# EVALUATING RECREATIONAL DEMAND FOR ELK IN MICHIGAN

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Agricultural, Food, and Resource Economics – Master of Science

2024

# ABSTRACT

Michigan's Northern Lower Peninsula supports a reintroduced elk herd of around 1,300 animals, centered in Pigeon River Country and Atlanta State Forests. These public lands are popular for visitors to engage in a variety of outdoor recreation activities, with some activities such as elk viewing and elk hunting created by the presence of elk. The first essay examines the demand for the elk hunting by implementing a discrete choice experiment among elk lottery applicants. We use the choice experiment results to model the number of applicants, revenue, and elasticity of applicants at varying application fee levels under different program attributes seen in other state elk hunting lottery systems. Applicants were found to have very inelastic demand across all scenarios. Auctioning tags for fundraising and increasing the license fee reduces lottery demand at all application fee levels, while implementing a dedicated fund increases demand. To illustrate the strong demand for hunting elk in Michigan, the agency could double the application fee and raise 95% more application revenue while only losing 2.3% of the applicants. The second essay examines preferences of various visitors to the Michigan elk range by using a discrete choice experiment to assess a preferences and willingness to drive further to experience elk-related attributes. We find that the average visitor to the Michigan elk range has a positive preference associated with experiencing elk-related attributes, but the results indicate significant variation in respondents' preferences. To analyze this variation, visitors are segmented by primary activity. Unsurprisingly, visitors engaging in wildlife-related activities such as wildlife viewing exhibit the strongest preferences associated with experiencing elk related attributes, while those engaging in water-related activities had lower preference for elk viewing attribute. Importantly though, all groups indicated a positive willingness to drive to experience elk-related attributes

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## ABSTRACT

The Northern Lower Peninsula of Michigan supports a reintroduced elk herd of around 1,300 animals. Each year a highly competitive lottery is used to allocate about 260 elk tags to Michigan elk hunters. To analyze demand among elk lottery applicants and explore alternate license pricing and structures, a discrete choice experiment was implemented through a survey of past elk lottery applicants. The choice experiment presents applicants with elk lottery scenarios with varying license and application fees, as well introducing alternate methods for securing funding for conservation purposes, such as setting aside tags to be auctioned for fundraising and steering revenues to a dedicated fund. Across all scenarios, applicants were found to have very inelastic demand for the elk lottery application. Introducing a tag auction and raising the license fee were found to reduce demand, while the introduction of a dedicated fund increased elk lottery demand. Compared to other studies for more common game species, the elk lottery application demand is about 10 times more inelastic. In particular, the findings suggest that the agency could double the application fee and raise 95% more application revenue while only losing 2.3% of the applicants. The results provide a framework for wildlife managers in Michigan to better understand the demand for elk lottery applications and consider alternate methods to secure adequate funding for elk conservation.

## INTRODUCTION

North America's rapid development throughout the 19th and 20th centuries resulted in habitat loss for many species, resulting in population declines of wildlife across the continent (Witmer 1990). In response to the vacancy left by many native species, demand grew for wildlife reintroduction, especially large charismatic mammals (Seddon et al. 2005). Reintroducing native game species is a tool conservationists use to recapture the ecological or recreation benefits that a species brings to an area (Griffith et al. 1989). One such reintroduction took place near Northern Michigan's Pigeon River Country State Forest (PRCSF) and Atlanta State Forest (ASF), where elk have been reintroduced and have existed in a small population for over 100 years (MDNR 2024). The reintroduction of elk to Northern Michigan has created a unique recreation demand in the area for elk hunting and viewing, in addition to recreational activities common on other nearby public lands such as camping and fishing.

Public land managers oversee competing interests of visitors with both consumptive and non-consumptive use values. Examples of consumptive use values include extractive practices such as harvesting timber or hunting elk. Non-consumptive use values include activities such as hiking and wildlife viewing. Protected public lands also provide value through ecosystem services and the non-use value of the existence of the protected land itself along with the flora and fauna it supports (Segerson 2017). Public land managers have an interest in species reintroduction, with evidence that ecological restoration contributes significantly to the economy, generating over $9.5 billion annually (BenDor et al. 2015). Hunting is a key priority of public land managers, with public hunting lands providing over $80 million in economic value to deer hunters in Michigan alone (Knoche & Lupi 2012) as well as generating license revenues for wildlife management. In fact, the largest portion of the Michigan Department of Natural

Resources (DNR) budget is comprised of State Restricted Funds, which are primarily funded through the sale of hunting and fishing licenses. In 2023, State Restricted Funds accounted for $340.4 out of the DNR's total budget of $535 million (MDNR n.d.).

Wildlife are a form of public good, and management institutions have their roots in the "Public Trust Doctrine," which is derived from ancient systems of property rights whereby states were given authority to regulate wildlife and other natural resources held in trust for the public good to ensure the long-term sustainability of these resources (Blumm & Paulson 2013, Jacobson et al. 2010). In North America, a model of game management emerged which sought to democratize game management relative to European systems of the past, where hunting opportunities were primarily afforded to the wealthy (Heffelfinger et al. 2013). The "North American Model" delegates the harvest of game animals to individuals through the sale of licenses, with license sales generating money for wildlife conservation. These licenses are often undervalued relative to what people are willing to pay for a hunt to retain users and prioritize equitable access to licenses.

Wildlife conservation in the United States is funded by a combination of hunting, fishing, and other recreational license sales in addition to Federal funding from excise taxes on firearms and hunting supplies (Crafton 2019, Pang 2024). State game agencies (hereafter, SGA) are funded by hunters and anglers from direct license sales, conservation excise taxes, and voluntary donations (Teisl et al. 1999, Heffelfinger et al. 2013). In 2006, $612 million was generated for SGAs through license sales, $233 million from excise taxes on purchases related to hunting and fishing, and $313 million was donated to conservation efforts across all U.S. state game agencies, totaling $1.2 billion (~$1.8 billion in 2023 dollars[1]) (Heffelfinger et al. 2013). Funding

[1] Federal Reserve Bank of Minneapolis, 2023

from Federal excise taxes was established by the Pittman-Robertson Wildlife Restoration Act, whereby an 11% tax on firearms, archery equipment, and ammunition, and a 10% tax on handgun sales is levied to fund wildlife restoration, conservation grants, hunter education, and administrative fees (Crafton 2019). States may apply to receive these funds in the form of grants for an approved wildlife project with a required match of state funds to federal funds, with $1 in state funds typically generated from license sales being allocated for each $3 in federal funding (Crafton 2019, Pang 2024). Thus, agency management budgets are directly tied to license sales.

License price increases happen relatively infrequently within a state, but SGAs often increase prices to keep up with inflation or to keep license pricing in line with nearby states (Pang 2024). The most recent Michigan elk application fee increase was in March of 2014, enacted by Section 324.43529 of the Michigan Legislature, when the price increased from $4 to $5 (Michigan Legislature, n.d.) Hunting licenses generally have inelastic demand, meaning that license prices can be increased without losing a significant number of applicants (Pang 2024, Sun 2005, Reiling 1980). Pang, 2024 finds a price elasticity of demand of -0.176 for resident hunting licenses and -0.066 for nonresident hunting licenses. Sun, 2005, finds a short-run elasticity of about -0.2 and a long-run elasticity of about -0.3. Reiling, 1980 finds an elasticity of -0.17 for hunting licenses, -0.25 for fishing licenses, and -0.40 for a combined fishing and hunting license. There is evidence that demand for specialty hunting licenses, such as highly competitive draws, may be more inelastic than hunting licenses for deer or other common game animals. An analysis of Michigan's elk draw found an elasticity of -0.00027, indicating that demand for Michigan elk licenses may be considerably more inelastic than other hunting licenses (Link, 2022).

Because licenses are not priced in a market setting, the true demand for hunting and fishing licenses is not known to state game agencies. SGAs have an interest in understanding the true demand surrounding hunting and fishing licenses as well as the factors which influence demand, including license type, license price, and how the agencies manage lottery and license revenue. License prices are typically set by statute, with no variation across consumers of licenses and little variation across time. Without any meaningful price variation, wildlife managers cannot rely on a revealed preference approach to analyzing demand. A stated preference approach using a Discrete Choice Experiment (DCE) can overcome this lack of variation by providing respondents with trade-off scenarios that vary attributes such as price. Respondents' choices among the discrete alternatives reveals their demand and preferences for the attributes. This approach has been utilized in many previous studies including for deer (Reeling et al. 2023, Mackenzie, 1990, Serenari et al. 2019), wild boar (Engelmann et al. 2016), and turkey hunting (Schroeder et al. 2018).

This study will examine the preferences related to the Michigan elk lottery using a choice experiment to determine the demand for elk lottery license types. The variables in the choice experiment include the price of the lottery application, the price of the license upon successfully drawing an elk tag, an allotment number of tags to be auctioned off for fundraising purposes, and whether the money goes into the DNR general fund or a dedicated fund for elk management. The results reveal that across all scenarios, applicants were found to have very inelastic demand for the elk lottery application. Introducing a tag auction and raising the license fee were found to reduce demand, while the introduction of a dedicated fund increased elk lottery demand. Compared to other studies for more common game species, the elk lottery application demand is about 10 times more inelastic. In particular, the findings suggest that the agency could double the application fee and raise 95% more application revenue while only losing 2.3% of the applicants.

## BACKGROUND

Elk are native to Michigan but were extirpated from the state as it developed due to habitat loss and overhunting (Witmer 1990). The last native Eastern Elk was killed in Michigan around 1875 around the same time as the subspecies' extinction (MDNR 2024). Elk were reintroduced to Michigan in 1918, when 7 animals were released near the town of Wolverine in the Northern Lower Peninsula (hereafter, NLP) (MDNR 2024). The first restricted elk hunting season opened shortly thereafter in the 1920's (Popp et al. 2014). The elk population in Michigan grew to between 900 and 1,000 animals by 1958, and the population expanded in the early 1960s to around 1,500 animals (Frawley 2020). Legal harvest of elk was opened in 1964 and 1965 to control the expanding elk population, however the elk herd experienced population swings from loss of habitat and poaching that delayed the annual season until nearly two decades later. (MDNR 2024). An annual elk hunting season opened in 1984 and has continued to this day (Frawley 2020). Today, Michigan has an estimated 1,277 elk (95% CI: 870-1,684 elk) (Stewart 2024).

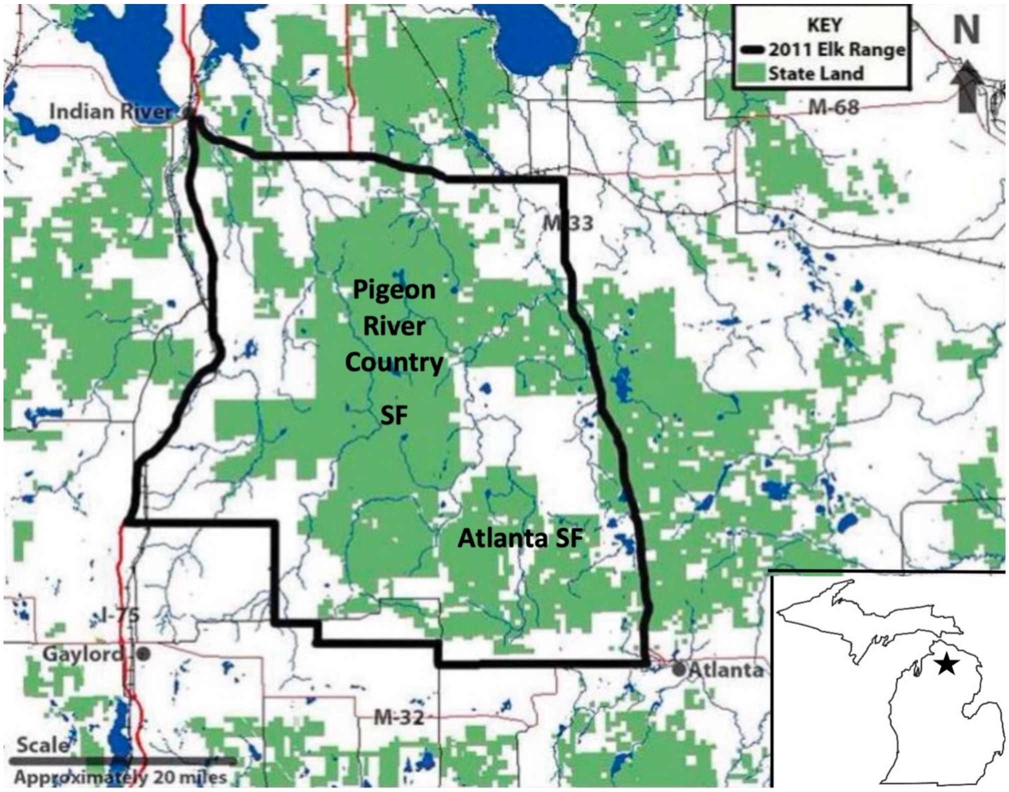


**Figure 1.1:** Michigan Elk Range. Source, Austin Hunt, 2019

The Michigan elk herd occupies areas of the interior NLP, with much of their population residing in the public land areas of PRCSF and ASF. Ten Northern Michigan Counties are included in the region open to elk hunting, with 3 elk management units (EMU's). The 3 EMU's include unit H which includes PRCSF, unit I which includes ASF, and the much larger unit X encompassing the remainder of the 10 counties. Unit X offers an earlier hunting season beginning in late August, while seasons for units H and I open in mid-December (MDNR 2024).

