |              |             |             |              |                |
| Dale Hollow  | 1          | 0         |              |              |             |             |              |                |
| Great Falls  | 1          | 0         |              |              |             |             |              |                |
| Normandy     | 1          | 0         |              |              |             |             |              |                |
| Old Hickory  | 1          | 0         |              |              |             |             |              |                |
| Percy Priest | 1          | 0         |              |              |             |             |              |                |
| Tims Ford    | 1          | 0         |              |              |             |             |              |                |
| Woods        | 1          | 0         |              |              |             |             |              |                |

**(East Tenn.)**

|                   | <u>Yes</u> | <u>No</u> | <u>Trips</u> | <u>Miles</u> | <u>Hrs.</u> | <u>Min.</u> | <u>Catch</u> | <u>Release</u> |
|-------------------|------------|-----------|--------------|--------------|-------------|-------------|--------------|----------------|
| Boone             | 1          | 0         |              |              |             |             |              |                |
| Calderwood        | 1          | 0         |              |              |             |             |              |                |
| Cherokee          | 1          | 0         |              |              |             |             |              |                |
| Chickamauga       | 1          | 0         |              |              |             |             |              |                |
| Chilhowee         | 1          | 0         |              |              |             |             |              |                |
| Douglas           | 1          | 0         |              |              |             |             |              |                |
| Ft. Loudon        | 1          | 0         |              |              |             |             |              |                |
| Ft. Patrick Henry | 1          | 0         |              |              |             |             |              |                |
| Guntersville (TN) | 1          | 0         |              |              |             |             |              |                |
| John Sevier       | 1          | 0         |              |              |             |             |              |                |
| Melton Hill       | 1          | 0         |              |              |             |             |              |                |
| Nickajack         | 1          | 0         |              |              |             |             |              |                |
| Norris            | 1          | 0         |              |              |             |             |              |                |
| Parkesville       | 1          | 0         |              |              |             |             |              |                |
| South Holston     | 1          | 0         |              |              |             |             |              |                |
| Tellico           | 1          | 0         |              |              |             |             |              |                |
| Watauga           | 1          | 0         |              |              |             |             |              |                |
| Watts Bar         | 1          | 0         |              |              |             |             |              |                |

### Other Reservoirs

|              | <u>Yes</u> | <u>No</u> | <u>Trips</u> | <u>Miles</u> | <u>Hrs.</u> | <u>Min.</u> | <u>Catch</u> | <u>Release</u> |
|--------------|------------|-----------|--------------|--------------|-------------|-------------|--------------|----------------|
| Guntersville | 1          | 0         |              |              |             |             |              |                |
| Hiwassee     | 1          | 0         |              |              |             |             |              |                |
| Ocoee        | 1          | 0         |              |              |             |             |              |                |
| Santeelah    | 1          | 0         |              |              |             |             |              |                |
| Wheeler      | 1          | 0         |              |              |             |             |              |                |

28l. In the last six months, how many meals of fish taken from reservoirs have you eaten? \_\_\_\_\_

28m. When fishing in reservoirs, is there a particular kind you prefer to fish for?

01 Yes -----> **GO TO Q28n.**

00 No -----> **GO TO Q28o.**

28n. What kind is that? **(CIRCLE ALL MENTIONED.)**

| <u>Kinds</u>         | <u>Yes</u> | <u>No</u> |
|----------------------|------------|-----------|
| <b><u>BASS</u></b>   |            |           |
| Largemouth bass      | 01         | 00        |
| Smallmouth bass      | 01         | 00        |
| Spotted bass         | 01         | 00        |
| Striped bass, hybrid |            |           |
| bass, or rockfish    | 01         | 00        |
| Rock bass (Redeye)   | 01         | 00        |
| White bass           | 01         | 00        |
| Other bass (generic) | 01         | 00        |

|                        |    |    |
|------------------------|----|----|
| <b><u>OTHER</u></b>    |    |    |
| Bluegill/sunfish/bream | 01 | 00 |
| Carp                   | 01 | 00 |
| Catfish                | 01 | 00 |
| Crappie                | 01 | 00 |
| Sauger                 | 01 | 00 |
| Trout                  | 01 | 00 |
| Walleye                | 01 | 00 |
| Other                  | 01 | 00 |

(Specify) \_\_\_\_\_

28o. Did you fish for striped bass or hybrid bass between March 1 and August 31, 1994?

