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TRAVEL COST MODELS OF DEER HUNTING IN MICHIGAN

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TRAVEL COST MODELS OF DEER HUNTING IN MICHIGAN

By

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ABSTRACT

TRAVEL COST MODELS OF DEER HUNTING IN MICHIGAN

By

Scott Daniel Knoche

Hunting white-tailed deer is an important recreational activity in Michigan. It has been estimated that 740,500 deer hunters spent 10,449,000 days deer hunting, harvesting approximately 476,200 white-tailed deer in Michigan during the 2002 deer hunting seasons. Deer hunters derive utility from the hunting experience while also providing population management services that benefit other stakeholders. Identifying the hunting site attributes that influence the site choices of deer hunters will provide managers with a more thorough understanding of the impacts of quality changes at hunting locations. The random utility travel cost method was used for modeling choice of hunting regions and estimating economic benefits to hunters. Data used for model estimation were collected in a 2003 survey of a random sample of licensed deer hunters in Michigan (response rate = 67%, N=1955). Models for two separate hunting seasons (bow and firearm) were estimated, with results showing that for both models the estimated parameters on each of the four measures of publicly accessible hunting land within a region are highly significant ($p<0.0001$) and positive, indicating that increases in publicly accessible hunting land within a region result in more trips to that region. The findings suggest that the total economic benefits provided to hunters by publicly accessible hunting land are about $85,000,000 per year.

To my mother and father

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CHAPTER 1

INTRODUCTION

White-tailed deer (Odocoileus Virginianus) in the State of Michigan are managed by the Michigan Department of Natural Resources (MDNR). Official deer management in the State of Michigan began in 1859 with the elimination of year-round market hunting. Numerous states experienced severe population declines during the late 19^{th} and early 20^{th} centuries, with the white-tail deer threatened with extirpation from Maryland (Curtis and Lynch, 2001) and New York (Decker and Connelly, 1989) during the late 19^{th} and early 20^{th} centuries, which resulted in strict regulations placed on deer hunting due to population declines. Such was the case in many states throughout the Northeast and Upper Midwest, and in Michigan the population estimate in 1914 was 45,000 animals (MDNR, 5.18.2005). Strict regulations were placed on deer hunting as a result of these population declines, marking a departure from the previous view that wildlife were an inexhaustible resource and ushering forth an era in which deer would be managed as a renewable resource. Over the next 100 years the deer population and wildlife specialists faced unique challenges as the characteristics of Michigan's deer population changed markedly. The deer population increased in the 1930's and 1940's due to the implementation of effective population management techniques, with a population decrease observed in the 1950's, 60's and 70's, as logged lands and edge habitat were being replaced by mature stands of timber (MDNR, 5.18.2005). The deer population rebounded to an estimated 2,000,000 by 1989.

In the 21st century, hunting white-tailed deer continues to be an important recreational activity in Michigan. An estimated 740,500 hunters spent 10,449,400 days hunting during the 2002 hunting seasons, harvesting 476,200 white-tailed deer during the 2002 hunting seasons (Frawley, 2003). While the proportion of Michigan residents purchasing a general hunting license declined from 10.1% in the mid 1960's to 8.7% during 2000-2002, the proportion of Michigan residents purchasing a deer hunting license steadily increased in all regions of Michigan (Frawley, 2004). During that time period, the number of deer hunters in Michigan increased 64%, from 481,000 to 788,000, while the deer population in Michigan has increased 157%, from approximately 700,000 to an estimated 1,800,000 (Frawley, 2004). This large increase in the deer population relative to gains in hunter recruitment increases the challenge for wildlife officials to effectively manage the deer population. Currently, the 2005 estimated deer population is within the Upper and Northern Lower Peninsula MDNR draft goals for 2006-2010. However, the estimated 2005 Southern Lower Peninsula deer population is 50% greater than the draft goals for the same time period.

STAKEHOLDERS

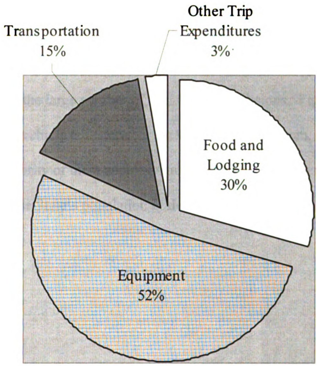
Effective management of the deer population in Michigan requires an awareness of the interests of the various stakeholder groups in Michigan, as well as an understanding of how various management strategies and proposed changes in policies affect the welfare of these groups. License sales to hunters are also a main source of revenue that supports the DNR Fisheries and Wildlife programs (MDNR website, 1.13.2005). As a result, wildlife managers are concerned with the development and implementation of regulations and policy goals that are sensitive to the needs of deer hunters. The deer population level desired by deer hunters, however, often conflicts with the needs of motorists and farmers. Yet to address abundant deer numbers, the Michigan DNR relies on hunter harvest as a management tool. The following paragraphs outline the main stakeholder groups who are affected by the deer population in Michigan.

Deer Hunters

Hunters appear to have an array of values, motivations and behaviors that guide the hunting experience. Results from the 2003 Michigan Deer Hunter Opinion Survey (Bull et al., 2006) show that hunters place a high level of importance on deer hunting as a recreational activity. According to survey results, approximately one quarter of Michigan's resident deer hunting population rated deer hunting as their most important recreational activity (Bull et al. 2006). Almost 85 % of respondents ranked deer hunting as either their most important or one of their more important recreational activities, while only 3% ranked deer hunting as less important than other activities.

Deer hunting is an important economic activity throughout the United States and in the state of Michigan. The Michigan portion of the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (USDOI, 2002) does not provide the dollar amount of expenditures for deer hunting, however, the survey report lists the hunter expenditures for big game hunting. As the number of bear hunting licenses purchased in 2002 was 9,107 and the number of elk hunting licenses purchased was 142 (Frawley, 2004), which combined is just over 1% of the number of deer licenses purchased, it is reasonable to say that the vast majority of big game expenditures were incurred by deer hunters. Big game hunters spent approximately $265 million on trip and equipment expenditures in 2001(USDOI, 2002). Figure 2 below illustrates the breakdown of big game hunting expenditures.

Figure 1. 2001 Big Game Hunting Expenditures in Michigan by U.S. Residents

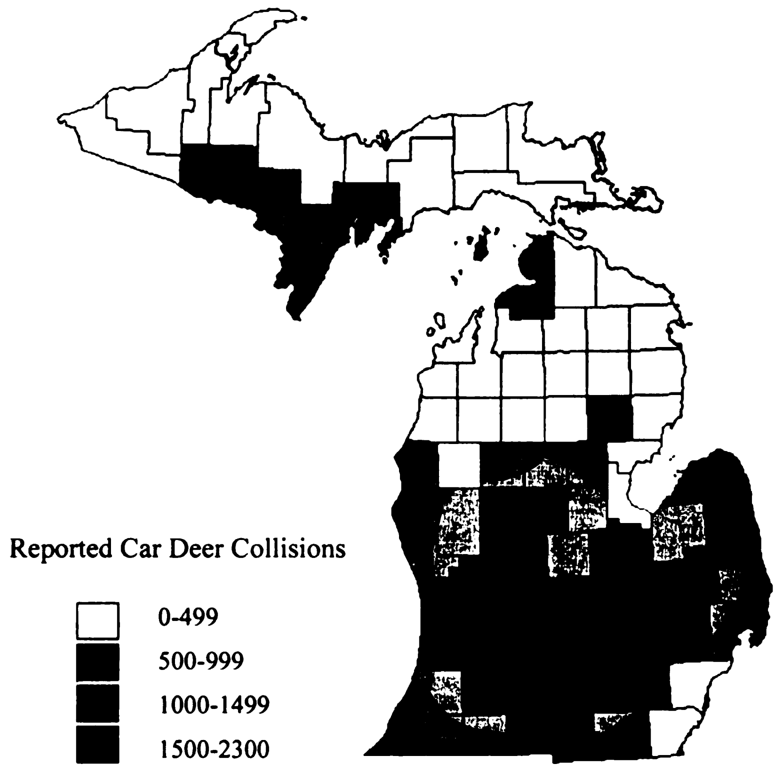


Equipment is the largest hunter expenditure as shown in Figure 1, accounting for over half of the big game hunting expenditures in the State of Michigan in 2001. Equipment expenditures consisted of hunting equipment such as guns and firearms, bows and arrows, ammunition, as well as auxiliary equipment, which includes camping equipment, hunting clothing such as camouflage, and binoculars. By aggregating "Food and Lodging", Transportation" and "Other Trip Expenditures" together to create a broader "Trip Expenditures" category, we see that the level of expenditures on equipment and costs associated with a deer hunting trip were similar.

Motorists

There are significant economic impacts resulting from a deer population that is large enough to support and reward the hunting and viewing efforts of hundreds of thousands of hunters and wildlife enthusiasts. A primary negative impact of the deer herd in Michigan is the large number of deer-vehicle collisions. Figure 2 presents the distribution of deer-vehicle collisions for each county in Michigan. From Figure 2, one can see that the majority of these accidents take place in the Southern Lower Peninsula, which has 50% of the State's population of deer and 80% of the State's human population.

Figure 2. Reported Deer-Automobile Collisions by County



Source: 2002 Michigan Traffic Crash Facts

In 2002, there were 63,016 deer-vehicle collisions, which resulted in 2,220 injuries and five deaths (University of Michigan Transportation Research Institute, 2003). The average damage to a vehicle was $2000 (Danielson and Hubbard, 1998), resulting in approximately $126 million in vehicle damages during 2002. With the 2004 Value of a Statistical Life calculated at $3,000,000 by the U.S. Department of Transportation, and economic costs of minor and major injuries ranging from $33,000 to $170,000 (ODPS, 1997), respectively, it is apparent that the annual economic costs of deer-vehicle collisions approach $200 million.

Farmers, Foresters, and Landowners

Deer browse results in damages to agricultural crops, commercial and public forests, and homeowners' gardens and ornamental plantings. The damage is difficult to accurately estimate, partly because of potentially high measurement costs, and also because those experiencing property damage may lack incentives to report damages accurately. Nevertheless, 67% of farmers nationally have reported problems with deer (Conover, 1994), with damage to crops nationwide estimated at $100 million annually (Conover, 1997). However, other researchers have estimated that the annual damage of crop depredation by deer solely in Pennsylvania may be as much as $52.7 million (Ritz and Ready, 2001).

Deer browse results in economic losses for foresters, and deer overabundance can negatively affect the ecological health and plant and animal diversity of their habitat. Even relatively sparse populations of deer (4 deer/km or less) can inhibit or prevent the regeneration of particular woody plant species (Alverson et al., 1998). Conover (1997) estimated nationwide economic costs of deer incurred by timber harvesters at $750,000,000.

The prolific nature of deer can also cause problems for homeowners. An estimated 4% of households experienced deer damage to gardens of ornamental plants according to a survey by Conover (1997), and he provides an estimate of $251 million in damages throughout the U.S. Combating the damage caused by deer in areas of dense human population is difficult, as many cities and townships have ordinances that prohibit discharging a firearm within their boundaries. Complicating measures further is that many residents of urban and suburban areas prefer non-lethal solutions to deer problems, such as immunocontraception and live trapping, which are more expensive and less efficient population control methods when compared to hunting or sharp shooting (Messmer et al., 1997).

HUNTING ACCESS IN MICHIGAN

Deer hunters not only derive utility and personal satisfaction from the hunting experience, but they also provide valuable services to other stakeholders. Motorists experience a reduced number of deer-vehicle collisions as a result of deer harvests, and property owners also realize less deer browse damage than would be experienced without the services provided by deer hunters. While the management strategy regarding white-tailed deer has typically been one of protection and distribution of a scarce resource (Riley et al., 2003), predict and advocate for a new paradigm of managing the impacts of deer. In order for these impacts to be managed effectively it is necessary that deer hunters have access to hunting areas. The Association of Fisheries and Wildlife Agencies assists in generating benefits for all stakeholders through the provision of support and funding to develop and advance programs that seek to create, improve or facilitate access for hunters (AFWA, 2006). Publicly accessible hunting land has the potential to contribute to the welfare of the deer hunter by providing the individual with places to hunt, while also providing deer herd management services that benefit other stakeholders.

The state of Michigan has a diversity of hunting opportunities on both public and private land. Approximately 80% of deer hunters hunted on privately owned lands at least once in 2002, while 40% of hunters pursued deer on public lands or in publicly accessible commercial forest (Bull et al., 2006). Michigan deer hunters are able to choose from a variety of publicly accessible hunting areas that provide individuals with access to deer habitat, including National Forests, State Forests, and County-owned or managed recreation areas. The State of Michigan provides individuals with access to hunting land through the Commercial Forest Act and the Hunter Access Program. Below I will describe the characteristics of publicly accessible hunting lands in Michigan.

National Forests:

There are four National Forests in Michigan which contain approximately 2.9 million acres of land. The Ottawa National Forest in the Western Upper Peninsula accounts for nearly 1 million of these acres. The 879,000 acre Hiawatha National Forest is split into two sections, with one section in the central portion of the Upper Peninsula and the other portion occupying the eastern portion of the Upper Peninsula. The Huron-Manistee National Forests occupy nearly 1 million acres of land in the Northern Lower Peninsula. The National Forests largely provide access free of charge, while some high-impact areas charge a nominal fee for access.

State Forests:

There are numerous State Forests in Michigan that provide a total of 3.8 million acres of publicly accessible land. Michigan's Northern Lower Peninsula contains approximately 2 million acres of State Forest land, while just over 1.5 million acres are in the Upper Peninsula. State Forests are part of Michigan's State Park system, which charges $6 for a daily resident motor vehicle permit or $24 for an annual pass.

County-Owned or Managed Parks and Recreation Areas:

There are numerous county-owned and managed parks and recreation areas that provide public access for deer hunters. Unlike the National and State Forest lands, which are located almost exclusively within the Upper Peninsula and the Northern Lower Peninsula, many of the county parks and recreation areas are located in the Southern Lower Peninsula, where publicly accessible hunting areas are scarce. These parks and recreation areas generally require the purchase of a state motor vehicle permit for entrance.

Commercial Forest Act Land:

Hunters and anglers have access to privately held forest lands that are receiving tax breaks under the Commercial Forest Act (CFA) of 1994. For CFA lands, property tax rates are reduced to $1.10/acre if the forest land is kept in long-term timber production. Participation in the program requires that lands also be open to sportspersons. The State of Michigan pays the county in which the Commercial Forest Act land is located $1.20 per acre. There is approximately 2.2 million acres of publicly accessible CFA land open to hunters and anglers through the Commercial Forest Act of 1994. The vast majority of this land is located in the Upper Peninsula, with only 5,000 acres located in the Southern Lower Peninsula.