Michigan elk hunters enjoy a high harvest success rate, with about 85% of elk hunters harvesting an elk in 2019 (Frawley 2020). Michigan's elk lottery is highly competitive, with 47,724 applicants competing for 260 tags in 2023. This results in a generalized tag drawing success rate (without regard to preference points) of 0.54% (MDNR 2024). In contrast, Montana had 51,202 first choice applicants for the resident elk draw, and issued 10,651 tags, which results in a generalized tag drawing success rate of 20.80% (MFWP 2023). Many eastern states restrict elk lottery applications to residents only (including Michigan); however, Kentucky, Virginia, and Pennsylvania allow nonresident applications for their elk seasons (See Table 1.1). Some states allow for multiple entries into hunting lotteries. Pennsylvania has 3 elk license types, “Archery,” “General,” and “Late,” and despite awarding successful applicants one license per year, they allow applicants to apply for all 3 elk seasons (Pennsylvania Game Commission n.d.).

SGA’s utilize multiple types of lottery systems to allocate licenses. Simple lotteries award one chance per application equally across all applicants. Weighted chance lotteries benefit those who apply for a hunting lottery over multiple years, giving applicants an opportunity to accumulate “preference points” which give applicants an extra chance in the lottery for each preference point they have. Michigan’s system changed from a simple lottery to a weighted chance lottery in 2005 to accommodate a growing demand for elk licenses. (Frawley, 2020). Michigan residents may apply for an elk license with a $5 application fee. If successfully drawn for an elk license, applicants must purchase a $100 elk license and attend an orientation course prior to hunting. All hunters must carry a base hunting license, which costs $11 for residents, and pass a required hunter safety course prior to the purchase of the base elk license. Tag types cannot be changed after application, and tags can only be transferred to a youth hunter (someone 10-16 years of age) or those with a terminal illness. Applicants are chosen proportional to the number of applicants from three regions, the Upper Peninsula, the Northern Lower Peninsula, and the Southern Lower Peninsula. Successful applicants will receive either an “Any-elk license” or an “Antlerless only” license, with all applicants being eligible for the “Any-elk license,” while those who selected “Bull or Antlerless license” could be selected for the “Antlerless only” license if they are not chosen for an “Any-elk license.” Successful recipients of a Michigan bull elk tag may not apply to another elk lottery in their lifetime, while successful recipients of an antlerless tag have a 10-year waiting period before they are eligible to apply again. Michigan elk hunters have the option of applying for either a “Bull only” license or a “Bull or Antlerless license.” Michigan also conducts a tag raffle, the Pure Michigan Hunt. Contrary to the elk or bear lottery applications, individuals may put in for an unlimited number of entries at $5 each in the Pure Michigan Hunt, and only three winners are chosen each year (MDNR 2024).

**Table 1.1**: Elk application landscape among select Eastern States with elk hunting seasons*

| State | Application Fee (Resident; Nonresident) | License Fee (Resident; (Nonresident) | Approximate Elk Population | Approximate generalized draw odds in 2023 | Lottery structure | Tag Auction | Dedicated fund |
|---|---|---|---|---|---|---|---|
| Michigan | $5<br>n/a | $100<br>n/a | ~1,300 | 0.54% | Weighted chance | No | No |
| Wisconsin | $10<br>n/a | $49<br>n/a | ~500 | 0.037% | Simple chance | No | Yes<br>70% dedicated |
| Minnesota | $5<br>n/a | $288<br>n/a | ~150 | 0.057% | Weighted chance | No | No |
| Kentucky | $10<br>$10 | $100 bull-<br>$60 cow<br>$550 bull-<br>$400 cow | ~10,000 | 0.76% | Simple chance | Yes | Yes |
| Virginia | $15<br>$20 | $40<br>$400 | ~250 | 0.025% | Simple chance | Yes | No |
| Missouri | $10<br>n/a | $50<br>n/a | ~250 | 0.058% | Weighted chance | No | No |
| Pennsylvania | $11.97<br>$11.97 | $25<br>$250 | ~1,300 | 0.25% | Weighted chance | Yes | No |

* See Appendix A for table citations

Managing agency funding is a key aspect of maintaining public trust in wildlife managers. Some agency funds are put into a general pool of agency funding, while other funds may be earmarked for a certain purpose. The latter type of fund is called a dedicated fund, which ensures that money raised from certain license sales go to a specific purpose. Dedicated funds are often used to secure broad funding sources for conservation efforts through sales taxes, excise taxes, and lottery funds (McKinney et al. 2005). A common form of securing dedicated funding is through sales of wildlife stamps, with a successful example being the federal duck stamp. All waterfowl hunters in the U.S. are required to purchase the federal duck stamp at a price of $25 in 2019, and it has raised over $850 million over the duration of the program with over 98% of funds being used to protect waterfowl habitat (Ufer et al. 2022). Despite some cases of political backlash to dedicated funding initiatives (McKinney et al. 2005), successful dedicated funding streams may be popular among those engaging with a natural resource since they communicate plainly to users of a resource that they are supporting the continued management of that resource.

Some states have also used alternate methods to raise funding for conservation, such as setting aside several tags to be auctioned off to the highest bidder. Colorado has authorized auctioning or raffling 18 tags annually across several game species according to Colorado Revised Statute (C.R.S.) 33-4-116. This program uses raffle funds for habitat improvement, research, and education. Tags are raffled through conservation organizations such as the Rocky Mountain Bighorn Society, The Rocky Mountain Elk Foundation, the Mule Deer Federation, and organizations are permitted to keep 25% of proceeds, while 75% of proceeds must be paid to the Colorado Parks and Wildlife Agency. In 2021, the Colorado Auction and Raffle Program generated $1 million to go toward wildlife conservation in Colorado (Colorado Parks and Wildlife n.d.). Virginia reintroduced 75 elk between 2012-2014, and the herd has since grown to 250 animals. In 2022, Virginia offered 5 tags in a lottery application which drew over 30,000 applicants, as well as a 6$^{th}$ tag given to the Rocky Mountain Elk Foundation to be auctioned for fundraising. The lottery generated $513,000 for the Virginia Department of Wildlife Resources, and the auctioned tag was purchased for $90,000, with funds required to be used for conservation purposes within the elk management zone centered in Buchanan County, Virginia (Gabriel 2022). Kentucky's elk reintroduction is regarded as one of the most successful of any state to attempt an elk reintroduction, in part because of the massive scale of the reintroduction relative to other states' reintroduction campaigns. Between 1997 and 2002, 1,541 elk were transported to 16 Kentucky counties from 6 Western donor states. The elk population has grown to an estimated

10,000 animals as of 2018 (Kentucky Department of Fish and Wildlife Resources 2024). In 2015, Kentucky hunters had the opportunity to apply for 1 of 900 licenses through the state's lottery, which received about 70,000 applications. Kentucky utilizes several tag types for fundraising purposes and to incentivize landowners to allow hunting on private land. The state apportions 10 either-sex elk permits to be given to conservation non-profits for auctioning according to statute KRS 150.177, with funds mandated to go toward conservation purposes. A landowner will receive one either-sex tag which may be transferred or sold for each 5,000 acres of private land enrolled in a public hunting agreement with the Kentucky Department of Fish and Wildlife Resources (Kentucky Department of Fish & Wildlife Resources 2016). The Aurora Land Group has Kentucky elk tags listed for sale at $7,000 each (Aurora Recreation n.d.). Thus, lottery tags and dedicated funds are a potential program attributes that can be explored for Michigan's elk hunting program.

## SURVEY AND CHOICE EXPERIMENT

A survey utilizing a discrete choice experiment was implemented to investigate demand for alternate elk lottery systems, pricing, and funding management options. The survey was sent to 28,228 email addresses of people who purchased an elk lottery application or a "chance only" application in 2019. This number is less than the annual lottery application numbers because not all applicants had valid email addresses and duplicates were dropped. The survey was launched July 25, 2024, and two reminder emails were sent in the following weeks. A total of 6,247 hunters completed at least one choice experiment questions for an effective response rate of 25.6%. The survey collects information on hunting in Michigan and other states, Michigan elk lottery application history, perceived lottery chances, preference points, and it includes the choice experiment, a section of attitudinal questions related to hunting, and demographic questions.

To develop and evaluate the survey, draft survey questions were reviewed by several wildlife managers in Michigan. Then, following best practices for stated preference survey development (Johnston et al. 2017; Kaplowitz et al. 2004), a focus group was conducted on April 1, 2024 with 4 hunters who had experience elk hunting in western states to test the survey's reception among respondents who are familiar with the subject matter. In this interview, the 4 hunters completed the survey until they had finished the choice experiment, paused for questions and probes to ascertain their understanding of the choice experiment, then resumed the survey until they were finished. The focus group results indicated all 4 elk hunters demonstrated comprehension of the lottery structure, the choice experiment attributes, and the choice questions.

In the survey, respondents were presented with 6 elk lottery choice experiment questions and given four response options representing the real application options faced by elk lottery applicants (see Figure 1.2). These options included “Apply for a Bull only license,” “Apply for a Bull or Antlerless License,” “Apply for chance only,” and “I would no longer apply.” Before the discrete choice experiment, respondents were presented with a table showing the current landscape of fees related to the elk lottery application. As shown in Figure 1.2 and Table 1.2, the attributes of the choice experiment included the total number of tags available in the Michigan elk lottery in 2023, when 260 tags were available to Michigan elk hunters. For scenarios where some of the tags were to be auctioned off, the number of total tags available would be 260 minus the number of tags to be auctioned. The lottery application system requires a base hunting license, so this attribute, which never varied across choice sets, was presented as a reminder of all costs associated with a successful elk draw in Michigan. The elk license fee, or “elk receipt,” is shown as the cost of an elk license if successfully drawn in the elk lottery. The variable “Money goes to” is a binary dummy variable for whether license money goes to the Michigan DNR’s General Game and Fish Fund, as in the current system, or a dedicated fund for Elk Conservation.

**Scenario 1**

- 260 elk tags available for lottery
- Base hunting license: $11 (discounted for seniors and youth hunters)
- Lottery application fee: $20
- Elk license fee (if drawn): $200
- Number of tags to be auctioned for fundraising, available to the highest bidder: 0
- Money goes to a dedicated fund for Elk Conservation

Under this elk application scenario, what would you do?

○ Apply for a Bull only license

○ Apply for a Bull or Antlerless license

○ Apply for chance only

○ I would no longer apply

**Figure 1.2:** Example Choice Experiment Question

Attribute levels for the scenarios in the choice experiment were chosen to be realistic based on the current prices of elk licenses and application fees with reasonable fee increases based on other states' elk lottery application and license fees. Levels were chosen with input from the Michigan DNR to ensure scenarios were kept realistic. All level changes corresponding to fees were increases in relation to the current system, in part reflecting Michigan's low elk application fees relative to other states (see Table 1.1), as well as knowing Michigan elk hunters are likely price inelastic regarding elk hunting fees (Link 2022). To create the scenarios, attributes were combined using the experimental design software NGene, a program which creates alternatives within choice experiments with given constraints to increase the statistical efficiency of the combinations (Choice Metrics 2018). For the tags to be auctioned attribute, a constraint was placed on the design to reduce the number times the larger values occurred in the design to enhance realism since the current system does not allow auctioning of tags.

**Table 1.2:** Choice Experiment Levels

| Attributes | Levels |
|---|---|
| Tags available for lottery | 260 – (number of tags to be auctioned) |
| Base hunting license ($)* | 11 |
| Lottery Application Fee ($) | {5, 10, 15, 20, 25} |
| Elk License Fee ($) | {100, 200, 300} |
| Number of tags to be auctioned | {0, 2, 5, 10, 20} |
| Money goes to: | {The General Game and Fish Fund, |
| | A dedicated fund for Elk Conservation} |

* Note: The base hunting license does not vary across choice scenarios.

## EMPIRICAL MODEL

The empirical modeling of the elk lottery application choices follows the Random Utility Model approach proposed by Daniel McFadden (1974) to analyze discrete choices. Within this framework, an analyst has incomplete information over a respondents' choices, and hence utility is comprised of both observed and unobserved portions. Holmes et al. (2017) describes this relationship as:

$$V_{ik} = v_{ik}(X_k, y_i - f_k) + \varepsilon_{ik} \tag{1}$$

where $V$ represents the indirect utility for individual $i$ choosing alternative $k$, $f_k$ is the price of alternative $k$, and $X$ is a vector of attributes for alternative $k$, and $y_i$ represents the income of individual $i$. The observed portion of indirect utility is represented by $v$, and $\varepsilon$ corresponds to the unobserved portion. Equation 1 can be rewritten as the following linear function:

$$V_{ik} = \beta_0 + \beta X_k + \lambda(y_i - f_k) + \varepsilon_{ik} \tag{2}$$

The linear utility function is comprised of marginal utilities for each attribute (i.e., preference parameters), $\beta$, and the marginal utility of income, $\lambda$. The error term ($\varepsilon$) represents the unobserved attributes of alternatives or the person that affect indirect utility.

The utility for each alternative $j$ is

$$V_j = \alpha_j Z_i + \varepsilon_{ik} \tag{3}$$

where $Z$ is a vector of demographic characteristics for each individual $i$, and $\alpha$ represents the coefficient on vector $Z$.

The probability of individual $i$ choosing alternative $k$ over all other alternatives ($j$) is given by the following function:

$$P_{ik} = Prob\left[V_{ik} > V_{ij}\right] \; for \; all \; j \tag{4}$$

Our baseline empirical model to analyze the choice experiment in this survey will employ a conditional logit model, a standard approach to estimating preferences between alternatives without heterogeneity. A conditional logit model can be used to estimate respondents' preferences, yielding results of parameter estimates at a point (β).[2]The choice probabilities for the alternatives in a conditional logit model are given by the following function.

$$P_{ik} = \frac{exp(\beta X_k + a_k Z_i)}{\Sigma_{j \in c} exp(\beta X_j + a_k Z_i)} \tag{5}$$

In the above function, individual $i$ may choose alternative $k$ over alternatives $j \in c$, where $c$ represents the choice set of available alternatives.

