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Estimating wildlife viewing recreational demand and consumer surplus

James Cory Mingie

ESTIMATING WILDLIFE VIEWING RECREATIONAL DEMAND AND CONSUMER SURPLUS

By

James Cory Mingie

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By

James Cory Mingie

Approved:

Changyou Sun Associate Professor of Forestry (Major Professor)	W. Daryl Jones Associate Extension Professor of Wildlife and Fisheries (Committee Member)
Daniel R. Petrolia Assistant Professor of Agricultural Economics (Committee Member)	Andrew W. Ezell Professor of Forestry Department Head and Graduate Coordinator
George M. Hopper Dean and Director of the College Forest Resources	

Name: James Cory Mingie

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Institution: Mississippi State University

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Major Professor: Dr. Changyou Sun

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Candidate for Degree of Master of Science in Forestry

Motivated by the increasing popularity of wildlife viewing and a growing emphasis on management for nontimber outputs, wildlife viewing demand was assessed. Specific objectives included determining factors affecting participation and frequency of use, and furthermore, deriving 2006 nationwide wildlife viewing consumer surplus estimates. With the travel cost method as the theoretical basis, the empirical estimation method employed was a two-step sample selection model that included a probit first step and a negative binomial second step. Consumer surplus per trip estimates ranged from $215.23 to $739.07 while aggregate national estimates ranged from $44.5 billion to $185.1 billion. Results reveal that age, race, and urban residence affect participation and frequency similarly. This research can help policymakers in particular better understand determinants of wildlife viewing participation and frequency. The value of wildlife viewing access can be used to justify funding initiatives aimed at protecting or managing for this use.

Key words: consumer surplus, sample selection, travel cost method, wildlife viewing

DEDICATION

I would like to dedicate this research to my family and especially to my parents, Fred and Marie Mingie.

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I would like to thank a number of individuals who have helped me greatly during my time at Mississippi State University. First and foremost, I need to express my sincere gratitude to my major professor, Dr. Changyou Sun. I am indebted to Dr. Sun for a number of reasons, but chiefly among these is the financial and advising support he has given me as a graduate student. Though I am not remotely close to following the example demonstrated by Dr. Sun, I hope his principles pertaining to organization, productivity, efficiency, and work ethic will remain with me wherever I am led after Mississippi State.

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CHAPTER I

INTRODUCTION

Outdoor recreational activities have been increasing in popularity in recent decades. Trends identified as reasons for growing participation in outdoor recreation include general growth in wealth, increased access to transportation, and a better awareness of recreational opportunities (USDA 2007). One activity which has experienced an increase in participation in recent years is wildlife viewing. From 1996 to 2006, the number of wildlife viewing participants increased from 62.8 million to 71.1 million (USDI 2006). Taking into account population growth, the percentage of Americans who viewed wildlife remained 31 percent in both 1996 and 2006. During this same period, the percentage of Americans who hunt or fish decreased from 20 to 15 percent (USDI 2006). Despite the popularity of wildlife viewing, less is known about wildlife viewing demand compared to hunting and fishing demand.

To evaluate demand for non-market goods and services such as wildlife viewing, the travel cost method has been utilized by many researchers. With the travel cost method, trip expenditures are studied to ascertain a proxy price associated with the non-market good (Pearse and Holme 1993). Concerning wildlife viewing travel cost studies, a limited number exist in the literature. Rockel and Kealy (1991) was the first study to examine nationwide wildlife viewing demand while more recent studies (e.g. Zawacki et al. 2000, Marsinko et al. 2002) have focused on demand and trips taken but have neglected the decision to participate. By studying only trip takers, information regarding factors influencing an individual's decision to participate was not evaluated by these studies. In addition, since only trip takers were considered as part of the relevant population by these recent previous studies (Zawacki et al. 2000, Marsinko et al. 2002), selection bias concerns arose because not all individuals are potential wildlife viewing trip takers.

To fill a knowledge gap left by previous studies, the primary objectives of this study were to determine factors influencing wildlife viewing demand and participation and to derive consumer surplus estimates associated with this activity. Factors influencing whether or not an individual chooses to participate in wildlife viewing recreation were examined first. After identifying wildlife viewing participants, factors affecting trip frequency were evaluated. From this second component, the outcomes from the demand analyses were utilized to derive consumer surplus estimates. Consumer surplus is a measure of net benefit defined as the difference between an individual's willingness to pay for a unit of a good and the good's market price.

To achieve the objectives of this study, a two-step sample selection model was utilized. With sample selection estimation, an outcome variable is observed only when a certain criterion of the selection variable is met (Greene 2008). By measuring participation and frequency jointly, concerns related to selection bias and truncated data are alleviated and a better understanding of factors affecting both wildlife viewing participation and frequency was obtained. As a result, the methodological contribution of this study was the use of a two-step sample selection model with a count data second step to analyze wildlife viewing participation and trip frequency jointly.

Anticipating results that will be described to a greater extent later in the document, certain demographics and activities such as hunting and fishing were found to influence an individual's wildlife viewing participation and frequency of participation. Older, wealthier, educated, white individuals who live in rural areas have prior fishing experience were found to have a greater likelihood to participate in wildlife viewing. Older and white individuals who live in rural areas and have prior hunting experience were found to have a greater likelihood of taking more trips. In addition, derived consumer surplus estimates indicate that the value of wildlife viewing is probably increasing.

This thesis attempts to provide a better understanding of recreational wildlife viewing participation, demand, and consumer surplus. CHAPTER II provides background information, motivations for this research, objectives, and potential implications. CHAPTER III details the methods used for this study. Points of interest include the research's theoretical basis, empirical model, estimation technique, and data source. CHAPTER IV provides results of this research. Factors affecting wildlife viewing participation and trip frequency are presented along with consumer surplus estimates. CHAPTER V provides a discussion of the research's major findings, potential policy implications, and a possible direction for future research.

CHAPTER II

BACKGROUND, MOTIVATIONS, AND OBJECTIVES

Background

America's forests are utilized for a variety of goods and services by individuals with often different needs and wants. In addition to timber, forests provide society with benefits involving water, minerals, carbon sequestration, aesthetics, and outdoor recreation. Understanding the value society places on these benefits can provide policymakers and landowners a direction for future management aimed at maximizing the benefits provided by these resources. Currently, increased demand for many uses of the nation's forests has resulted in increased pressure on resources and increased conflicts between users. For example, even though timber harvesting has slowed in recent decades, an increase in domestic production is expected to occur through 2050 (USDA 2007). In addition, population growth will likely increase freshwater consumption in the United States considerably during the same period (USDA 2007). Meanwhile, concerns associated with global warming will likely lead to further carbon sequestration efforts aimed at reducing levels of carbon dioxide and other greenhouse gases in the atmosphere. Similar to the uses described above, demand has also increased for many forms of outdoor recreation. Recreational activities such as camping, bicycling, hiking, and wildlife viewing experienced substantial increases in participation between 1994 and 2001 (USDA 2007). Due to increased pressure on resources caused by increased demand for many uses, a greater understanding of the value society places on these uses needs to be ascertained.

Wildlife associated recreation is a significant use that includes activities such as hunting, fishing, and wildlife viewing. As identified by the US Fish and Wildlife Service's 2006 Fishing, Hunting, and Wildlife Associated Recreation survey, wildlife recreation in the form of hunting, fishing, and wildlife viewing generated approximately 122 billion dollars in expenditures in 2006. This amount was roughly one percent of the nation's gross domestic product (USDI 2006). In 2006, wildlife viewing expenditures totaled 45.6 billion dollars with nearly 28 percent of this amount being related to trip expenditures and 21 percent directed to the purchase of wildlife viewing equipment (USDI 2006). A previous study estimated that wildlife viewing expenditures generated 95.8 billion dollars in total industry output and created over one million jobs (Valentine and Birtles 2004). In the state of Mississippi, wildlife viewing expenditures during 2006 generated approximately 829 million dollars in total industry output and created 20,985 jobs (Henderson et al. 2010). Undoubtedly, wildlife viewing is an important economic component of the uses of the nation's and the state's natural resources.

In the future, participation rates in many outdoor recreation activities such as wildlife viewing are expected to grow faster than rates of population growth (USDA 2007). As a result, the popularity of wildlife viewing will likely continue to grow. Increasing at a faster rate than population growth, the number of new non-consumptive wildlife recreation participants is expected to increase by 61% over the next 52 years (Bowker et al. 1999). In addition, the number of days spent involving nationwide non-consumptive wildlife recreation is expected to increase by 97% over the next fifty years (Bowker et al. 1999). Due to the increasing popularity of non-consumptive recreation such as wildlife viewing, a better understanding of this particular use needs to be obtained.

Consumptive vs. non-consumptive wildlife recreation

Wildlife associated recreation can involve both consumptive and non-consumptive activities. Consumptive wildlife-associated activities such as hunting and fishing involve participants consuming the resource by catching, capturing or killing the wildlife of interest (Higginbottom 2004). In contrast, non-consumptive wildlife recreation involve participants simply viewing the animal or animals being pursued and appreciating the resources for their aesthetic and educational values. Non-consumptive goods such as wildlife viewing can be considered non-rival goods as well since the good can be consumed by multiple individuals. Wildlife viewing can take the form of many different types of activities. Forms include unguided tours of wildlife in natural areas such as national parks, specialized tours such as whalewatching, general sightseeing tours that involve incidental encounters with wildlife, and stays at tourist facilities that promote wildlife viewing activities (Valentine and Birtles 2004). In addition, zoos can be identified as wildlife tourism businesses (Higginbottom 2004). Experience and skill level varies with wildlife viewing participants. For instance, experienced birders often have highly developed bird identification skills while casual tourists are typically less experienced and possess more generalized tastes and preferences (Valentine and Birtles 2004). Due to the non-consumptive nature of wildlife viewing, participants do not seek to capture or kill the wildlife of interest but to view it for its aesthetic value.

Market vs. non-market goods

Goods and services provided by natural resources can be classified as either market or non-market goods. In an effort to evaluate the economic value of resources, welfare economics seeks to obtain monetary values that are often based on an individual's willingness to pay for a particular use (Tisdell and Wilson 2004). However, some uses such as access to recreational wildlife viewing are non-market goods since the recreational experience cannot be bought or sold directly in a market. In contrast to non-market goods, market goods such as timber and minerals possess a quantifiable price and can be bought and sold directly in the market. Since non-market goods such as recreational wildlife viewing access do not possess a market price, it is difficult to obtain legitimate and reliable estimates of the true economic value of these goods (Tisdell and Wilson 2004). To better compare the value of non-market goods such as wildlife viewing with the value of market goods such as timber and minerals, quantifiable measurements are needed by policy-makers, managers of public areas, and landowners (Zawacki et al. 2000). Overall, since wildlife and access to recreational activities such as hunting, fishing, and wildlife viewing provides benefits to local, state, and national economies, governments have an incentive to conserve wildlife and provide recreational access (Tisdell and Wilson 2004).

Current knowledge status

Numerous studies have researched the economic value of recreational activities using non-market techniques (Majumdar and Zhang 2009, Whitehead 1992, Mendes and Proenca 2007, Martinez-Espiñeira and Amoako-Tuffour 2007, Bowker et al. 2007). Of these, very few studies have explicitly studied demand and consumer surplus, a measure of net social benefit, associated with recreational wildlife viewing (Rockel and Kealy 1991, Marsinko et al. 2002, Zawacki et al. 2000). Other previous studies have examined the decision to participate in non-consumptive wildlife recreation and how variables such as amount of habitat and species diversity affect the participation decision (Hay and McConnell 1979, 1984). The study conducted by Rockel and Kealy (1991) utilized a joint approach where the participation decision was examined first before modeling frequency of use or the number of trips taken. The model for the participation decision utilized a binary regression approach while number of trips was calculated using Heckman's and Cregg's regression techniques (Rockel and Kealy 1991). With time, researchers began to favor using count-data models such as Poisson and negative binomial regression to measure non-negative integer variables such as demand in the form of number of trips taken. As a result, more recent studies have used count-data models to calculate demand due to the ability of these models to account for the heteroskedastity and skewed distributions of non-negative data (Zawacki et al. 2000).

However, as identified by Zawacki et al. (2000), limitations exist involving the use of untruncated count-data models due to the presence of sample selection bias.

Welfare estimates such as consumer surplus related to wildlife viewing have been obtained by previous studies. Using data from the 1980 FHWAR, Rockel and Kealy (1991) found per trip Hicksian and Marshallian welfare estimates for wildlife viewing to fall within a range of $178 to $3,731 based on model specifications. In addition, aggregate estimates ranged from $7.8 billion to $164.5 billion. Using data from the 1991 FHWAR, Zawacki et al. (2000) found per trip untruncated consumer surplus for nonhunters to fall within a range $63.20 to $327.50. For hunters, per trip estimates fell within a range from $37.40 to $161.60. Aggregate estimates ranged from $5.8 to $66.4 billion (Zawacki et al. 2000).