Hunter Access Program:

The State of Michigan leases land from landowners (primarily farmers) through the Hunter Access Program in an effort to provide hunters publicly accessible hunting lands in the Southern Lower Peninsula. The program has experienced declining enrollment for some time, and in 2002 there were slightly less than 20,000 acres enrolled (Oliver, 2005). The lease rates paid to each landowner varies and depends on the quantity and quality of habitat. Total lease fees paid to landowners in 2002 was $107,000, an average of just over $5 an acre.

Goal

The primary goals of this paper are to identify the attributes of hunting sites that influence the site choice of deer hunters, as well as to provide wildlife managers with economic values associated with these attributes. A special focus is placed on publicly accessible hunting lands in the analysis due to the potential for access to increase hunter welfare while managing the impacts of the deer herd. Explicit research objectives are listed at the end of Chapter 2.

CHAPTER 2

NON-MARKET VALUATION

Information on the retail transactions and other direct expenditures of deer hunters is regularly collected by some agencies. The U.S. Fish and Wildlife Service administers an extensive survey every five years, the "National Survey of Fishing, Hunting, and Wildlife-Associated Recreation" (USFWS, 2002), which documents trip and equipment expenditures for the various types of hunting in the United States. This survey also examines the hunting trips and expenditures on a state-by-state basis. While this information is useful for understanding the economic impacts of hunting, it does not address issues related to hunter demand for hunting sites and the economic benefits associated with hunting.

Various types of non-market valuation techniques have been used to estimate the economic value of the big game hunting experience in North America. The following paragraphs define and provide a conceptual framework for non-market valuation, followed by a review of non-market valuation literature on big game hunting in North America. Special emphasis is placed on studies that focus on deer hunting in the United States.

Non-market goods differ from market goods in that non-market goods are not traded between parties in a market. Also differentiating the two is that non-market goods can change as a result of society's choices, and the nature of non-market goods often means that individuals may not unilaterally select the level of the good they will consume (Parsons, 2003). Thus, non-market valuation estimates the value individuals place on a level or quality of good that does not vary across an individual's choice set, but is chosen by society as a whole. For example, market goods such as candy bars, bicycles, or automobiles can be purchased up to the individual's budget constraint. Quality attributes of hunting sites, however, are examples of non-market goods, as an individual can not personally choose the number of deer, the amount of public access, or the level and quality of other attributes of the hunting site. Whether the good in question is a market good or a non-market good, people have a preference for the bundle of goods that provides the highest level of utility. An economically efficient society will choose the level of the non-market good that will maximize the welfare of the population.

There are two primary methods of non-market valuation; the revealed preference method and stated preference method. The revealed preference method uses the observed behavior of individuals to estimate the value of a non-market good. The travel cost approach to non-market valuation is a type of revealed preference method that examines the trip expenditures incurred through visiting a particular recreational site, as in the single site travel cost model, or examines the tradeoffs individuals make between the cost of traveling to the location and the quality of attributes at the particular site, as in the random utility travel cost model. For example, by examining the tradeoffs an individual makes between trip cost and the population of deer, the value of changes in the population of deer at a site (or sites) can be estimated. An additional type of revealed preference method is the hedonic method, which is used to estimate the value of a non-market good through observation of the differences in market prices of similar or identical goods that differ only in the level or quality of the non-market good present. For example, the value beachfront homeowners place on clean ocean water can be estimated through observing the differences in the market prices of beach front houses with access to non-polluted water and comparing those prices to similar houses that have access to polluted water. Similarly, the value of hunting site attributes can be estimated through observing the differences in value of nearly identical land holdings, differing only in that one site has a greater level of a particular site attribute than another site.

The stated preference method of non-market valuation, instead of utilizing the observed behavior of individuals, uses survey instruments to obtain information about individuals' preferences, intended behaviors, or values in relation to a particular level or quality of resource. One type of stated preference method is the contingent valuation approach to non-market valuation. This approach utilizes a scientific survey to estimate the value that individuals place on a particular non-market good. For example, a researcher desiring to estimate the value of larger antler size on deer might utilize an open-ended approach, asking individuals to state maximum amount they would pay to harvest an eight-point buck instead of a four-point buck. A dichotomous choice contingent valuation approach would ask individuals whether they would pay $X to harvest a deer with a bigger rack, whereas a third approach would provide numerous dollar amounts, with the individual instructed to select the highest dollar amount they would pay to harvest a deer with larger antlers. Stated preference methods such as the various types of contingent valuation are somewhat controversial as transactions are not explicitly witnessed in the marketplace, which may lead to "hypothetical bias" in which individuals respond with a higher willingness to pay than they would if an actual cash payment was required. In response to this and other criticisms, the National Oceanic and Atmospheric Administration (NOAA) convened a panel of experts to address the capability of contingent valuation in providing estimates to be used in natural resource damage assessments (Portney, 1994). The contingent valuation method now sees fairly broad acceptance and application, with the approach being used around the world by government agencies and the World Bank for assessing a variety of investments (Hanemann, 1994).

LITERATURE REVIEW

The literature review below consists of non-market valuation studies that estimate the value of various aspects of the big game hunting experience in North America. This list of non-market valuation studies is not intended to be exhaustive, but to identify major travel cost, hedonic, and contingent valuation studies of elk, moose and deer hunting.

Hedonic Valuation

There are a limited number of studies that use the hedonic method to value aspects of the hunting experience. In one study that measures the effects of ranchland attributes on the lease value of hunting land in Florida, it is estimated that ranchers maintaining 22% trees and cover on their ranchland receive an additional $16.15 per-acre per-year for hunting leases (Alavalapati and Shrestha , 2004). The effect of private hunting land attributes on the value of deer hunting leases was also examined in Louisiana. Contrary to the results of the research in Florida, this analysis indicates that services and amenities provided by landowners do not have a significant effect on the value of a deer hunting lease (Messonier and Luzar, 1990). Another hedonic study estimates the value of white-tailed deer from markets for hunting leases in Texas. The study showed that lease hunters were willing to pay $25 to be assured of harvesting one deer and an additional $13 to harvest another deer (Livengood, 1983). Henderson and Moore (2005) review other studies that document the effects of deer and deer densities on lease values and on land values more generally.

Contingent Valuation

There are several studies that have estimated the value of big game hunting by using the contingent valuation method, with California being the site of numerous contingent valuation studies examining the benefits of deer hunting. One study of deer hunters in California estimated the welfare generated through an additional harvested deer to be $222 (Gonzalez-Cabin et al., 2003). Loomis et al. (1989) used the dichotomous choice contingent valuation method, estimating deer hunter willingness to pay per hunting trip to be $191.45. A hunting trip could be one day or many weeks, and as such one trip was not defined by a specific amount of time but rather the act of departing from one's primary residence for the purposes of hunting and returning to the primary residence after the hunting experience. A contingent valuation study by Cooper and Loomis (1992) of deer hunting in California deer estimated hunter welfare measures resulting from different management actions. It was estimated that hunters were willing to pay $164 to harvest an additional deer. The study also estimated the value of doubling the chances of harvesting a 4 point buck to be $267 per hunter, and the value of doubling the length of the hunting season to be $234 per hunter. Consistent with declining marginal utility concepts in economics theory, the study finds that the per-day value of the additional days of hunting ($21) is less than the value of the days of the current hunting season ($69).

Two additional contingent valuation studies estimate the consumer surplus measures of deer hunting in Southwest Manitoba and the mean willingness to pay for elk hunting in Colorado. The study in Manitoba estimated the aggregate consumer surplus from deer hunting in Southwest Manitoba to be between C$100,700 and C$142,000 (Capel and Pandey, 1973). Per-hunter welfare measures are not provided by the researchers in this study. For elk hunting in Colorado, the dichotomous choice contingent valuation method was used to query elk hunters regarding whether they would continue to purchase a license if the price was increased by $X. The mean willingness to pay above the current license fee was $164, with a 95% confidence ratio of $149-$179 (Fried et al., 1995).

The final two contingent valuation studies focused on a deer hunters' willingness to pay for access to private hunting land. Hussain et al. (2004) used a dichotomous choice contingent valuation survey, estimating willingness to pay for hunting leases of $1.29 per acre. An open-ended contingent valuation survey was used by Goodwin et al. (1993) to estimate the value of access to privately owned land in Kansas. The study found that 38.6% of individuals were willing to pay for access to private land, with an average bid of $81.23 to hunt at the most preferred private hunting site, from individuals with a positive willingness to pay.

Travel Cost Valuation

There have been a number of travel cost valuation studies that have estimated hunter welfare measures and the values associated with hunting regulation changes. There are two basic types of travel cost models that can be used to compute welfare measures and other economic values. The single site travel cost model does not take into consideration substitute sites, but computes welfare measures by examining how trips to a site change as a function of trip cost. The random utility travel cost model, on the other hand, estimates hunter welfare measures and the value of site attributes through an examination of individual site selection among a set of substitute sites, which is a function of trip cost and the level and quality of the attributes of various sites.

The majority of travel cost studies of big game hunting have used the single site model. Balkan and Kahn (1988) used a single site travel cost approach to estimate seasonal consumer surplus and welfare measures that resulted from changes in deer hunting quality. Consumer surplus is calculated to be $1063 for the deer hunting season using the Ordinary Least Squares (OLS) method. The change in consumer surplus is calculated assuming 10% and 50% increases in the average per-hunter harvest rate, as well as a 10% change in the deer population. Harvest rate increases of 10% and 50% yielded increases of consumer surplus of $48 and $242, respectively. In contrast, a 10% increase in the deer population yielded a consumer surplus increase of $10. Another single site travel cost study examined the economic impact of deer hunting on public land in Louisiana (Luzar et al., 1992). Per-trip consumer surplus measures in this study were calculated by using two different demand cut-off points, 198 miles and 480 miles, which yielded per-trip consumer surplus measures of $24.70 and $59.52, respectively. The demand for hunting trips in Kansas is examined by Offenbach and Goodwin (1994), utilizing a multiple site travel cost analysis. This study estimated per-trip consumer surplus measures to be between $160.79 and $176.55.

There have been several travel cost valuation studies in Canada that have estimated economic values associated with deer, elk, moose, and antelope hunting. Capel and Pandey (1972) estimated the total benefits from deer hunting in Manitoba to be between C$9.31 and C$11.50 a day, and the value of moose hunting in Manitoba as between C$7.04 and C$8.71. The economic value of moose hunting in Canada is also examined by Sarker and Surry (1998), who estimated the value of a moose hunting trip in Ontario to be between C$175 and $C210. Finally, a random utility travel cost model is used to estimate the value of different aspects of antelope hunting. Boxall (1994) estimated the economic value of obtaining a permit to hunt antelope to be between C$29.56 and C$64.06. As discussed earlier, the random utility model structure allows the researcher to examine the economic impact of site quality changes. A 25 % reduction in the amount of publicly accessible hunting land per hunting site resulted in a C$50,100 decrease in hunter welfare, whereas a 25% increase in the hunter density at each particular site resulted in a C$26,300 decrease in hunter welfare.

A prime example of a random utility travel cost model examining the tradeoffs individuals make between trip cost and the quality of site attributes is a study by Schwabe et al. (2001) that examined the values of changes in deer season length with the application of the nested multinomial logit model. Unlike the multiple site travel cost model of hunting trips in Kansas discussed previously, this model explicitly defined the attributes of 23 hunting sites. The mean per-hunter compensating variation was calculated in three separate fashions, as the authors of the study assumed in two of the cases that a one day increase of the deer hunting season would have to correspond with a one day decrease of the hunting season for other species. The mean per-hunter compensating variation can be interpreted as the willingness-to-pay per-hunter for one extra day to hunt deer, while in two of the cases the one day increase of the deer season was assumed to result in a corresponding one day decrease in hunting seasons for other species. A one day increase in the deer hunting season, with no corresponding decrease in other season lengths, resulted in a mean per-hunter compensating variation of $3.41. When the lengthening of the deer hunting season was combined with a corresponding decrease in another hunting season, the mean compensating variation decreased to $2.92 with the reduction of one day from a 10/19-12/1 hunting season, and to $3.36 with a one-day reduction of a 12/15-12/31 hunting season. The two reduced hunting seasons were quite similar, allowing the taking of squirrel, dove, grouse, waterfowl, pheasant, quail, fox, raccoon, opossum, and deer (archery). The primary difference is that turkey hunting was permitted only during the 10/19-12/1 season, and deer hunting with a primitive weapon was allowed only during the 12/15-12/31 hunting season. This appears to be the only travel cost model of deer hunting in the peer-reviewed literature that relies on contemporary multiple site travel cost approaches such as the random utility model.

Table 1 displays the non-market values of the big game hunting experience that are discussed in the previous paragraphs. The table is organized first by the type of non-market valuation study, and then chronologically by the date of journal publication. Welfare measures calculated using the Canadian Dollar are identified with "C$".

Table 1. Non-Market Valuation Studies of Deer, Elk, Moose and Antelope Hunting

Author(s) and Date of Publication	Economic Value or Welfare Impact Estimated	Dollar Value (C$= Canadian)
Hedonic Valuation Method		
Shrestha and Alavalapati, 2004	Value of maintaining 22% cover on ranchland	$16.15
Messonier and Luzar, 1990	Additional value of hunting lease due to land attributes	No value
Livengood, 1983	Value of being assured the harvest of one deer	$25
	Value of the harvest of a second deer	$13
Contingent Valuation Method		
Hussain et al., 2004	Willingness to pay per-acre for hunting leases in Alabama	$1.29
Gonzalez-Caban et al., 2003	Mean willingness-to-pay to harvest another deer in California	$222
Fried et al., 1995	Mean willingness-to-pay for elk license in Colorado	$164
Goodwin et al., 1993	Percentage of individuals willing to pay for private hunting access in Kansas	38.6%
	Willingness-to-pay per acre for hunting access in Kansas, provided individual is willing to pay for access to private lands	$81.23
Cooper and Loomis, 1992	Mean willingness-to-pay to harvest another deer in California	$164
	Value of doubling the chances of harvesting a four-point buck	$267
	Value of doubling the length of the hunting season	$234
Loomis et al., 1989	Hunter willingness to pay per hunting trip	$191.45
Capel and Pandey, 1973	Aggregate consumer surplus from deer hunting in a region of Southwest Manitoba	C$100,700-C$142,000

Table 1 (Cont). Non-Market Valuation Studies of Deer, Elk, Moose and Antelope Hunting

Author(s) and Date of Publication	**Economic Value or Welfare Impact Estimated**	**Dollar Value (C$= Canadian)**
	Travel Cost Valuation Method	
Gonzalez-Caban et al., 2003	Mean willingness-to-pay to harvest another deer	$257
Schwabe et al., 2001	Consumer surplus for one-day increase in hunting season in Ohio	$3.41
Boxall, 1994	Economic value of obtaining a permit to hunt antelope in Alberta, Canada	C$29.56-$64.06
	Welfare increase with a 25% increase in access	C$50,100
	Welfare decrease with a 25% increase in hunter density	C$26,300
Offenbach and Goodwin, 1994	Per-trip consumer surplus for deer hunting in Kansas	$160.79-$176.55
Luzar et al., 1992	Per-trip consumer surplus for deer hunting in Louisiana	$24.70-59.52
Balkan and Kahn, 1988	Average per-hunter consumer surplus for deer hunting in New York	$1063
	Change in per-hunter consumer surplus with a 10% increase in per hunter harvest rate	$48
	Change in per-hunter consumer surplus with a 50% increase in per hunter harvest rate	$242
	Change in per-hunter consumer surplus with a 10% increase in deer population	$10
Donnelly and Nelson, 1988	Per-trip consumer surplus for deer hunting in Idaho	$43.74
Capel and Pandey, 1973	Estimated total per-day benefits from deer hunting in Manitoba	C$9.31-C$11.50
Capel and Pandey, 1972	Estimated total per-day benefits from moose hunting in Manitoba	C$7.04-C$11.50

RESEARCH OBJECTIVES

For this project, I will be utilizing the random utility travel cost model to estimate the economic values associated with deer hunting in Michigan. The research objectives are listed below.