Price elasticity of demand is a measure of how changes in price affect demand. It is calculated as follows:

$$e_f = \frac{\partial P_{ik}}{\partial f} \times \frac{f}{P_{ik}} \tag{6}$$

where $e_f$ denotes own-price elasticity of demand, representing the percentage change in quantity demanded for a percentage change in the price of the good, $f$ represents the price of an application, and $P_{ik}$ represents the probability of applying to the lottery. When absolute value of own-price elasticity is between zero and 1, a good is said to be inelastic, indicating that consumers of a good are more likely to continue purchasing a product if the price changes, whereas an elasticity greater than 1 indicates more responsiveness to price changes. Inelastic demand for elk lottery applications means that even though increases to application fees will increase revenues even though some applicants will stop applying for a license, whereas with elastic demand an increase in price will reduce revenues because the drop in applicants offsets any revenue gains due to the higher price.

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[2] Time permitting, more advanced models that allow for preference heterogeneity will be estimated.

**RESULTS**

Table 1.3 shows the results from the conditional logit estimation. The conditional logit estimates describe elk lottery applicant preferences for each of the lottery attributes (the first four variables in Table 1.3) as well as the effect of demographic variables on the lottery choices. The demographic variables are interacted with each of the three application types and are shown in Table 1.3 after the four lottery attributes. All lottery attribute parameters were significant at the 0.01 level. As expected, the attributes for application fee, license fee, and tags to be auctioned had negative parameters, indicating an aversion to increases in these attributes. The coefficient on application fee had a higher negative value than that of license fee, indicating that respondents will be more likely to forego applying for the elk lottery if the application fee increases by a dollar than if the license fee increases by a dollar. This follows intuitively since all surveyed applicants were required to pay the $5 application fee, whereas only about 260 applicants each year must pay the $100 application fee. The results suggest the implementation of a tag auction for fundraising in Michigan will lower demand for elk lottery applications. There is a positive coefficient associated with implementing a dedicated fund for elk management, showing that this form of conservation fund management may be popular among elk lottery applicants.

To explain the effect of each variable on the probability of a license application, the marginal effects were calculated and are presented in the last two columns of Table 1.3. For the four program attributes (application fee, license fee, tags to be auctioned, and dedicated fund), the marginal effects are for the probability of *any* application rather than for one of the three types of applications because the way the program works the attributes must be the same for each of the three application types, which must be accounted for when deriving the marginal effects. The results show that the marginal effect of a 1 dollar increase in application fee results reduces the probability of an application by about 0.004. A 1 dollar increase in license fee had a smaller marginal effect on the probability of applying, reducing it by about 0.0001 (i.e., a 100 dollar increase in license fee would reduce the chance of applying by about 0.01 percentage point). Each additional tag to be auctioned was projected to reduce the application probability by about 0.004. It is estimated that the usage of a dedicated fund would increase likelihood of application by about 0.006 percentage points.

Income had a small but significant marginal effect on applicants' application choices with the exception of a chance only application. As income increases, applicants will be more likely to apply for a bull only license and less likely to apply for a bull or antlerless license or to opt out from purchasing a license. The average income of the sample is $113,437. In general, if an applicant's income increases by $1,000, their application probability increases by about 0.0006 for a bull only license and decreases by about 0.0002 for a bull or antlerless license.

Younger applicants were more likely to apply for a bull only license or a chance only, while older applicants favored applying for a bull or antlerless license, which has a higher draw likelihood. The average applicant in this sample is 56 years of age. For each year older applicants are, their likelihood of application decreases by about 0.007 for a bull only license, increases by about 0.006 for a bull or antlerless license, and decreases by about 0.0005 for a chance only license. Within the survey sample of elk lottery applicants, 96% of respondents were male. Male applicants favored purchasing a bull only license, while female applicants were more inclined to apply for a bull or antlerless license. If an applicant is a male, their likelihood of applying for a bull only license increases by 0.086, decreases by 0.116 for a bull or antlerless license, and decreases by about 0.01 for a chance only license (though the latter effect was not significantly different than zero).

Applicants who had more preference points, which corresponds to a greater chance of being drawn across all license types, were more likely to apply for a bull only license than the other alternatives. The average number of preference points in the sample is about 13, meaning the average survey respondent has been applying for about 13 years. For each additional preference point applicants had, their likelihood of applying increases by about 0.013 for a bull only license, decreases by about 0.009 for a bull or antlerless license, and decreases by about 0.0033 for a chance only. The variable hunt importance is based on a self-reported level of how important hunting was in relation to an applicant's other recreational activities. A self-reported hunt importance of "2" corresponds to hunting being the most important recreational activity relative to an applicant's other recreation activities. The average value for hunt importance in the sample is 1.4, meaning that many applicants list hunting as an important recreational activity relative to their other activities. Respondents who indicated that hunting was more important in relation to their other activities were more likely to apply for a bull only license (an increase in application probability of about 0.03) and less likely to apply for the other alternatives, though this effect was not significant for the bull or antlerless application. About 38% of the sample had engaged in elk hunting in other states, primarily states located in the Rocky Mountain West such as Wyoming, Colorado, and Montana. Applicants who engaged in out of state hunting were more likely to apply for a bull only license, and less likely to apply for the other license alternatives. If an applicant had hunted elk in other states, their likelihood of application is projected to increase by about 0.09 for a bull only license, decrease by about 0.04 for a bull or antlerless license, and decrease by about 0.01 for a chance only application.

**Table 1.3**: Conditional Logit Results with interaction terms

| Attribute | Estimated coefficients | Standard Error | Marginal Effect | Standard Error |
|---|---|---|---|---|
| Application fee | -0.0516*** | (0.00191) | -0.00385*** | (0.000158) |
| License fee | -0.00156*** | (0.00172) | -0.000114*** | (0.0000116) |
| Tags to be auctioned | -0.0560*** | (0.00221) | -0.00418*** | (0.000181) |
| Dedicated fund=1 | 0.0896*** | (0.0230) | 0.00629*** | (0.00163) |
| Interactions with "bull only" option | | | | |
| Income (1,000s) | 0.00443*** | (0.000423) | 0.000644*** | (0.000088) |
| Age | -0.0254*** | (0.00242) | -0.00687*** | (0.000541) |
| Sex (male=1) | -0.0295 | (0.172) | 0.0862*** | (0.0330) |
| Preference points | 0.0349*** | (0.00524) | 0.0127*** | (0.00115) |
| Hunt importance | 0.151*** | (0.0441) | 0.0295*** | (0.00873) |
| Out state hunting | 0.511*** | (0.0636) | 0.0925*** | (0.0136) |
| Constant | 2.398*** | (0.225) | | |
| Interactions with "bull or antlerless" option | | | | |
| Income (1,000s) | 0.00219*** | (0.000460) | -0.00022** | (0.000096) |
| Age | 0.00743*** | (0.00260) | 0.00626*** | (0.000595) |
| Sex (male=1) | -0.548*** | (0.157) | -0.116*** | (0.0320) |
| Preference points | -0.0205*** | (0.00542) | -0.00930*** | (0.00119) |
| Hunt importance | 0.0549 | (0.0452) | -0.00738 | (0.00916) |
| Out state hunting | 0.182*** | (0.0675) | -0.0441*** | (0.0142) |
| Constant | 1.826*** | (0.226) | | |
| Interactions with "chance only" option | | | | |
| Income (1,000s) | 0.00249*** | (0.000937) | -0.0000075 | (0.000032) |
| Age | -0.0192*** | (0.00530) | -0.000461** | (0.000193) |
| Sex (male=1) | -0.601** | (0.275) | -0.0114 | (0.00878) |
| Preference points | -0.0863*** | (0.0108) | -0.00327*** | (0.000783) |
| Hunt importance | -0.220*** | (0.0836) | -0.0110*** | (0.00326) |
| Out state hunting | -0.00825 | (0.162) | -0.00965* | (0.00516) |
| Constant | 2.0628*** | (0.393) | | |
| N=6,247 respondents with 34,039 choice observations | | | | |

*** p<0.01, ** p<0.05, * p<0.1

While the marginal effects of each attribute are helpful for understanding demand, we can also use the results to simulate demand under various scenarios. To predict application demand, the expected probability of a lottery applicant selecting each license alternative is calculated using Equation 5. When these probabilities are summed, they represent the probability applicants that will choose to purchase an elk lottery application. In other words, using the estimated models we can predict demand for elk lottery applications as a function of the lottery attributes (application prices, license fee, auction tags, and whether the money goes to a dedicated fund). Through this method, we can model the expected probability of applying for an elk license under any possible combination of the attributes. For illustration purposes four different possible elk lottery scenarios will be examined each for 5 different application fee levels. The base scenario represents the attributes of Michigan's current elk lottery structure, but for the application fee. The second scenario involves introducing a tag auction of 10 tags, reducing the overall lottery quota from 260 to 250 tags. The level of 10 tags was chosen to be equal to the number of auction tags apportioned in Kentucky (Kentucky Department of Fish and Wildlife Resources n.d.). The third scenario involves raising the elk license fee, which is only paid upon successfully being drawn for an elk license, to $300. While some states' elk licenses may be listed for more than $300, the change in the license fee in this scenario is kept lower to reflect a realistic possible change from Michigan's low elk license fee of $100. In the fourth scenario, a dedicated fund for elk conservation is introduced while the license fee is kept at $100.

**Table 1.4**: Elk lottery scenarios used illustrate results of the application demand model

| | License fee | Auction tags | Dedicated fund |
|---|---|---|---|
| Scenario 1 | $100 | 0 | No |
| Scenario 2 | $100 | 10 | No |
| Scenario 3 | $300 | 0 | No |
| Scenario 4 | $100 | 0 | Yes |

Figure 1.3 plots the predicted demand curves (i.e., the relationships between application purchases and application prices) for two scenarios with the greatest difference in demand, scenarios 1 and 2. Demand curve 1 represents demand for elk lottery applications in the current system at different application fee levels (i.e., license fee is $100, no auction tags, no dedicated fund). Demand curve 2 in Figure 1.3 shows how demand shifts to the left when a tag auction is introduced with 10 tags allocated for auction. Demand curve 2 indicates that fewer people will apply for the elk lottery at all application fee levels. A line is shown at the current price point of $5 as a baseline for comparison between demand at the current application fee.

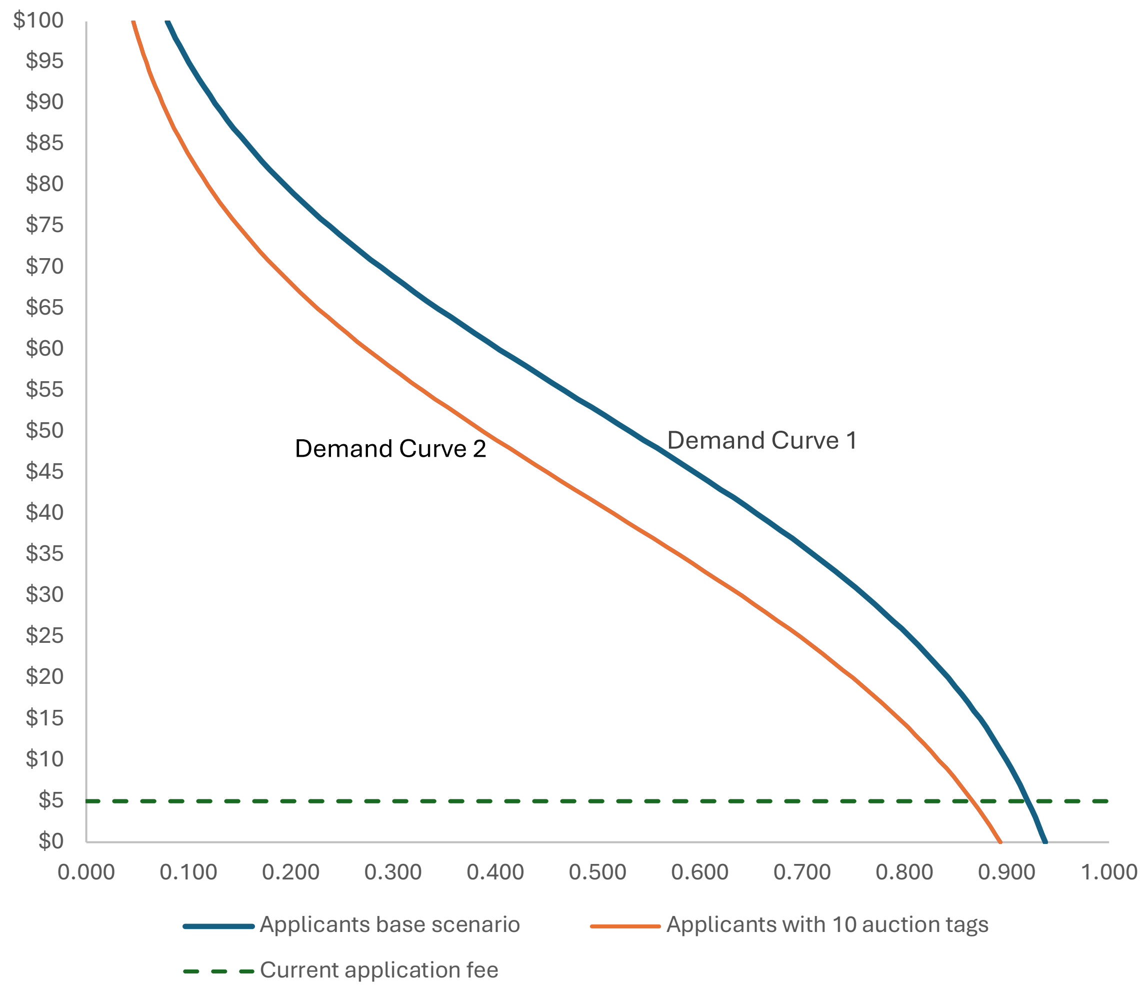


**Figure 1.3**: Predicted demand curves for base scenario vs when auction tags are increased to 10

In Figure 1.3, the steep demand curve around the current price of $5 indicates that demand for elk lottery applications is more inelastic at lower application fee levels. Demand generally becomes more elastic as the price increases, meaning that proportionally more applicants forego applying as the application fee increases. To further examine elasticity, point elasticities are calculated at different application fee levels given in the choice experiment (Table 1.5). In the base scenario at an application fee of $5 (reflecting the current lottery system), applicants have an own-price elasticity of about -0.02, indicating that for a 1% increase in application price, 0.02% of applicants will forego applying for an elk license, i.e., demand is inelastic. The point elasticity is more inelastic in Scenario 4, where the implementation of a dedicated fund was seen as positive and overall application demand increased. Likewise, demand was projected to become more elastic in Scenarios 2 and 3, with respondents being averse to the implementation of a tag auction, and to a lesser extent, an increase in the elk license fee. Across all scenarios, demand becomes more elastic as the application fee increases, yet remain inelastic at all fee levels.