Past researchers using non-market techniques have encountered methodological concerns that arose with the use of recreational survey data to calculate demand. The non-market valuation technique known as the travel cost method is a revealed preferences approach that became the focus of the current research due its reliance on survey data of the actual behavior of recreationists. In contrast to contingent valuation studies which are based on an individual's stated preferences, the travel cost method is a revealed preferences approach since the actual behavior of recreationists is observed (Zawacki et al. 2000). For many travel cost studies, demand was measured as the number of trips took to a site for the purpose of recreating (Rockel and Kealy 1991, Zawacki et al. 2000). Since the dependent variable for these studies was the number of trips taken, demand was measured as a discrete, non-negative integer. As a result, the use of ordinary least squares regression was not appropriate (Yen and Adamowicz 1993). To overcome the limitations of ordinary least squares regression, earlier researchers utilized Heckman's and Cragg's regression models to determine wildlife associated recreational demand (Rockel and Kealy 1991). However, count-data models such as Poisson and negative binomial regression models have been utilized by numerous researchers in recent years to ascertain recreational demand (Yen and Adamowicz 1993, Zawacki et al. 2000, Majumdar and Zhang 2009). In addition, another common feature of recreational survey data is the presence of truncated data (Majumdar and Zhang 2009). Since information related to non-participants is often not gathered especially when the survey is conducted on site, recreational survey is often truncated as only information pertaining to participants is available. The presence of truncated data can affect welfare estimates such as consumer surplus resulting in often biased and inconsistent estimates (Zawacki et al. 2000). A third methodological concern arises as a result of endogeneous stratification. Since recreational survey data is often gathered on-site, the likelihood of an individual being surveyed increases with the number of trips the individual takes (Majumdar and Zhang 2009). In addition, the presence of multi-purpose and multi-destination trip takers in the survey data has the potential to impact welfare estimates such as consumer surplus (Martinez-Espiñeira and Amoako-Tuffour 2009).

With travel cost studies related to wildlife recreation, the construction of the trip cost variable can often impact demand and consumer surplus estimates. In general, with travel cost studies, a consensus often does not exist concerning which costs to include in the cost variables (Pearse and Holmes 1993). As a result, to reflect different concepts of which travel costs to include, studies have incorporated both a full and reduced model that includes various cost categories (Zawacki et al. 2000, Marsinko et al. 2002). A reduced travel cost variable is a reduced representation of trip costs that often only takes into account the individual's transportation costs and fees. A reduced trip cost model that takes into account only transportation costs and fees was utilized by Zawacki et al. (2000) and Marsinko et al. (2002). A full version of the travel cost variable can contain additional categories such as food and lodging (Zawacki et al. 2000). Additionally, the opportunity cost of time was included in many studies to represent the time costs associated with taking a trip. Opportunity cost of time is often represented as the average number of days spent per trip times the wage rate times a multiplier (Zawacki et al. 2000, Majumdar and Zhang (2009). Researchers such as Majumdar and Zhang (2009) utilized a multiplier such as 0.30 while Zawacki et al. (2000) used multipliers of 0, 0.25, and 0.5. Rate of travel was also considered by studies such as Zawacki et al. (2000).

For travel cost studies related to wildlife viewing, demographic information and potential substitute activities are often included in the analysis. Besides trip costs, additional independent variables used in previous studies include income, demographics such as age, urban residence, and race, potential substitutes such as hunting and fishing, and landscape or supply variables such as percentage of forestland (Zawacki et al. 2000, Rockel and Kealy (1991). As demonstrated by Zawacki et al. (2000), hunting and fishing dummy variables were included to identify hunters and fishermen. Interaction terms involving the hunting dummy with hunting costs and the fishing dummy with fishing costs were included to identify potential hunting and fishing substitutes for those individuals who were hunters or fishermen (Zawacki et al. 2000). Another potential substitute variable involved identifying trip costs associated with non-consumptive trips to other sites or states (Zawacki et al. 2000). Supply variables such as percentage of forestland or rangeland within a state were utilized by previous studies as well (Rockel and Kealy 1991, Zawacki et al. 2000).

Knowledge gap and research need

Previous research related to wildlife viewing demand has left a knowledge gap due to past methodological concerns and a reliance on survey data that is now at least thirty years old. Recent studies such as Zawacki et al. (2000) and Marsinko et al. (2002) focused solely on wildlife viewing trip frequency and neglected the decision to participate. As a result, factors affecting an individual's decision to become a wildlife viewing participant were not examined. In addition, selection bias concerns were present in Zawacki et al. (2000) and Marsinko et al. (2002) due to the presence of truncated data. Rockel and Kealy (1991) studied wildlife viewing participation and trip frequency but utilized a two-step approach that did not take into account the count data nature of the trip frequency variable. To this researcher's knowledge, no study has examined wildlife viewing demand using a two-step method involving a participation model first step and a frequency of use count data model second step. In addition to methodological concerns, previous studies utilized survey data that has become outdated. For instance, Rockel and Kealy (1991) utilized 1980 survey data while Zawacki et al. (2000) and Marsinko et al.

(2002) utilized data from 1991. By using more recent data, the current research hopes to provide up to date findings related to wildlife viewing demand and consumer surplus.

Objectives

To fill the knowledge gap left by previous studies, the objective of this study was to determine recreational demand and consumer surplus associated with nationwide wildlife viewing for the year 2006 using a two-step sample selection model.

Similar to Rockel and Kealy (1991), the current study had two essential components. The first component involved determining factors that influence an individual's decision to participate in wildlife viewing. Similar to previous studies and due to constraints imposed by the dataset used, factors of interest related to wildlife viewing participation included demographics and potential substitute activities such as hunting and fishing. Similar to Rockel and Kealy (1991), Zawacki et al. (2000), and Marsinko et al. (2002), the second component of the current research involved determining factors affecting the number of trips a wildlife viewing participant takes. Similar to the first component, factors of interest for the second component include demographics and potential substitute activities such as hunting and fishing. Using the demand models created from the study's second component, consumer surplus estimates were obtained. By utilizing data from the year 2006, the study aimed to provide updated consumer surplus estimates and updated information regarding determinants of wildlife viewing participation and demand. In addition to the previously described primary objectives, a secondary objective of the study was to determine the effectiveness of using a two-step sample selection estimation technique with a count data second step in evaluating wildlife viewing demand.

Research contributions and significance

Numerous potential implications involving policymakers exist as a result of better understanding the value of recreational wildlife viewing. Since nearly all publicly owned forestland is open for recreational use and access to privately owned land varies from owner to owner, the majority of wildlife viewing activities are likely to continue to occur on public lands such as parks and refuges (USDA 2007). As a result, policymakers and managers of parks and refuges could potentially introduce measures to better take into account the value of uses such as wildlife viewing. Potential measures may include regulatory and economic instruments. Regulatory instruments involve a higher degree of government intervention and may include provisions such as land use restrictions and the licensing of wildlife viewing providers (Tisdell and Wilson 2004). A common economic instrument involves the levying of a fee upon entrance into a public park or refuge. For instance, if administrators of a public park can ascertain the value of recreational uses such as wildlife viewing within the park, the administrators could possibly charge an entrance fee to those visiting the park that reflects the value of the use. This revenue creating measure can then be used to protect the wildlife resources of the park and manage for recreational uses such as wildlife viewing. By providing policymakers with a better understanding of the wildlife viewing benefits of public lands, measures could justifiably be enacted to protect and enhance resources that are managed for this use.

Evaluating demographic trends involving recreational wildlife viewing has many potential implications with regard to policy-making and budget allocation as well. For instance, by gaining an understanding of determinants for wildlife viewing participation and demand, landowners and policy-makers can gain a better awareness of the factors affecting both the participation decision and how many trips a participant takes. A better understanding of these determinants can be particular useful in light of recent trends affecting natural resources. Such trends include increased pressure on resources due to population growth, increased urbanization, and increased forest conversion into urban and developed uses (USDA 2007). By gaining a better understanding of determinants of wildlife viewing participation and trip frequency, policymakers could potentially promote incentives or educational programs aimed at increasing wildlife viewing awareness among specific demographics of the American population.

By understanding demographic trends and the value associated with wildlife viewing, policymakers and managers of public land can better fulfill the objectives of legislation concerning public lands and forests. Increased knowledge of recreational wildlife viewing participation and demand can help policymakers and managers of public lands better understand the benefits and importance of parks and refuges. Since the passage of the Multiple Use Sustained-Yield Act of 1960, managers of United States Forest Service lands have been mandated to take into account uses such as outdoor recreation, fish and wildlife habitat, and water quality when prescribing management actions to be performed (Kessler et al. 1992). The National Forest System Land and Resource Management Planning Act also recognizes important uses such as outdoor recreation, biological diversity, clean water, and aesthetic values such as beauty (Zawacki et al. 2000). To better assess all of the resources found in national forests and rangelands, assessments pertaining to the Renewable Resources Planning Act regularly attempts to ascertain trends involving uses such as outdoor recreation, wilderness, and fish and wildlife (USDA 2007). Continued and future management of public lands will rely on better understanding ecosystems, patterns of resource use, and the values humans place on use (Kessler et al. 1992). Understanding the importance of various uses of the forest allows policymakers and managers to better meet the needs of society.

Overall, the current research hopes to provide a better understanding of the value of recreational wildlife viewing as well as determinants of recreational wildlife viewing participation and frequency of use. Demand and welfare measures such as consumer surplus related to recreational wildlife viewing are less understood than demand related to timber production and forms of consumptive wildlife recreation activities such as fishing and hunting. Due to increasing popularity related to non-consumptive recreational activities such as wildlife viewing, information related to the economic value of this activity is needed and can be useful for policymakers and managers who hope to better understand all of the economic values of their land. As a result, potential management and policy-making implications of this study may include private landowners and public officials devoting more resources and initiating revenue creating measures to preserve or expand an individual's ability to view wildlife. By understanding the value and importance of uses such as wildlife viewing, policymakers and managers can better align management decisions with the needs of society.

CHAPTER III

METHODS

Theoretical basis

To evaluate demand for recreational wildlife viewing, a non-market valuation method was employed. To evaluate demand for non-market goods, methods such as contingent valuation (CV) and the travel cost method have been utilized by many researchers. In contrast to CV studies which are based on an individual's stated preferences, the travel cost method is a revealed preferences approach as the actual behavior of recreationists is observed (Zawacki et al. 2000). The theoretical basis of the travel cost method centers on the economic concept of utility maximization (Mendes and Proenca 2007). A basic utility function can be expressed with the following: $U_i = f(X)$ where U_i is an individual's utility that is a function of a set of variables (X). The travel cost method assumes that increasing trip costs decrease the number of trips a participant takes all else equal (Pearse and Holmes 1993). As a result, a participant maximizes utility by taking a number of trips that reflects his or her budgetary capabilities and appreciation for the activity.

Concerning recreation, the travel cost method attempts to ascertain a value for access to the recreational experience. In theory, the travel costs incurred by recreationists to a site can be used to determine a proxy price for access that they would be willing to pay (Pearse and Holmes 1993). The two basic techniques for using the travel cost method are the individual and zonal travel cost approaches. With the individual approach, the dependent variable is the number of trips an individual or household makes while, with the zonal approach, the dependent variable is per capita visitation rates to a specific geographic area or zone (Pearse and Holmes 1993). Similarly, explanatory variables associated with the individual approach include individual demographics and costs incurred by the individual while the zonal approach utilizes costs and characteristics associated with the site as a whole (Pearse and Holmes 1993). Due to the structure of the data source and its focus on individual participation and expenditures, the travel cost method technique utilized for this research was the individual approach.

Through the use of the individual travel cost approach, an individual's demand function for access to the recreational site can be generated. By aggregating the individual demand functions, an aggregate demand function associated with recreational wildlife viewing access can be constructed. As demonstrated by previous researchers (Zawacki et al. 2000, Rockel and Kealy 1991), the travel cost method can be further exploited to estimate measures of welfare and to establish a lower bound for the value of the good. Consumer surplus, a measure of social welfare, is the difference between an individual's willingness to pay for access to a good or service and the actual expenditures he or she has to pay for it (Zawacki et al. 2000). To estimate consumer surplus, the integral below the demand curve and above market price is calculated. Since recreational access is a non-market good, a measure of market price does not exist and is replaced with average trip expenditure (Zawacki et al. 2000). Individual consumer surplus estimates can then be aggregated to ascertain values of aggregate social value.