1) Develop a travel cost model of hunting site choices that is capable of identifying hunting site attributes that influence the site choice of Michigan deer hunters.

Identifying the statistical significance of site attribute variables in influencing deer hunter site selection is an important first step in estimating the welfare impact of quality changes at hunting sites. Wildlife managers would also benefit from a thorough understanding of the hunting site attributes that drive the site selection process. For any travel cost model, it is expected that the cost of a trip to a hunting site has a significant influence on a hunter's decision to make a trip to that site. Economic theory states that as the price of a good increases, the quantity of the good decreases. Thus, it is expected that a significant and negative correlation exists between the cost of traveling to a hunting site and the number of trips taken to the site. Likewise, deer density and the amount of publicly accessible hunting land at a hunting site is expected to be positively correlated with the number of trips to a site.

2) Calculate the marginal implicit values for relevant hunting site variables.

Wildlife managers will also benefit from the estimates of the marginal implicit values of hunting site attribute variables. The marginal implicit value estimates the per-hunter welfare impact from a change in the level of the site attribute value at each of the hunting sites. For example, the marginal implicit value of a deer population variable would indicate the per-trip hunter welfare impact of an equal increase in deer population across all hunting sites. Marginal implicit values will not be calculated for variables which could not be feasibly adjusted, such as the square miles of the hunting site or the number of people living in a hunting region.

3) Estimate the probability each hunting site will be selected for a given choice occasion and estimate the number of hunters who will visit the hunting site.

Identifying hunting sites that receive the highest number of hunter visits will provide wildlife managers with a more thorough understanding of the mobility of deer hunters, and also allow managers to allocate resources to the most heavily used locations. The random utility model can also be used to calculate the predicted changes in visits to hunting sites that would be expected to result from changes in the characteristics of hunting sites.

4) Estimate the benefits to deer hunters of access to public lands in Michigan.

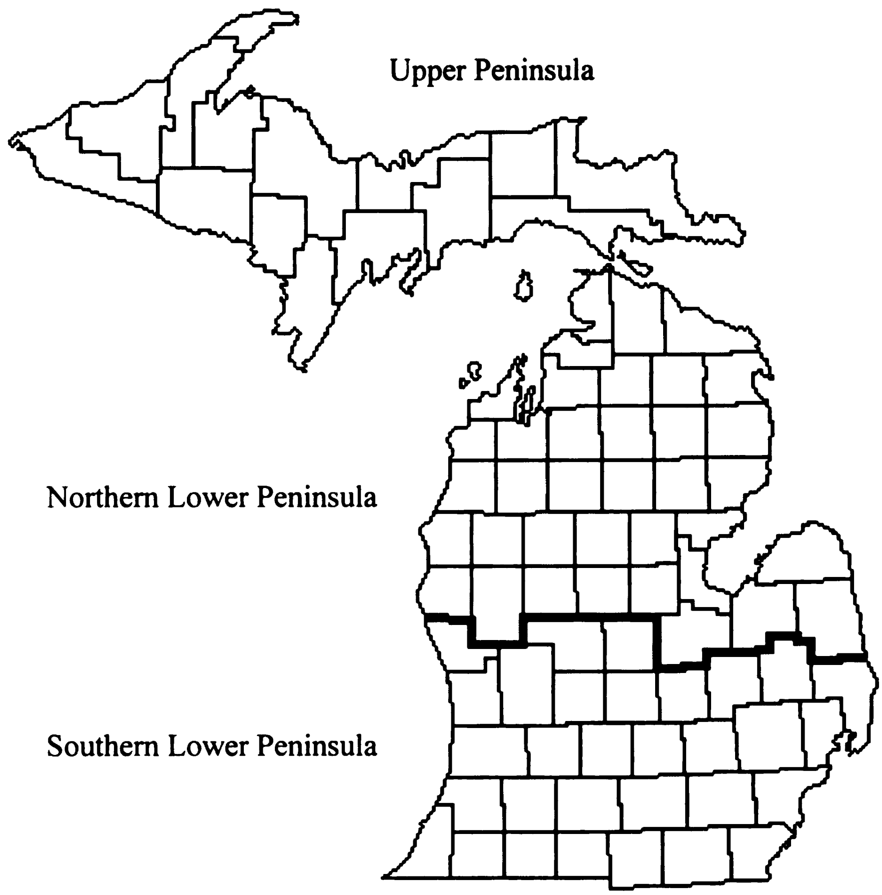
Michigan's National Forests, State Forests, County owned land and Commercial Forest Act Land also provide access for deer hunters. Per-trip and seasonal hunter welfare measures will be estimated for each type of publicly accessible land for purposes of comparison. Additionally, the total benefits realized by hunters through the provision of all publicly accessible hunting land will be estimated.

CHAPTER 3

SURVEY METHODS/IMPLEMENTATION

The random utility travel cost model developed within this thesis relied on behavioral data from a mail survey of Michigan deer hunters (Bull et al., 2006). The survey sample was drawn from a random sample of 15,000 individuals eighteen years of age as of 1/15/2002, who had purchased a deer-hunting license in 2002. The names and addresses of these individuals were provided by the Michigan Department of Natural Resources. From these 15,000 individuals, a stratified random sample of 2999 individuals was drawn consisting of randomly selected individuals from each of the following regions: the Upper, Northern Lower, and Southern Lower Peninsulas of Michigan. The survey regions are illustrated in Figure 3. The northern boundaries of Muskegon, Kent, Montcalm, Gratiot, Shiawassee, Genesee, Lapeer, and St. Clair form the dividing line between the Southern Lower and Northern Lower Peninsula.

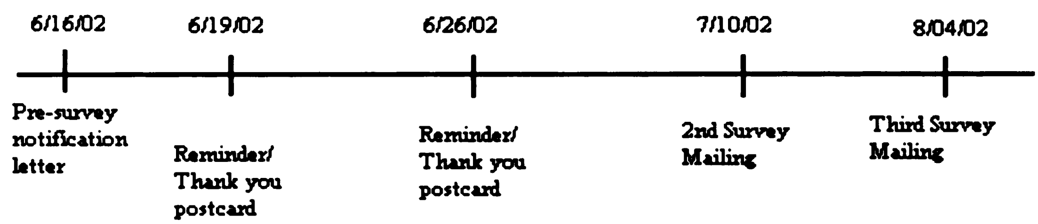
Figure 3. Michigan Survey Regions



The survey was implemented by mail during the summer of 2002 using the modified total design method (Dillman, 2000). The survey questionnaire was 5 pages long and was printed on 8.5" by 14" colored paper, forming booklet pages that were 4.25" by 7" each. The pages containing survey questions are reproduced in Appendix A, and the correspondence and survey covers are also presented in Appendix A.

The survey consisted of 5 contacts (waves): a pre-survey notification letter, survey mailing 1, a reminder/ thank you postcard, survey mailing 2, and survey mailing 3. A timeline of the five mailings is presented below. All surveys included a stamped return envelope. Only those not returning a survey were sent subsequent surveys (i.e. survey mailings 2 or 3). Letters were printed on official letterhead from the Fisheries and Wildlife Department at Michigan State University. All correspondence was hand signed with blue ink by the project coordinator.

Figure 4. Timeline of Five Survey Mailings



The first mailing was a pre-survey letter that was mailed on June 16, 2002. The letter indicated that a deer hunting survey conducted by Michigan State University would be arriving in a few days. The letter also explained the importance of the survey to deer hunting research, and closed with a thank-you.

The second mailing was the first mailing of the actual survey, which was mailed on June 19, 2002. This mailing consisted of a questionnaire and a postage-paid return envelope. Approximately one-half of the sample (1500 individuals) received three thirty-seven cent stamps, in an effort to examine whether stamps were an effective mechanism in increasing the survey return rate.

The third mailing consisted of a postcard that served as a reminder to individuals who had not returned the survey and as a thank you to individuals who had completed and returned the questionnaire. The reminder/thank you postcard was mailed on June 26, 2002.

The fourth mailing included the second mailing of the questionnaire (printed on green paper), along with a postage-paid return envelope. The second questionnaire was mailed on July 10, 2002. The differences in this version of the survey consist of the wording of the invitation letter on the cover of the survey as well as the color of the paper the questionnaire was printed on.

The fifth mailing included a third mailing of the questionnaire, along with a postage-paid return envelope. To assess whether it influenced response rate, 1500 survey recipients were identified beforehand to receive this mailing via "Priority Mail", providing that neither of the previous two surveys were returned. This cost $3.85 per survey, and was done to make the mailing look different than the previous two mailings. Priority Mail also uses a different envelope and is usually delivered in two days. This mailing included a separate reminder letter indicating that the records show that neither the first or second questionnaire had been returned. The letter states the importance of participation by the individual, and reaffirms the confidentiality of the respondents' information. The letter concludes by urging the individual to call or e-mail if there are any questions, and a hand-written signature signs off. This mailing took place on August 4^{th}, 2002.

RESPONSE RATE

Table 2 presents the complete disposition of cases and displays the missing, non-deliverable, mailed and returned questionnaires by study region. The top number reflects the percentage of questionnaires and the number in parentheses reflects the actual number of questionnaires.

Table 2. Survey Response Rates by Region

	Upper Peninsula	**Northern Lower Peninsula**	**Southern Lower Peninsula**	**Total**
Total number of surveys sent	1000	931	1068	2999
Missing (not returned by end of survey)	29.7% (297)	30.9% (288)	31.8% (340)	30.8% (925)
Non-deliverable	3.5% (35)	4.4% (41)	4.0% (43)	4.0% (119)
1st questionnaire mailing: surveys returned out of 2999 copies sent	44.4% (444)	41.6% (387)	42.9% (458)	43.0% (1289)
2nd questionnaire: surveys returned out of 1591 copies sent	25.7% (134)	25.8% (130)	20.1% (114)	23.8% (378)
3rd questionnaire: surveys returned out of 1213 copies sent	23.3% (90)	22.8% (85)	24.9% (113)	23.7% (288)
Overall Returns and Response Rate	69.2% (668)	67.6% (602)	66.8% (685)	67.9% (1955)

The starting survey sample consisted of 2999 individuals. Of this number, 925 were missing (not returned), and 119 surveys were returned by the post office marked as non-deliverable. In total, 1955 completed surveys were returned out of the 2880 valid addresses, yielding a response rate of 67.9% for the overall survey. The second wave (first questionnaire) was sent to 2999 individuals. Out of these 2880 valid addresses, 1289 subjects returned the first questionnaire, yielding a first-questionnaire response rate of 43.0%. The fourth wave of mailings included a second copy of the questionnaire. In this mailing 1591 second copies were mailed out, with 378 survey respondents mailing in the second copy. The response rate for the second mailing was 23.8%. The fifth wave of mailings included a third copy of the questionnaire, with 288 survey respondents returning the third questionnaire out of 1213 third copies that were mailed out. The response rate for the third copy of the questionnaire was 23.7%.

HUNTER CHARACTERISTICS

Survey results should be representative of the population of interest. With this in mind, Table 3 below compares the results of the 2003 Deer Hunter Opinion survey to the results obtained from a harvest survey sent to hunters after the 2002 hunting season. Note the large size of the harvest survey (52,589 individuals) relative to the smaller sample size of the 2003 Hunter Opinion Survey used in this paper. Where relevant and applicable, survey results are shown from the 2002 Michigan Census.

Table 3. Demographic Characteristics of the 2003 Deer Hunter Opinion Survey, Frawley Harvest Survey, and State of Michigan 2000 Census

	2003 Deer Hunter Opinion Survey	**2002 MDNR Harvest Survey**	**2000 Michigan Census**
Median Income	\$50,000	N.A.	44,667
Age[a]	47.36	41	35.5
Female	7.7%	7.9%	51.0%
Children Under 18 in Household	0.83	N.A.	0.92
Hunted with Bow	41.4%	42.8%	N.A.
Hunted with Firearm[b]	85.9%	92.4%	N.A.
Muzzle loader	25.0%	25.0%	N.A.
Purchased Antlerless	49.6%	51.9%	N.A.
Bachelors Degree or Higher	19.1%	N.A.	21.8%

a- 2003 Hunter Opinion Survey sampled only individuals 18 years of age or older, whereas the 2002 Harvest report sampled all deer hunters

b- 2003 Hunter Opinion Survey asks hunters whether they hunt with a firearm or shotgun, and the 2002 Harvest report asks hunters if they use a firearm

Comparing columns in Table 3, the percentage of the deer hunting population in Michigan that hunts with a bow differs by 1.4%, and the percentage of the population that hunts with a muzzleloader is the same in both surveys. On the other hand, the percentage of the population that hunts with a firearm differs in the two surveys. It is likely that this difference arose from the 2003 Hunter Opinion Survey asking hunters whether they hunt with a rifle/shotgun, while the 2002 MDNR Harvest Survey reported the number of hunters that hunt with a firearm. Thus, the firearm results from the 2003 Hunter Opinion Survey posted in the above table did not include hunting with a muzzleloader or a handgun. There is also a difference in the mean age of a hunter throughout both surveys, and this is likely due in part to surveying a sample of all license purchasers in the 2002 MDNR Harvest Survey, whereas the 2003 Hunter Opinion Survey restricted it's sample to only those hunters 18 years of age or older. Finally, the percentage of female hunters surveyed is nearly identical in both surveys.