**Table 1.5:** Point elasticities at varying application fee levels across different elk lottery scenarios

| Application fee | Scenario 1 Base scenario | Scenario 2 Auction tags=10 | Scenario 3 License Fee=$300 | Scenario 4 Dedicated fund=1 |
|---|---|---|---|---|
| $5 | -0.0205 | -0.0344 | -0.0277 | -0.0192 |
| $10 | -0.0517 | -0.0858 | -0.0695 | -0.0487 |
| $15 | -0.0976 | -0.159 | -0.130 | -0.092 |
| $20 | -0.162 | -0.259 | -0.213 | -0.153 |
| $25 | -0.251 | -0.390 | -0.326 | -0.238 |

Using the scenarios from Table 1.4, the estimated number of people who would continue to apply for an elk license at different application fee levels are shown in Table 1.6. These estimates are derived by using equation (5) to compute the expected probability of applying under each scenario's attributes (i.e., the $X_j$'s for each scenario) along with the conditional logit coefficient estimates in Table 1.3 (i.e., the $\beta$'s) and the demographic interactions evaluates at the means (i.e., the $a_k\overline{Z_\iota}$'s). The estimated probabilities are multiplied by the population of lottery applicants and calibrated to replicate the total applicants in 2023. The predicted revenue generated under each scenario is presented in Table 1.7 and is computed by multiplying the estimated applicants by the application fee and adding money generated from elk license sales.

Table 1.6 indicates an ability to increase application fees across all scenarios without losing significant numbers of applicants. This is unsurprising given that hunting licenses are typically sold below market value to ensure equitable access. The implications of the inelastic demand can be illustrated by comparing demand and revenue for the current application program to a doubling of the application price from $5 to $10. In this case, applications fall from 47,724 applications to 46,636, and the application fee portion of revenues almost doubles (i.e., that application revenues go from 47,724×$5=$238,620 to 46,636×$10=$466,360). Thus, doubling the current application fee leads to about 2.3% fewer applicants but increases application revenues by 95% due to the inelastic application demand.

For the other scenarios examined, the greatest loss in applicants is seen in Scenario 2 across all application fee levels. This loss of applicants corresponds to a loss in revenue from the demand reduction that occurs when allocating tags to a lottery (see Table 1.7). From these estimates we can calculate that if application fees remain at $5, each of the 10 auction tags must sell for at least $1,404 to make up for the loss in lottery revenue. Given the higher elasticities at higher application fee levels, if a tag auction were to be implemented in addition to increasing the application fee to $25, each tag would have to sell at auction for at least $13,895 to make up for the lost revenue.

By comparing scenario 3 to scenario 1, we can weigh the ability to generate revenue through changes in license fee or changes to application fee. Increasing the license fee to $300 yields a similar loss of applicants as raising the application fee to $10 in the scenario 1, but the combined revenue generated from increasing the application fee far outpaces revenue gains from changes to the license fee because the $5 application fee was paid by each of the 47,724 applicants in 2023, but the license fee is only paid by the 260 applicants who successfully draw an elk tag. Increasing the application fee to $10 under the base scenario will retain more applicants overall compared to increasing the license fee to $300, while yielding an additional $183,000 in combined revenue. In scenario 4, we see that implementing a dedicated fund for elk management may translate into higher applications overall to the lottery and corresponds to higher revenues across all prices compared to the base scenario.

**Table 1.6**: Estimated total applicants under different elk lottery scenarios at different application fee levels

| Application fee | Scenario 1 Base scenario | Scenario 2 Auction tags=10 | Scenario 3 License fee=$300 | Scenario 4 Dedicated fund=1 |
|---|---|---|---|---|
| $5 | 47,724 | 44,916 | 46,272 | 47,973 |
| $10 | 46,636 | 43,218 | 44,856 | 46,945 |
| $15 | 45,299 | 41,202 | 43,146 | 45,677 |
| $20 | 43,679 | 38,855 | 41,117 | 44,134 |
| $25 | 41,745 | 36,187 | 38,758 | 42,285 |

**Table 1.7**: Estimated revenues from applications and licenses under different elk lottery scenarios at different application fee levels

| Application fee | Scenario 1 Base scenario | Scenario 2 Auction tags=10 | Scenario 3 License fee=$300 | Scenario 4 Dedicated fund=1 |
|---|---|---|---|---|
| $5 | $264,620 | $250,579 | $309,360 | $265,866 |
| $10 | $492,361 | $458,179 | $526,556 | $495,446 |
| $15 | $705,491 | $644,026 | $725,186 | $711,152 |
| $20 | $899,573 | $803,103 | $900,337 | $908,676 |
| $25 | $1,069,629 | $930,678 | $1,046,938 | $1,083,118 |

## CONCLUSION

Elk hunting in Michigan is rationed using a lottery system. This essay examines the demand for the elk hunting by estimating the demand for elk lottery applications. One challenge for demand modelling is that lottery application and license fees are administratively set and rarely change over time, which means there is no variation in prices. We overcome this obstacle by using stated preference questions and a population of real applicants to model the probability of applying for various licenses.

The results of this demand analysis show remarkably inelastic demand for elk lottery applications. Demand was found to be about 10 times more inelastic than literature for general hunting licenses (Pang 2024, Reiling 1980, Sun 2005), likely due to the scarcity of elk hunting compared to other forms of hunting. This analysis found that demand was more elastic than the Link, 2022 study, perhaps due to a difference in methods and the increased range of prices enabled by stated preference methods. These results indicate that elk application fees may be increased without losing many applicants and indicate that fewer applicants may be lost relative to price increases for general hunting licenses. Despite some variation between scenarios in this analysis, all scenarios indicate inelastic demand. In particular, the results suggest that if application fees were doubled, application revenues would almost double—increasing by just over 95% while retaining 97.7% of elk lottery applicants.

This study indicates there is a greater capacity to increase license revenue through an increase in application fee rather than an increase in license fee. The results indicate fewer applications will be received if a tag auction is implemented in Michigan. The reduction in participation after implementing a tag auction provides a framework to weigh the benefits of increased funding against a potential loss in hunter participation. The capacity to generate revenue from auction tags is likely greater than the difference in lottery revenue, with auctioned elk tags in other states selling from $7,000 to $90,000 (Aurora Recreation n.d., Gabriel 2022), although open-ended comments to the survey indicated the presence of a subset of hunters adamantly opposed to auctioning any tags. Despite instances of public disapproval for the implementation of dedicated funds for conservation (McKinney et al. 2005), our projections of applications received in Scenario 4 show support for a dedicated fund for elk conservation in Michigan.

Hunting license sales are an essential revenue source for wildlife management via the "user pays" approach under the North American Model of wildlife management (Heffelfinger et al. 2013). Wildlife managers face a dilemma of maintaining low fees to retain hunters and ensure equitable access to hunting licenses, while generating adequate funding for conservation purposes. Michigan's elk application and license fees are relatively low compared to other eastern states with an elk season, and other states have explored alternate conservation funding mechanisms. The findings from this study provide a framework for wildlife managers to explore increased revenue sources to fund elk conservation and management in Michigan.

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APPENDIX A: TABLE 1.1 CITATIONS

| | |
|---|---|
| Michigan | Michigan Department of Natural Resources. (2024). *Elk hunting digest*. Retrieved from https://www.michigan.gov/-/media/Project/Websites/dnr/Documents/LED/digests/Elk_Hunting_Digest.pdf?rev=8a773775c7894525ab767588fd13ea5b |
| Wisconsin | Rocky Mountain Elk Foundation. (2023). *Report: Wisconsin elk herd to top 500 in 2023*. Retrieved July 21, 2024, from https://www.rmef.org/elk-network/report-wisconsin-elk-herd-to-top-500-in-2023/<br><br>WXPR. (2021). *Getting involved in Wisconsin's elk management plan.* Retrieved July 21, 2024, from https://www.wxpr.org/natural-resources/2021-01-11/getting-involved-in-wisconsins-elk-management-plan<br><br>Outdoor News. (2024). *Wisconsin DNR to allow elk hunt in central herd, Jackson County for the first time in 2024, as well as northern*. Retrieved July 21, 2024, from https://www.jsonline.com/story/sports/outdoors/2024/04/13/wisconsin-dnr-allow-elk-hunt-central-herd-jackson-county-first-time-2024-as-well-as-northern/73301475007/<br><br>Wisconsin Department of Natural Resources. (n.d.). *Elk hunting*. Retrieved July 21, 2024, from https://dnr.wisconsin.gov/topic/hunt/elkhunting |
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| Virginia | Rocky Mountain Elk Foundation. (2024). *Application period closes March 30 for 2024 Virginia elk hunt*. Retrieved July 21, 2024, from https://www.rmef.org/elk-network/application-period-closes-march-30-for-2024-virginia-elk-hunt/#:~:text=General%20%7C%20February%208%2C%202024&text=Applications%20require%20a%20nonrefundable%20fee,out%2Dof%2Dstate%20residents |
| Missouri | Rocky Mountain Elk Foundation. (2022). *Five elk permits available for 2022 Missouri elk hunt.* Retrieved July 21, 2024, from https://www.rmef.org/elk-network/five-elk-permits-available-for-2022-missouri-elk-hunt/ |

| | |
|---|---|
| Pennsylvania | Rocky Mountain Elk Foundation. (2023). *2023 Pennsylvania elk hunting season is a record setter*. Retrieved July 21, 2024, from https://rmef.org/elk-network/2023-pennsylvania-elk-hunting-season-is-a-record-setter/#:~:text=General%20%7C%20September%2029%2C%202023&text=%E2%80%9CWe%20had%20over%2057%2C000%20people,a%20great%20season%20so%20far.%E2%80%9D<br><br>Pennsylvania Game Commission. (2024). *Digest 2024-25*. Retrieved July 24, 2024, from https://www.pgc.pa.gov/HuntTrap/Law/Documents/Digest%202024-25%20low%20res.pdf |

APPENDIX B: AVERAGE VALUES OF INTERACTION TERMS

**Table 1.8:** Average values of demographic variables used as interaction terms in the model

| Variable | Mean |
|---|---|
| Income ($) | 113,437 |
| Age (years) | 55.97 |
| Male | 0.96 |
| Preference Points | 12.98 |
| Hunt Importance | 1.39 |
| Out of State Hunting | 0.39 |

# CHAPTER 2: EVALUATING VISITOR PREFERENCES IN THE MICHIGAN ELK RANGE[3]


## ABSTRACT

The interior Northern Lower Peninsula of Michigan is popular for a variety of outdoor recreation activities, including activities related to the area's elk herd. This essay analyzes the preferences of visitors to the Michigan elk range for experiencing elk-related attributes through a discrete choice experiment. Visitors were intercepted on-site and then in a follow-up survey were asked to choose between two hypothetical recreation sites which varied in driving distance and likelihood of experiencing four elk-related attributes. We find that the average visitor has a positive preference for experiencing elk-related attributes, but we also find significant variation in preference across visitors. To analyze this variation, visitors were segmented based on primary activity. Visitors engaging in activities related to wildlife had the highest preference for seeing and hearing elk, while those engaging in water-related activities had the lowest preference for seeing or hearing elk. Despite this variation in preference, all groups had positive willingness to drive estimates for each elk-related attribute.


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[3] This essay extends the choice experiment and questions developed by Hunt (2019) by collecting additional survey data and estimating updated preference models. This essay also extends Hunt (2019) by adding supplemental regressions to explain preference heterogeneity via demographics and visitor activities.

## INTRODUCTION

Humans enjoy a variety of benefits from protected natural areas, including value gained through the harvest of wild game and plant species as well as benefits to the local ecosystem through ecosystem services (Balmford et al. 2002). Although attempts have been made to value ecosystem services from natural areas (Balmford et al. 2002, Costanza et al. 1997), this value can be difficult to quantify given the non-market nature of these natural resources. Natural areas that are being protected for purposes of wildlife conservation, especially large, charismatic species or colorful species, can create significant demand for traveling to protected land (Lindsay et al. 2007, Everett 1978). Those engaging in outdoor recreation may have different preferences related to the wildlife they are viewing, such as size, color, or their calls (Everett 1978). As such, wildlife are valued by recreationists for different reasons, necessitating a focus not only on each species but the qualities of these species that recreationists value and variation in preferences across user groups. Therefore, the ability to understand visitor preferences for attributes of wildlife across differing recreational activities can provide insights into wildlife management.

In this chapter, I estimate preferences of visitors to the Michigan elk range. This study is unique in its approach by estimating the preferences that visitors have for several elk-related attributes. The study location is notable in that it is an area where elk have been reintroduced, with conservation of elk being a key priority of public land managers. Due to the unique presence of charismatic megafauna with few nearby substitutes, visitors to this area across a variety of outdoor recreation activities enjoy wildlife viewing in addition to their primary recreation activity. The range of different activities that occur within the elk range raise the potential for user-group conflicts if some user groups are adversely affected by elk. This presents a unique case to study wildlife preferences across a variety of recreationists.