Data source

To utilize the travel cost method and identify determinants of nationwide wildlife viewing participation and demand, data from the 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation (FHWAR) was utilized. This large and vast survey was designed by the United States Fish and Wildlife Service (USFWS) which is under the direction of the Department of the Interior. Carried out consistently every five years since 1955, the FHWAR is a very detailed assessment of the following three major areas of wildlife recreation: hunting, fishing, and wildlife watching (FHWAR 2006). The 2006 FHWAR contains a wide variety of thorough information relating to wildlife recreation participation, trip expenditures, equipment expenditures, and demographics.

Designed by the USFWS and administered by the United States Census Bureau (USCB), the FHWAR is conducted using both telephone and in-person surveys. Carried out in two phases by the USCB, data collection for the screening file began in April 2006 while more detailed information was gathered on the following three dates: April 2006, September 2006, and January 2007. If a person from a contacted household was identified as a hunter, fishermen, or wildlife watcher, the respondent was placed into the sportsperson or wildlife watcher group. More detailed information concerning trips, expenditures, and equipment was then obtained at one of the three later dates. One caveat of the survey is that only individuals who were at least 16 years of age were considered in the second phase of the survey. Consisting of three major datasets, the 2006 FHWAR comprises of a screening file containing 144,509 records, a sportsperson file containing 21,942 records, and a wildlife watching file containing 11,285 records.

Datasets for the 2006 FHWAR were provided in text files and analyzed using statistical and econometric software. ASCII text files containing FHWAR datasets provided by the USFWS were imported into the following statistical software packages: R, SAS, and LIMDEP. The software environment known as R was used primarily for the numerous data transformations performed prior to more detailed data analysis that was conducted using the econometric software package LIMDEP. R is a powerful and fairly user friendly platform for statistical analysis that is recognized for its free of charge cost and the programming freedom it gives to its users. The statistical package SAS was used sparingly for this study and only as a result of memory concerns that arose when attempting to import the very large FHWAR sportsperson dataset into R. Sample selection regression models used for the study were estimated using LIMDEP, a econometrics software package noted for its extensive regression capabilities.

Empirical model

To identify determinants of wildlife viewing participation and demand, two empirical models were established. First, to identify wildlife viewing participants and to avoid potential selection bias concerns, the following generalized model was constructed:

Wildlife Viewing Participation: $X_i = f(D_i, S_{ij})$ (3-1) where X_i is the individual's decision to participate in a wildlife viewing trip, D_i is a set of demographic variables, and S_{ij} are potential substitute or complementary variables and their associated prices. For this study, the potential substitute and complementary variables of interest were hunting and fishing. More specifically, the following utility function was constructed to model wildlife viewing participation:

$$\text{Participation: } X_i = \beta_0 + \beta_2\, Age + \beta_3\, Age^2 + \beta_4\, Income + \beta_5\, Education + \beta_6\, White + \beta_7\, Urban + \beta_8\, Hunting + \beta_9\, Hunting\ Prices + \beta_{10}\, Fishing + \beta_{11}\, Fishing\ Prices + \varepsilon \qquad (3\text{-}2)$$

where X_i is the individual's decision to participate in a wildlife viewing trip, β_0 is the constant, β is the coefficient for each respective variable, and ε is the error term. Further explanation of variable selection can be found in the next chapter.

To estimate demand for wildlife viewing trips, the following generalized model similar to the one created by Zawacki et al. (2000) was adopted:

$$\text{Wildlife Viewing Demand: } Y_{ij} = f(C_{ij}, S_{ij}, D_i) \qquad (3\text{-}3)$$

where Y_{ij} is the number of wildlife viewing trips a participant takes to a state, C_{ij} is the individual's trip costs to the state, S_{ij} are potential substitute or complementary variables and their associated prices, and D_i is a set of demographic variables. Similar to the participation model, the potential substitute and complementary variables of interest were hunting and fishing. More specifically, the following utility function was constructed to model wildlife viewing demand:

$$\text{Demand: } Y_{ij} = \beta_0 + \beta_2\, Age + \beta_3\, Age^2 + \beta_4\, Income + \beta_5\, White + \beta_6\, Urban + \beta_7\, Hunting + \beta_8\, Hunting\ Prices + \beta_9\, Fishing + \beta_{10}\, Fishing\ Prices + \beta_{11}\, Trip\ Costs + \varepsilon \quad (3\text{-}4)$$

where Y_{ij} is the number of wildlife viewing trips a participant takes to a state, β_0 is the constant, β is the coefficient for each respective variable, and ε is the error term. Similar to participation, further explanation of variable selection can be found in the next chapter. Coinciding with previous research (Zawacki et al. 2000, Rockel and Kealy 1991), the dependent variable, trips taken, was aggregated by state due to limitations associated with the data source. In addition, following the procedure of previous research (Zawacki et al. 2000, Rockel and Kealy 1991), individual trips to additional states were counted as additional separate observations.

Estimation technique

To estimate wildlife viewing participation and demand, a two-step sample selection estimation technique was utilized. Adopting estimation elements from previous studies (Zawacki et al. 2000, Rockel and Kealy 1991), a two-step sample selection model was estimated with a probit first step to estimate participation and a count data second step to estimate demand. The basic logic of sample selection estimation is that an outcome variable is observed only when a certain criterion of the selection variable is met (Greene 2008). For this research, the selection component was wildlife viewing participation while the outcome component was wildlife viewing trip frequency. Since the selection variable was binary and the outcome variable was a count, the first stage was estimated using a binary probit regression model and the second stage was measured using a count-data model such as Poisson or negative binomial regression (Sun et al. 2008). Borrowing the framework from the previous study by Sun et al. (2008), the participation decision can be modeled by the following:

Participation: $z_i^* = g(w_i)$ (3-5)

$z_i = 1$ if $z_i^* > 0$; 0 otherwise

where z_i is a binary variable indicating participation or not and w_i is a set of explanatory variables used to predict participation. The second stage, or frequency of participation, can be expressed by the following model:

Frequency: $y_i = f(x_i)$ (3-6)

y_i is only observed when $z_i = 1$

where y_i is trip frequency contingent on participation measured by non-negative integers and x_i is a set of explanatory variables predicting frequency (Sun et al. 2008).

Binary regression component

To identify participants of recreational wildlife viewing, the first component consisted of a binary probit regression model. Regarding this study, the binary dependent variable is whether or not an individual at least 16 years old has taken a trip of at least one mile away from his or her home for the purpose of viewing wildlife. The value of one for this variable indicates participation. In contrast to logit regression models which utilize the logistic cumulative distribution, probit models utilize the standard normal distribution (Greene 2008). As a result, an assumption is that the errors of the probit model follow a normal distribution. Estimating either the probit or logit model involves the use of maximum likelihood estimation (Greene 2008). Explanatory variables for the model include trip socio-economic and demographic variables such as income, age, and race, participation in potential substitutes such as hunting and fishing, and costs related to the potential substitutes of hunting and fishing. A table containing variable definitions and descriptive statistics can be found in Chapter Four.

Count data regression component

To evaluate demand for wildlife viewing, count-data regression models were adopted. Since demand was measured as a discrete, non-negative integer, Poisson and negative binomial regression models were appropriate models to be used for the study since ordinary least squares (OLS) regression assumes that the dependent variable is normal distributed (Yen and Adamowicz 1993). With count-data, the distribution is rarely normally distributed. With Poisson regression models, the conditional mean and conditional variance of the distribution are equal (Yen and Adamowicz 1993). As a result, the distribution does not exhibit overdispersion. However, if the conditional variance is greater than the conditional mean, overdispersion does exist within the distribution and the Poisson model will likely produce standard errors of the parameter estimates that are biased (Yen and Adamowicz 1993). When overdispersion does exist within the distribution, use of a negative binomial regression model is favored over a Poisson regression model (Zawacki et al. 2000).

Similar to the participation decision, explanatory variables for the model included trip costs, socio-economic and demographic variables such as income, age, and race, participation in potential substitutes such as hunting and fishing, and costs related to the potential substitutes of hunting and fishing. A table containing variable definitions and descriptive statistics can be found in Chapter Four.

Estimating components jointly

With two-step sample selection estimation techniques, the selection and outcome components must be estimated jointly. As demonstrated by Sun et al. (2008), estimating the participation and frequency decisions jointly can be approached using techniques such as full information maximum likelihood (FIML) and Greene's two step method. Greene's two step non-least squares approach was found to be preferable for the study by Sun et al. (2008) because a joint distribution did not have to be defined and convergence problems were associated with the use of FIML. In addition, for all two step methods to produce effective results, the asymptotic covariance matrix for the intensity or frequency of use decision has to be corrected in order to correct for the randomness that is carried over from the selection equation (Greene 2008). With Greene's two step method, the Inverse Mills Ratio (IMR) is calculated and tested to determine if not using the two step method would result in biased parameter estimates (Sun et al. 2008).

However, for the current research, the FIML approach for estimating the equations jointly did produce some convergence problems but was preferred over other two-step approaches due to its ability to produce reasonable results similar to findings of previous research. With the FIML approach, the distributions of the first and second step equations are defined jointly. Unlike Greene's two step non-least squares approach, the correction associated with the FIML approach is performed internally rather than through the use of an IMR.

Consumer surplus

Using the demand component of the two-step sample selection estimation technique utilized, individual per trip and aggregate consumer surplus estimates were obtained. Consumer surplus is defined as the difference between a consumer's willingness to pay for a product and the actual amount the consumer has to pay to obtain the product (Mendes and Proenca 2007). In the count-data regression model, a point estimate of an individual's consumer surplus can be obtained by calculating the negative reciprocal of the cost coefficient (Yen and Adamowicz 1993). Individual per-trip consumer surplus estimates and per trip variance estimates were obtained using the following formulas:

$$\text{Point estimate (CS)} = -(\beta_{TC})^{-1} \quad (3\text{-}7)$$

$$\text{Variance (CS)} = var(\beta_{TC}) / \beta_{TC}^{4} \quad (3\text{-}8)$$

where β_{TC} is the coefficient for the wildlife viewing trip cost variable and $var(\beta_{TC})$ is the variance of the wildlife viewing trip cost variable. Following Zawacki et al. 2000, aggregate consumer surplus estimates were obtaining by multiplying individual consumer surplus estimates by the number of wildlife viewing trips (232 million) that took place in the year 2006 (USDI 2006).

Variable construction

After importing each of the three FHWAR datasets into R, a number of data transformations were made to facilitate data analysis. Concerning the FH2 or screening file dataset, the following dummy variables were created: sex (1 = male), marital status (1 = married), race (1 = white), urban residence (1 = residing in urban area), employment (1 = currently employed), ever hunted (1 = ever hunted in one's lifetime), and ever fished (1 = ever fished in one's lifetime). In addition, since the FHWAR presented survey results related to an individual's education on an ordinal scale, two education dummy variables were created. One education dummy variable indicated that an individual possessed some college education up to the completion of a bachelor's degree while a second variable indicated that an individual possessed a graduate degree. A continuous variable utilized was age while, in accordance with previous literature (Zawacki et al. 2000), the variable age squared was created to indicate possible quadratic relationships between age and the dependent variables participation and trips taken. Similar to education, the FHWAR presented survey results related to household income on an ordinal scale. For example, respondents were able to indicate if their household income fell within a range of $10,000 to $19,999, $20,000 to $24,999, and so on. To make household income a continuous variable, the midpoints of the aforementioned ranges became the value for an individual's response. For instance, for the two ranges identified above, responses became $15,000 and $22,500 respectively.

Data transformations were made also to data found within the FH4 or wildlife watcher data file. Within this dataset, the two dependent variables of concern for this study were created. If an individual who was at least 16 years old took a trip of at least one mile away from the home for the explicit purpose of viewing, photographing, or feeding wildlife, this individual was identified as a trip taker. Therefore, the dummy variable trip taker indicates with the presence of a one that the individual took a wildlife viewing trip in the year 2006. The second dependent variable, number of trips taken by a participant, was more complex to create. In accordance with previous literature (Zawacki et al. 2000, Rockel and Kealy 1991), an individual's trips to multiple states were counted as additional separate observations. As a result, the dependent variable trips taken is the number of wildlife viewing trips an individual took to a specific state. Independent variables for wildlife viewing trip costs were also constructed using the FH4 dataset. Similar to previous literature (Zawacki et al. 2000, Rockel and Kealy 1991), reduced and full trip costs versions of wildlife viewing trip costs were created. A reduced version of the wildlife viewing trip costs variable included costs associated with transportation (private vehicle, public transportation, and air) and fees (guide, public access, and private access). The full trip cost version contained all of the categories associated with the reduced version and added the categories of lodging and food.

