NDOT Research Report

Report No. 701-18-803 TO 5

TPF-5(358)
INCORPORATING DEER AND TURTLE TOTAL VALUE IN COLLISION MITIGATION BENEFIT-COST CALCULATIONS

October 2021

Nevada Department of Transportation
1263 South Stewart Street
Carson City, NV 89712

Contributing Partners

Alaska DOT
ARC Solutions, Inc.
Arizona DOT
California DOT
Iowa DOT
Ontario Ministry of Transportation
Oregon DOT
Michigan DOT
Minnesota DOT
New Mexico DOT
Parks Canada
Washington DOT

Disclaimer

TECHNICAL REPORT DOCUMENTATION PAGE

<table>
<tr><td>1. Report No.
701-18-803 TO 5</td><td>2. Government Accession No.</td><td colspan="2">3. Recipient's Catalog No.</td></tr>
<tr><td colspan="2">4. Title and Subtitle
Incorporating deer and turtle total value in collision mitigation benefit-cost calculations</td><td colspan="2">5. Report Date
September 2021
6. Performing Organization Code</td></tr>
<tr><td colspan="2">7. Author(s): John Duffield and Chris Neher</td><td colspan="2">8. Performing Organization Report No.</td></tr>
<tr><td colspan="2">9. Performing Organization Name and Address
Bioeconomics, Inc.
240 N Higgins Ave Ste 14
Missoula, MT 59802</td><td colspan="2">10. Work Unit No.

11. Contract or Grant No.</td></tr>
<tr><td colspan="2">12. Sponsoring Agency Name and Address
Nevada Department of Transportation
1263 South Stewart Street
Carson City, NV 89712</td><td colspan="2">13. Type of Report and Period Covered
Task Report – 2020-21
14. Sponsoring Agency Code</td></tr>
<tr><td colspan="4">15. Supplementary Notes
Prepared for: Western Transportation Institute, College of Engineering, Montana State University and Nevada Department of Transportation NAS-NRC, for the following larger project: Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity Task 1 – Cost Effective Solutions Transportation Pooled-Fund Project TPF-5(358) (Administered by: Nevada Department of Transportation).</td></tr>
<tr><td colspan="4">16. Abstract
This document is a task report for a larger Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity pooled fund study. It addresses the potential use of passive use economic values for wildlife to inform the mitigation of wildlife-vehicle collisions. Passive use, also known as non-use values, are the values individuals place on the existence of a given animal species or population as well as the bequest value of knowing that future generations will also benefit from preserving the species. This report describes a pilot survey and study of willingness to pay by Minnesota households to pay for exclusionary fencing and passage structures to reduce vehicle/animal collisions in the state. The species of focus were deer and turtles. The study found strong support for fencing and passage structures, and statistically significant willingness to pay increased taxes to support their construction.</td></tr>
<tr><td colspan="2">17. Key Words
Analyses, analysis, animals, benefits, biological, collisions, connectivity, conservation, costs, crashes, decision, deer, ecology, economics, existence, highways, large, mammals, mitigation, monetary, non-use, parameters, passive, population, reptiles, roads, support, tool, traffic, tourism, turtles, ungulates, values, wildlife</td><td colspan="2">18. Distribution Statement
No restrictions. This document is available through the: National Technical Information Service.
Springfield, VA 22161</td></tr>
<tr><td>19. Security Classif. (of this report)
Unclassified</td><td>20. Security Classif. (of this page)
Unclassified</td><td>21. No. of Pages
63</td><td>22. Price</td></tr>
</table>

ACKNOWLEDGMENT OF SPONSORSHIP

This work was sponsored by one or more of the following as noted:

- American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program,
- Federal Transit Administration and was conducted in the Transit Cooperative Research Program,
- Federal Aviation Administration and was conducted in the Airport Cooperative Research Program,
- Research and Innovative Technology Administration and was conducted in the National Cooperative Freight Research Program,
- Pipeline and Hazardous Materials Safety Administration and was conducted in the Hazardous Materials Cooperative Research Program,
- Federal Railroad Administration and was conducted in the National Cooperative Rail Research Program which is administered by the Transportation Research Board of the National Academies

DISCLAIMER

Incorporating deer and turtle total value in collision mitigation benefit-cost calculations

Task Report

Prepared for
Western Transportation Institute
College of Engineering
Montana State University
and
Nevada Department of Transportation NAS-NRC

For the following larger project:

Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity

Task 1 – Cost Effective Solutions

Transportation Pooled-Fund Project TPF-5(358)

(Administered by: Nevada Department of Transportation)

Prepared by:
Bioeconomics, Inc.
Missoula, Montana
September 2021

Table of Contents

Table of Figures

Table of Tables

Abstract

This document is a task report for a larger Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity pooled fund study. It addresses the potential use of passive use economic values for wildlife to inform the mitigation of wildlife-vehicle collisions and providing for wildlife crossing structures. Passive use, also known as non-use values, are the values individuals place on the existence of a given animal species or population as well as the bequest value of knowing that future generations will also benefit from preserving the species. This report describes a pilot survey and study of willingness to pay by Minnesota households to pay for exclusionary fencing and passage structures to reduce vehicle/animal collisions in the state. The species of focus were deer and turtles. The study found strong support for fencing and passage structures, and statistically significant willingness to pay increased taxes to support their construction.