This study is part of an ongoing effort to estimate visitor preferences related to outdoor recreation and wildlife viewing in Pigeon River Country State Forest in Michigan. This approach to understand elk-related preferences was first developed by Austin Hunt (2019) and is expanded upon here through additional intercept and follow-up surveys to extend and enrich the data. The follow-up survey used a choice experiment to collect visitor preferences for elk-related attributes of recreation sites. In the choice experiment, two alternative recreation sites were described by the chances of experiencing elk-related attributes and driving time. The elk attributes include the chances of seeing one elk, hearing an elk bugle, seeing a bull elk, and seeing 10 or more elk. Respondent choices reveal their preferences and willingness to trade driving time for each attribute.

Finds reveal that the average visitor has a positive preference for experiencing elk-related attributes, but the findings also demonstrate that there is significant variation in preference across visitors. Visitors engaging in activities related to wildlife (e.g., viewing) had the highest preference for seeing and hearing elk, while those engaging in water-related activities (e.g. swimming) had the lowest preference for seeing or hearing elk. Despite this variation in preference, all groups had positive preferences for elk in the study area, suggesting that there is some common ground among these groups that can help managers set goals for the area and the elk herd.

**BACKGROUND**

North America experienced rapid economic and population growth throughout the $19^{th}$ and $20^{th}$ centuries. During this expansion, many natural areas were converted into agricultural or residential land. Habitat loss and overhunting resulted in many areas of North America losing big game species (Witmer 1998). Elk (*Cervus elaphus canadensis*) were one such species that experienced a vast reduction in its historic range. At the time of the first European settlement of North America, there were an estimated 10 million elk in the continent (U.S. Forest Service n.d.). The elk population then took a precipitous decline, with two of the six elk subspecies, the Eastern and Merriam's elk, becoming extinct in the late $19^{th}$ century (Di Silvestro 2013). The presence of these game animals supported unregulated market hunting industries, which contributed to the species' population decline (Witmer 1998). In the vacuum left by massive population declines, demand grew for reintroduction of game animals. These animals were de-facto prioritized for reintroduction according to their worth to humans, which resulted in animals most sought after for hunting such as elk being among the first with reintroduction efforts.

The reintroduction of both deer and elk to their historic ranges was successful and populations rapidly expanded due to many native predators such as wolves being driven to extirpation, along with conservative hunting practices implemented by state game agencies (Witmer 1998). Despite successful reintroduction efforts for both deer and elk at the beginning of the $20^{th}$ century, white-tailed deer expanded to inhabit suburban and agricultural areas and became widespread throughout much of the continent, whereas elk remained more isolated to wilderness areas. This created the present isolated nature of elk populations in the eastern states, with many herds in eastern states centered in remote areas, creating a unique recreation demand with few nearby substitutes for wildlife viewing (Popp et al. 2014). As a result of this reintroduction, unique recreation demand has been created from elk hunting, viewing, and other outdoor recreational activities in and around areas of elk reintroduction.

Michigan was home to one of the first reintroductions of wild elk east of the Mississippi River following the extinction of its native subspecies, the Eastern Elk, in the late 19$^{th}$ century. In 1918, a herd of the Rocky Mountain Elk subspecies was released near the town of Wolverine, Michigan. This herd expanded rapidly and now inhabits the semi-wilderness area known as Pigeon River Country State Forest (PRCSF) in the Northern Lower Peninsula of Michigan, along with Atlanta State Forest (ASF) and much of the surrounding land in the Northern Lower Peninsula. Despite elk having been present in Michigan for over 100 years, they are still confined to a small portion of their historic range. Concerns such as crop damage and disease have kept the state from prioritizing elk expansion outside of their current range (MDNR 2022). In the 1964-65 hunting season, the Michigan DNR determined that the population of elk had reached 1500 animals and elk hunting in Michigan resumed after a nearly 100-year respite of legal elk harvest. The latest survey of elk populations in January of 2022 found there to be around 1,277 animals, with a 95% confidence interval between 870 and 1684 animals. (Stewart 2024).

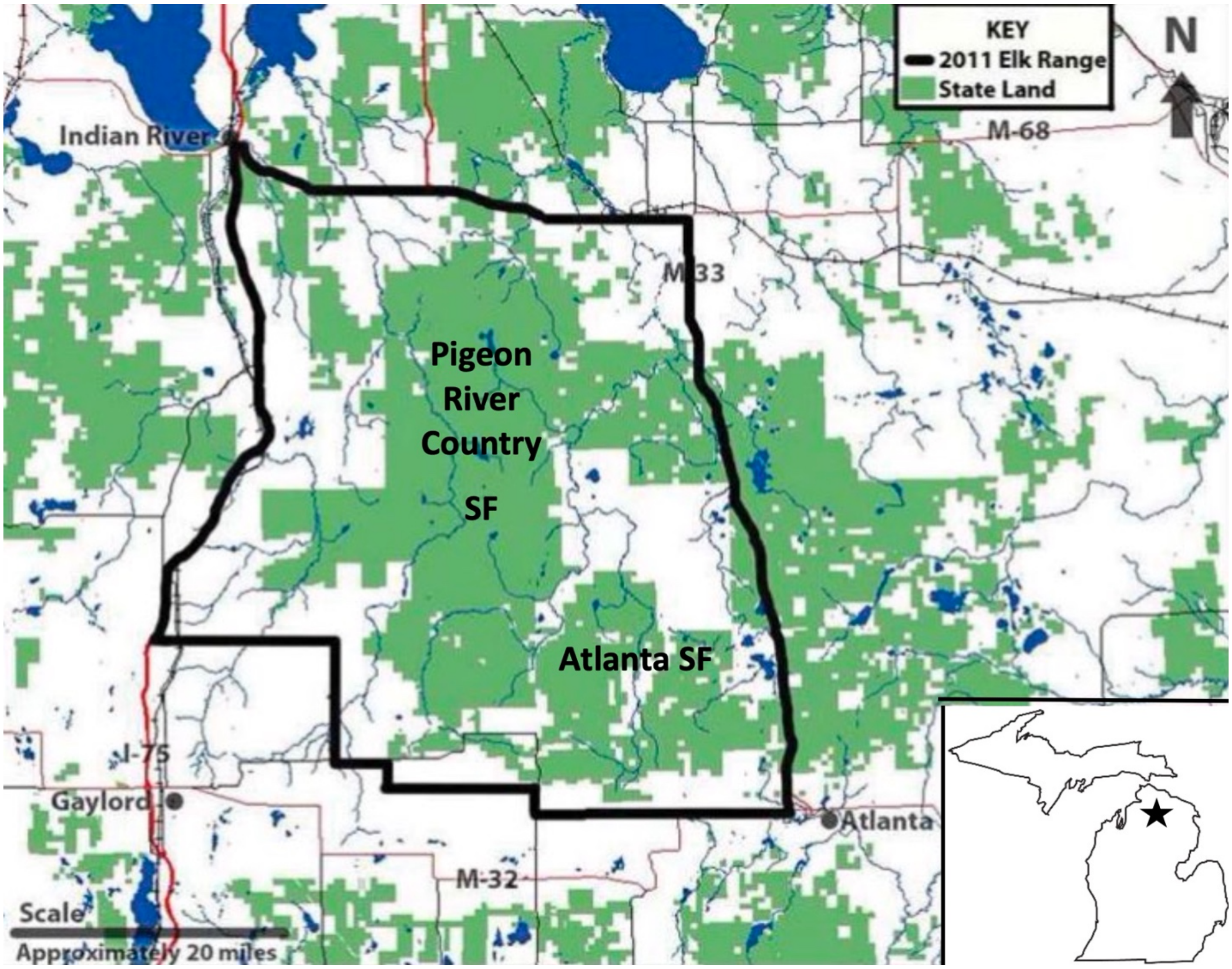


**Figure 2.1:** Michigan Elk Range. Source, Austin Hunt, 2019

PRCSF and ASF are similar given their proximity and in that they both contain public land and elk viewing sites. PRCSF maintains regulations centered on reducing human/elk conflict, such as limiting off-road vehicle access to trails, a popular recreational activity in Michigan which is legal on public land throughout ASF and many other public lands in Michigan. PRCSF maintains more restrictive regulations compared to ASF to mitigate human-wildlife conflict to keep recreation from disrupting the elk population and to "Keep it wild." The DNR maintains campgrounds in PRCSF which were included in the survey route. Visitors travel to both areas to participate in recreational activities such as hiking, backpacking, mountain biking, wildlife viewing, camping, fishing, hunting, mushroom hunting/foraging, and off-roading/driving for pleasure (Pigeon River Discovery Center n.d.).

Understanding preferences related to outdoor recreation has implications on the management of natural areas. The Experience Based Management Framework (EBM) was developed by Manfredo et al. (2002) to evaluate preferences of people engaging in outdoor recreation. The EBM framework describes recreational enjoyment of visitors to natural areas as dependent on visitor activity, setting preference, and the activities and experience that visitors engage in. Visitors' enjoyment is informed by the latter category as the "outcomes" of their experience as they relate to their initial "desired psychological outcomes." Everett (1978) evaluated preferences of wildlife viewing across all species in the Dalby Forest in the UK, finding a high preference for large, charismatic megafauna such as deer. Everett (1978) also found a higher preference for colorful birds or more common birds that respondents were knowledgeable about. Lindsey et al. (2007) noted preference differences across different demographic groups of visitors to South African protected lands, and they found that non-local tourists had higher preferences for charismatic megafauna while locals had higher preference for smaller animals, birds, and plants.

Several studies have used revealed preference methods to quantify the value that elk bring to an area of protected land. Chapagain & Poudyal (2022) estimated a travel cost model of elk viewing in the reintroduced Tennessee elk herd, which found a total consumer surplus for elk viewing of $53 per household per trip. Donovan and Champ (2009) used a single site travel cost model to estimate a mean per day consumer surplus of $138 ($200.68 in 2023) (U.S. Bureau of Labor Statistics (BLS) 2023) per elk viewer per trip in the Jewell Meadows in Oregon. Shafer et al. (1993) estimated the consumer surplus that elk viewers receive from viewing the reintroduced elk herd in central Pennsylvania, finding a consumer surplus of $20.43 ($43.99 in 2023) (U.S. Bureau of Labor Statistics (BLS) 2023) for elk viewers in Pennsylvania. Although these studies establish the value of elk viewing, they do not provide information about the relative preferences for attributes of elk herds or about differences in preferences across user groups. This essay addresses this gap in the literature.

## SURVEY AND DATA

Visitor data were collected from a survey[4] of visitors to Pigeon River Country State Forest (PRCSF) and Atlanta State Forest (ASF). This survey was comprised of two segments, an on-site intercept survey and an online follow-up survey across two time periods, with visitor intercept surveying taking place in 2018 and 2021.[5] Compared to surveying the general population, finding visitors using on-site interviews is useful for this analysis because only a small percentage of the Michigan population utilizes the area.

On-site interview procedures sought to randomly intercept visitors. When a group of multiple people were encountered, the person with the most recent birthday was chosen to randomize the respondent selection, and the interview was conducted on a tablet using Qualtrics software. When a vehicle was encountered without a person nearby, an envelope was left on the windshield. The envelope contained (1) a paper copy of the intercept survey (See Appendix C), (2) a map of the area with the elk viewing sites listed for reference, (3) a survey consent form and (4) an envelope with a return address and a prepaid stamp. The survey intercept interviews conducted by the author took place between July 7th and August 25, 2021. The intercepts were conducted on a rotational basis, with 4 days of surveying followed by 4 days off during the summer between July and August 2021. In the fall 2021, additional surveying was conducted over 3-day periods over the weekends of September 24-26, and October 1-3, 2021.

The intercept interviews collected e-mail addresses for a more in-depth follow-up survey. The follow-up survey contained the choice experiment questions (which did not depend on the intercepted trip) and was administered in the summer of 2023. The data collected by the author

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[4] The MSU Institutional Review Board (IRB) reviewed and approved all study procedures related to conducting surveys on human subjects.

[5] The 2018 intercept interviews were conducted by Austin Hunt (Hunt 2019) and the 2021 intercept interviews conducted by the author.

are combined with data collected by Austin Hunt (2019). Hunt's intercept interviews took place between June 7th and September 1st, 2018, with fall surveying dates between September 9th and November 3rd. Compared to 2021 efforts, the timing of the 2018 survey efforts better captures popular hunting seasons in the area (See Table 2.1). Although this study was designed to be repeated in 2020, due to COVID-19 the MSU IRB paused the interviewing due to safety concerns given the close contact, in-person nature of the intercept surveys. In this essay, data across the two time periods are combined.

Survey responses were collected from public land areas in the Michigan elk range where visitors have broad access to elk viewing and outdoor recreation opportunities. Most interactions with respondents were in areas with considerable recreational demand, such as campgrounds, rivers, lakes, trailheads, and the DNR's 13 maintained elk viewing sites between the two State Forests (MDNR 2019). Most of these elk viewing areas are accessible by vehicle, however some have more restricted access and are accessible by hiking in only. As such, survey routes were designed to balance the chance of encountering a person engaging in outdoor recreation and visiting the remote areas of the over 100,000 acre state forest areas. The survey routes took place on a rotational basis as well, with a static morning and afternoon route, accompanied by a 3-day rotational evening route. The three rotational routes were labeled "evening north," "evening south," and "campgrounds." By having rotations of both surveying days and a different rotation of driving routes, survey sites were randomized to allow accessing sites at different days of the week yet still cover the vast area. The evening north route was comprised of more remote areas, whereas the evening south route covered multiple elk viewing sites in ASF that are popular and have a high likelihood of encountering elk in the evening. The campground route visited each campground, which is where the highest density of respondents was encountered. Since elk are crepuscular, many visitors would frequent the elk viewing sites at sunset for the best chance of elk viewing. Survey routes began at 7AM and went until sunset, which in summertime is around 10 PM.