To create cost variables associated with the possible substitute activities hunting and fishing, data transformations were made to the FH3 or sportsperson dataset. Similar to previous literature (Zawacki et al. 2000, Marsinko et al. 2002), an individual's hunting and fishing trip costs were represented in this study as the statewide average of hunting and fishing costs where the wildlife viewing trip took place. For wildlife viewing non-participants, an individual's hunting and fishing trip costs were represented as the statewide average of the individual's state of residence since it is assumed that, if a non-participant decided to take a wildlife viewing trip, it would take place in his or her state of residence (Zawacki et al. 2000). In addition, distinctions were made between resident and non-resident hunting and fishing trip costs. As a result, costs associated with hunting and fishing for a state were different for residents and non-residents of that state.

Similar to wildlife viewing trip costs, hunting and fishing trip costs were represented using full and reduced costs versions. A reduced version of the hunting trip costs variable included costs associated with transportation (private vehicle, public transportation, and air) and fees (guide, public access, and private access). The full trip version contained the categories of the reduced version and added the categories of food and lodging. Relying on previous literature (Zawacki et al. 2000, Marsinko et al. 2002), the reduced version of the fishing trip cost variable contained costs associated with transportation (private vehicle, public transportation, and air), fees (guide, public access, and private access), bait and ice, and essential boating costs (boat rental, launching, mooring, storage, maintenance, insurance, and fuel). A full fishing trip costs variable added the categories of food and lodging. Within the FHWAR, costs associated with boat rental, launching, and fuel are separate cost categories while costs associated with mooring, storage, maintenance, and insurance are lumped into a single category. The basic assumption underlying the fishing costs variables is that the use of a boat is essential for many fishermen. Finally, to avoid forcing hunting and fishing trip costs on individuals who do not hunt or fish, the interaction terms ever hunted times hunting costs and ever fished times fishing costs were created. One disclaimer should be noted concerning the construction of the hunting costs variables. No hunting costs were reported in the District of Columbia, and as a result, average hunting costs for the District of Columbia are zero. Specifying hunting costs in the District of Columbia as zero seemed reasonable since hunting is illegal in this area.

A provision for the opportunity cost of time was included in each of the cost variables. Following Zawacki et al. (2002), individual per trip opportunity cost of time estimates were calculated by multiplying trip time by a fraction of the wage rate. Trip time estimates were obtained by dividing an individual's total number of days at the states by the total number of trips at the days. Wage rate estimates were obtained by dividing household income by a full time 2,080 hour work year. Consistent with other studies (Zawacki et al. 2000, Marsinko et al. 2002), a fraction of the wage rate was utilized in the calculation of opportunity cost of time estimates. Similar to Zawacki et al. (2002), this study uses the wage rate multipliers 0.25 and 0.50. As noted by previous researchers such as Majumdar and Zhang (2009), a more theoretically sound approach to account for time costs was unfeasible due to data limitations associated with the FHWAR.

Sample construction

After variable transformations were made, a sample of the data was constructed to carry out data analysis. After removing records with missing observations, records associated with the top five percent of trip costs observations were removed in accordance with a procedure used by previous researchers (Zawacki et al. 2000, Rockel and Kealy 1991). The removal of these observations helps to take into account possible recording errors as well as individuals who took multiple purpose or multiple destination trips. Of the remaining observations, a random sample of 25% of the remaining records was used for the analysis of this study. Twenty-five percent of the remaining usable data produced a sample size of 23,111. Similar to Zawacki et al. (2002) which used an untruncated sample size of 20,699, the use of a large sample size helps to alleviate possible selection bias concerns that are associated with the removal of a large number of records with missing data. In Rockel and Kealy (1991), a smaller sample size was used along with weights found in the original datasets. Since ten percent of the relevant population took a wildlife viewing trip away from home in 2006 (USDI 2006), the sample was constructed to coincide with this finding. As a result, out of the total sample of 23,111 individuals, ten percent or 2,311 took a wildlife viewing trip away from home.

CHAPTER IV

EMPIRICAL RESULTS

Descriptive statistics

The sample contained 23,111 observations detailing nationwide information related to demographics, wildlife viewing participation, trips taken, and trip costs for the year 2006. Information related to demographics, hunting and fishing experience, wildlife viewing participation, and wildlife viewing trips took can be found in Table 4.1. The average household income was $58,270 and the average age for an individual was 46.24 years. Regarding further demographic information, 48% of individuals were male, 62% were married, and 85% were white. In addition, 67% lived in urban areas, 66% were currently employed, 43% possessed some college education up to the completion of a Bachelor of Arts or Science degree, and 12% possessed a graduate degree. Concerning wildlife viewing participation and frequency, 10% of individuals had taken a trip one mile away from the home for the purpose of viewing wildlife and the average number of trips taken by a participant to a site was 8.14. Concerning hunting and fishing participation, 23% of respondents had ever hunted and 53% had ever fished in their lifetime.

Table 4.1 Descriptive statistics of demographics and dependent variables for wildlife viewing sample for the year of 2006

Variable	Explanation	Mean	Std. Deviation	Min	Max	Exp. Sign
	Demographic Variables					
Age	Individual's age in years	46.24	17.53	16	90	+
Age squared	Individual's age squared	2445.58	1736.51	256	8100	-
Sex	1 if male; 0 if female	0.48	–	0	1	?
Married	1 if currently married; 0 otherwise	0.62	–	0	1	?
Household income	Household income in thousands of dollars	58.27	28.94	15	100	+
Some college to BA/BS	1 if individual possesses some college to a BA/BS degree; 0 if otherwise	0.43	–	0	1	+
Graduate degree	1 if individual possesses a graduate degree; 0 otherwise	0.12	–	0	1	+
White	1 if white; 0 otherwise	0.85	–	0	1	+
Urban residence	1 if resides in urban area; 0 if resides in rural area	0.67	–	0	1	-
Employment	1 if currently employed; 0 otherwise	0.66	–	0	1	?
	Fishing and Hunting Experience					
Ever hunted	1 if individual had ever hunted; 0 otherwise	0.23	–	0	1	+
Ever fished	1 if individual had ever fished; 0 otherwise	0.53	–	0	1	+
	Dependent Variables					
Trip taker	1 if individual took a trip of at least one mile away from the home for the purpose of viewing wildlife	0.10	–	0	1	
Trips to site	Number of wildlife viewing trips a participant took to a state	8.14	21.20	1	350	

Trip costs associated with wildlife viewing, hunting, and fishing were organized by costs and wage rate specifications and are presented in Table 4.2. Reduced trip costs for the wildlife viewing and hunting variables contained the categories of transportation and fees while the full trip costs versions added the categories of lodging and food. In contrast to wildlife viewing and hunting, reduced trip costs for fishing contained the categories of transportation, fees, bait and ice, and essential boating costs such as launching, mooring, and fuel. Opportunity cost of time was included in the calculation of all of the trip costs variables at either 25% or 50% of the wage rate. Focusing on trip costs possessing the reduced costs and quarter wage rate specifications, average wildlife viewing trip costs was $57.59 while average hunting and fishing costs were $148.73 and $100.34 respectively (Table 4.2). Trip costs for wildlife viewing, hunting, and fishing followed expected patterns as full costs values were greater than reduced costs values and costs containing the half wage rate specification were greater than costs containing the quarter wage rate specification. The largest trip costs values contained the full costs and half wage rate specifications. Focusing on this group, average wildlife viewing trip costs was $157.17 while average hunting and fishing costs were $246.61 and $190.18 respectively.

Table 4.2 Descriptive statistics of wildlife viewing, hunting, and fishing per trip costs for the year of 2006

Variable	Costs	Categories	Wage Rate	Mean ($)	Std. Deviation ($)	Min	Max
Wildlife	Reduced	Transportation and fees	Quarter	57.59	79.22	0.55	453.37
viewing	Reduced		Half	74.22	95.78	1.10	901.44
	Full	Add food and lodging	Quarter	140.54	280.36	0.55	4618.58
	Full		Half	157.17	291.55	1.10	4706.39
Hunting	Reduced	Transportation and fees	Quarter	148.73	244.50	0	1951.51
	Reduced		Half	168.79	251.22	0.00	2004.02
	Full	Add food and lodging	Quarter	226.55	327.06	0	2069.01
	Full		Half	246.61	343.34	0.00	2121.52
Fishing	Reduced	Transportation, fees, bait, ice	Quarter	100.34	96.53	12.96	1027.02
	Reduced	and essential boating costs	Half	116.72	102.08	20.93	1062.04
	Full	Add food and lodging	Quarter	173.81	169.97	15.46	1573.48
	Full		Half	190.18	175.89	23.43	1608.49

Model selection

Wildlife viewing participation and frequency were modeled using a sample selection model consisting of a binary probit first step and a count data model second step. Four models were constructed to take into account trip costs and wage rate specifications. Issues concerning multicollinearity arose with regard to the variables sex, ever hunted, and ever fished. The variables sex and ever hunted possessed a correlation coefficient value of 0.380 while the variables sex and ever fished possessed a correlation coefficient value of 0.247. Though these correlation values are not large, the potential of multicollinearity and a lack of literature support to justify the inclusion of sex in the models led to the omission of this variable. The variable household income was positively correlated with such variables as marital status, graduate level education, and employment, but correlation coefficient values did not exceed 0.263 for any of these variables. However, to ascertain the potential impact of these variables on household income, participation and demand models were constructed which included and excluded the variables marital status, graduate level education, and employment. The reduced form which excluded the three variables resulted in household income obtaining significance for the participation decision but not demand. Ultimately, the final model excludes the three variables since economic theory suggests that income should be a significant factor and variables such as employment and marital status have no relevant potential policy implication. Concerning further variable selection for the second step of the sample selection models, the education variable signifying some college experience up to the completion of a bachelor's degree was found to be insignificant in preliminary analysis and was omitted from the second step due to a lack of literature support to justify its inclusion.

For the count data second step, the negative binomial overdispersion parameter theta was found to be significant in all four models (Table 4.4). Preliminary analysis involving the dispersion parameter alpha also indicated the presence of overdispersion. Essentially, the presence of overdispersion indicates that the dependent variable number of trips taken is positively skewed since the majority of participants took a few trips while a small number of participants took a large number of trips. Since the overdispersion parameter was significant, the use of a negative binomial regression model was appropriate for all of the sample selection models.

Wildlife viewing participation

Determinants of nationwide wildlife viewing participation were obtained through the use of probit regression models. Results modeling an individual's decision to participate in a wildlife viewing trip of at least one mile away from the home can be found in Table 4.3. Results indicate that a number of demographic variables significantly and positively impacted an individual's decision to participate in a wildlife viewing trip. For instance, all models indicate that age positively impacted participation while age squared negatively impacted participation. These combined results indicate a quadratic relationship and show that an individual's likelihood of participation increased with age but decreased once an individual reached a certain age. In addition, education was found to be a positive and significant factor. Individuals possessing some college education up to the completion of a bachelor's degree were shown to have a higher probability of wildlife viewing participation. Similar to education, an individual's race was found to have a significant and positive impact on participation as white individuals were more likely to participate in a wildlife viewing trip than those of other ethnicities. Household income was found to be a positive and significant factor as well. As a result, an individual's likelihood of participation increases as household income increases.

Table 4.3 Nationwide determinants of individual wildlife viewing participation for the year of 2006 using the probit first stage of a two-step sample selection model

Variable	Reduced 0.25 Coefficient (Std. Error)	Full 0.25 Coefficient (Std. Error)	Reduced 0.50 Coefficient (Std. Error)	Full 0.50 Coefficient (Std. Error)
Constant	-3.231***	-3.193***	-3.219***	-3.189***
	(0.161)	(0.141)	(0.164)	(0.140)
Age	0.051***	0.049***	0.051***	0.049***
	(0.005)	(0.005)	(0.005)	(0.005)
Age squared	-0.001***	-0.001***	-0.001***	-0.001***
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Household income	0.002***	0.002***	0.002***	0.002***
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
BA/BS degree	0.107***	0.102***	0.108***	0.103***
	(0.025)	(0.025)	(0.025)	(0.025)
Race	0.526***	0.522***	0.523***	0.521***
	(0.052)	(0.051)	(0.052)	(0.050)
Urban residence	-0.146***	-0.151***	-0.148***	-0.152***
	(0.026)	(0.026)	(0.026)	(0.026)
Ever hunted	0.029	0.070*	0.015	0.063
	(0.040)	(0.040)	(0.043)	(0.041)
Ever fished	-0.450***	-0.469***	-0.550***	-0.530***
	(0.048)	(0.040)	(0.052)	(0.048)
Int Hunting costs	0.003***	0.001***	0.002***	0.001***
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Int Fishing costs	0.013***	0.008***	0.012***	0.008***
	(0.001)	(<0.001)	(0.001)	(<0.001)
Log-likelihood	-6289.400	-6162.896	-6281.268	-6165.460
$\chi 2$	2446.745	2699.754	2463.010	2694.625

*** and * indicate significance at the 1% and 10% level respectively
n = 23,111

A significant demographic variable that negatively impacted participation was urban residence. As a result, individuals who lived in rural areas were found to have a higher probability of participating than individuals who lived in urban areas.