CHAPTER 4

TRAVEL COST THEORY

While one may not purchase outdoor recreational experiences in the market, individuals and households spend time and money to participate in outdoor recreational activities. The travel cost demand model is a behavioral model that utilizes the observed behavior of individuals in order to estimate the economic benefits, or welfare, individuals derive from the participation in outdoor recreation. The travel cost method was originally suggested by Harold Hotelling in an unpublished reply to the Department of the Interior, which requested a means of evaluating the economic benefits of public land (Haab and Mcconnell, 2003). In this model, the "price" of the product, trip cost, is essentially used to purchase a bundle of site attributes. The direct use of an individual's behavior in the application of the travel cost model (a revealed preference method), has allowed it to avoid some of the criticisms faced by contingent valuation.

Single Site Travel Cost Model

The first application of the travel cost model, the single site travel cost method, was performed by Clawson and Knetsch (1966) in the seminal book "Economics of Outdoor Recreation". This approach models the demand for trips to a recreation site by a person over a season. The basic equation for the single site travel cost model is

$$r = f(tc_r, tc_s, y, z) \quad (1)$$

where r is the number of trips taken to a particular site, tc_r is the price (trip cost) of reaching a particular site, tc_s is a vector of trip costs to other recreation sites, y is income, and z is a vector of demographic variables believed to influence the number of trips (Parsons, 2003). The single site travel cost model is useful in valuing the welfare changes associated with the closing of a particular site. However, unless one makes relatively stringent assumptions, it is impossible to value the quality changes at a particular site (Bockstael et al., 1992). To more accurately estimate the value of the welfare changes resulting from quality changes at a particular site, information is needed regarding the tradeoffs individuals make between trip cost and the attributes of a particular site. A multiple site travel cost approach is useful in modeling how individuals make site choice decisions by weighing travel costs against the services and amenities available at various locations.

RANDOM UTILITY TRAVEL COST MODEL

In this paper we adopt the Random Utility Model (RUM), which is a common multiple site travel cost approach. The random utility model was developed by Nobel Prize recipient Daniel McFadden (1973), in the seminal work "Conditional Logit Analysis of Qualitative Choice Behavior". The RUM and the original single-site travel cost models differ in that the subject of interest in the RUM is the site choice of the hunter, whereas the quantity of trips taken to a single site is of interest in the single site model. With the RUM, when an individual makes the choice of which site to visit on a trip, the individual is assumed to consider both the characteristics of the site, as well as the “price” of the trip, which is the travel cost. The amount of utility derived from a particular site is defined as *site utility*, and can be expressed mathematically as

$$V_i = \beta_{tc} tc_i + \beta_q q_i + \varepsilon_i \tag{2}$$

where tc_i is the cost of reaching site *i*, q_i is a vector of site characteristics, ε_i is a random error term, and the β*'s* are parameters (Parsons, 2003). The site utility function above gives the indirect utility conditional upon a visit to the site, which is also known as the conditional indirect utility of visiting a site. The parameters are the marginal utilities of the site characteristics and can be thought of as the weight attached to the different site characteristics and the trip cost. The higher a site characteristic is valued, the greater the parameter will be for that particular characteristic. For example, since travel costs are expenses that could be used for other items that yield utility, the β attached to “trip cost” is expected to be negative and serves as a measure of the marginal utility of income. It is also hypothesized that site utility increases with desirable characteristics, such as deer density or public access.

In RUM theory, an individual chooses the site that offers the highest indirect utility. With this assumption, site *k* would be chosen over another site *i* when

$$V_k > V_i \quad \text{for all i in C} \tag{3}$$

where C is the set of possible sites in an individual’s choice set. Recognizing that the expressions in equation (3) contain random terms, one can formulate an expected demand function for a site based on the probability that expression (3) holds. Upon selecting a distribution of the error terms, the probabilities can then be used to estimate the model parameters.

The specific model utilized in this random utility travel cost application is the nested logit model (McFadden, 1981). The development of the nested logit model followed work by McFadden regarding the development of the conditional logit model, and the conditional logit model is a special case of the nested logit model (McFadden, 1981; Haab and McConnell, 2003). The nested logit model was developed by McFadden (1981) to relax the Independence of Irrelevant alternatives (IIA) restriction when utilizing choice sets in which some of the choice options are closer substitutes than others.

Independence of Irrelevant Alternatives

The IIA principle states that the relative probability of choosing between two alternatives is independent of all other alternatives. For example, imagine that an individual has the option of selecting either a red car or a blue bus as his mode of transportation to work. Assume that the probability of selecting either transportation alternative is 0.5. Now assume that a perfect substitute for the red car, a blue car, is added. Since the IIA principle states that the probability of choosing between two alternatives is independent of all other alternatives, in this simple example each option in the choice set (red car, blue car, and blue bus) now has roughly a 33% chance of being selected. More formally, the IIA principle states that

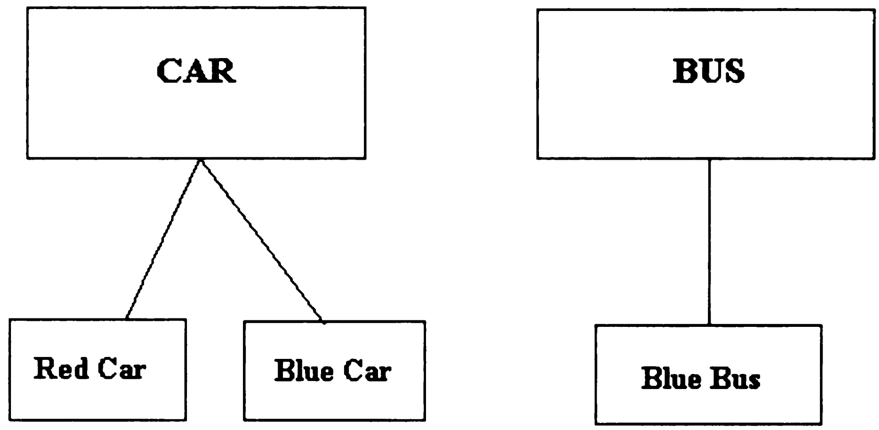
$$\frac{\Pr(l \mid S_R)}{\Pr(m \mid S_R)} = \frac{\Pr(l \mid S_{R+1})}{\Pr(m \mid S_{R+1})} \tag{4}$$

where $\Pr(l \mid S_R)$ indicates the probability that alternative l *is* chosen from among the set S_R. The following equation shows that the IIA principle holds for the conditional logit model.

$$\frac{\Pr(m)}{\Pr(p)} = \frac{e^{v_m}}{\sum_{n=1}^{J} e^{v_n}} \div \frac{e^{v_m}}{\sum_{n=1}^{J} e^{v_n}} = \frac{e^{v_m}}{e^{v_p}} \tag{5}$$

Equations 4 and 5 show that the probability of choosing between sites will remain constant, even if a perfect substitute is introduced. In the prior example with the red car, blue car and blue bus, we see that the IIA restriction requires that the relative probability of choosing between the red car and the blue bus remains the same, despite the addition of the blue car to the choice set, which is a perfect substitute for the red car. However, with the introduction of a perfect substitute, one would expect the relative probability of choosing the bus to remain at 0.5, whereas the remaining 0.5 would be divided among the red car and blue car equally, so that Pr (red car) = Pr (blue car) =0.25. The nesting structure for this model is illustrated in Figure 5 below.

Figure 5: Example Two-Level Nested Logit Model on Choice of Transportation



Relaxing the IIA restriction introduces error term correlation among choice options, which allows for more general patterns of substitution in the model (Parsons, 2003). In the case of a nested logit model, the equation below illustrates the relative probability of choosing alternative j,k to alternative p,r.

$$\frac{\Pr(j,k)}{\Pr(p,r)} = \frac{a_k e^{\frac{v_{jk}}{\theta_k}} \left[\sum_{l=1}^{J_k} e^{\frac{v_{jk}}{\theta_k}} \right]^{\theta_k - 1}}{\sum_{m=1}^{K} a_m \left[\sum_{l=1}^{J_m} e^{\frac{v_{jm}}{\theta_m}} \right]^{\theta_m}} \div \frac{a_r e^{\frac{v_{pr}}{\theta_r}} \left[\sum_{l=1}^{J_r} e^{\frac{v_{lr}}{\theta_r}} \right]^{\theta_r - 1}}{\sum_{m=1}^{K} a_m \left[\sum_{l=1}^{J_m} e^{\frac{v_{jm}}{\theta_m}} \right]^{\theta_m}}$$

$$= \frac{a_k e^{\frac{v_{jk}}{\theta_k}} \left[\sum_{l=1}^{J_k} e^{\frac{v_{jk}}{\theta_k}} \right]^{\theta_k - 1}}{a_r e^{\frac{v_{pr}}{\theta_r}} \left[\sum_{l=1}^{J_r} e^{\frac{v_{lr}}{\theta_r}} \right]^{\theta_r - 1}} \qquad (6)$$

Equation 6 shows that IIA no longer holds across nests *k* and *r*, though changes outside these two nests are still irrelevant. The equation below shows that when alternatives *j* and *p* are in the same nest, *r*, the relative probabilities are

$$\frac{\Pr(j,r)}{\Pr(p,r)} = \frac{e^{\frac{v_{jr}}{\theta_r}}}{e^{\frac{v_{pr}}{\theta_r}}} = e^{(v_{jr} - v_{pr})/\theta_r} \qquad (7)$$

which is independent of all other alternatives in nest *r* as well as all other nests (Haab and McConnell, 2002). To summarize, the nested logit model relaxes the IIA assumption across nests, but maintains the assumption within nests.

Nested Logit Model

The nested logit model is utilized in this paper to relax the restrictions inherent in the conditional logit model, taking into account the correlation of error terms across different sites. This type of model may have numerous levels to account for the different correlation patterns among the alternatives.

Generating a two-level nested logit model assumes that the CDF (Cumulative Distribution Function) is

$$\begin{aligned} F(<e_{mj}>) &= \exp\{-\sum_{m=1}^{M} a_m [\sum_{j=1}^{J_m} e^{-s_m e_{mj}}]^{(1/s_m)} \\ &= \exp\{-\sum_{m=1}^{M} [\sum_{j=1}^{J_m} e^{-s_m(e_{mj}-a_m)}]^{(1/s_m)}\} \end{aligned} \qquad (8)$$

where $a_m = e^{am}$, $a_m > 0$ and $s_m \geq 1$ $\forall m$ (Haab and McConell, 2002).

Equation 8 can be decomposed into the following equations to estimate the probability of choosing an alternative (nest) of type *n* and the probability of selecting alternative *i* conditional on choosing alternative *n*.

$$\Pr(n) = \frac{a_n[\sum_{j=1}^{J_n} e^{s_n v_{nj}}]^{1/s_n}}{\sum_{m=1}^{M} a_m[\sum_{j=1}^{J_m} e^{s_m v_{mj}}]^{1/s_m}} \quad (9)$$

and

$$\Pr(i \mid \mathrm{n}) = \frac{e^{s v_{ni}}}{\sum_{j=1}^{J_n} e^{s v_{nj}}} \quad (10)$$

The mathematical equation for determining the probability of an individual selecting *ni* is

$$\Pr(ni) = \frac{e^{s_n v_{nj}} a_n[\sum_{j=1}^{J_n} J_n e^{s_n v_j}]^{(1/s_n)-1}}{\sum_{j=1}^{J_m} a_m[\sum_{j=1}^{J_m} e^{s_m v_{mj}}]^{1/s_m}} \quad (11)$$

WELFARE MEASUREMENT

The RUM approach can be used to estimate the changes in hunter welfare measures resulting from site quality changes. The marginal implicit prices are computed as the ratio of the parameter estimate for a variable to the absolute value of the travel cost parameter. Equation 12 below displays the basic approach for calculation of marginal implicit prices.

$$Marginal\ Implicit\ Price = \beta/\mu \qquad (12)$$

where β is one of the coefficients for the explanatory variables in the regression, and μ is the negative of the coefficient for trip cost. In the context of equation (2) $\mu = -\beta_{tc}$ and $\beta = \beta_q$. The marginal implicit prices facilitate comparisons across models because they are independent of any underlying, unidentified, differences in variance across models. The marginal implicit prices can also be identified as the marginal per-trip value of a unit change in the characteristic at all sites (Hanemann, 1983).

In calculating the willingness to pay (WTP) welfare measure resulting from specific quality changes at particular sites, one compares the expected maximum indirect utility across sites with and without the change and computes the amount that could be taken from income to equate the two. In the nested logit, this expression has a closed form solution and is given by

$$\begin{aligned} WTP = [\ln(\sum_{m=1}^{K} a_m [\sum_{l=1}^{J_m} \exp(\frac{-\mu c_{lm} + q_{lm}^{*} B + s_m^{*} \gamma}{\theta})]^{\theta_m} \\ - \ln(\sum_{m=1}^{K} a_m [\sum_{l=1}^{J_m} \exp(\frac{-\mu c_{lm} + q_{lm}^{*} B + s_m^{*} \gamma}{\theta_m})]^{\theta_m})]\mu^{-1} \end{aligned} \qquad (13)$$

which is the change in indirect utility, normalized by the marginal utility of income (Haab and McConnell, 2002).

The seasonal value per individual can be estimated by multiplying a person's total number of trips by their conditional on a trip welfare measure. The equation utilized is

$$S = WTP * s \qquad (14)$$

where S is the seasonal mean willingness to pay and s is the sample mean number of trips and WTP is willingness to pay conditional on taking a trip. The aggregate welfare impact of the quality change is simply the seasonal value in equation 14 multiplied by the population, as shown below.

$$AS = S * Pop \tag{15}$$

In the equation above, AS is the aggregate seasonal welfare impact, and Pop is the population of users being analyzed (Parsons, 2003).