**Table 2.1:** Descriptive Statistics of demographic and activity variables by year*

| | 2021-2023 data | | 2018-2019 data | | Combined data | |
|---|---|---|---|---|---|---|
| | Observations | Mean | Observations | Mean | Observations | Mean |
| Education (in years) | 119 | 15.94 (2.29) | 309 | 15.49 (2.29) | 428 | 15.62 (2.30) |
| Age (years) | 119 | 52.03 (15.01) | 309 | 51.94 (13.90) | 428 | 51.96 (14.20) |
| Income (in $1000's) | 115 | 103.91 (61.45) | 309 | 88.97 (49.81) | 424 | 93.02 (53.55) |
| Male=1 | 119 | 0.60 (0.49) | 309 | 0.70 (0.46) | 428 | 0.67 (0.47) |
| Path | 120 | 0.29 (0.46) | 309 | 0.21 (0.41) | 429 | 0.23 (0.42) |
| Water | 120 | 0.28 (0.45) | 309 | 0.23 (0.42) | 429 | 0.24 (0.43) |
| Hunting | 120 | 0.02 (0.14) | 309 | 0.18 (0.39) | 429 | 0.14 (0.34) |
| Camp | 120 | 0.25 (0.43) | 309 | 0.23 (0.42) | 429 | 0.24 (0.42) |
| Wildlife | 120 | 0.17 (0.37) | 309 | 0.15 (0.36) | 429 | 0.16 (0.36) |

*Standard deviations appear below each mean

## CHOICE EXPERIMENT

As mentioned above, the role elk play in visitation was elicited using a choice experiment technique that involves trade-offs. The choice experiment is designed to elicit future visitation behaviors of those recreating in Michigan. Respondents were asked to choose between two state forest areas for the primary activity given in the intercept survey. The two sites differed in their attributes which included driving distance and four elk-related attributes: chances of seeing one elk, chances of hearing an elk bugle, chances of seeing a bull elk, and chances of seeing 10 or more elk (see Figure 2.2). A difference between the 2018 and 2021 data is that bugling was not included in the second wave choice experiment. Bugling was statistically well-identified in the 2018 data (Hunt 2019), so it was not included in the subsequent effort to improve the statistical efficiency of estimating demand for the other elk-related attributes. Bugling is notable from the other attributes in that it doesn't require seeing an elk, therefore it has different characteristics for visitors of the state forest compared with the other attributes.

| | **Area A** | **Area B** |
|---|---|---|
| **Recreation Features** | campgrounds, hiking/biking trails, equestrian trails, and places for hunting, fishing, and morel hunting | campgrounds, hiking/biking trails, equestrian trails, and places for hunting, fishing, and morel hunting |
| **Elk Range** | **Inside Elk Range**<br>**25%** chance of seeing at least one elk<br>**20%** chance of hearing an elk bugle<br>**10%** chance of seeing a bull (male) elk<br>**10%** chance of seeing 10 or more elk | **Inside Elk Range**<br>**40%** chance of seeing at least one elk<br>**35%** chance of hearing an elk bugle<br>**15%** chance of seeing a bull (male) elk<br>**20%** chance of seeing 10 or more elk |
| **Additional Driving Time Beyond Area A** | **0** additional minutes | **120** additional minutes |

**Figure 2.2:** Example of choice experiment

Respondents were presented with 8 sets of choice experiments in the follow-up survey. The first question is a choice between visiting one of two state forest areas or neither. The areas were destinations the respondent would consider visiting in future recreational trips to the Michigan Elk Range. The choice question consisted of two columns, with an alternative area A (left-hand side), an alternative area B (right-hand side), and an option to not go to either site (None). The right-hand side area alternative (B) was designed to have higher elk attribute levels, but be a further drive, in addition to the respondent's driving time from home.

The attribute levels in Table 2.1 were chosen to be realistic for the actual likelihood that visitors to the Michigan elk range might expect to experience each elk attribute. In this regard, the upper bound of the chance of seeing a single elk is higher than that of either seeing a bull or seeing 10 or more elk. The distance between levels, although designed to be reasonable and accurate to the real elk-viewing experience, were chosen in part to maximize the distance between the upper and lower bounds for efficiency in statistical estimation. The driving time levels were chosen as reasonable trips that elk-viewers might take within the Michigan elk range, with an upper bound of 120 minutes, or two hours. The upper bound of two hours was chosen because the Michigan elk range is generally not big enough to go on trips greater than two hours and still be within the elk range.

**Table 2.2:** Elk attribute levels

| Attribute | Levels |
|---|---|
| See one elk | {0, 1, 15, 20, 25, 30, 45, 60} % chance |
| Hear elk bugle | {0, 5, 10, 20, 25, 50} % chance |
| See bull elk | {0, 1, 5, 10, 15, 20, 50, 55} % chance |
| See 10 or more elk | {0, 1, 5, 10, 15, 20, 50, 55} % chance |
| Additional one-way driving time | {15, 30, 60, 90, 120} one-way driving time (minutes) |

Attribute combinations within and across the alternatives were set through the experimental design software NGene, which creates alternatives for respondents to choose from to improve the statistical efficiency of the design given certain constraints (Choice Metrics 2018). To account for uncertainty in the priors about preferences, a Bayesian design was used with priors derived from Hunt (2019). For the pairings of alternatives within the experimental design, constraints were implemented to ensure the combinations were realistic (see Appendix B). For example, it would not make sense to have a 10% chance of seeing an elk yet have a 30% chance of seeing 10 elk.

## EMPIRICAL MODEL

The Random Utility Model proposed by Daniel McFadden (1974) is used to model the respondent's choices. The approach posits that individuals make decisions that maximize their utility. An analyst of these decisions does not have a full view into each individual's choice between alternatives, which necessitates a utility function comprised of both observed and unobserved portions. This relationship is outlined as:

$$V_{ij} = \beta X_j + \varepsilon_{ij} \tag{1}$$

where $V_{ij}$ corresponds to the indirect utility of individual *i* receives from alternative *j*. This linear function is comprised of preference parameters, $\beta$, for each attribute describing alternative *j* and *X* representing a vector of attributes of alternative *j*. The error term ($\varepsilon$) represents unobserved attributes of the alternatives and the individual.

In addition to the elk attributes, the selected alternative "none", i.e., $k$=0, represents not visiting areas A or B, which does not have any travel time or elk attributes. Thus, the utility for alternative $k$=0 is

$$V_0 = \alpha Z_i + \varepsilon_{ik} \tag{2}$$

where $Z_i$ is a vector of attributes for each individual *i,* and $\alpha$ represents the coefficient on vector *Z*. The probability of each individual *i* choosing alternative *k* over all other alternatives *j* is given by the function:

$$P_{ik} = Prob[V_{ik} > V_{ij}]\ for\ all\ j \tag{3}$$

To estimate respondents' preferences three models are employed: a conditional logit without demographics, a conditional logit with demographics, and a mixed logit. These three models are employed to analyze respondent preferences to capture preferences with and without preference heterogeneity. Specifically, the second conditional logit introduces heterogeneity in a limited way by adding demographic variables to explain heterogeneity in preferences for the no trip alternative, while the third model, mixed logit, adds a very general form of preference heterogeneity.

The conditional logit estimation will yield results with parameter estimates at a point (β). The choice probabilities for each alternative in conditional logit is given by:

$$P_{ik} = \frac{exp(\beta X_k)}{\Sigma_{j \in c} exp(\beta X_j)} \tag{4}$$

where $P_{ik}$ gives the probability individual *i* selects alternative *k* from alternate choices $j \in c$, where *c* represents a choice set of alternatives. The base conditional logit does not capture any heterogeneity unless demographic variables are specifically interacted with the attributes or the alternatives.

As a generalization of conditional logit, mixed logit provides estimates of the mean β and the distribution of these preferences across the population. This allows the mixed logit model to be a flexible model which can account for variability in preference within the population (McFadden & Train 2000). The mixed logit estimation is modeled as the integral of the above conditional logit function over the distribution of preferences represented by *f(β):*

$$P_{ik} = \int \left( \frac{exp(\beta X_k)}{\Sigma_{j \in c} exp(\beta X_j)} \right) f(\beta) d(\beta) \tag{5}$$

While the mixed logit provides information about the mean and distribution of preferences for each attribute, it does not directly characterize what types of respondents hold different preferences. However, since each respondent makes a sequence of choices, it is possible to obtain individual $\beta$ estimates that can be regressed back on individual demographic variables to provide insights into the distribution of preferences (Revelt & Train 2000). To accomplish this, Bayes theorem is used to provide a conditional expectation of a respondent's preferences ($\beta$) across a density distribution ($\beta|\theta$),

$$h(\beta|\, y_r, X_r, \theta) = \frac{P(y_r\,|X_r,\beta)\cdot g(\beta|\theta)}{P(y_r\,|X_r,\theta)} \tag{6}$$

where $P(y_r|\, X_r, \beta)$ represents the probability of a respondent making the sequence of observed choices $y_r$ when facing the sequence of attributes levels $X_r$ given their expected preferences $\beta$, and g($\beta|\theta$) represents the population distribution. The denominator, $P(y_r\,|X_r, \theta)$ represents the probability of the sequence of observed choices given $\theta$, the population distribution of the preference parameters.

The above function (equation 6) is used to derive the expected preference parameter $\beta^r$ for each individual's observed choices in the face of the attributes they were given. These individual preference parameters can then be regressed on the variables we know about each respondent (the 4 demographic variables and 4 activity groups), as shown below:

$$\beta^r = \alpha + \delta_{age} + \delta_{male} + \delta_{education} + \delta_{income} + \delta_{path} + \delta_{wildlife} + \delta_{hunt} + \delta_{water} + \varepsilon \tag{7}$$

The regressions use demographic characteristics of the individual visitors and indicator variables for the activity the individual engaged in on their intercept trip. The activity group "camp," indicating that respondents were engaged in the activities "camping," "picnicking," or "family gatherings" was chosen to be the base variable since these activities are common among visitors to the Michigan elk range. By regressing each respondent's individual $\beta^r$ conditional on above observable regressors, we can estimate an individual's posterior preference parameter to understand the variability of preferences surrounding each mean estimate of the elk attributes.

To understand the preferences for the different attributes, it is convenient to express them as trade-offs between attributes. A common approach for expressing the trade-offs is to compute the Marginal Rate of Substitution (MRS), which shows the trade-offs between attributes that leave utility unchanged (i.e., the trade-offs between attributes where a respondent is indifferent). The MRS is calculated as:

$$MRS_{1,2} = \frac{\partial V/\partial x_2}{\partial V/\partial x_1} = -\left(\frac{\beta_2}{\beta_1}\right) \tag{8}$$

For example, the MRS of each elk attribute and driving time compares the mean $\beta$ estimate of each elk attribute over the mean $\beta$ for driving time. This allows for the relative comparison between each attribute with regard to the respondent's willingness to drive (WTD), i.e., the maximum additional minutes a visitor would drive for a change in an attribute.

## RESULTS

Table 2.3 displays parameter estimates across the three models, the conditional logits models 1 and 2 and the mixed logit. The conditional logit model 1 shows the parameter estimates from each elk related attribute without demographic variables in the model. Model 2 presents results of the conditional logit model that includes the following additional variables: “Outside Elk Range” (a variable indicating that the choice experiment referred to an area that had a 0% chance of experiencing any elk-related attribute), one-way driving time from a visitor’s home to PRCSF, and three demographic variables for male, education, and income. In this estimation, the alternative “None,” meaning respondents would choose neither area, was interacted with the demographic variables. The parameter estimate for the no trip constant, “none,” is significant and negative which follows intuitively since this alternative was not commonly chosen by respondents. The interactions in Model 2 between “none” and demographic variables did not yield any significant estimates, which suggests this simple way of introducing heterogeneity does not improve upon Model 1. The variable “additional one-way driving time” was significant in all 3 models, indicating that all else equal visitors are averse to increased driving time. The conditional logit model output shows that “See one elk” and “Hear elk bugle”[6] had significant parameter estimates, with “See bull” significant at the 10% level. “See 10 or more elk” did not yield significant parameter estimates in the conditional logits. The estimates displayed in Table 2.3 indicate the average visitor to the Michigan elk range has positive preferences for experiencing elk-related attributes, with the highest degree of significance found in the attributes “see one elk” and “hear elk bugle.” This is not surprising given the feasibility constraints in the

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[6] Discrete choice models are identified off the differences in attributes across alternatives in the choice experiment. Even though the attribute “Hear elk bugle” was not included in the 2021 data, it can be entered in the model with the pooled data since all the differences across alternatives in the 2021 data are zero but the differences in the 2018 data are nonzero. Thus it is as if the bugling attribute was the same across both alternatives in the 2021 data.

survey design, which stipulated that the chance of encountering a bull elk or seeing 10 or more elk must be less than that of seeing one elk. Therefore, the preference parameters for “see bull” and “see 10 or more elk” can be interpreted in addition to each model’s parameter for “see one elk.”