The impacts of other forms of wildlife recreation were considered in the wildlife viewing participation model as well. According to results from all four models, an individual who had ever fished in his or her lifetime was less likely to participate in a wildlife viewing trip than an individual who had never fished. A less conclusive variable relating to participation was whether or not an individual had ever hunted in his or her lifetime. The model containing the full trip costs and quarter wage rate specifications indicated that ever hunted was a positive and significant factor affecting wildlife viewing participation. However, all other models indicated that ever hunted was a positive but insignificant variable. Costs associated with hunting and fishing was considered in the models as well. Hunting and fishing costs were found to be positive and significant in all four models indicating that as hunting and fishing costs increased, the likelihood of an individual choosing to participate in a wildlife viewing trip increased. As a result, increasing hunting and fishing costs for an individual led to an increased probability of an individual becoming a wildlife viewing participant.

Wildlife viewing demand

Determinants of nationwide wildlife viewing demand were obtained through the use of two-step sample selection negative binomial regression models. Results modeling the number of wildlife viewing trips of at least one mile away from the home an individual made in 2006 can be found in Table 4.4. Similar to wildlife viewing participation, a number of demographic variables were found to significantly impact the number of wildlife viewing trips a participant takes. For instance, similar to participation, all models indicate that age positively impacted trip frequency while age squared negatively impacted trip frequency. These results indicate a quadratic relationship involving age and show that the number of trips a participant took increased with age but decreased once an individual reaches a certain age. Race was found to be a significant and positive factor for all models as white individuals were likely to take more trips than individuals of other ethnicities.

A significant demographic variable found to negatively impact the number of wildlife viewing trips taken by a participant was urban residence. As a result, participants living in urban areas were likely to take fewer trips than those living in rural area. Household income was found to be a negative and insignificant factor affecting trip frequency.

Similar to participation, the impacts of other forms of wildlife recreation were considered in the wildlife viewing frequency models as well. According to the results from the two models containing full costs versions of trip costs variables, an individual who had ever fished in his or her lifetime was likely to take more wildlife viewing trips than an individual who had never fished. For the reduced costs versions, the variable ever fished was positive but insignificant. As a result, for these two models, an individual's past fishing experience had no impact on the number of trips a wildlife viewing participant took. In addition, the variable ever hunted was found to be positive and significant for all four models. As a result, an individual who had ever hunted in his or her lifetime was likely to take more wildlife viewing trips than an individual who had never hunted.

Table 4.4 Nationwide determinants of individual wildlife viewing frequency for the year of 2006 using the negative binomial second stage of a two-step sample selection model

Variable	Reduced 0.25 Coefficient (Std. Error)	Full 0.25 Coefficient (Std. Error)	Reduced 0.50 Coefficient (Std. Error)	Full 0.50 Coefficient (Std. Error)
Constant	-0.623	-0.800**	-0.576	-0.789**
	(0.409)	(0.345)	(0.417)	(0.344)
Age	0.043***	0.044***	0.043***	0.044***
	(0.011)	(0.010)	(0.011)	(0.010)
Age squared	-4.589E-04***	-4.575E-04***	-4.470E-04***	-4.548E-04***
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Household income	-0.001	-0.001	-2.020E-04	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
White	0.269*	0.280**	0.259*	0.279**
	(0.143)	(0.134)	(0.143)	(0.134)
Urban residence	-0.132**	-0.124**	-0.135**	-0.125**
	(0.054)	(0.053)	(0.054)	(0.052)
Ever hunted	0.343***	0.345***	0.334***	0.348***
	(0.064)	(0.064)	(0.066)	(0.065)
Ever fished	0.114	0.185***	0.108	0.176**
	(0.072)	(0.069)	(0.076)	(0.070)
Int Hunting costs	-2.142E-04	-2.615E-04	-2.443E-04	-2.699E-04
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Int Fishing costs	6.380E-04	3.646E-04	5.603E-04	3.703E-05
	(0.001)	(<0.001)	(<0.001)	(<0.001)
Trip Costs	-4.646E-03***	-1.366E-03***	-3.969E-03***	-1.353E-03***
	(0.001)	(<0.001)	(<0.001)	(<0.001)
Overdispersion (θ)	0.087***	0.074***	0.089***	0.073***
Log-likelihood	-12763.46	-12640.41	-12751.97	-12638.87
$\chi2$	29802.58	29704.30	29855.92	29631.85

*** , **, and * indicate significance at the 1%, 5%, and 10% level respectively

n = 2,311

Trip costs associated with wildlife viewing, hunting, and fishing were included in the wildlife viewing demand models as well. In agreement with assumptions related to the travel cost method, wildlife viewing trip costs was a negative and significant factor that influenced the number of trips a participant took. As a result, participants were likely to take fewer wildlife viewing trips as trip costs associated with wildlife viewing increased. Costs associated with hunting and fishing was considered in the models as well to determine the impacts of potential substitute activities. Hunting costs were found to be negative but insignificant in all four models indicating the possibility of a weak complementary relationship between wildlife viewing and hunting. Since the hunting costs variables were found to be negative, the number of wildlife viewing trips a participant took decreased as hunting costs increased. However, the relationship between hunting costs and wildlife viewing trip frequency was statistically insignificant. Similar to hunting costs, fishing costs were found to be an insignificant factor. Unlike hunting costs, fishing costs positively impacted trip frequency but were insignificant. The insignificance yet positive signs of the fishing costs variables indicate that fishing and wildlife viewing potentially are weak substitutes.

Consumer surplus estimates

By utilizing the outcomes from the wildlife viewing demand analyses, individual per trip and nationwide aggregate consumer surplus estimates were obtained. Consumer surplus estimates organized by trip cost and wage rate specification can be found in Table 4.5. Overall, individual per trip consumer surplus estimates ranged from $215.23 to

$739.07. As expected, the most conservative per-trip consumer surplus estimate was found using the reduced costs and quarter wage rate specification. Individual per-trip consumer surplus estimates using this model specification equaled $215.23 with a standard deviation of $23.57. In agreement with previous studies, the model specification containing the most robust individual consumer surplus estimate involved the full costs and half wage rate specifications. Individual per-trip consumer surplus estimates using this model specification equaled $739.07 with a standard deviation of $58.69. According to the results, models that contained the full cost versions of the trip costs variables produced much larger consumer surplus estimates than models that contained the reduced cost versions of the trip costs variables. Compared to trip cost specification, wage rate specification did not have as a significant impact on consumer surplus estimates. Aggregate consumer surplus estimates were obtained by multiplying consumer surplus point estimates by the number of wildlife viewing trips (232 million) that occurred in 2006. Aggregate consumer surplus estimates ranged from $44.5 billion to $185.1 billion and followed the same patterns demonstrated by the consumer surplus individual per trip estimates.

Table 4.5 Wildlife viewing individual per trip and aggregate national consumer surplus estimates for the year of 2006

Costs Specificatior	Wage Rate	Point estimate ($)	Std. deviation ($)	Aggregate Range ($ billions)
Reduced	Quarter	215.23	23.57	44.5 - 55.4
Reduced	Half	251.95	27.66	52.0 - 64.9
Full	Quarter	732.33	59.07	156.2 - 183.6
Full	Half	739.07	58.69	157.8 - 185.1

CHAPTER V

DISCUSSION AND CONCLUSION

Using data from the 2006 Fishing, Hunting, and Wildlife Associated Recreation (FHWAR) survey, wildlife viewing participation and demand was modeled using a two-step sample selection approach. From the second step, consumer surplus estimates were calculated. The use of a two-step model with a count data second step improves upon past methodology by eliminating selection bias concerns and accounting for the non-negative integer nature of wildlife viewing trips. As in previous studies, consumer surplus estimates were highly sensitive to assumptions related to categories to include in the trip costs variables as well as wage rate specification. Comparing to previous studies, consumer surplus estimates obtained by this research were fairly similar and moderately higher. For a nationwide population of individuals who are at least 16 years old, aggregate consumer surplus estimates obtained for the year 2006 ranged from $44.5 to $185.1 billion based on modeling assumptions involving costs and wage rate specifications. Adjusting for inflation and reflecting its findings in 2006 dollars, Zawacki et al. (2000) found aggregate consumer surplus estimates to range from $8.5 to $97.7 billion for the same population of interest. In addition, Rockel and Kealy (1991) found aggregate consumer surplus estimates to range from $18.9 to $400 billion while Boyle et al. (1994) calculated an aggregate consumer surplus estimate of $19.6 billion. Results indicate that the net social benefit of recreational wildlife viewing appears to be increasing.

A possible increase in the net social benefit of wildlife viewing has many potential implications with regard to policymakers. As identified by Zawacki et al. (2000), knowledge of per trip consumer surplus estimates and visitation trends can help to measure benefits lost or gained from pursuing management alternatives such as logging. Information regarding benefits of wildlife viewing can be used along with obtained costs to perform cost benefit analyses which can be useful for policy purposes. Overall, since the value of wildlife viewing access seems to be increasing, policymakers potentially have an impetus to introduce legislation aimed at increasing funding and access for recreational activities such as wildlife viewing on public lands. However, in order to accurately reflect the value of access to recreational wildlife viewing on their specific park or refuge, managers would likely need to consider performing valuation studies and cost benefit analyses specific to their area of interest.

Unlike fishing and hunting, a federal aid program aid program does not exist which specifically targets non-consumptive wildlife viewers and the preservation of wildlife viewing resources. The 1937 Pittman-Robertson Act and the 1950 Dingell-Johnson Act provides funds used for the preservation and restoration of wildlife habitat and fisheries resources respectively through the implementation of federal excise taxes on related equipment such as sporting arms, rods, and reels (McKinney et al. 2005). Similarly, the 1934 Migratory Bird Conservation Act provides funding for the establishment of migratory bird wetland habitat through the sale of "Duck Stamps" that can be bought by hunters who wish to hunt migratory birds and non-consumptive users who wish to enter federal refuges free of charge (McKinney et al. 2005). The examples of these previously enacted aid programs can be useful in implementing a federal program that targets wildlife viewers and the preservation and restoration of wildlife viewing habitat. For example, since wildlife viewing equipment expenditures totaled $9.9 billion in 2006, policymakers may consider placing federal excise taxes on equipment such as binoculars, cameras, and bird feed that can be used to fund non-game wildlife viewing habitat preservation and restoration efforts (USDI 2006). Assuming that recreation is elastic as opposed to gasoline which is an essential good and therefore inelastic, the taxation of wildlife viewing equipment would likely decrease participation. However, the concept of equitability suggests that wildlife viewers need to play a role in providing funding for the preservation of habitat they are receiving benefits from. In addition, policymakers could consider the sale of wildlife viewing or non-consumptive stamps that can give buyers free admission to federal refuges and national parks. Funds generated from these stamps can then be used to foster wildlife viewing habitat. At the state level, numerous and diverse mechanisms aimed at funding wildlife have been enacted. From general sales taxes in Arkansas and Missouri to vehicle license plates in Georgia and Washington, the example of these measures can be useful in the formation of future efforts both at the state and national level (McKinney et al. 2005).

Due to the benefits Americans receive from access to recreational wildlife viewing, managers of parks and refuges may have a justification to explore the possibility of entrance fees. The trip frequency impacts of such entrance fees could potentially be examined using the travel cost method models used for this study by introducing various fee scenarios. However, a possibly more useful route for further research may include travel cost studies of specific parks and refuges and examining the impact of entrance fees on these specific areas. Though examples of user fees specifically targeting wildlife viewers and non-consumptive users are limited, attempts have been made in Alaska and Virginia. In Alaska, a 2003 bill was introduced to the state legislature which attempted to place a non-consumptive user fee on non-residents who take commercial viewing tours (McKinney et al. 2005). This measure however ultimately failed due to opposition whose primary concern was the specific targeting of cruiseliner patrons. In contrast, a more successful measure was recently enacted in Virginia. In May of 2011, the Virginia Department of Game and Inland Fisheries began charging non-consumptive users a five dollar daily fee for entrance into land managed by this agency (Cochran 2011). Non-consumptive users can also purchase a yearly license that is priced at $23. These two examples illustrate the possibility of charging wildlife viewers and other non-consumptive users fees for entrance into public parks and refuges.