CHAPTER 5

MODEL ESTIMATION

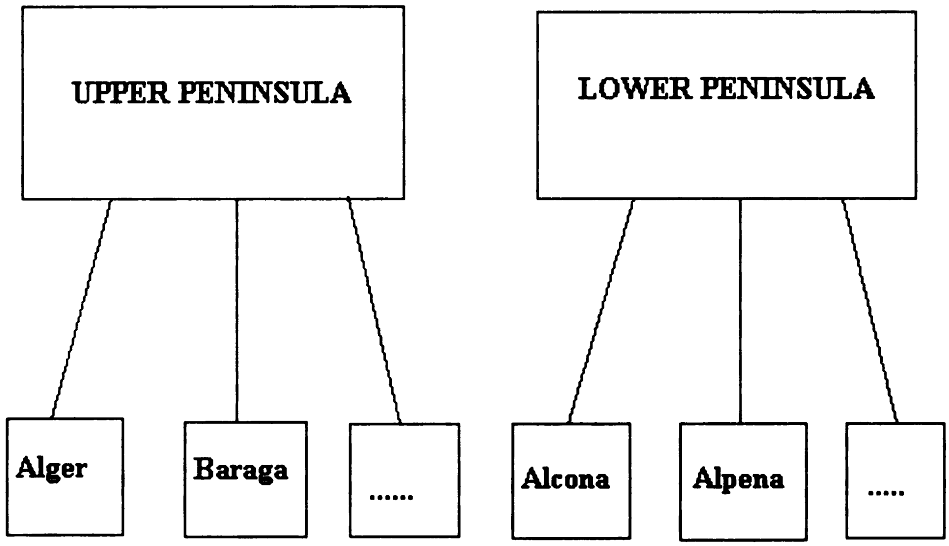
This model will be estimated by using the Full Information Maximum Likelihood estimation method (FIML). This method maximizes the log of the likelihood function in one step by using a numerical algorithm to find the vector of parameters that maximize it (Morey,1997). FIML is the preferred method over other estimation methods, such as the two-stage sequential estimation method (SE), as FIML produces estimates that are both consistent and asymptotically efficient (Morey,1997).

The exact model specification below is derived from equation 2, and includes specific variables that are hypothesized to have an influence on site utility for individual *i*, thus influencing the probability *i* selects site *j* from the choice set. The utility *i* gets from site *j*, assuming a linear form is

$$\begin{aligned} v_{ij} = {} & \beta_1 Travel\_Cost_{ij} + \beta_2 Deer\_Population + \beta_3 National\_Forest \\ & + \beta_4 State\_Forest + \beta_5 Commercial\_Forest + \beta_6 Parks + \beta_7 County\_Size \\ & + \beta_8 County\_Population + \beta_9 Upper\_Peninsula \\ & + \beta_{10} Northern\_Lower\_Peninsula \end{aligned} \tag{16}$$

The nesting structure of the model appears in Figure 6 below.

Figure 6. Nesting Structure for Random Utility Model of Deer Hunting in Michigan



The nesting structure utilized in this model places Upper Peninsula hunting sites and Lower Peninsula hunting sites into two distinct nests. This structure allows hunting sites within each particular nest to be more correlated with other sites in the same nest. The practical effect of such a nesting structure is that sites within a nest tend to be closer substitutes than sites across nests. A nested model in this situation has the effect of relaxing the IIA Assumption between the Upper Peninsula nest and the Lower Peninsula nest, while still holding the IIA assumption for sites within each nest, thus providing for richer patterns of substitution (Parsons, 2003).

Table 4. Variables Used in the Estimation of the Utility Function

Variable	Variable Definition
***Travel_Cost**$_{ij}$*	The round-trip travel cost incurred from origin *i* to county *j*
Deer_Population	The estimated deer population per county
National_Forest	Acres of National Forest that are open to the public for deer hunting
State_Land	Acres of land owned or managed by the State of Michigan that are open to the public for deer hunting
Commercial_Forest	Acres of Commercial Forest Act land that are open to the public for deer hunting
County_Land	Acres of land owned or managed by the county that are open to the public for deer hunting
County_Size	Size of county in square miles
County_Population	The number of people living in each county
Upper_Peninsula	Dummy variable indicating whether or not the county is located in the Upper Peninsula
Northern_Lower_Peninsula	Dummy variable indicating whether or not the county is located in the Northern Lower Peninsula

The variables listed in Table 4 were hypothesized to influence a hunter's selection of a hunting site.. The travel cost variable was computed as the round-trip time and driving costs from each hunter's residence to the 83 different counties. The distance was obtained by using PCmiler™ software to calculate the distance from each hunter's residence to the zip code that is closest to the geographic center of each county. The driving cost is the cost of operating a vehicle calculated as the per-mile operating cost multiplied by the distance to the site. Per-mile vehicle operating costs were obtained from the American Automobile Association (AAA, 2002), using the costs associated with operating a 2002 Chevrolet Cavalier. The per-mile operating costs for this vehicle were 5.2 cents for gas and oil, 3.9 cents for maintenance, 1.5 cents for tires, and 20.4 cents for vehicle depreciation, resulting in total operating costs of 31 cents per mile (AAA, 2002). Insurance costs were not included in this computation.

The other component of travel costs was time spent traveling to the site, which is time that could have been devoted to other endeavors. These lost opportunities are referred to as the opportunity costs of the travel time. Generally, the income of the individual is used to calculate an individual's opportunity cost of taking the trip. Though an ongoing and active area of research, the recreation literature has generally accepted 1/3 of an individual's wage as a lower bound and an individual's full wage as an upper bound for the hourly value of time spent driving (Parsons, 2003). The rate of 1/3 of the wage of the individual will be used in this model. The wage imputation follows the literature by dividing annual income by 2080 hours of work time (52 weeks at 40 hours per week). The survey utilized for this research did not ask individuals to list their exact income, but instead provided potential survey respondents with 6 household income range options that could be selected. The choices were: 0-$20,000, $20,000-$40,000, $40,000-$60,000, $60,000-$80,000, $80,000-$100,000, and over $100,000. The midpoint of the range was used for the first five categories, assigning an individual an income of $10,000 if they responded with an answer of 0-$20,000, $30,000 if they responded with an answer of $20,000-$40,000, and so on. Individuals indicating an income of over $100,000 were assigned a household income of $150,000. To convert the distance traveled into an estimated time spent traveling to the hunting site, an average speed of the trip of 40 miles per hour was used. A final estimation of travel costs is obtained by multiplying the distance to the hunting site by the per-mile operating costs, and then adding travel time multiplied by one-third the wage rate. The final equation used to calculate travel cost is displayed below.

$$
\begin{aligned}
\textit{Price} &= \textit{driving cost} + \textit{time cost} \\
&= \textit{per mile driving cost} * \textit{miles} + \textit{one-third wage rate} * \textit{driving time} \qquad (17) \\
&= (\$0.31*\textit{Distance}) + (1/3)*(\textit{Income}/2080)*(\textit{Distance}/40)
\end{aligned}
$$

Data on the deer population in each deer management unit was obtained from the Michigan Department of Natural Resources. In the Lower Peninsula of Michigan, deer management units are based on county boundaries, except in a few select areas with special management concerns. However, this is not the case in the Upper Peninsula. Thus, some interpolation was necessary in order to transfer deer population figures in each management unit to the county level. The amount of National Forest land, State land and County land was obtained from a study of Michigan's forest resources (Leatherberry and Spencer,1996). The number of acres of Commercial Forest Act land in each county was obtained from the Michigan Department of Natural Resources. Human population per county and the geographic size of each county were each obtained from the U.S. Census Bureau. Since the county is not one hunting site but rather an aggregation of hunting sites, county size is included as a measure of the size of the aggregated hunting site (Lupi and Feather, 1998) which helps control for different levels of aggregation across alternatives.

Table 5. Random Utility Model Estimation Results for Firearm and Bow Models

	Firearm Model			Bow Model[1]		
Variable (X)	**Coef.**	**t-stat**	**p-value**	**Coef.**	**t-stat**	**p-value**
Travel_Cost	0.037	-114.31	<0.0001	0.039	-119.84	<0.0001
Deer_Population	0.193	17.19	<0.0001	0.059	4.86	<0.0001
National_Forest	0.038	11.17	<0.0001	0.073	19.49	<0.0001
State_Land	0.058	15.38	<0.0001	0.074	17.85	<0.0001
Commercial_Forest	0.089	17.08	<0.0001	0.054	7.87	<0.0001
County_Land	0.148	6.08	<0.0001	0.161	6.31	<0.0001
County_Size	-0.00076	-7.87	<0.0001	-0.00013	-1.35	0.1783
County_Population	-0.011	-16.63	<0.0001	-0.0065	-15.46	<0.0001
Upper_Peninsula	-0.481	-2.28	0.0228	1.61	10.46	<0.0001
Northern_Lower_ Peninsula	0.591	15.93	<0.0001	0.50	14.04	<0.0001
Nested Logit IV	0.356	36.44	<0.0001	NA[1]		
LogL	-26,252			-26,038		
McFadden R^2	0.4105			0.4048		
Number of Hunters	1,416			685		

[1] The nested logit model for bow hunting would not converge under a variety of specifications and starting values. For a sense of how this might affect results, Appendix B compares the nested and conditional logit results for the firearm model. The results are qualitatively similar.

Table 5 presents the estimated coefficients, t-statistics and p-values for the firearm model and the bow model. All of the coefficients for both models were significant at the 5% level, except for the *County_Size* variable in the bow model. As expected, the coefficient for the travel cost variable was highly significant and negative for both models. All else held equal, the number of trips to a hunting site decreased as cost of traveling to a particular site increased. Another variable that was expected to influence site visitation is the population of deer in a particular county. The higher the population of deer, the greater the number of trips expected to that particular site. This holds true in this analysis, with a higher deer population being highly correlated with more trips to a hunting site, all else held equal. The similarity of the travel cost parameters in the two models allows for simple comparisons between parameters for other site attributes across the bow and firearm models. Estimation results show that the population of deer was relatively more important in influencing trips to the site for firearm hunters than for bow hunters. Additionally, all eight of the model-specific public access variables are significantly correlated with an increase in hunting trips to a particular county. The presence of National Forest land or State land at a hunting location was relatively more important for bow hunters than for firearm hunters, while Commercial Forest Act land was more important to firearm hunters.

The signs for all the estimated coefficients make intuitive sense, with the probability of a deer hunting trip to a county increasing with site attributes that are assumed to be desirable to deer hunters, such as number of deer and acres of publicly accessible land. Similarly, the probability of a trip to a site was expected to decrease with increased trip cost and higher human population levels, and does so. The size and human population of the county were two other variables that were controlled for. The size of a county was statistically significant and negative in the firearm model, negatively influencing the number of hunting trips to a particular county. This would seem to be intuitive, as the larger the size of the county, holding other important variables (such as the access variables) constant, results in more private land in the area, which may be inaccessible to many deer hunters. However, this intuition does not hold in the bow model, as the coefficient is not statistically significant. It is also logical that the number of people living in a county results in a higher percentage of urbanized and residential areas that are not suitable for deer hunting. The results support this idea, with the human population variable for both the bow and the firearm model being statistically significant and negative.

The effect of a hunting site being located in the Upper Peninsula or Northern Lower Peninsula of Michigan was examined. This is the only variable where there was a qualitative difference between the bow and the firearm models. The dummy variables are inserted into this model to make sure that the predicted shares per region match the sample shares per region. Thus, these variables indicate the average effect not explained by other variables. The location of a hunting site in the Upper Peninsula had no noticeable effect on the probability of a trip to the site by a bow hunter, while in the firearm model the location of a site in the Upper Peninsula was statistically significant and resulted in a lower probability of a trip to that site, *all else held equal*. Coefficients for the Northern Lower Peninsula dummy variable were significant and positive for each model.

Table 6. Marginal Implicit Prices for Changes in Site Characteristics

Variable	Firearm	Bow
Deer (10,000 deer)	$5.22	$1.51
National Forest (10,000 acres)	$1.03	$1.87
State Land (10,000 acres)	$1.57	$1.90
CFA Land (10,000 acres)	$2.41	$1.38
County Land (10,000 acres)	$4.00	$4.10

Table 6 shows the marginal implicit prices of increasing the deer population and the level of public access in each county. Recall from equation 12 that the marginal implicit prices are computed as the ratio of the parameter estimate for a variable to the absolute value of the travel cost parameter. The marginal implicit prices facilitate comparisons across models because they are independent of any underlying, unidentified, differences in variance across models. The marginal implicit prices can also be identified as the marginal value per trip of a unit change in the characteristic at all sites (Hanemann, 1983). Table 6 shows that an increase of 10,000 deer in each county would provide firearm hunters with a welfare increase of $5.22 per trip, with archery hunters realizing a welfare increase of $1.51 per trip. These welfare measures are conditional on a hunter taking at least one hunting trip. The welfare differences between the two models reveal that firearm hunters place a higher value on deer population as a site attribute relative to archery hunters. Disparities between the two models also exist with the public access variables. Bow hunters place a higher value on National Forest and State land than do firearm hunters. However, increasing the amount of CFA land throughout each county provides firearm hunters with greater benefits than bow hunters. Marginal implicit prices for county land are similar in both models.

Table 7. Total Number of Predicted Trips and Predicted Probability of Trips Across Regions and Models

	Firearm Model	**Bow Model**	**Total Predicted Trips**
Upper Peninsula	447,000 (9.8%)	247,000 (5.4%)	694,000 (7.6%)
Northern Lower Peninsula	1,497,000 (32.7%)	1,361,000 (29.6%)	2,858,000 (31.1%)
Southern Lower Peninsula	2,639,000 (57.6%)	2,988,000 (65.0%)	5,627,000 (61.3%)
Total Predicted Trips	4,583,000	4,596,000	9,179,000

Table 7 displays the predicted number of trips and the predicted probability of trips across three different regions of Michigan. The model predicts that the majority of hunting trips are taken to hunting locations in the Southern Lower Peninsula of Michigan, with this region receiving approximately twice the number of predicted trips as the Northern Lower Peninsula and 8 times as many hunting trips as the Upper Peninsula. Individuals hunting in the firearm season are predicted to take significantly more trips to the Upper Peninsula as opposed to individuals hunting in the bow season. There were slightly more hunting trips in the Northern Lower Peninsula during the firearm season than in the bow season, whereas bow-hunting trips were more frequent than firearm-hunting trips in the Southern Lower Peninsula. Overall predicted trips when comparing the firearm model and bow model were quite similar. Even though there are less than half as many bow hunters when compared to firearm hunters (684,000 to 317,000, respectively)(Frawley, 2003), there are more than twice as many trips taken during the roughly two-month long bow season by the average bow hunter (14.5) when compared to the average number of trips taken during the two week long firearm season by firearm hunters, which is 6.7 (Bull et al. 2006). Because of the presence of the regional dummy variables, the models predict exactly the same number of trips to each of the three regions (Upper Peninsula, Northern Lower Peninsula, and Southern Lower Peninsula) as in the actual survey data used to estimate the models.