**Table 2.3:** Conditional and mixed logit results with standard errors below each estimated parameter, combined 2018-2023 data, PRCSF and ASF

| | Conditional Logits | | Mixed Logit | | |
|---|---|---|---|---|---|
| Attribute | Model 1 | Model 2 | Mean | S.D. | % with Parameter >0 |
| See one elk | 0.0301*** | 0.0297*** | 0.0460*** | 0.0390*** | 88% |
| | 0.00387 | 0.00389 | 0.00671 | 0.0101 | |
| Hear elk bugle | 0.0208*** | 0.0206*** | 0.0293*** | 0.0489*** | 73% |
| | 0.00519 | 0.00519 | 0.00831 | 0.0161 | |
| See bull elk | 0.00504* | 0.00508* | 0.0122** | 0.0165 | 100% |
| | 0.00305 | 0.00307 | 0.00597 | 0.0135 | |
| See 10 or more elk | 0.00357 | 0.00257 | 0.00505 | 0.0618*** | 53% |
| | 0.00378 | 0.00378 | 0.00759 | 0.0190 | |
| Additional one-way driving time | -0.0148*** | -0.0145*** | -0.0274*** | | |
| | 0.00181 | 0.00183 | 0.00234 | | |
| Outside Elk Range | 0.589*** | 0.549*** | -0.349 | | |
| | 0.209 | 0.209 | 0.224 | | |
| None (opt-out dummy) | -2.257*** | -3.290* | -2.792*** | | |
| | 0.269 | 1.988 | 0.213 | | |
| Driving time from home to PRCSF | | -0.000698 | | | |
| | | 0.00111 | | | |
| Male | | 0.555 | | | |
| | | 0.460 | | | |
| Education | | 0.0566 | | | |
| | | 0.112 | | | |
| Income | | -0.00156 | | | |
| | | 0.00672 | | | |
| Observed choices | 1872 | 1824 | | 1872 | |
| Respondents | 428 | 422 | | 428 | |

*** p<0.01, ** p<0.05, * p<0.1, Standard errors appear below each estimate

The mixed logit estimates display both the average preference and the heterogeneity of preferences across visitors to the elk range through the estimated standard deviations of the mean preferences. The standard deviations in a mixed logit model describe the heterogeneity of visitor preferences, with the standard errors of the standard deviations describing the certainty of the distribution of preferences. The average preference for "see one elk" and "hear elk bugle" were found to be significant at the 1% level, while "see bull" was significant at the 5% level. Three attributes, see one elk, see 10 or more elk, and hear an elk bugle, had a high degree of heterogeneity of preference as indicated by the significant estimated standard deviations. The results in table 2.3 indicate that 88% of respondents had a positive preference associated with the attribute "see one elk", with only 12% of respondents falling into the negative part of the preference distribution. The attribute "See 10 or more elk" had the highest variation in preference, with the standard deviation being over 10 times that of the mean estimate. This attribute also had the smallest percent parameter greater than zero, meaning that 53% of respondents indicate that they prefer seeing 10 or more elk, while 47% have a negative preference associated with this attribute, which likely explains why this attribute was not significant in the conditional logits that ignore this heterogeneity. It is notable that seeing a bull elk did not have a significant standard deviation, indicating homogenous preferences. With a significant positive preference parameter in the mixed logit model for "see bull," we can interpret the homogenous preference for "see bull" as being 100% positive. The attribute "hear elk bugle" had a standard deviation over 1.5 times the mean estimate, with 73% of respondents having a positive preference for elk bugling.  The variable "Outside elk range" was significant in the conditional logit but not significant in the mixed logit. It should be noted that while the term "negative preference" is used to describe preferences in relation to the overall preference distribution, it may not suggest that visitors are averse to seeing elk. This mixed logit model assumes a normal mixing distribution with infinite support, which may imply that someone has infinitely negative preferences for experiencing an elk-related attribute. It may be that this lack of preference reflects indifference rather than aversion to elk, but that cannot be determined with the normally distributed preferences that were estimated in the mixed logit model.

The significant standard deviations between three of the four elk-related attributes in the mixed logit indicates that there is a distribution of preferences among individual visitors to the Michigan elk range for each significant elk-related attribute. The mixed logit estimates only suggest at this distribution, but to understand if any observable characteristics of respondents explain the heterogeneity of visitor preference for each elk attribute, we use the mixlbeta command in Stata18 from the mixlogit package (Hole 2007) to estimate the individual posterior preference parameter for each respondent conditional on their choices (see equation 7). Specifically, the estimated preference parameters are regressed on 4 demographic variables (age, male, education, and income) as well as 4 activity categories (path, wildlife, hunt, water, which are interpreted relative to the omitted base case of camp).

Table 2.4 displays the results of the secondary regression of each visitor's posterior preference parameters from the mixed logit on the demographic and activity group variables. Demographic variables were not significant predictors of preference heterogeneity for any elk-related attributes. Some of the activity categories do significantly explain preference heterogeneity. As displayed in Table 2.4, the two activity groups that display significant estimates explaining heterogeneity are the "wildlife" and "water" activities. The "wildlife" category is a group comprised of those who indicated that their primary activities were "viewing elk," "viewing wildlife," "viewing or photographing wildlife or scenery," and "mushroom picking" on the date they were intercepted. Activities in this category are ones which involve visitors being dispersed, off-trail, or close to wildlife. Those engaging in water activities indicated their primary activities were "swimming or wading in water," "kayaking, canoeing, or boating," or "fishing." Respondents who engaged in water activities had negative preference parameters relative to the camp activity when the individual mixed logit estimates were regressed on demographic and activity variables, as seen in Table 2.4. This might be because recreationists engaging in water activities such as swimming, boating, and fishing may travel to the elk range for a specific recreational activity further removed from viewing wildlife.

In Table 2.5, each regression is used to predict the average group's posterior preference parameter using equation 7 evaluated at the sample average for the demographic variables. This regression yields mixed logit posterior preference parameters conditional on the average of the demographic variables for each activity group relative to the base term "camp." The negative parameters indicate those in the "water" activity group have a preference less than those in the "camp" activity group but does not necessarily imply that the groups preference is net negative, as shown below. These estimates illuminate the net effect on each group's average preference for the select attributes.  Table 2.5 shows that those engaging in both "path" and "hunt" activities had posterior preference parameters similar to the general average preference in the mixed logit estimates. Unsurprisingly, respondents that fall into the "wildlife" category had the highest posterior preference for each elk related attribute, and notably had markedly higher estimates for the attributes "see 10 or more elk" and "hear elk bugle" relative to the other activity group estimates. Those engaging in "water" activities had the lowest posterior preference parameters across all elk-related attributes, including a negative value for "see 10 or more elk." The large variation across activity groups in the posterior preference parameters for "see 10 or more elk" indicates that heterogeneity of preference for seeing a herd of elk may be explained by the activities visitors engage in.

**Table 2.4:** Individual-level Mixed Logit preference estimates regressed on demographic and activity variables

| Variables | See one elk | Hear elk bugle | See bull elk | See 10 or more elk |
|---|---|---|---|---|
| **Age** | 4.88E-05 | 0.000121 | 2.54E-05 | 0.000147 |
| | 0.000107 | 0.000121 | 4.56E-05 | 0.000178 |
| **Male** | 0.00214 | 0.00247 | 0.000920 | 0.00366 |
| | 0.00329 | 0.00375 | 0.00141 | 0.00550 |
| **Education** | -0.000260 | -0.000514 | -0.000115 | -0.000620 |
| | 0.000685 | 0.000780 | 0.000293 | 0.00115 |
| **Income** | -1.41E-06 | -3.11E-06 | -6.76E-07 | -3.18E-06 |
| | 2.95E-05 | 3.36E-05 | 1.26E-05 | 4.93E-05 |
| **Path** | -0.00339 | -0.00474 | -0.00140 | -0.00624 |
| | 0.00435 | 0.00495 | 0.00186 | 0.00727 |
| **Wildlife** | 0.0135*** | 0.0159*** | 0.00581*** | 0.0233*** |
| | 0.00494 | 0.00562 | 0.00211 | 0.00825 |
| **Hunt** | -0.00328 | -0.00445 | -0.00144 | -0.00604 |
| | 0.00514 | 0.00585 | 0.00220 | 0.00859 |
| **Water** | -0.0133*** | -0.0132*** | -0.00561*** | -0.0207*** |
| | 0.00435 | 0.00495 | 0.00186 | 0.00727 |
| **Constant** | 0.0489*** | 0.0322** | 0.0132*** | 0.00883 |
| | 0.0119 | 0.0136 | 0.00509 | 0.0199 |
| **Observations** | 423 | 423 | 423 | 423 |
| **R-squared** | 0.073 | 0.073 | 0.073 | 0.074 |

*** p<0.01, ** p<0.05, * p<0.1; Standard errors appear below each estimate

**Table 2.5:** Mean individual-level mixed logit parameters by activity group (coefficient plus constant)

| | See one elk | Hear elk bugle | See bull elk | See 10 or more elk |
|---|---|---|---|---|
| Wildlife* | 0.0622 | 0.0477 | 0.0191 | 0.0323 |
| Water* | 0.0353 | 0.0186 | 0.0077 | -0.0117 |
| Path | 0.0453 | 0.0271 | 0.0119 | 0.0027 |
| Hunt | 0.0454 | 0.0274 | 0.0118 | 0.0029 |
| Camp | 0.0487 | 0.0318 | 0.0132 | 0.0089 |

*Activity groups with significant parameters (see Table 2.4)

To illuminate the trade-offs implied by the preferences, willingness to drive (WTD) estimates are calculated using the MRS approach with changes in driving time as the cost that respondents incur for the ability to experience changes elk-related attributes (equation 8). As noted above, the attributes “see 10 or more elk” and “see bull elk” are interpreted by adding their coefficients to the coefficient on “see one elk,” because respondents cannot experience these attributes without also experiencing seeing one elk. The attribute “hear elk bugle” is interpreted as it is, since it is not dependent on seeing an elk to hear a bugle.

As shown in Table 2.6, the WTD estimates from conditional logit models 1 and 2 yield similar results, showing that interacting demographic variables with the “none” alternative does not substantially change the estimates of how far respondents are willing to drive for each elk-related attribute. For both of these models, the WTD is around 2 for the attribute see one elk, meaning that respondents are willing to drive about 2 additional minutes for a 1% chance increase in seeing one elk. Put another way, respondents will drive about an additional 20 minutes for a 10% greater chance of seeing one elk, 14 minutes for a 10% chance increase of hearing an elk bugle, about 24 minutes for a 10% increased chance of seeing a bull elk, and about 22 minutes for a 10% increased chance of seeing 10 or more elk.

The mixed logit WTD estimates, which account for the underlying heterogeneity in visitor preferences, indicates a sample average willingness to drive an additional 16.8 minutes for a 10% increased chance of seeing one elk, 10.7 minutes for a 10% increased chance of hearing an elk bugle, about 21 minutes to see a bull elk, and 18.6 minutes for a 10% increased chance of seeing 10 or more elk. It should be noted that the attribute "see bull" was significant at the 5% level in the mixed logit estimates (see table 2.3), while "see 10 or more elk" was not significant. These results indicate that respondents are willing to incur a cost in order to experience elk-related attributes on average and are willing to drive further to experience seeing a bull elk. The mixed logit WTD estimates are lower on average than those of the conditional logit models due to the higher coefficient on "one-way driving distance" and because they account for heterogeneity in the attribute preferences, as shown in Table 2.3.

**Table 2.6:** Mean Willingness to Drive (WTD) estimates for conditional and mixed logit models (additional minutes to obtain a one unit change in the attribute)

| | Conditional Logits | | Mixed Logit |
|---|---|---|---|
| Attribute | Model 1 | Model 2 | Mean |
| See one elk | 2.031 | 2.053 | 1.677 |
| Hear elk bugle | 1.402 | 1.422 | 1.069 |
| See bull elk | 2.371 | 2.404 | 2.122 |
| See 10 or more elk | 2.272 | 2.231 | 1.861 |

The MRS calculations in Table 2.7 and Figure 2.3 show the tradeoffs visitors are willing to make across activity groups from the individual mixed logit estimates of Table 2.3 and the secondary regressions of Table 2.4. From these data we can interpret willingness to drive for the average visitor, those engaging in water-related activities, and those engaging in wildlife-related activities. Those engaging in wildlife-related activities had higher WTD for all elk-related attributes, including markedly higher WTD to experience seeing a bull or see 10 or more elk. Those within the "wildlife" activity category demonstrated a willingness to drive 22.7 minutes for a 10% increased chance of seeing one elk, 17.4 additional minutes to hear an elk bugle, about 29.7 additional minutes for 10% greater chance to see a bull elk, and 34.5 additional minutes to see 10 or more elk. Visitors engaging in water-related activities were on average less willing to drive additional minutes to experience elk-related attributes, but still demonstrated positive WTD estimates. Those engaging in "water" activities were willing to drive an additional 12.9 minutes for a 10% increased chance of seeing one elk, 6.8 minutes for a 10% increased chance to hear an elk bugle, 15.7 additional minutes for a 10% increased chance of seeing a bull elk, and 8.6 additional minutes to see 10 or more elk. The positive WTDs for each attribute across all activity groups indicate that visitors to the Michigan elk range are generally willing to incur costs through additional driving time to experience elk-related attributes, even among visitors who engage in activities not directly related to the presence of elk in the region.