Determinants of participation and participation frequency have many potential implications for policymakers as well. Even though one should be cautious of applying national results to specific local areas, results from this research highlight some potential important trends. Consistent with previous research, age was found to positively impact both participation and frequency. Due to the large number of individuals from the babyboomer generation nearing retirement, it can be expected that wildlife viewing participation and frequency will likely continue to increase in the immediate years to come. However, as indicated by the age squared variable, participation and frequency both decrease once an individual reaches a certain age. Therefore, it can be expected that participation and frequency numbers will likely decrease when the majority of the babyboomer generation is no longer able to recreate. As a result, in an effort to promote recreational wildlife viewing, policymakers could possibly consider incentives as well as outreach and educational programs aimed at increasing wildlife viewing awareness among young people in particular. Incentives aimed at increasing wildlife viewing participation and trip frequency among young people could include providing free transportation to public parks, providing gasoline cards or vouchers, and possibly providing tax incentives to individuals who perform volunteer work related to parks and wildlife viewing. Under the hypothetical entrance fee scenarios mentioned earlier, waiving the entrance fee on younger individuals possibly could incentivize this group but would also introduce price discrimination. Concerning education, the creation of more youth conservation awareness programs administered by universities and groups such as non-profit organizations could also be explored by policymakers and agencies in order to promote greater environmental awareness among this group.

Additional demographic variables with potential policy implications include race and urban residence. Consistent with previous research, white individuals were found to be more likely to participate and to take more trips than those individuals of other ethnicities. In addition, consistent with previous research urban residence was found to negatively impact both wildlife viewing participation and frequency. This finding is intuitive considering that rural individuals have a greater access to forests and wildlife habitat than those living in urban areas. Considering general nationwide demographic trends involving rising minority and, in particular, Hispanic populations as well as a general increased movement of individuals from rural to urban areas, policymakers may consider the use of incentives as well as outreach programs aimed at increasing wildlife viewing awareness among those in the Hispanic population and those living in urban areas. Increasing conservation awareness among the Hispanic population is potentially critical given past indications that suggest that this ethnicity does not consider conservation to be a priority. As identified earlier, potential financial incentives may involve providing free transportation or defraying gasoline costs and also specific tax incentives that are intended for individuals who are Hispanic and living in urban areas. These incentive and outreach programs could likely target school-aged individuals and be coupled with attempts to increase exercise activity. To increase outdoor exercise activity among young individuals, incentives may include directly compensating individuals for the number of days or hours spent recreating or volunteering at public parks or refuges.

In addition, another demographic variable with potential policy implications includes education. Some college experience up to the completion of a bachelor's degree was found to be a positive and significant factor affecting wildlife viewing participation but not demand. Regarding the effect of education on participation, this result seems intuitive since individuals who are more highly educated generally possess a higher regard for the environment and would therefore likely be more willing to participate in outdoor recreation activities such as wildlife viewing. However, education may in fact be acting as a proxy for wealth as educated individuals generally have more money and a greater capability to recreate. Even though urban individuals are generally more educated than rural ones, familiarity with forests and outdoor recreation likely led to increased participation among rural individuals. The insignificant impact of education on wildlife viewing demand may be attributed to time pressures related to work and other activities that highly educated individuals likely face. As a result, one potential policy implication may involve marketing wildlife viewing to individuals who are more highly educated. In addition, to increase wildlife viewing awareness at an early age, outdoor and wildlife viewing financial incentives and recreation outreach programs targeting those in secondary and high schools could be promoted.

Results indicate that household income did not significantly impact wildlife viewing frequency but did positively and significant impact participation. Regarding demand, household income was found to be negative and significant. Though not intuitive, this result is similar to findings from Zawacki et al. (2000) and Rockel and Kealy (1991) who found negative or insignificant income coefficients. One possible explanation of this finding could involve data limitations, a lack of actual continuous data related to income, and how the variable was ultimately constructed. Another possible explanation could center on the idea that a potentially large segment of wildlife viewers take less costly trips that do not require a substantial amount of income. In other words, unlike activities such as going to an amusement park where an entrance fee is required or hunting or fishing where at least some travel is required, costs and distance traveled associated with wildlife viewing are almost entirely at the discretion of the recreationist.

Unlike previous studies such as Zawacki et al. (2000), both hunting and fishing costs for the demand equation were found to be insignificant. With regard to the hunting price variables, the coefficient was consistently negative but not significant. The significance of the hunting price variable found by Zawacki et al. (2000) indicated that hunting and wildlife viewing were possibly complementary activities. Even though this research did not find significance involving the hunting price variable, land managers in particular may be interested in exploring increasing either hunting or wildlife viewing opportunities found on their land. If hunting and wildlife viewing are indeed complementary activities, increasing opportunities for one of the recreational activities would likely increase both the number of hunting and wildlife viewing trips a participant takes. However, due to a critical assumption of the travel cost method that trips are taken for the single purpose of wildlife viewing, one cannot state with absolute certainty that wildlife viewing and hunting are complementary activities. Similar to both Zawacki et al. (2000) and Rockel and Kealy (1991), this study found fishing costs to be positive but insignificant for the demand equation indicating that no considerable relationship between fishing costs and the number of wildlife viewing trips a participant takes exists. If, however, wildlife viewing and fishing were substitutes, managers attempting to promote wildlife viewing could emphasize the potential low cost nature of wildlife viewing trips. With regard to wildlife viewing participation, hunting and fishing costs were found to be positive and significant variables. As a result, as costs associated with hunting and fishing increase, an individual's likelihood of participating in wildlife viewing increases. As a result, due to the high costs often associated with hunting and fishing especially on areas distant to one's home, managers of public parks could attempt to increase wildlife viewing participation by promoting the wildlife viewing resources of their land and the low cost nature of visiting public parks and refuges.

Despite the findings made from this research, methodological concerns are still present. As identified by previous researchers, wildlife viewing consumer surplus estimates are highly sensitive to researcher imposed assumptions involving the construction of cost variables. In order to better accurately derive the net social benefit of access to recreational wildlife viewing, a better consensus needs to be established regarding which specific costs should be included in the trip costs variable. Other more general methodological concerns involving the use of the travel cost method to derive consumer surplus estimates. One issue identified by Randall (1994) is that travel cost is "inherently unobservable". As a result, following the basic assumption of the travel cost method that the number of trips taken decreases with rising costs, travel costs can only be measured ordinally. Therefore, consumer surplus can only be estimated on an ordinal scale (Randall 1994). In addition, it is difficult to fully identify and take into account multi-purpose and multi-destination trip takers. As identified by Martinez-Espiñeira and Amoako-Tuffour (2009), the presence of multi-purpose and multi-destination trip takers has the potential to bias welfare estimates. For this study, trip takers are identified in the FHWAR as individuals who take a trip of at least one mile away from their home for the "primary purpose" of viewing wildlife (USDI 2006). As a result, potential issues associated with multi-purpose and multi-destination trip takers were hopefully avoided.

The current research provides greater insight concerning aspects of wildlife viewing participation and demand. By using a two-step sample selection estimation technique, participation and demand were able to be studied simultaneously and possible concerns involving selection bias and truncated data were alleviated. In addition, by utilizing a sample selection model with a count data second step, the study improves estimation compared to previous studies since possible concerns involving selection bias were assuaged and the non-negative integer nature of wildlife viewing trips was accounted for. Overall, the use of improved methodology and recent survey adds to the current body of knowledge concerning wildlife viewing. Even though the research possessed methodological concerns such as the specification of costs variables, the study identified demographic patterns involving wildlife viewing participation and demand and identified the possibility of the increasing value of wildlife viewing access. In the future, wildlife viewing will likely continue to grow in popularity and more research will be needed to better understand this significant use of America's forests.

The models developed for this study can potentially be useful for future research. For instance, one specific area of future research could involve using a consistent method to measure demand and consumer surplus changes across time. All previous research related to wildlife viewing demand have used varied methodological techniques. By using a consistent method to measure demand and consumer surplus, a better understanding of trends involving the value of the activity can be ascertained. In addition, another avenue of potential research could involve the feasibility of wildlife viewing markets aimed at providing private landowners an opportunity to take advantage of the wildlife viewing value of their lands.