Table 8. Probability of Site Selection and Predicted Trips to each Hunting Site

Largest 5 and smallest 5 in bold: *= largest, **=smallest

County	Firearm Nested Logit Model N=1416		Conditional Logit Bow Model N=685	
	Probability of Trip	*Predicted Number of Trips*	*Probability of Trip*	*Predicted Number of Trips*
Alcona	**0.25%**	**11,457****	0.21%	9,653
Alger	0.35%	16,040	0.20%	9,193
Allegan	1.62%	74,241	2.34%	107,558
Alpena	0.28%	12,832	0.16%	7,354
Antrim	0.28%	12,832	0.16%	7,354
Arenac	0.90%	41,245	0.68%	31,256
Baraga	**0.06%**	**2,750****	**0.05%**	**2,298****
Barry	2.48%	113,653	1.97%	90,551
Bay	1.00%	45,828	1.04%	47,804
Benzie	0.36%	16,498	0.25%	11,491
Berrien	0.76%	34,829	0.91%	41,828
Branch	1.26%	57,743	1.14%	52,400
Calhoun	2.12%	97,155	1.49%	68,488
Cass	1.11%	50,869	0.97%	44,586
Charlevoix	0.36%	16,498	0.15%	6,895
Cheboygan	0.55%	25,205	0.16%	7,354
Chippewa	0.87%	39,870	0.61%	28,039
Clare	0.85%	38,954	0.79%	36,312
Clinton	1.52%	69,659	1.40%	64,351
Crawford	0.77%	35,288	0.71%	32,635
Delta	0.78%	35,746	0.56%	25,740
Dickinson	0.46%	21,081	0.29%	13,330
Eaton	1.77%	81,116	1.55%	71,246
Emmet	0.42%	19,248	**0.11%**	**5,056****
Genesee	1.74%	79,741	2.27%	104,341
Gladwin	1.28%	58,660	1.03%	47,344
Gogebic	0.46%	21,081	0.31%	14,249
Grand Traverse	0.51%	23,372	0.34%	15,628
Gratiot	1.06%	48,578	1.02%	46,884
Hillsdale	1.15%	52,702	1.11%	51,021
Houghton	0.26%	11,915	0.23%	10,572
Huron	0.82%	37,579	0.74%	34,014
Ingham	1.57%	71,950	1.37%	62,972
Ionia	2.12%	97,155	2.03%	93,309
Iosco	0.53%	24,289	0.52%	23,902
Iron	0.57%	26,122	0.32%	14,709
Isabella	1.39%	63,701	1.20%	55,158
Jackson	2.89%	132,443	2.00%	91,930
Kalamazoo	1.99%	91,198	1.78%	81,818
Kalkaska	0.69%	31,621	0.58%	26,660
Kent	1.43%	65,534	2.04%	93,769
Keweenaw	**0.11%**	**5,041****	**0.05%**	**2,298****
Lake	1.24%	56,827	1.42%	65,270
Lapeer	**3.11%**	**142,525***	3.09%	142,032
Leelanau	**0.18%**	**8,249****	**0.11%**	**5,056****

Table 8: Probability of Site Selection and Predicted Trips to each Hunting Site (Cont.)

County	**Firearm Nested Logit Model N=1416**		**Conditional Logit Bow Model N=685**	
	Predicted Probability of Trip	*Predicted Number of Trips*	*Predicted Probability of Trip*	*Predicted Number of Trips*
Lenawee	1.64%	75,158	2.03%	93,309
Livingston	**3.05%**	**139,775***	3.21%	147,548
Luce	0.56%	25,664	0.24%	11,032
Mackinac	1.81%	82,949	0.58%	26,660
Macomb	2.34%	107,238	**3.79%**	**174,207***
Manistee	0.66%	30,246	0.59%	27,119
Marquette	1.94%	88,906	1.19%	54,698
Mason	0.86%	39,412	0.75%	34,474
Mecosta	2.25%	103,113	1.70%	78,141
Menominee	0.69%	31,621	0.16%	7,354
Midland	1.33%	60,951	1.20%	55,158
Missaukee	0.86%	39,412	0.74%	34,014
Monroe	**3.76%**	**172,313***	**5.99%**	**275,330***
Montcalm	1.57%	71,950	1.55%	71,246
Montmorency	0.40%	18,331	0.26%	11,951
Muskegon	1.42%	65,076	1.87%	85,955
Newaygo	**3.04%**	**139,317***	**3.41%**	**156,741***
Oakland	1.42%	65,076	2.70%	124,106
Oceana	1.34%	61,410	1.60%	73,544
Ogemaw	0.88%	40,329	0.73%	33,554
Ontonagon	0.49%	22,456	0.33%	15,168
Osceola	0.57%	26,122	0.49%	22,523
Oscoda	0.53%	24,289	0.59%	27,119
Otsego	0.35%	16,040	0.24%	11,032
Ottawa	1.33%	60,951	1.92%	88,253
Presque Isle	**0.20%**	**9,166****	**0.11%**	**5,056****
Roscommon	0.85%	38,954	0.70%	32,176
Saginaw	1.56%	71,492	1.86%	85,495
St. Clair	2.41%	110,445	**3.32%**	**152,604***
St. Joseph	1.23%	56,368	1.06%	48,723
Sanilac	1.54%	70,575	1.56%	71,705
Schoolcraft	0.39%	17,873	0.25%	11,491
Shiawasee	1.88%	86,157	1.73%	79,519
Tuscola	1.90%	87,073	1.87%	85,955
Van Buren	0.99%	45,370	0.94%	43,207
Washtenaw	**4.24%**	**194,311***	**4.61%**	**211,899***
Wayne	0.60%	27,497	1.84%	84,576
Wexford	0.80%	36,662	0.83%	38,151

Table 8 displays the predicted probability that a bow hunter or a firearm hunter will select a particular hunting site in a given choice occasion, and the seasonal predicted number of trips to each site for the total population of deer hunters in Michigan. Four out of the five sites with the most predicted visits for firearm hunters were located in the Southern Lower Peninsula. These four sites (Washtenaw, Monroe, Lapeer, and Livingston) border the highly populated tri-county Detroit Metropolitan region, which consists of Oakland, Macomb, and Wayne counties. The five counties with the fewest predicted trips are either in the Upper Peninsula or the Northern Lower Peninsula. Baraga county (2,750 trips) and Keewenaw county (5,041 trips) are the counties with the least and second least amount of predicted trips, respectively. Three counties in the Northern Lower Peninsula, Leelanau, Presque Isle, and Alcona, have the third, fourth and fifth lowest number of predicted trips, respectively.

Results for the bow model are similar to the firearm model results. Four out of the five sites with the highest predicted trips are located in the Southeastern Lower Peninsula. However, Macomb County has the third highest number of predicted trips (174,207), and St. Clair County, which is just north of Macomb County, has the fourth highest number of predicted trips (152,604). These counties were not in the top five for the firearm model. The five counties with the lowest number of predicted trips in the bow model are similar to the firearm model, with the exception of Emmet County which has the fifth lowest number of predicted trips in the bow model whereas this place is held by Alcona County in the firearm model.

WELFARE IMPACTS

This section examines the welfare impacts resulting from quality changes in the characteristics of the hunting sites (counties), and also estimates deer hunter per-trip and seasonal consumer surplus measures. Welfare benefits provided to deer hunters via National Forest land, State land, County land and Commercial Forest Act land are estimated, along with hunter benefits from all publicly accessible hunting land accounted for in the models. Finally, estimates are provided for the welfare impacts to hunters that result from a decrease in the population of deer in the Southern Lower Peninsula.

Table 9. Regional Differences in Predicted Trips and Hunter Welfare Measures Resulting from the Elimination of Publicly Accessible Hunting Land in Michigan

	CFA Land	National Forest	State Land	County Land	All Public Access
Firearm Model					
Trip Change Upper Peninsula	-27,000 (-6.0%)	-20,000 (-4.5%)	-33,000 (-7.4%)	negligible	-78,000 (-17.4%)
Trip Change Northern L.P.	+19,000 (+1.3%)	-33,000 (-2.2%)	-27,000 (1.8%)	+10,000 (+0.7%)	-31,000 (-2.1%)
Trip Change Southern L.P.	+7,000 (+0.3%)	+53,000 (+2.0%)	+59,000 (+2.2%)	-10,000 (-0.4%)	+108,000 (+4.1%)
Per-Trip Welfare	-$2.78	-$1.76	-$4.49	-$1.07	-$9.98
Seasonal Welfare **(millions)**	-$12.74	-$8.07	-$20.58	-$4.90	-$45.74
Bow Model					
Trip Change Upper Peninsula	-3,000 (-1.2%)	-17,000 (-6.9%)	-13,000 (5.3%)	negligible	-20,000 (-8.1%)
Trip Change Northern Lower Peninsula	+2,000 (+0.1%)	-79,000 (-5.8%)	-38,000 (-2.8%)	+29,000 (2.1%)	-36,000 (-2.6%)
Trip Change Southern L.P.	+2,000 (0.1%)	+96,000 (+3.2%)	+51,000 (+1.7%)	-28,000 (-0.9%)	+56,000 (+1.9%)
Per-Trip Welfare	-$1.07	-$2.42	-$3.89	-$1.06	-$8.60
Seasonal Welfare **(millions)**	-$4.92	-$11.12	-$17.88	-$4.87	-$39.53
Total Welfare **(millions)**	**-$17.66**	**-$19.19**	**-$38.46**	**-$9.78**	**-$85.27**

Table 9 displays the regional differences in the changes in predicted hunting trips that are estimated to result from the elimination of the publicly accessible hunting lands examined in this model. The table also presents the estimated impacts to hunter welfare resulting from these changes. The loss of hunter welfare associated with the elimination of publicly accessible hunting lands can also be described as the welfare benefits accrued to hunters through the existence of the different types of public accessible hunting land. As the vast majority of publicly accessible hunting lands are located in the Upper Peninsula and the Northern Lower Peninsula, it is intuitive that the predicted trips of hunters shifted away from these regions and into the Southern Lower Peninsula with the elimination of Commercial Forest Act land, National Forest land and State land. However, the elimination of County land shifted predicted trips out of the Southern Lower Peninsula and into the Northern Lower Peninsula, as much of this land is located in the Southern Lower Peninsula in the form of local parks and recreation areas. Table 9 shows that State land generated the highest seasonal welfare measure, with over $38,000,000 in estimated annual economic benefits realized by Michigan hunters. Estimated economic benefits to hunters from National Forest land and Commercial Forest Act land are similar, at $19,190,000 and $17,660,000 annually, respectively, with each having generated approximately half the estimated value for State land. Despite only 255,000 acres of county land, much less than either of three other public access variables, county land still generated nearly $10,000,000 in estimated annual benefits to deer hunters. The total benefit to deer hunters from publicly accessible hunting land is estimated at over $85,000,000 annually, with about $40,000,000 in benefits to bow hunters and $46,000,000 in benefits to firearm hunters.

Table 10. Per-trip Benefits and Aggregate Seasonal Welfare from a 50% Reduction in the Deer Population in the Southern Lower Peninsula

Decrease in the Deer Population of the Southern Lower Peninsula by 50%		
Firearm Model Trip Changes	*Upper Peninsula*	+4,000 (0.9%)
	Northern Lower Peninsula	+97,000 (+6.5%)
	Southern Lower Peninsula	-102,000 (-3.9%)
Bow Model Trip Changes	*Upper Peninsula*	No change
	Northern Lower Peninsula	+29,000 (+2.1%)
	Southern Lower Peninsula	-28,000 (0.9%)
Firearm Model Welfare	*Per-Trip Welfare*	-$2.92
	Seasonal Welfare	-$13,382,000
Bow Model Welfare	*Per-Trip Welfare*	-$0.88
	Seasonal Welfare	-$4,045,000
Total Welfare		**-$17,427,000**

Table 10 above shows that a 50% reduction in the deer population is estimated to have a greater welfare impact on firearm hunters than on bow hunters. Predicted trips to the Southern Lower Peninsula by firearm hunters decreased by over 110,000, with an increase of 130,000 trips predicted for the Northern Lower Peninsula region. Smaller effects are seen in the bow model, as the Southern Lower Peninsula is predicted to experience a 30,000 decrease in trips, while the Northern Lower Peninsula is predicted to realize a corresponding increase in trips. The estimated hunter welfare losses associated with the reduction in deer population are more than three times as large in the firearm model when compared to the bow model, and the firearm hunters are predicted to experience a reduction in welfare of over $13,000,000 versus a predicted reduction of $4,000,000 in welfare for bow hunters. Total hunter welfare loss due to a 50% reduction in the population of deer in the Southern Lower Peninsula was estimated to be about $17,000,000.

CHAPTER 6

SUMMARY /CONCLUSIONS

Deer hunting is an important recreational activity and economic engine in the State of Michigan, one in which 750,000 participants incur expenses of about $265,000,000. However, the impact on other stakeholders can be substantial, and should be considered when managing the deer population to provide benefits to society. Understanding the welfare impacts of hunting site attributes and policy changes will assist managers in the development and implementation of management strategies that consider the welfare of all stakeholders.

Despite the importance of deer hunting, very few travel cost models of deer hunting appear in the literature, and even fewer published studies have used random utility (multiple site) travel cost methods to value changes in the quality of deer hunting sites (Schwabe et al. 2001 is a notable exception). This gap in the literature is surprising given the prominence of deer hunting in the US. The research presented in this thesis contributes to this area of study by partially filling this gap. The estimation results and welfare impacts provide wildlife managers with an added understanding of determinants of hunting site selection and the net economic benefits or losses associated with changes in the level of particular hunting site attributes.

The models that were developed related hunter's site choices, at the county level, to attributes of the county they hunted in. Separate models are developed for the firearm season and the archery season. Key variables included the travel costs to a county, the deer population in a county, and several measures of the amount of publicly accessible hunting land in a county. The variables representing publicly accessible hunting lands in a county included acres of private land available under the Commercial Forest Act, and acres of public land open to hunting for each of three types: National Forest land, State land, and County land. These access measures and the Deer Population variable are statistically significant and positive across both the firearm and bow hunting models, indicating that counties with increased levels of hunting site characteristics thought to be desirable, such as publicly accessible hunting lands and deer population, do in fact receive higher numbers of hunting trips, all else equal. The travel costs were also found to be a significant and negative factor explaining choice of a county for deer hunting, demonstrating that hunters are less likely to hunt at counties farther from their residence, all else equal. Of course, all else is not equal since counties differ in their site characteristics and their travel costs relative to hunter's residences. Thus, forecasting trip patterns requires use of the models to balance the county characteristics, travel costs, and the distribution of hunters in the state. Further, since there are separate models for the archery season and for the firearm season, the effect of changes in site characteristics can differ across seasons. For example, the estimation results suggest that, relative to travel costs, the number of deer in the county is more important in explaining firearm hunters' site choices than it is for archery hunters.