- 01 Yes -----> GO TO Q28p.  
00 No -----> GO TO Q28r.  
98 Don't know ----> GO TO Q28r.

28p. About how many times did you fish for striped bass or hybrid bass from March 1 through August 31, 1994? \_\_\_\_\_

28q. On average, how many did you catch? \_\_\_\_\_

28r. Do you ever fish for sauger?

- 01 Yes  
00 No

28s. Do you support or oppose the current size limit for sauger?

- 01 Support  
02 Oppose  
03 No opinion  
04 Other (Specify) \_\_\_\_\_  
05 Don't know

28t. Would you support or oppose a 10" minimum size limit for crappie?

- 01 Yes  
00 No

28u. If NO....Would you support or oppose a 9" limit on crappie?

- 01 Yes  
00 No

28v. Have tournament anglers ever interfered with your enjoyment of a fishing trip?

- 01 Yes -----> On what lake? \_\_\_\_\_  
00 No

28w. Have commercial fisherman or their gear ever interfered with a fishing trip?

- 01 Yes -----> On what lake? \_\_\_\_\_  
00 No

28x. Have commercial mussel divers ever interfered with a fishing trip?

- 01 Yes -----> On what lake? \_\_\_\_\_  
00 No

29. Do you belong to a fishing club?

- 01 Yes
- 00 No

30. Do you fish in tournaments?

- 01 Yes
- 00 No

31. Do you lease any land from someone else for fishing?

- 01 Yes
- 00 No

32. How many years have you been fishing? \_\_\_\_\_

33. Overall, how satisfied are you with how the Tennessee Wildlife Resources Agency manages the fishery resources in Tennessee? Would you say: **[READ LIST]**

- 01 Very dissatisfied
- 02 Somewhat dissatisfied
- 03 Neither dissatisfied, nor satisfied
- 04 Somewhat satisfied
- 05 Very satisfied
- 98 Don't know (Do not read)

#### **DEMOGRAPHICS**

34. Did you buy a 1994/95 license to hunt or fish in Tennessee?

- 01 Yes -----> **GO TO Q34a.**
- 00 No -----> **GO TO Q35.**

34a. What type of license did you buy? **(Do not read list.)**

- 01 Combination fishing/hunting
- 02 Sportsman
- 03 Daily Permit
- 04 Combination with trout supplement
- 05 Senior citizen/disabled veteran
- 06 Combination with big game/archery
- 07 Other (Specify) \_\_\_\_\_
- 98 Don't know

34b. Do you know about how much you paid for your license?

35. Have either of your parents hunted or fished?

01 Yes  
00 No

36. Do you own a boat?

01 Yes  
00 No -----> **GO TO Q37**

36a. Do you do most of your fishing from a boat? **(Skip if you don't fish.)**

01 Yes  
00 No

37. Are you aware that the Tennessee Wildlife Resources Agency sponsored a Free Fishing Day on June 11, 1994?

01 Yes  
00 No -----> **GO TO Q38**

37a. If **YES**, how did you find out about it? **(Circle all that apply.)**

|                           | <u>Yes</u> | <u>No</u> |
|---------------------------|------------|-----------|
| Radio                     | 01         | 00        |
| Television                | 01         | 00        |
| Newspaper                 | 01         | 00        |
| Advertisement in Store    | 01         | 00        |
| Word of Mouth             | 01         | 00        |
| TWRA Regulations Brochure | 01         | 00        |
| Other                     | 01         | 00        |
| (Specify) _____           |            |           |

37b. Did you participate in Free Fishing Day this year as a non-licensed angler?