**Table 2.7:** Mean Willingness to Drive (WTD) estimates from mixed logit conditional on activity groups (additional minutes to obtain a one unit change in the attributes)

| | Activity Groups | | |
|---|---|---|---|
| Attributes | Average preference | Wildlife | Water |
| See one elk | 1.677 | 2.270 | 1.289 |
| Hear elk bugle | 1.069 | 1.741 | 0.679 |
| See bull elk | 2.122 | 2.967 | 1.568 |
| See 10 or more elk | 1.861 | 3.449 | 0.861 |

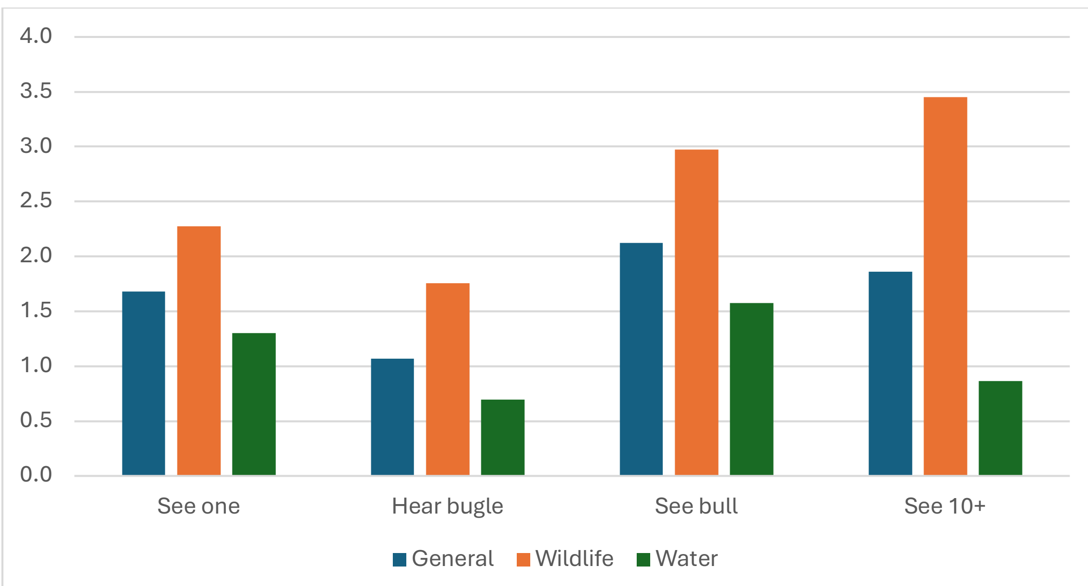


**Figure 2.3:** Willingness to drive for an increased chance of experiencing each attribute, by type of visitor

## CONCLUSION AND DISCUSSION

This study uses a choice experiment survey to elicit elk attribute preferences of visitors to Michigan's elk range across a variety of recreation activities. Generally, we find a positive preference for experiencing all elk-related attributes across all visitor groups to the Michigan elk range. Seeing a bull elk yielded the most homogenous preference, indicating that all visitor types favor seeing the larger, antlered bull elk consistent with the assertion that people prefer charismatic species (Lindsay 2007; Everett 1978). The most heterogenous preference was found in the attribute "see 10 or more elk." To understand the heterogeneity in visitor preferences across all elk-related attributes, individual mixed logit estimates were regressed on demographic and activity variables. While demographics are a common way to attempt to explain preference heterogeneity (Lindsey et al. 2007, Chapagain & Poudyal 2007), this study did not find demographics to be significant predictors of preference. Rather, a visitor's primary activity, especially activities relating to wildlife, was shown to be a predictor of positive preference. Those engaging in water activities displayed preferences that were lower than the base group engaging in "camp" activities, yet still positive for most elk attributes. However, the water activity group had a negative preference for seeing 10 or more elk compared to seeing one elk. The WTD estimates provide a tangible, quantitative measure of visitor preference in terms of the trade-offs they are willing to incur to experience the elk-related attributes.[7] Despite significant

[7] In principle, the WTD estimates could be converted into dollar values and compared to other willingness to pay estimates in the literature. However, as noted by Boudreaux et al. (2023), since the WTD values come from stated preferences for hypothetical recreations sites, they do not account for the real choice set of sites faced by visitors and thus overestimate the actual distances consumers would drive when they face closer substitute sites.

heterogeneity in preferences among visitors to the elk range, all categories of visitors were willing to incur costs to see or hear elk.

This study builds upon the work of Hunt (2019) and finds similar results for the conditional and mixed logit outputs. This study differs from Hunt (2019) through the methods employed to understand the underlying heterogeneity of preference. Hunt's approach to understand heterogeneity involved manually segmenting recreationists into groups, including segmentation of visitors based on the same activity groups as this study. However, secondary regression of individual mixed logit estimates conditional on activity group were not estimated in Hunt's analysis. Both approaches offer important insights into heterogeneity of preference among visitors to the Michigan elk range and demonstrate the merits of segmenting survey samples into activity groups for analysis of preference. Future research could expand upon these studies' evaluation of elk preferences with questions designed to explore if negative preference parameters are indicative of indifference towards elk, or if a class of people exists that is averse to seeing elk.

This study's findings are consistent with the Experience Based Management (EBM) framework outlined by Manfredo et al. (2002). In the EBM framework, one's recreational enjoyment is determined by activity, setting preference, and activities/experience, with enjoyment of the latter category often informed by desired psychological outcomes of a recreational visit. Visitors who travel to the Michigan elk range for activities related to wildlife, such as elk viewing or wildlife photography, naturally have higher individual preference parameters for experiencing elk-related attributes because this is consistent with their desired psychological outcome of their recreational visit and receive a greater deal of enjoyment from viewing elk. Visitors engaging in water related activities such as swimming and fishing have priorities for their visit further removed from the presence of elk in the region, therefore experiencing elk-related attributes is less of a factor for their overall enjoyment.

While studies on wildlife management preferences often center on certain stakeholder groups and their enjoyment of a specific resource, this analysis suggests that enjoyment of the elk is shared across a range of outdoor recreationists with varying objectives and preferences. Wildlife management decisions such as harvest quotas and season dates are informed through biological factors such as controlling disease, overall ecosystem health, and carrying capacity of an area, while considering tradeoffs to direct users of a wildlife resource such as hunters. The results of this survey suggest these management decisions have broad implications on the recreational enjoyment of all visitors to the Michigan elk range, and not just hunters. Understanding the degree of enjoyment the presence of elk bring to different classes of outdoor recreationists may inform a more holistic approach to wildlife management, despite competing interests of visitors to Michigan's elk range and different priorities between visitors and managers. This analysis indicates that in the Michigan elk range, the priorities of these parties may be aligned.

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APPENDIX A: ACTIVITY GROUPS

**Table 2.8:** Activity Groups of Visitors to the Michigan Elk Range

| Primary Activity | Frequency | Percentage |
|---|---|---|
| **Path Activities** | | |
| Bicycling | 12 | 2.8% |
| Horseback Riding | 11 | 2.6% |
| Rock Hunting | 1 | 0.2% |
| Hiking, trail running, or backpacking | 70 | 16.3% |
| Educational/Getting Information | 5 | 1.2% |
| Total Path Activities | 99 | 23.1% |
| **Water Activities** | | |
| Fishing at a lake | 39 | 9.1% |
| Fishing at a stream | 36 | 8.4% |
| Swimming or wading in water | 12 | 2.8% |
| Kayaking, canoeing, or boating | 17 | 4.0% |
| Total Water Activities | 104 | 24.3% |
| **Hunting** | | |
| Hunting | 58 | 13.5% |
| **Camping** | | |
| Camping | 84 | 19.6% |
| Picnicking or family day gatherings | 1 | 0.2% |
| Relaxing or hanging out | 16 | 3.8% |
| Total Camping Activities | 101 | 23.6% |
| **Wildlife Activities** | | |
| Viewing Elk | 46 | 10.7% |
| Viewing Wildlife | 1 | 0.2% |
| Mushroom Picking | 4 | 0.9% |
| Viewing/Photographic wildlife or scenery | 16 | 3.7% |
| Total Wildlife Activities | 67 | 15.5% |
| **Total** | **429** | **100.0%** |

## APPENDIX B: EXPERIMENTAL DESIGN CONSTRAINTS ON ATTRIBUTE VALUES

1. The chance of seeing a bull elk or 10 or more elk will always be less than the chance to see one elk.
2. All elk-related attributes must be equal to zero if the scenario is Outside of the Elk Range.
3. If any elk-related attribute is greater than zero, all other elk related attributes must also be greater than zero if scenario is Inside of the Elk Range.
4. The chance of hearing an elk is independent of seeing one elk.
5. All right-hand side alternatives (B) must be greater than the left-hand side alternatives (A) since alternative B is always farther away.
6. The distance levels are additional minutes of driving time to travel to the right-hand side area on top of the distance from the respondents' house, which was calculated using the distance from the respondents' zip code to the Pigeon River Country Discover Center.

# APPENDIX C: PAPER VERSION OF ONSITE SURVEY

**18. Including this visit, about how many times have you visited the Pigeon River Country or Atlanta State Forests for recreation in the past year?** ________ times

**19. How many people, including you, traveled to the Pigeon River Country or Atlanta State Forests in the same vehicle as you?** ________ people

**20. How many of those people are less than 18 years old?** __________ children

**21. What is your age?** ___________ years

**22. What is your gender?**

- □ Female
- □ Male

**23. What is the highest level of education you have completed?**

- □ Did not complete High School
- □ High School/GED
- □ Some College
- □ Bachelor's Degree
- □ Postgraduate Degree

**24. Please provide an e-mail address where we can send a short follow-up survey.** The invitation would come this summer from Michigan State University. The survey is confidential, and your e-mail would not be used in any other way.

E-mail: ____________________________

If you cannot share an e-mail for the follow-up survey, please share your mailing address.

Full name: ________________________________________

Address: ________________________________________

City, State, Zip: ________________________________________

**Thank you for your help!**

**Please return in the postage paid envelop <u>or</u> mail to:**

Prof. Frank Lupi
301b Agriculture Hall, Box 181
Michigan State University
East Lansing, MI 48824

## Forest Recreation Survey

MICHIGAN STATE
UNIVERSITY

***We need your help with this voluntary recreation survey that will guide the Michigan DNR as they serve visitors to this area.*** *For more information about your rights, please see enclosed page.*

**1. Have you previously completed <u>this</u> Survey or been interviewed by Michigan State University while visiting Pigeon River Country or Atlanta State Forests?**

- □ Yes, on this visit (*Survey completed; please **return** this survey*)
- □ Yes, on a previous visit (*Survey completed; please **return** this survey*)
- □ No (*go to question **2***)

**2. What is your ZIP code?** ________________ ZIP code

**3. Please list your arrival and departure times for the <u>location where you received this survey</u>. If you were at the location overnight, please include dates.**

Arrival: __________________

Departure: ________________

**4. Which activities did you or anyone else in your vehicle participate in <u>while parked at the location where you received this survey</u>?** (*Select all that apply*)

- □ Hiking, trail running, or backpacking
- □ Bicycling, including mountain bikes
- □ Horseback riding
- □ Driving for pleasure (immediately before or after receiving this survey)
- □ Relaxing or hanging out
- □ Viewing/photographing wildlife or scenery
- □ Viewing Elk
- □ Bird Watching
- □ Picnicking or family day gatherings
- □ Camping
- □ Fishing at a stream
- □ Fishing at a lake
- □ Hunting
- □ Morel Hunting
- □ Kayaking, Canoeing, tubing or Boating
- □ Swimming or wading in water
- □ Education/Getting Information
- □ OTHER: ______________________

**5. Which of these activities was the primary activity that you or anyone else in your vehicle participated in <u>while parked at the location where you received this survey</u>?**

______________________________

**6. On the visit in which you received this survey, did you or anyone else in your group visit any other locations in the forest?**
- ☐ Yes _(go to question **7**)
- ☐ No (go to question **8**)

**7. <u>If you answered yes to question 6</u>, please indicate whether you visited any of the following locations. A map is enclosed to help you.** (*Select all that apply*)

- ☐ Elk Site 1 (Fontinalis Road)
- ☐ Elk Site 2 (E Sturgeon Valley Road)
- ☐ Elk Site 4 (CCC Fields)
- ☐ Elk Sites 6&7 (E Sturgeon Valley/Tin Shanty Rd)
- ☐ Elk Site 10 (CR 622)
- ☐ Inspiration Point
- ☐ Pigeon Bridge Trailhead/Parking
- ☐ Cornwall Flooding Day Use Area
- ☐ Green Timbers Trailhead/Parking
- ☐ Pigeon River Country Headquarters
- ☐ Pigeon River CG/ "Tubes"
- ☐ Elk Hill CG
- ☐ Pickerel Lake CG
- ☐ Round Lake CG
- ☐ Pine Grove CG
- ☐ Town Corner Lake CG
- ☐ Sinkhole Lakes
- ☐ OTHER: ______________________
- ☐ I did not visit any of these locations

**8. Did you stay away from home overnight on the visit in which you received this survey?**
- ☐ Yes _(*go to question* **10**)
- ☐ No (*go to question* **9**)

**9. If you <u>were not</u> away from home overnight, how much time did you spend <u>overall</u> in the Pigeon River Country or Atlanta State Forests (see green areas on the enclosed map)?**

____ Hours, _____ Minutes _(*go to question **15***)

**10. If you <u>were</u> away from home overnight, how many nights did spend away from your home during this trip?** ______ Nights

**11. What type of lodging did you use during the visit in which you received this survey?**
- ☐ A campground in Pigeon River Country or Atlanta State Forest

  if so, which one? ___________________________ (*go to question **15***)
- ☐ A dispersed campsite on state forest land _(*go to question **15***)
- ☐ A campground outside the state forests _(*go to question **12***)
- ☐ A hotel, motel or rental _(*go to question **12***)
- ☐ A friend/relative's house _(*go to question **12***)
- ☐ A second home/cottage _(*go to question **12***)

**12. <u>If you were on an overnight trip and stayed outside of the state forests</u>, how many days did you visit the Pigeon River Country or Atlanta State Forests?**

______ Day(s)

**13. Over the day(s) that you indicated in question 12, how many <u>total</u> hours did you spend in the Pigeon River Country or Atlanta State Forests?**

_______Total hours

**14. <u>If you were on an overnight trip and stayed outside of the state forests</u>, was recreation in the Pigeon River Country or Atlanta State Forests a main reason for your overall trip?**
- ☐ Yes, recreating in these State Forests was a main reason for taking the trip
- ☐ No, recreating in these State Forests was not a main reason for taking the trip

**15. Did you leave and re-enter <u>Pigeon River Country State Forest</u> before leaving the final time?**
Please refer the map for the entry and exit roads for Pigeon River Country State Forest.

Atlanta State Forest users should skip this question if they did not enter the Pigeon River Country State Forest on the visit in which they received this survey.

*Example: A visitor camped 4 nights in Pigeon River Country State Forest and went to town twice for gas and ice. This visitor would check "Yes" and enter "2" times.*

- ☐ No
- ☐ Yes ⇒ If yes, how many times? ______________________

**16. The areas in and around the Pigeon River Country State Forest are home to Michigan's only wild elk herd. What role did the chance of seeing elk play in your decision to visit?** (*Select one*)
- ☐ The chance of seeing elk was my primary reason for visiting
- ☐ The chance of seeing elk played a role in my decision to visit, but was not my primary reason
- ☐ The chance of seeing elk played no role in my decision to visit

**17. Did you see any elk on the visit in which you received this survey?**
- ☐ No
- ☐ Yes If yes, where? ______________________