The travel cost models can also be used to estimate the economic benefits, above and beyond the costs, that accrue to hunters due to the various site characteristics in the models. The model estimates suggest that the seasonal economic benefits realized by deer hunters through the existence of publicly accessible hunting land exceeded $85,000,000 annually. State land accounted for over half of this figure. Commercial Forest Act land, which is land that receives tax breaks to remain as working commercial forest land while also providing public access to hunters and anglers, yielded an estimated economic benefit to deer hunters of $17,700,000 annually.

The hunter welfare impacts associated with a regional reduction in the deer population was also examined. A proposed target for the size of the deer herd in the Southern Lower Peninsula that is about 50% lower than the present population is currently being considered by the Michigan Department of Natural Resources. The travel cost models suggest that a 50% reduction in deer numbers in the Southern Lower Peninsula would decrease seasonal hunter welfare by about $17,400,000 annually. However, other stakeholders such as motorists and farmers are likely to realize benefits through reduced deer-vehicle collisions and crop damage. To illustrate, if a 50% reduction in the deer population in the Southern Lower Peninsula resulted in a 50% reduction in deer-vehicle collisions, then vehicular damages realized by motorists would be reduced by about $23,651,000 (about 11,825 fewer collisions with repair cost of about $2,000 each). Moreover, the models suggest that some of the losses to hunters from a large reduction in herd size could be offset by increases in publicly accessible hunting land in the Southern Lower Peninsula. Finally, other studies of hunter preferences suggest that losses due to decreases in deer numbers can be offset to some degree by increases in the numbers of mature bucks (Wallmo, 2003), thus mitigating the welfare losses realized by hunters (though the models presented here lack the data to distinguish the effects of quality-related changes in the composition of the deer herd).

Deer hunters experiencing reductions in welfare due to quality changes at hunting sites may adjust to their different choice set by selecting a new hunting location. Since the site choice models are capable of predicting changes in trip locations in response to changes in site attributes, a regional analysis was performed to measure the predicted number of trips after the quality change against the predicted number of trips prior to the quality change. Recall that Table 8 provided the number of predicted trips to each of the 83 hunting sites and this data serves as the reference for computing the regional difference in hunting trips. Table 8 also identified the locations that were predicted to receive the highest and lowest number of trips, using the baseline predictions of the model. For both the archery and firearm models, counties bordering the heavily populated Detroit Metropolitan region had high numbers of predicted trips, which partially reflects the importance of travel costs relative to the large number of hunters that reside in the area.

For the hunter access scenarios, since most of the publicly accessible hunting lands are located in the Upper and Northern Lower Peninsulas, eliminating public access tends to shift trips away from these regions and into the Southern Lower Peninsula. An elimination of all public access for deer hunters is estimated to result in an additional 164,000 trips to the Southern Lower Peninsula, whereas Upper Peninsula and Northern Lower Peninsulas would realize trip reductions of 98,000 and 67,000, respectively. Alternatively, reducing the deer population by 50% in the Southern Lower Peninsula reduced the number of trips to this region by 102,000, while the reduction increased the number of trips to the Northern Lower Peninsula by 97,000. Since these are not biological models, the economic model predictions take for granted that deer populations could continue to be reduced even as hunter effort shifted away from the region. In all of these scenarios, it is also important to bear in mind that the site choice models predict allocations of trips, but hold the total number of trips and participants constant. In reality, trips are likely to decline as some prior participants are likely to take fewer trips, or even decline to hunt, under some of the scenarios examined. With this in mind, the next section reviews several limitations of the research.

LIMITATIONS

One caveat of the modeling and trip predictions presented here has to do with the trip data. Given the limited survey research budget, data was obtained for up to two sites for each hunter so the model is not based on complete trip information. Although relatively few published multiple site travel cost models have complete trip data, the lack of complete trip information may omit some variation in trip patterns, and it may depress predicted trip numbers. In our case, 87% of all deer hunters surveyed indicated they hunted deer in two counties or fewer, and less than 1% hunted deer in more than four counties. Nonetheless, we may be underestimating the total number of trips. On the other hand, our data on trip numbers per season is based on hunter's recall of the number of trips they made to the two sites, and as such it may be subject to the type of recall biases noted in the literature on recreation surveys. Finally, our trip models and underlying data cannot distinguish between trips that are several days long versus a few hours. Thus, it would be difficult to use the models to forecast regional hunting effort, in days or hours.

Next, because this model used aggregate areas as sites (counties), it is possible that there may be errors introduced through the aggregation process. Unlike some types of recreation site choices with clearly defined spatial locations (e.g., lakes), hunting trips can occur over a vast and almost continuous number of locations across the landscape, making it difficult to conceive of easily identified discrete "sites". In this sense, the county scale is reasonable. However, counties do consist of heterogeneous types of hunting locations that may or may not be available to an individual hunter such as privately owned or leased land, access to private land owned by friends or family, and publicly accessible lands. The literature on travel cost models notes the potential biases in demand estimation and welfare evaluation that can occur when heterogeneous recreation sites are aggregated into regional sites. Fortunately, the policies examined here affect broad areas rather than individual sites within aggregate groups, so they are less likely to compound any site aggregation errors (Lupi and Feather, 1998). Never the less, the model estimates and policy evaluations need to be understood in the context of a regional demand model that cannot identify the specific location or type of sites hunted within a county.

It is also relevant to note that the firearm model used in this paper included only trips made by firearm and shotgun hunters, and does not utilize trip data from hunters who use a muzzleloader. Thus, we may be underestimating welfare impacts in the firearm model by not including this method of firearm hunting. Although survey data was available on these trips, the number of trips is small and did not warrant a modeling effort.

Especially important for understanding polices that may affect deer numbers is the fact that the models did not include certain "herd-quality" attributes of the deer population that may influence hunter site choice. For example, Wallmo (2003) shows that hunters are concerned with the number of mature bucks at a hunting site, and not simply the number of deer at a site. The negative welfare impacts predicted from a reduction in the deer population in the Southern Lower Peninsula might be reduced if management efforts or regulations could also lead to a relatively higher population of bucks. However, the economic models presented here relate trips to deer numbers per county, and therefore lack the necessary data on deer quality variables to assess potential welfare impacts of such a scenario.

Many of the policies studied here, such as elimination of hunter access, could have a dramatic effect on both the number of trips taken by hunters and on the number of participants in deer hunting. However, the model used here captures the site allocation part of hunter demand, but cannot account for changes in numbers of trips or numbers of deer hunters. Future research could explore extension of this model to the seasonal and hunting participation levels which may matter substantially for some types of policies examined here.

Finally, the site choice models include some factors that influence site choices of hunters and statistical evidence suggests these factors do relate to hunter site choices. However, there is surely a complex and broad array of physical, social, cultural, and historical factors that also influence hunter's selection of hunting locations that are not accounted for in the model, yet are worthy of further study.

APPENDICES

APPENDIX A

This appendix contains:

1. Survey Questionnaire
2. Pre-Survey Letter- used in the first mailing-without notification of incentive
3. Pre-Survey Letter- used in the first mailing-with notification of incentive
4. Reminder Postcard- used in third mailing
5. Reminder letter- used in fifth mailing

2003 Michigan Deer Hunter Opinion Survey

August 2003

PLEASE REFER TO THIS MAP WHEN IDENTIFYING COUNTIES IN THE SURVEY.

1

PART A: Your Deer Hunting Background

1) As a recreational activity, how important is deer hunting to you compared to your other recreational activities? (check one)

___ MY MOST IMPORTANT RECREATIONAL ACTIVITY
___ ONE OF MY MORE IMPORTANT RECREATIONAL ACTIVITIES
___ NO MORE IMPORTANT THAN ANY OTHER RECREATIONAL ACTIVITY
___ LESS IMPORTANT THAN MOST OF MY OTHER RECREATIONAL ACTIVITIES
___ NOT AT ALL IMPORTANT TO ME AS A RECREATIONAL ACTIVITY

2) In about how many different years have you hunted deer?

___ YEARS

3) Which do you *prefer* to use when hunting deer?

___ BOW ___ FIREARM ___ I EQUALLY ENJOY BOW AND FIREARM

4) Please check any of the following organizations which you have belonged to in the past three years (check all that apply):

___ MICHIGAN UNITED CONSERVATION CLUBS (MUCC)
___ ANY OF: WHITETAILS FOREVER, WHITETAILS UNLIMITED, UP WHITETAILS, THE QDMA
___ MICHIGAN BOWHUNTER'S ASSOCIATION
___ A LOCAL OR REGIONAL SPORTSMAN'S CLUB
___ ANOTHER ORGANIZATION WITH A *MAJOR INTEREST IN DEER HUNTING AND MANAGEMENT* (PLEASE NAME THE ORGANIZATION): ______________

5) Did you hunt deer in the 2002 deer season?

___ YES...Please continue with Question 6
___ NO.....Please skip to Question 22 (page 8)

6) In how many different counties did you hunt deer during the 2002 deer season? (Refer to the map on page 1)

_____ COUNTIES

PART B: Your Deer Hunting Locations

This section is about where you hunt deer. First we would like to know if you deer hunt an area that is less than 50 miles from your home. Next we would like to know if you hunt deer in an area that is more than 50 miles from your home.

MICHIGAN DEER HUNTING AREA *LESS THAN* 50 MILES FROM YOUR HOME

7) Please identify the area *less* than 50 miles from your home where you deer hunted most in 2002.

___ I DID NOT DEER HUNT A COUNTY LESS THAN 50 MILES FROM MY HOME **(SKIP TO QUESTION 11)**

I HUNTED MOST IN ______________________________ COUNTY (PLEASE REFER TO THE MAP ON PAGE 1)

NEAREST TOWN/ CITY______________________ (PLEASE *DO NOT* RESTRICT YOUR ANSWERS TO THE TOWNS SHOWN ON PAGE 1)

8) What was the first year you hunted deer in that area *less* than 50 miles from your home?

_________ YEAR

9) Please answer the following about your 2002 deer hunting activities in that area *less* than 50 miles from your home (if none write '0').

	number of trips to the area	total number of days spent
A) BOW HUNTING FOR DEER	___ TRIPS	___ DAYS
B) RIFLE/SHOTGUN HUNTING FOR DEER.............	___ TRIPS	___ DAYS
C) MUZZLE LOADER HUNTING FOR DEER............	___ TRIPS	___ DAYS
D) PRESEASON ACTIVITIES (SCOUTING, BLIND CONSTRUCTION, FOOD PLOTS ETC.).....	___ TRIPS	___ DAYS

10) What type of land did you hunt in that area *less* than 50 miles from your home in 2002? (check all that apply)

___ PRIVATE LAND WHICH I OWN
___ PRIVATE LAND WHICH I DON'T OWN BUT HUNT FOR FREE
___ PRIVATE LAND LEASED BY ME AND/OR CLOSE RELATIVES/FRIENDS
___ PUBLIC LAND OR PUBLICALLY ACCESSIBLE COMMERCIAL FOREST AREAS

MICHIGAN DEER HUNTING AREA *MORE THAN* 50 MILES FROM YOUR HOME

11) Please identify the area more than 50 miles from your home where you deer hunted most in 2002.

___ I DID NOT DEER HUNT A COUNTY MORE THAN 50 MILES FROM MY HOME **(SKIP TO PAGE 5)**

I HUNTED MOST IN ______________________________ COUNTY (PLEASE REFER TO THE MAP ON PAGE 1)

NEAREST TOWN/ CITY______________________ (PLEASE *DO NOT* RESTRICT YOUR ANSWERS TO THE TOWNS SHOWN ON PAGE 1)

12) What was the first year you hunted deer in that area *more* than 50 miles from your home?

_________ YEAR

13) Please answer the following about your 2002 deer hunting activities in that area *more* than 50 miles from your home.

	number of trips to the area	total number of days spent
A) BOW HUNTING FOR DEER	___ TRIPS	___ DAYS
B) RIFLE/SHOTGUN HUNTING FOR DEER..............	___ TRIPS	___ DAYS
C) MUZZLE LOADER HUNTING FOR DEER.............	___ TRIPS	___ DAYS
D) PRESEASON ACTIVITIES (SCOUTING, BLIND CONSTRUCTION, FOOD PLOTS ETC.)...............	___ TRIPS	___ DAYS

14) What type of land did you hunt in that area *more* than 50 miles from your home in 2002? (check all that apply)

___ PRIVATE LAND WHICH I OWN
___ PRIVATE LAND WHICH I DON'T OWN BUT HUNT FOR FREE
___ PRIVATE LAND LEASED BY ME AND/OR CLOSE RELATIVES/FRIENDS
___ PUBLIC LAND OR PUBLICALLY ACCESSIBLE COMMERCIAL FOREST AREAS

MICHIGAN COUNTY YOU DEER HUNT *THE MOST*

NOTE: To answer 15, 16 and 17, refer to the one deer hunting area where you spent the most days in 2002 on deer hunting related activities (as reported in questions 7 and 11).

15) How important are the following for selecting the area *you hunt most*?*(see note above)*

	very important reason	*important reason*	*somewhat important reason*	*not a reason*	*not sure*
A) I SEE MANY DEER	1	2	3	4	NS
B) THE NUMBER OF MATURE BUCKS (2.5 YEARS OR OLDER)	1	2	3	4	NS
C) IT IS NEAR FAMILY/FRIENDS	1	2	3	4	NS
D) LOW HUNTER NUMBERS	1	2	3	4	NS
E) I HAVE A TRADITIONAL DEER CAMP THERE WITH FAMILY (OR FRIENDS)	1	2	3	4	NS
F) I'M OFTEN SUCCESSFUL THERE	1	2	3	4	NS
G) THE DEER ARE HEALTHY	1	2	3	4	NS
H) THE SIZE OF THE AREA I CAN HUNT	1	2	3	4	NS
I) I OWN LAND THERE	1	2	3	4	NS
J) I SEE A DIVERSITY OF WILDLIFE	1	2	3	4	NS
K) I CAN LEGALLY BAIT THERE	1	2	3	4	NS
L) IT IS NEAR MY RESIDENCE/HOME	1	2	3	4	NS
M) I LIKE OTHER LEISURE ACTIVITIES/ ACCOMMODATIONS IN THE AREA	1	2	3	4	NS

16) What are the first and second most important reasons for selecting the area you hunt the most. The letters refer to each of the reasons given in question 15 above.