01 Yes  
00 No -----> **GO TO Q38**

37c. Did you participate in a TWRA sponsored event?

01 Yes  
00 No

37d. If you participated in Free Fishing Day as a non-licensed angler, did it provide incentive for you to:

|                                     | <u>Yes</u> | <u>No</u> |
|-------------------------------------|------------|-----------|
| Purchase a fishing license          | 01         | 00        |
| Go fishing again                    | 01         | 00        |
| Take a friend/family member fishing | 01         | 00        |
| Other _____                         | 01         | 00        |

38. Do you own a woodlot of 10 acres or more in the State of Tennessee?

01 Yes -----> **GO TO Q38a.**  
00 No  
98 Don't know

38a. How many acres of woods do you own? \_\_\_\_\_

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

39. What is your county of residence? \_\_\_\_\_

40. In what town (or nearest town) do you live? \_\_\_\_\_

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

00 No -----> **GO TO Q42.**  
01 Full-time -----> **GO TO Q42.**  
02 Part-time -----> **GO TO Q41a.**

41a. Did you have an agricultural income of \$1,000 or more in 1993?

01 Yes  
00 No  
98 Don't know

42. What is your age, please? \_\_\_\_\_

43. What is the highest grade of school you completed? **[READ LIST]**

01 8 years or less  
02 9 - 11 years  
03 High school graduate (12)  
04 Some college (13 - 15)  
05 College graduate (16)  
06 Post-graduate (17)  
999 Refused

44. What is your ethnic origin? **[READ LIST]**

- 01 African - American
- 02 American Indian
- 03 Asian or Pacific Islander
- 04 Caucasian
- 05 Hispanic
- 06 Other (Specify) \_\_\_\_\_
- 999 Refused

45. I am going to read a list of income categories for household income from all sources before taxes during 1993. Please stop me when I get to yours.

- 01 Under \$10,000
- 02 \$10,001 to \$19,999
- 03 \$20,000 to \$24,999
- 04 \$25,000 to \$29,999
- 05 \$30,000 to \$49,999
- 06 \$50,000 to \$74,999
- 07 \$75,000 or more
- 98 Don't know
- 999 Not reported

46. And, I have one last question that is not related to this survey. In the future, if we have questions about natural resources management in Tennessee, may we contact you?

- 00 No -----> Thank you, etc.
- 01 Yes -----> In order to contract you, we would like to have your name.

**NAME:** \_\_\_\_\_

**PHONE:** (    ) \_\_\_\_\_

Would you be willing to give us the name and telephone number of a person who is likely to know how to reach you if you were to move?

- 00 No -----> Thank you, etc.
- 01 Yes ----->

**NAME:** \_\_\_\_\_

**PHONE:** (    ) \_\_\_\_\_

Gender (Do not ask):      01 Male                      02 Female

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

## VITA

Laurienne Elise Whinstanley was born in Montego Bay, Jamaica, W.I. on October 11, 1970. She is the daughter of Mr. and Mrs. James Lloyd Whinstanley and the sister of Mrs. Toni-Marie McLean. She attended primary and high school in Montego Bay until leaving Jamaica in 1984 to join her family in New York. She continued her education at the White Plains High School where she graduated with honors in May 1988. She went on to Binghamton University in upstate New York in pursuit of her undergraduate degree.

She served as a Resident Assistant and also was on the executive body of the African Student Organization. She graduated in May 1992 with a bachelor's degree majoring in Economics and minoring in Environmental Science. Upon graduating, she spent a year working at Empire Blue Cross/Blue Shield before accepting admission to the Department of Agricultural Economics and Rural Sociology at the University of Tennessee in Knoxville. She was able to gain experience through a graduate research assistantship she received through the Agricultural Experiment Station. In August 1995, she received a Master of Science degree in Agricultural Economics from the University of Tennessee, Knoxville. She is currently pursuing a doctoral degree in the Department of Resource Economics at the University of Rhode Island.

737 NE TH 1328  
12/06/95 45408 SOL