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APPENDIX A

R PROGRAM CODES FOR CHAPTER III

```
# FHWAR code

setwd("C:\\aTwoStepNew"); getwd()
library(car); # recode
library(erer)
source("fhtriprev.r")

# 1 _______ fh2 screeing data transformation __________________________

load("Dfh2.Rdata")
object.size(fh2); str(fh2); dim(fh2); colnames(fh2)
colnames(fh2) <- tolower(colnames(fh2))
fh2a <- fh2[, c("personid", "i_resident", "perwgt", "age", "sex",
"marital", "school", "scrace", "gemsast", "hincome", "geur",
"job", "retire", "everhunt", "hunt05", "hunt06", "huntlike06",
"everfish", "fish05",  "fish06", "fishlike06", "trip05", "trip06",
"triplike06")]
pool <- data.frame(fh2a[, 1:2],
    as.data.frame(lapply(fh2a[, -c(1,2)], as.numeric)))
str(pool)

pool2 <- subset(pool, !is.na(hincome) & !is.na(marital) &
!is.na(school)& !is.na(scrace) & !is.na(geur) & !is.na(job) )
inc <- "1=5; 2=15; 3=22.5; 4=27.5; 5=32.5; 6=37.5; 7=45.0; 8=62.5;
9=87.5; 10=100"
pool2$hincome2  <- recode(pool2$hincome, inc)
pool2$school2   <- recode(pool2$school,  "13:16=1; else=0")
# 1-Some college to BS/BA
pool2$school3   <- recode(pool2$school,  "17:18=1; else=0")
# 1-Graduate degree
pool2$sex2      <- recode(pool2$sex,     "1=1;     2=0")
# 1-Male 0-Female
pool2$marital2  <- ifelse(pool2$marital  == 1, 1, 0)
# 1-Married 0-Not
pool2$scrace2   <- ifelse(pool2$scrace   == 1, 1, 0)
# 1-White 0-Other
pool2$geur2     <- ifelse(pool2$geur     == 1, 1, 0)
# 1-Urban 0-Rural
pool2$job2      <- ifelse(pool2$job      == 1, 1, 0)
# 1-Employed 0-not
pool2$retire2   <- ifelse(pool2$retire   == 1, 1, 0)
# 1-Retired 0-not (many NAs)
pool2$gemsast2  <- ifelse(pool2$gemsast  == 1, 1, 0)
# ?
pool2$agesq     <- (pool2$age)^2
# Age Squared
pool2$everfish2 <- ifelse(pool2$everfish == 1, 1, 0)
# Ever fish dummy
pool2$everhunt2 <- ifelse(pool2$everhunt == 1, 1, 0)
# Ever hunt dummy

pool3 <- subset(pool2, , select=c(personid, i_resident, age, agesq,
sex2, marital2, hincome2, school2, school3, scrace2, geur2, job2,
everhunt2, everfish2))
```

```
pool3[is.na(pool3)] <- 0
tail(pool3); dim(pool); dim(pool2); dim(pool3)

# 2 _______ fh4 wildlife watching data transformation _________________

load("Dfh4m.Rdata")
fha <- data.frame(fh4, stringsAsFactors=FALSE)
object.size(fha); str(fha); dim(fha); colnames(fha)
nam <- c("personid", "I_RESIDENT", "ncu_std1", "ncu_std2", "ncu_std3",
"ncu_std4", "ncu_std5", "ncu_std6", "ncu_std7", "ncu_std8", "ncu_std9",
"ncu_std10", "ncwgt", "age", "sex", "marital", "school", "scrace",
"gemsast", "geur", "hincome", "observe", "observe_day", "ncu_hnt",
"ncu_fish", "ncutotd1", "ncutotd2", "ncutotd3", "ncutotd4", "ncutotd5",
"ncutotd6", "ncutotd7", "ncutotd8", "ncutotd9", "ncutotd10",
"ncushr1d1", "ncushr1d2", "ncushr1d3", "ncushr1d4", "ncushr1d5",
"ncushr1d6", "ncushr1d7","ncushr1d8", "ncushr1d9", "ncushr1d10",
"ncushr2d1", "ncushr2d2", "ncushr2d3","ncushr2d4", "ncushr2d5",
"ncushr2d6", "ncushr2d7", "ncushr2d8", "ncushr2d9","ncushr2d10",
"ncushr3d1", "ncushr3d2", "ncushr3d3", "ncushr3d4", "ncushr3d5",
"ncushr3d6", "ncushr3d7", "ncushr3d8", "ncushr3d9", "ncushr3d10",
"ncushr4d1", "ncushr4d2", "ncushr4d3", "ncushr4d4", "ncushr4d5",
"ncushr4d6", "ncushr4d7", "ncushr4d8", "ncushr4d9", "ncushr4d10",
"ncushr5d1", "ncushr5d2", "ncushr5d3", "ncushr5d4", "ncushr5d5",
"ncushr5d6", "ncushr5d7", "ncushr5d8", "ncushr5d9", "ncushr5d10",
"ncushr6d1", "ncushr6d2", "ncushr6d3", "ncushr6d4", "ncushr6d5",
"ncushr6d6", "ncushr6d7", "ncushr6d8", "ncushr6d9", "ncushr6d10",
"ncushr7d1", "ncushr7d2", "ncushr7d3", "ncushr7d4", "ncushr7d5",
"ncushr7d6", "ncushr7d7", "ncushr7d8", "ncushr7d9", "ncushr7d10",
"ncushr8d1", "ncushr8d2", "ncushr8d3","ncushr8d4", "ncushr8d5",
"ncushr8d6", "ncushr8d7", "ncushr8d8", "ncushr8d9", "ncushr8d10",
"ncudaysd1", "ncudaysd2", "ncudaysd3", "ncudaysd4", "ncudaysd5",
"ncudaysd6", "ncudaysd7", "ncudaysd8", "ncudaysd9", "ncudaysd10")
pig <- fha[, nam]
bird <- data.frame(pig[, 1:12],
    as.data.frame(lapply(pig[, -c(1:12)], as.numeric)))
colnames(bird) <- tolower(colnames(bird))
str(bird); dim(bird)

bird2 <- subset(bird, !is.na(hincome)); dim(bird2)
bird2$hincome2 <- recode(bird2$hincome, inc)
bird2$school2  <- recode(bird2$school,  "13:16=1; else=0")
bird2$school3  <- recode(bird2$school,  "17:18=1; else=0")
bird2$sex2     <- ifelse(bird2$sex     == 1, 1, 0)
bird2$marital2 <- ifelse(bird2$marital == 1, 1, 0)
bird2$scrace2  <- ifelse(bird2$scrace  == 1, 1, 0)
bird2$geur2    <- ifelse(bird2$geur    == 1, 1, 0)

bird2[is.na(bird2)] <- 0
bird2$agesq <- (bird2$age)^2
bird2 <- within(data=bird2, ntrip <- ncutotd1 +  ncutotd2 + ncutotd3 +
ncutotd4 + ncutotd5 + ncutotd6 + ncutotd7 + ncutotd8 + ncutotd9 +
ncutotd10)
bird2$triptaker <- ifelse(bird2$ntrip >= 1, 1, 0)
```

```
# To account for multiple observations
ta <- c("ncu_std", "ncutotd", "ncudaysd", "ncushr")
bird3a <- fhTriprev(bird2, 1, ta, 1:8, 3:8)
totala <- rbind(fhTriprev(bird2, 1, ta, 1:8, 3:8), fhTriprev(bird2, 2,
ta, 1:8, 3:8), fhTriprev(bird2, 3, ta, 1:8, 3:8), fhTriprev(bird2, 4,
ta, 1:8, 3:8), fhTriprev(bird2, 5, ta, 1:8, 3:8), fhTriprev(bird2, 6,
ta, 1:8, 3:8), fhTriprev(bird2, 7, ta, 1:8, 3:8), fhTriprev(bird2, 8,
ta, 1:8, 3:8), fhTriprev(bird2, 9, ta, 1:8, 3:8), fhTriprev(bird2, 10,
ta, 1:8, 3:8))
rownames(totala) <- 1:dim(totala)[1]

taker <- bird2[, c("personid","triptaker", "ntrip")]
bird3 <- merge(x = taker, y = bird3a, by='personid', all.y=TRUE)
total <- merge(x = taker, y = totala, by='personid', all.y=FALSE)
tail(total);
dim(total)
View(total)
summary(total)

# 3 _______ fh3 transformations_______________________________________

goose <- read.table("fh3hunt2.csv", header=T, sep=',',
stringsAsFactors=F)
colnames(goose) <- tolower(colnames(goose))
colnames(goose); dim(goose)
duck <- subset(goose, !is.na(hincome)); dim(duck)
duck$hincome2 <- recode(duck$hincome, inc)
duck[is.na(duck)] <- 0

# Hunting = big game + small game + migratory bird + other animal
tb <- c("huntstd", "bgtripd", "bgdaysd", "bgshar")
f.bg <- rbind(fhTriprev(duck, 1, tb, 1:8, 3:8), fhTriprev(duck, 2, tb,
1:8, 3:8), fhTriprev(duck, 3, tb, 1:8, 3:8), fhTriprev(duck, 4, tb,
1:8, 3:8), fhTriprev(duck, 5, tb, 1:8, 3:8), fhTriprev(duck, 6, tb,
1:8, 3:8),  fhTriprev(duck, 7, tb, 1:8, 3:8), fhTriprev(duck, 8, tb,
1:8, 3:8))
dim(f.bg)

tc <- c("huntstd", "smtripd", "smdaysd", "smshar")
f.sm <- rbind(fhTriprev(duck, 1, tc, 1:8, 3:8), fhTriprev(duck, 2, tc,
1:8, 3:8), fhTriprev(duck, 3, tc, 1:8, 3:8), fhTriprev(duck, 4, tc,
1:8, 3:8), fhTriprev(duck, 5, tc, 1:8, 3:8), fhTriprev(duck, 6, tc,
1:8, 3:8), fhTriprev(duck, 7, tc, 1:8, 3:8), fhTriprev(duck, 8, tc,
1:8, 3:8))

td <- c("huntstd", "mbtripd", "mbdaysd", "mbshar")
f.mb <- rbind(fhTriprev(duck, 1, td, 1:8, 3:8), fhTriprev(duck, 2, td,
1:8, 3:8), fhTriprev(duck, 3, td, 1:8, 3:8), fhTriprev(duck, 4, td,
1:8, 3:8), fhTriprev(duck, 5, td, 1:8, 3:8), fhTriprev(duck, 6, td,
1:8, 3:8), fhTriprev(duck, 7, td, 1:8, 3:8), fhTriprev(duck, 8, td,
1:8, 3:8))

te <- c("huntstd", "oatripd", "oadaysd", "oashar")
```

```
f.oa <- rbind(fhTriprev(duck, 1, te, 1:8, 3:8), fhTriprev(duck, 2, te,
1:8, 3:8), fhTriprev(duck, 3, te, 1:8, 3:8), fhTriprev(duck, 4, te,
1:8, 3:8), fhTriprev(duck, 5, te, 1:8, 3:8), fhTriprev(duck, 6, te,
1:8, 3:8), fhTriprev(duck, 7, te, 1:8, 3:8), fhTriprev(duck, 8, te,
1:8, 3:8))
f.hunt <- rbind(f.bg, f.sm, f.mb, f.oa)
f.hunt1 <- subset(f.hunt, i_resident == stateNow)
f.hunt2 <- subset(f.hunt, i_resident != stateNow)

# reduced trip cost
aggregate(f.hunt$rpertripq,  list(f.hunt$stateNow), mean)
aggregate(f.hunt1$rpertripq, list(f.hunt1$stateNow), mean)
aggregate(f.hunt2$rpertripq, list(f.hunt2$stateNow), mean)
aggregate(f.hunt$rpertriph,  list(f.hunt$stateNow), mean)
aggregate(f.hunt1$rpertriph, list(f.hunt1$stateNow), mean)
aggregate(f.hunt2$rpertriph, list(f.hunt2$stateNow), mean)

# full trip cost
aggregate(f.hunt$fpertripq,  list(f.hunt$stateNow), mean)
aggregate(f.hunt1$fpertripq, list(f.hunt1$stateNow), mean)
aggregate(f.hunt2$fpertripq, list(f.hunt2$stateNow), mean)
aggregate(f.hunt$fpertriph,  list(f.hunt$stateNow), mean)
aggregate(f.hunt1$fpertriph, list(f.hunt1$stateNow), mean)
aggregate(f.hunt2$fpertriph, list(f.hunt2$stateNow), mean)
dim(f.hunt); dim(f.hunt1); dim(f.hunt2)

# Fishing price variables _________________________________

moose <- read.table("fh3fish2.csv", header=TRUE, sep=',',
    stringsAsFactors=FALSE)
colnames(moose) <- tolower(colnames(moose))
tail(moose); dim(moose)
moose2 <- subset(moose, !is.na(hincome)); dim(moose2)
moose2$hincome2 <- recode(moose2$hincome, inc)
moose2[is.na(moose2)] <- 0

ma <- c("glksted", "gltripd", "glstdaysd", "glshar")
f.gs <- rbind(fhTriprev(moose2, 1, ma, 1:15, 3:15), fhTriprev(moose2,
2, ma, 1:15, 3:15), fhTriprev(moose2, 3, ma, 1:15, 3:15))

mb <- c("frsted", "frtripd", "frdaysd", "ofshar")
f.fr <- rbind(fhTriprev(moose2, 1, mb, 1:15, 3:15), fhTriprev(moose2,
2, mb, 1:15, 3:15), fhTriprev(moose2, 3, mb, 1:15, 3:15),
fhTriprev(moose2, 4, mb, 1:15, 3:15), fhTriprev(moose2, 5, mb, 1:15,
3:15), fhTriprev(moose2, 6, mb, 1:15, 3:15), fhTriprev(moose2, 7, mb,
1:15, 3:15), fhTriprev(moose2, 8, mb, 1:15, 3:15), fhTriprev(moose2, 9,
mb, 1:15, 3:15), fhTriprev(moose2, 10, mb, 1:15, 3:15),
fhTriprev(moose2, 11, mb, 1:15, 3:15), fhTriprev(moose2, 12, mb, 1:15,
3:15))

mc <- c("sltsted", "salttripd", "saltdaysd", "slshar")
f.sa <- rbind(fhTriprev(moose2, 1, mc, 1:15, 3:15), fhTriprev(moose2,
2, mc, 1:15, 3:15), fhTriprev(moose2, 3, mc, 1:15, 3:15),
fhTriprev(moose2, 4, mc, 1:15, 3:15),  fhTriprev(moose2, 5, mc, 1:15,
```

```
3:15), fhTriprev(moose2, 6, mc, 1:15, 3:15), fhTriprev(moose2, 7, mc,
1:15, 3:15))
f.fish <- rbind(f.gs, f.fr, f.sa)
f.fish1 <- subset(f.fish, i_resident == stateNow)
f.fish2 <- subset(f.fish, i_resident != stateNow)

# reduced trip cost
aggregate(f.fish$rpertripq,  list(f.fish$stateNow), mean)
aggregate(f.fish1$rpertripq, list(f.fish1$stateNow), mean)
aggregate(f.fish2$rpertripq, list(f.fish2$stateNow), mean)
aggregate(f.fish1$rpertriph, list(f.fish1$stateNow), mean)
aggregate(f.fish2$rpertriph, list(f.fish2$stateNow), mean)

# full trip cost
aggregate(f.fish$fpertripq,  list(f.fish$stateNow), mean)
aggregate(f.fish1$fpertripq, list(f.fish1$stateNow), mean)
aggregate(f.fish2$fpertripq, list(f.fish2$stateNow), mean)
aggregate(f.fish1$fpertriph, list(f.fish1$stateNow), mean)
aggregate(f.fish2$fpertriph, list(f.fish2$stateNow), mean)
dim(f.fish); dim(f.fish1); dim(f.fish2)

# State Means by Resident/Nonresidentfor Hunt/Price Variables
#    Organized in Excel, then CSV file (subprices2.csv)
# Reduced and Full costs, quarter and half of wage rate

subprices <-read.table("newsub.csv",
    header=TRUE, sep=',', stringsAsFactors=FALSE)
subprices <- within(data=subprices, i_resident <-
as.character(subprices$i_resident))
subprices$stateNow <- subprices$i_resident
subprices <- within(data=subprices, stateNow <-
as.character(subprices$stateNow))

# 5 _______ Subsetting, Merging for  Needed Variables ____________

# without multiple observations
bp <- merge(x=pool3, y=bird3, by=c('personid', 'i_resident'), all =
TRUE)
bp[is.na(bp)] <- 0
View(bp)
 head(bp); dim(pool3); dim(bird3); dim(bp)

# with multiple observations
poissonregre <- merge(x=pool3, y=total,
    by=c('personid', 'i_resident'), all = FALSE)
dim(pool3); dim(total); dim(poissonregre)
View(poissonregre)

# Match fish/hunt prices by stateNow
# If I_resident matches - resident price
# If I_resident does not match - nonresident price
# If not wildlife watcher, hunt/fish prices for state of residence

bp$huntpricedum[bp$i_resident==bp$stateNow] <- 1
```

```
bp$huntpricedum[bp$i_resident!=bp$stateNow] <- 0
bp$huntpricedum[bp$triptaker==0] <- 1

fb1 <- subset(bp, huntpricedum==1)
fb2 <- subset(bp, huntpricedum==0)

fb3 <- merge(x=fb1, y=subprices, by='i_resident');  dim(fb3)
fb4 <- merge(x=fb2, y=subprices, by='stateNow'); dim(fb4)

fb3$qhuntpricer <- fb3$hrrq; fb3$qhuntpricef <- fb3$hfrq
fb3$hhuntpricer <- fb3$hrrh; fb3$hhuntpricef <- fb3$hfrh

fb4$qhuntpricer <- fb4$hrnrq; fb4$qhuntpricef <- fb4$hfnrq
fb4$hhuntpricer <- fb4$hrnrh; fb4$hhuntpricef <- fb4$hfnrh

fb4$i_resident.y <- NULL; fb4$i_resident <- fb4$i_resident.x
fb4$i_resident.x <- NULL; fb3$stateNow.y <- NULL
fb3$stateNow <- fb3$stateNow.x; fb3$stateNow.x <- NULL

fb5 <- rbind(fb3, fb4)

bp$fishpricedum[bp$i_resident==bp$stateNow] <- 1
bp$fishpricedum[bp$i_resident!=bp$stateNow] <- 0
bp$fishpricedum[bp$triptaker==0] <- 1

fc1 <- subset(bp, fishpricedum==1)
fc2 <- subset(bp, fishpricedum==0)

fc3 <- merge(x=fc1, y=subprices, by='i_resident')
fc4 <- merge(x=fc2, y=subprices, by='stateNow')

fc3$qfishpricer <- fc3$frrq; fc3$qfishpricef <- fc3$ffrq
fc3$hfishpricer <- fc3$frrh; fc3$hfishpricef <- fc3$ffrh

fc4$qfishpricer <- fc4$frnrq; fc4$qfishpricef <- fc4$ffnrq
fc4$hfishpricer <- fc4$frnrh; fc4$hfishpricef <- fc4$ffnrh

fc4$i_resident.y <- NULL; fc4$i_resident <- fc4$i_resident.x
fc4$i_resident.x <- NULL; fc3$stateNow.y <- NULL
fc3$stateNow <- fc3$stateNow.x; fc3$stateNow.x <- NULL

fc5 <- rbind(fc3, fc4)
fc6 <- subset(fc5, , select=c(personid, qfishpricer, hfishpricer,
qfishpricef, hfishpricef))

part <- merge(x=fb5, y=fc6, by='personid')

part[is.na(part)] <- 0 # No hunting in DC

participation <- subset(part, , select=c(personid, age, agesq, sex2,
marital2, hincome2, school2, school3, scrace2, geur2, job2, everhunt2,
everfish2, qhuntpricer, qfishpricer, hhuntpricer, hfishpricer,
qhuntpricef, qfishpricef, hhuntpricef, hfishpricef, triptaker))
```

```
# Hunt/Fish prices only for hunters/fishermen
participation <- within(data=participation, qinthuntr <-
everhunt2*qhuntpricer)
participation <- within(data=participation, qintfishr <-
everfish2*qfishpricer)
participation <- within(data=participation, qinthuntf <-
everhunt2*qhuntpricef)
participation <- within(data=participation, qintfishf <-
everfish2*qfishpricef)

participation <- within(data=participation, hinthuntr <-
everhunt2*hhuntpricer)
participation <- within(data=participation, hintfishr <-
everfish2*hfishpricer)
participation <- within(data=participation, hinthuntf <-
everhunt2*hhuntpricef)
participation <- within(data=participation, hintfishf <-
everfish2*hfishpricef)

poissonregre$huntpricedum[poissonregre$i_resident==poissonregre$stateNo
w] <- 1
poissonregre$huntpricedum[poissonregre$i_resident!=poissonregre$stateNo
w] <- 0

zb1 <- subset(poissonregre, huntpricedum==1)
zb2 <- subset(poissonregre, huntpricedum==0)

zb3 <- merge(x=zb1, y=subprices, by='i_resident');  dim(zb3)
zb4 <- merge(x=zb2, y=subprices, by='stateNow'); dim(zb4)

zb3$qhuntpricer <- zb3$hrrq; zb3$qhuntpricef <- zb3$hfrq
zb3$hhuntpricer <- zb3$hrrh; zb3$hhuntpricef <- zb3$hfrh

zb4$qhuntpricer <- zb4$hrnrq; zb4$qhuntpricef <- zb4$hfnrq
zb4$hhuntpricer <- zb4$hrnrh; zb4$hhuntpricef <- zb4$hfnrh

zb4$i_resident.y <- NULL; zb4$i_resident <- zb4$i_resident.x
zb4$i_resident.x <- NULL; zb3$stateNow.y <- NULL
zb3$stateNow <- zb3$stateNow.x; zb3$stateNow.x <- NULL

zb5 <- rbind(zb3, zb4)

poissonregre$fishpricedum[poissonregre$i_resident==poissonregre$stateNo
w] <- 1
poissonregre$fishpricedum[poissonregre$i_resident!=poissonregre$stateNo
w] <- 0

zc1 <- subset(poissonregre, fishpricedum==1)
zc2 <- subset(poissonregre, fishpricedum==0)

zc3 <- merge(x=zc1, y=subprices, by='i_resident')
zc4 <- merge(x=zc2, y=subprices, by='stateNow')

zc3$qfishpricer <- zc3$frrq; zc3$qfishpricef <- zc3$ffrq
```

```
zc3$hfishpricer <- zc3$frrh; zc3$hfishpricef <- zc3$ffrh

zc4$qfishpricer <- zc4$frnrq; zc4$qfishpricef <- zc4$ffnrq
zc4$hfishpricer <- zc4$frnrh; zc4$hfishpricef <- zc4$ffnrh

zc4$i_resident.y <- NULL; zc4$i_resident <- zc4$i_resident.x
zc4$i_resident.x <- NULL; zc3$stateNow.y <- NULL
zc3$stateNow <- zc3$stateNow.x; zc3$stateNow.x <- NULL

zc5 <- rbind(zc3, zc4)

zc6 <- subset(zc5, , select=c(personid, qfishpricer, hfishpricer,
qfishpricef, hfishpricef))

dem <- cbind(zb5,zc6)

dem[is.na(dem)] <- 0

demand <- subset(dem, , select=c(personid, age, agesq, sex2,
marital2, hincome2, school2, school3, scrace2, geur2, job2, everhunt2,
everfish2, ntrip, qhuntpricer, qfishpricer, hhuntpricer, hfishpricer,
qhuntpricef, qfishpricef, hhuntpricef, hfishpricef, rpertripq,
fpertripq, rpertriph, fpertriph, stateTrip, triptaker))

# Remove top 5% of trip cost observations (Extreme values, coincides
with literature)

quantile(demand$rpertripq, probs = seq(0, 1, 0.05))
demand2 <- subset(demand, rpertripq<=456.0576923)
dim(demand2)

demand2 <- within(data=demand2, qinthuntr <- everhunt2*qhuntpricer)
demand2 <- within(data=demand2, qintfishr <- everfish2*qfishpricer)
demand2 <- within(data=demand2, qinthuntf <- everhunt2*qhuntpricef)
demand2 <- within(data=demand2, qintfishf <- everfish2*qfishpricef)

demand2 <- within(data=demand2, hinthuntr <- everhunt2*hhuntpricer)
demand2 <- within(data=demand2, hintfishr <- everfish2*hfishpricer)
demand2 <- within(data=demand2, hinthuntf <- everhunt2*hhuntpricef)
demand2 <- within(data=demand2, hintfishf <- everfish2*hfishpricef)


# 25% Sample

participation2 <- subset(participation, triptaker==0)
View(participation2)

set.seed(123); sam3 <- participation2[sample(1:nrow(participation2),
20800,replace=FALSE),]
set.seed(123); sam4 <- demand2[sample(1:nrow(demand2), 2311,
replace=FALSE),]

sam3$rpertripq <- NA; sam3$fpertripq <- NA; sam3$rpertriph <- NA
sam3$fpertriph <- NA; sam3$stateTrip <- NA; sam3$ntrip <- NA
```

```
bigtwosteppool <- rbind(sam3, sam4)                           #
Combine datasets
bigtwosteppool[is.na(bigtwosteppool)] <- 0

bigtwosteppool2 <- subset(bigtwosteppool, , select=c(age, agesq, sex2,
marital2, hincome2, school2, school3, scrace2, geur2, job2, everhunt2,
everfish2, qinthuntr, qintfishr, qinthuntf, qintfishf, hinthuntr,
hintfishr, hinthuntf, hintfishf, rpertripq, fpertripq, rpertriph,
fpertriph, triptaker, stateTrip))
dim(bigtwosteppool2)

# 3  __________Regressions_______________________________________

# Preliminary Regressions

binaryreg <- glm(triptaker ~ age + agesq + sex2 + marital2 + hincome2 +
school2 + school3 + scrace2 + geur2 + job2 + everhunt2 + everfish2,
data=participation,family=binomial(logit))

poissonreg <- glm(stateTrip ~ age + agesq + sex2 + marital2 + hincome2
+ school2 + school3 + scrace2 + geur2 + job2 + everhunt2 + everfish2 +
rpertrip, data=demand, family = poisson)

poissonreg2 <- glm(stateTrip ~ age + agesq + sex2 + marital2 + hincome2
+ school2 + school3 + scrace2 + geur2 + job2 + everhunt2 + everfish2 +
rpertrip, data=demand2, family = poisson)

summary(binaryreg)
summary(poissonreg)
summary(poissonreg2)

# 5 _____________Export Results______________________________________

# CSV for LIMDEP  (25% Sample)
wdata2 <- bigtwosteppool2
write.table(wdata2, file="revbig2.csv", sep=",", row.names=F,
col.names=F)


# Summary Statistics
wdata3 <- summary(bigtwosteppool)
write.table(wdata3, file="revsum1.csv", sep=",", row.names=T,
col.names=T)

wdata4 <- summary(sam4)
write.table(wdata4, file="revsum2.csv", sep=",", row.names=T,
col.names=T)
```