MOST IMPORTANT REASON FOR HUNTING THE AREA (circle one letter):

A B C D E F G H I J K L M

OTHER REASON (PLEASE DESCRIBE) ______________________

SECOND MOST IMPORTANT REASON FOR HUNTING THE AREA (circle one letter):

A B C D E F G H I J K L M

OTHER REASON (PLEASE DESCRIBE) ______________________

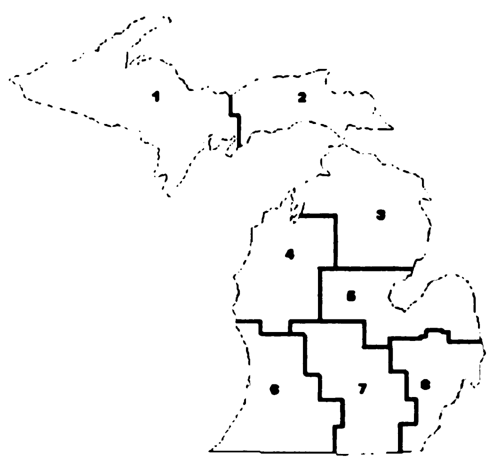
5

17) Please indicate how strongly you would agree/disagree with the following statements related to the area you deer hunted most in 2002.

I would continue to hunt deer in the area where I hunted most in 2002, even if...

	strongly agree	*agree*	*unsure*	*disagree*	*strongly disagree*
A) ...DEER NUMBERS THERE DECREASED BY 30%	1	2	3	4	5
B) ...CHANCES OF HARVESTING A 2½ YEAR OLD OR OLDER BUCK DECREASED THERE BY 50%	1	2	3	4	5
C) ... HUNTER DENSITY INCREASED THERE BY 30%	1	2	3	4	5
D) .. BOVINE TB WAS FOUND IN THE DEER THERE	1	2	3	4	5
E) ... A REGULATION REQUIRED THAT ALL HARVESTED BUCKS IN THE AREA HAVE A MINIMUM OF 3 POINTS ON ONE SIDE	1	2	3	4	5
F) ... BAITING WITH ANY SUBSTANCE IN ANY AMOUNT WAS BANNED IN THE AREA	1	2	3	4	5

18) Please indicate those Wildlife Management Units where you have hunted deer during the past 5 years by circling the numbers on the map below (circle all that apply).



Note: Please refer to the map on page 1 to help identify counties.

19) Many hunters invest money and time in deer hunting through their off-season activities. <u>For your deer hunting related activities in Michigan</u>, how much do you personally spend each year on each of the following? (If none, write "0").

A) LAND MANAGEMENT EQUIPMENT MAINTENANCE/ REPAIR (EG. TRACTORS, CHAIN SAWS ETC)............	$_______	_____ DAYS
B) MANAGING FOOD PLOTS (SEEDING, FERTILIZING, ETC).................................	$_______	_____ DAYS
C) CREATING OPENINGS/IMPROVING HABITAT................	$_______	_____ DAYS
D) BLIND CONSTRUCTION AND SCOUTING.....................	$_______	_____ DAYS
E) PAID FOR LABOR/HELP..	$_______	
F) LEASE FEES...	$_______	
G) PROPERTY TAXES..	$_______	
H) HUNT CLUB MEMBERSHIPS.......................................	$_______	
I) OTHER (PLEASE DESCRIBE)	$_______	_____ DAYS

20) If you took one or more overnight deer hunting trips in 2002, where did you stay? (Check all that apply)

___ *I didn't take an overnight deer hunting trip in 2002*

___ HOTEL/MOTEL

___ RENTED CABIN/HOUSE

___ NON-RENTED CABIN/HOUSE

___ PAID TO CAMP (E.G. PRIVATE OR PUBLIC CAMPGROUND)

___ CAMPED FOR FREE ON PUBLIC OR PRIVATE LAND

___ OTHER (please write in other location) ______________________________

PART C: **Deer Disease Issues**

21) In 2002, did you hunt in a county known to have bovine TB in the deer herd?

___ YES ___NO ___ UNSURE

22) Please indicate how much you agree or disagree with the following statements about bovine TB.

	strongly agree	*agree*	*unsure*	*disagree*	*strongly disagree*
A) I AM CONCERNED THAT DEER HAVE BEEN FOUND WITH BOVINE TB IN MICHIGAN.	1	2	3	4	5
B) THE BOVINE TB DISEASE IS A SERIOUS THREAT TO THE HEALTH OF THE DEER HERD IN MICHIGAN.	1	2	3	4	5
C) IT IS IMPORTANT FOR HUNTERS IN MICHIGAN TO HAVE THEIR DEER CHECKED FOR BOVINE TB.	1	2	3	4	5
D) BOVINE TB IN DEER IS A SERIOUS HUMAN HEALTH THREAT FOR THOSE WHO EAT VENISON.	1	2	3	4	5
E) BOVINE TB IN DEER IS A SERIOUS HUMAN HEALTH THREAT FOR THOSE WHO HANDLE VENISON (E.G. FIELD DRESSING DEER)	1	2	3	4	5

8

23) <u>In some states other than Michigan</u>, chronic wasting disease (<u>CWD</u>) has been found in white-tailed deer. Before getting this survey, were you aware of chronic wasting disease?

____YES ____NO

24) Please indicate how much you agree or disagree with the following statements about chronic wasting disease (CWD).

	strongly agree	*agree*	*unsure*	*disagree*	*strongly disagree*
A) I WOULD BE CONCERNED IF CWD WAS FOUND IN MICHIGAN'S DEER HERD.	1	2	3	4	5
B) CWD WOULD BE A SERIOUS THREAT TO THE HEALTH OF MICHIGAN'S DEER HERD.	1	2	3	4	5
C) IT IS IMPORTANT FOR HUNTERS IN MICHIGAN TO HAVE THEIR DEER CHECKED FOR CWD.	1	2	3	4	5
D) CWD IS A SERIOUS HUMAN HEALTH THREAT FOR THOSE WHO EAT VENISON.	1	2	3	4	5
E) CWD IS A SERIOUS HUMAN HEALTH THREAT FOR THOSE WHO HANDLE VENISON (E.G. FIELD DRESSING DEER)	1	2	3	4	5

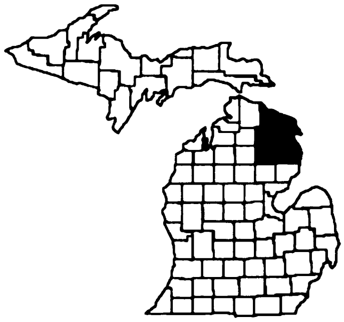
25) If a free-ranging (wild) deer with CWD was found in <u>the area of Michigan you deer hunt most</u>, which of the following would you be most likely to do. (Choose one)

___ NO CHANGE; I WOULD HUNT THE SAME AS USUAL.
___ CONTINUE TO HUNT AS USUAL, BUT HAVE MY DEER CHECKED FOR CWD.
___ CONTINUE TO HUNT AS USUAL, BUT I WOULD NOT EAT THE DEER.
___ SWITCH TO ANOTHER PART OF MICHIGAN WHICH DOES NOT HAVE CWD.
___ STOP DEER HUNTING IN MICHIGAN.
___ I AM UNSURE.

26) In 1998 deer baiting was no longer allowed in the shaded counties below, where bovine TB had been found. Did you hunt in any of those five counties (i.e. Presque Isle, Montmorency, Oscoda, Alcona or Alpena) <u>before 1998</u>?

____YES ____NO ___UNSURE

Note: Please refer to the map on page 1 to help identify counties



27) <u>In 2002</u>, did you hunt in any of the five counties shaded on the map above (i.e. Presque Isle, Montmorency, Oscoda, Alcona or Alpena)?

___YES ___NO ___unsure

28) What is your understanding of how each of the following have changed in the counties shaded in the map above, since management to eliminate bovine TB in the deer herd began.

	much higher	*higher*	*unchanged*	*lower*	*much lower*	*not sure*
A) PERCENTAGE OF DEER WITH TB	1	2	3	4	5	**NS**
B) NUMBER OF DEER HUNTERS USING THE AREA	1	2	3	4	5	**NS**
C) NUMBER OF DEER IN THE AREA	1	2	3	4	5	**NS**
D) NUMBER OF MATURE BUCKS IN THE AREA	1	2	3	4	5	**NS**
E) RATIO OF BUCKS TO DOES IN THE AREA	1	2	3	4	5	**NS**
F) NUMBER OF DEER-RELATED VISITS YOU MAKE TO THE AREA	1	2	3	4	5	**NS**

<u>PART D:</u> We need the following information to compare our respondents to all deer hunters in Michigan. This survey is completely confidential; your name will NOT be identified with your answers.

29) Please check your highest completed level of education. (check one)

___ LESS THAN HIGH SCHOOL
___ COMPLETED HIGH SCHOOL OR GED
___ VOCATIONAL OR TRADE SCHOOL
___ SOME COLLEGE
___ TWO YEAR DEGREE
___ FOUR YEAR DEGREE
___ GRADUATE SCHOOL (e.g. MS, PHD, MD)

30) Do you have access to the Internet <u>for personal use</u> either at work or at home?

___ YES ___ NO

31) How many children under the age of 18 currently live in your household?

________ CHILDREN

32) What was your gross household income (before taxes) in 2002?

___ LESS THAN $20,000
___ $20,000 TO $39,999
___ $40,000 TO $59,999
___ $60,000 TO $79,999
___ $80,000 TO $99,999
___ $100,000 OR MORE

Thank you for completing this survey. If you have any concerns or comments concerning deer management in Michigan, please write them below.

If you have misplaced your postage-paid envelope, please return this survey to: Peter Bull, Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources Building, East Lansing, MI 48824-1222

11

MICHIGAN STATE
UNIVERSITY

June 9, 2003

«FST_NAME» «LST_NAME»
«ADDRS_1» «ADDRS_2»
«CITY», «STATE» «ZIP»

In a few days you will receive a brief questionnaire in the mail. It is part of an important study being conducted by Michigan State University's Department of Fisheries and Wildlife. We have found that many people like to know ahead of time that they will be receiving a questionnaire.

Your response will help deer managers understand how their decisions affect your deer hunting opportunities in Michigan. When you receive the questionnaire, please take 10 minutes to fill it out and return it in the envelope we will provide.

Thank you in advance for your time and consideration. Deer managers depend on your input.

Sincerely,

Peter Bull
Project Coordinator

P.S. We will be enclosing a small token of our appreciation with the questionnaire as a way of saying thanks.

DEPARTMENT of
FISHERIES AND WILDLIFE

Michigan State University
13 Natural Resources Bldg
East Lansing MI
48824-1222

517 432 3636
Fax 517-432 1699

e-mail bullpe@msu edu

Dear Sir or Madam:

You were recently sent a questionnaire concerning deer hunting issues in Michigan. If you have returned the questionnaire, ***thank you***. If you have not yet completed the questionnaire, please take a few minutes to do so now. Your input is important for deer management in Michigan.

Sincerely,

Peter Bull
Project Coordinator
Michigan State University
bullpe@pilot.msu.edu
(517) 432-3636

MICHIGAN STATE
UNIVERSITY

DEPARTMENT of
FISHERIES AND
WILDLIFE

Michigan State University
13 Natural Resources Bldg
East Lansing MI
48824-1222

517-432-3636
Fax 517 432 1699

e-mail bullpe@msu.edu

August 4, 2003

«ID»
«FST_NAME» «LST_NAME»
«ADDRS_1»«ADDRS_2»
«CITY», «STATE» «ZIP»

Our records show we have not received a response to either of the two questionnaires we mailed to you inquiring about your deer hunting activities. Your response is necessary for us to make accurate recommendations to the Department of Natural Resources regarding the impact of regulations on deer hunters; i.e., how their decisions might impact where you choose to hunt. We are making one final attempt to obtain your input.

Mail surveys are a scientifically valid means of involving the public in Michigan's deer management. A good response rate will provide more representative information than attendance at public meetings or testimony to the Natural Resource Commission. However, surveys are only more effective than other methods if deer hunters are willing to participate.

Your name was randomly chosen, so your response represents not only your views, but also deer hunters who think like you, but who were not chosen to receive the questionnaire. Please take a few minutes to speak for yourself and those hunters by filling out this survey.

All responses are completely confidential - your name and address will never be connected to your responses. Rest assured, your privacy will be protected to the maximum extent allowable by law.

When the research is complete, you will be able to read a summary of our results at:

http//www.fw.msu.edu/misc/fwresults/survey_2.pdf

If you have any questions or comments about this study feel free to call me at 517-432-3636 or email me at bullpe@msu.edu. If you have further questions concerning your rights as a survey respondent, please call (517) 355-2180 to contact Dr. Ashir Kumar, Chairperson of the MSU Committee on Research Involving Human Subjects.

Thank you for your contribution to the success of this study.

Sincerely,

Peter Bull
Project Coordinator

APPENDIX B

This appendix contains:

1. Nested Logit and Conditional Logit Variables for the Firearm Models
2. Comparison of Nested Logit and Conditional Logit Firearm Policy Measures

Comparison of Nested Logit and Conditional Logit Firearm Model Results

	Firearm Model Nested Logit		Firearm Model Conditional Logit		
Variable	Coefficient (p-value)	Marginal Implicit Prices	Coefficient (p-value)	Marginal Implicit Prices	Ratio of $ Values
Travel_Cost	0.037 (<0.001)		0.033 (<0.001)		
Deer_Population	0.193 (<0.001)	$5.25	0.163 (<0.001)	$4.97	1.06
National_Forest	0.038 (<0.001)	$1.02	0.036 (<0.001)	$1.09	0.94
State_Forest	0.058 (<0.001)	$1.58	0.066 (<0.001)	$2.02	0.78
Commercial_ Forest_Land	0.089 (<0.001)	$2.42	0.064 (<0.001)	$1.94	1.25
County_Forest	0.148 (<0.001)	$4.04	0.153 (<0.001)	$4.66	1.31
County_Size	-0.000757 (<0.001)		-0.000558 (<0.001)		
County_ Population	-0.011 (<0.001)		-0.010 (<0.001)		
Upper_ Peninsula	-0.481 (0.0228)		-1.28 (<0.001)		
Northern Lower Peninsula	0.591 (<0.001)		-1.28 (<0.001)		

Comparison of Nested Logit and Conditional Logit Firearm Policy Measures

Policy/Program	**Hunter Welfare for Nested Logit Model**	**Hunter Welfare for Conditional Logit Model**	**Ratio of $ Values**
Value of Commercial Forest Act land	$12,740,000	$10,770,000	1.17
National Forest	$8,066,000	$8,478,000	0.94
State Land	$20,577,000	$25,526,000	0.79
County Land	$4,904,000	$5,637,000	0.86
Deer Reduction in SLP	-$13,382,000	-$12,603,000	1.06

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