APPENDIX B

LIMDEP PROGRAM CODES FOR CHAPTER III

```
RESET
READ  ;NAMES=age, agesq, sex, marital, hincome,
             school, school2, scrace, geur, job, everhunt,
            everfish, qinthr, qintfr, qinthf, qintff,
            hinthr, hintfr, hinthf, hintff, rtripq,
            ftripq, rtriph, ftriph, triptaker, statetrips
      ;NVAR=26;NOBS=23111;FILE="C:\Documents and
Settings\jmingie\Desktop\revbig.csv";
 $


NAMES;
L=age,agesq,sex,marital,hincome,school,school2,scrace,geur,job,everhunt
,everfish$

DSTAT;Rhs=L;output=2 $


_________FIML SAMPLE SELECTION REGRESSIONS___________________________

NAMES; V=one,age,agesq,hincome,school,scrace,geur,everhunt,everfish$
NAMES; U=one,age,agesq,hincome,scrace,geur,everhunt,everfish$


________________Quarter REDUCED______________________________________

Probit  ;Lhs=triptake ;Rhs=V,qinthr,qintfr;Hold$
NegBin ;Lhs=statetri ;Rhs=U,qinthr,qintfr,rtripq;Selection
      ;MLE
$

________________Quarter FULL_________________________________________
Probit  ;Lhs=triptake ;Rhs=V,qinthf,qintff;Hold$
NegBin ;Lhs=statetri ;Rhs=U,qinthf,qintff,ftripq;Selection
      ;MLE
$

________________Half REDUCED_________________________________________
Probit  ;Lhs=triptake ;Rhs=V,hinthr,hintfr;Hold$
NegBin ;Lhs=statetri ;Rhs=U,hinthr,hintfr,rtriph;Selection
      ;MLE
$

________________Half FULL____________________________________________
Probit  ;Lhs=triptake ;Rhs=V,hinthf,hintff;Hold$
NegBin ;Lhs=statetri ;Rhs=U,hinthf,hintff,ftriph;Selection
      ;MLE
$
```