Summary

Funding decisions on specific wildlife mitigation measures along roads are based largely on cost-benefit analysis and answering the question; do the benefits to humans and wildlife outweigh the direct fiscal costs of the mitigation measures? To date, one potentially significant component of the benefits of wildlife mortality and injury avoidance has been largely ignored in these calculations--passive use values to humans associated with species protection. This paper describes the methods and results of a pilot study designed to develop total value estimates for wildlife in a collision mitigation context. Total values include not only direct use such as hunting and viewing but also passive use values (biological conservation values).

Design of the repeat contact survey instrument began with individual cognitive interviews relating to an initial draft survey instrument designed based on previous successful household surveys of passive use wildlife-related values.

Following modification of the draft survey instrument based on focus group input, the primary data collection was a household repeat mailing survey effort conducted in May and June 2021. A current valid address sample (2500 names/addresses) of Minnesota households was purchased. These households received three separate mailings: 1) an initial postcard notification of the survey, 2) a complete survey packet along with postage paid return envelope, and 3) a reminder postcard. Our *a priori* target final number of completed surveys was 400+ (~16% response rate). Our final sample of completed and returned surveys easily met these goals with 466 returned surveys and a 20.25% response rate.

The goal of the survey administration was 1) solicit attitudes and experience related to wildlife/vehicle collisions, and 2) administer a type of survey called a discrete choice question format that could be used to estimate economic values. For the case at hand, the survey elicited priorities and willingness to pay values associated with funding collision avoidance and habitat connectivity measures. The use of the discrete choice question design allowed for efficient collection of sufficient data to estimate valuation models from limited samples of respondents. The mail survey included two discrete choice questions, each of which provided data for our valuation models.

Because there was no prior specific survey valuation work on vehicle/animal collision mitigation, it was anticipated that motivations might be broader than for simply species conservation (the focus of most prior passive use valuation studies of wildlife) and could include a desire for not only a more efficient, but also a more ethical or respectful treatment of wildlife in transportation design. Survey information on motivations for the public's support of collision mitigation could potentially be used to calibrate the existing wildlife valuation research to better capture the full value of mitigation measure for wildlife along highways.

Data collected from the survey was used to estimate species-specific values for deer and turtles in Minnesota. Deer and turtles provided an informative contrast in terms of passive use values for this study. Deer-vehicle collisions cause both property damage and potentially morbidity or mortality to both deer and humans. By contrast, vehicle-turtle collisions are less likely to significantly impact cars and their drivers, but still incur morbidity/mortality for the turtles.

Sources of currently available passive use values

Given the broad diversity of species potentially impacted by road collisions, combined with a large spectrum of geographic settings, the current literature on wildlife passive use values potentially involved in

collisions is spotty, at best. Several dozen species-specific passive use value estimates are found in the literature, but there are many gaps associated with species most at-risk in road collisions. Richardson and Loomis 2008 provide a summary which covers 22 species with a little over 60 estimates; however, only three of the species valued are terrestrial animals and most are marine mammals, freshwater fish, and birds. A 2018 literature review identifies 80 unique estimates, but the additional studies in this review are mostly from other countries.

In order to derive a specific passive use value for a species-location combination of interest, there are five possible sources of the values: using an available previously estimated value for that species-location pairing; conducting original valuation research or using an existing recent value estimate for the same species-location pairing; using benefit transfer to apply a passive use value from a separate, but similar, species/setting to the setting of interest; using a meta-analysis model to predict passive use values for a species or group of species based on a set of underlying original passive use value estimates; and using public policy spending decisions as a proxy for passive use values for a species. This research follows the path of conducting original site and species-specific research.

While there do not appear to be cases where federal or state agencies have relied on passive use values for transportation infrastructure, there is a precedent of prior reliance on passive use value estimates in other wildlife and infrastructure settings. This includes the use of passive use values for wildlife and fisheries to inform management of major water resource developments including Glen Canyon Dam on the Colorado River. In this case, hydroelectric production had impacted endangered fish and the riparian ecosystem for 250 miles of the Colorado through Grand Canyon National Park. In 1996, then Secretary of the Interior, Bruce Babbitt, signed a Record of Decision that limited hydropower operations to benefit ecosystem services. He noted that while changes in hydropower operations would result in losses of between $5.1 and $44.2 million per year in hydropower benefits, nonuse value studies indicate that “the American people are willing to pay much more than this loss to maintain a healthy ecosystem in the Grand Canyon”.

Passive use values have also informed the decision to remove some dams in the Western U.S. Elwah, and Glines Canyon dams on the Elwah River in and on the boundary of Olympic National Park were recently removed to restore historic salmon runs. The entire system of dams on the Klamath River including Iron Gate, J.C. Boyle, and Copco 1 and 2, are under consideration for removal, based in part on a Department of Interior passive use value study.

Passive use values have also been estimated for natural resource damage assessments of major oil spills and toxic releases, including the Exxon Valdez oil spill in Alaska. Passive use value studies and contingent valuation methods are explicitly authorized under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or “Superfund”) and the Oil Pollution Act of 1990, and they were recently applied to the Deepwater Horizon oil spill in the Gulf of Mexico.

Study Findings

The random household survey of Minnesota residents yielded a number of clear findings with several caveats. These findings and limitations include

- The overall subject of mitigating vehicle/wildlife collisions appears to be one of substantial public interest as demonstrated by the better than expected 20.25% response rate to the mail survey.
- Respondents to the survey were strongly in favor of the use of fencing and passage structures to reduce animal/vehicle collisions (84% either supported or strongly supported).
- Both the use of a discrete choice (DC) valuation questions format and a payment card (PC) question format were successful in eliciting statistically significant willingness to pay (WTP) estimates from the household sample responses.

- Considering both valuation question formats, the estimated conservative value of an avoided deer collision is between $4,100 and $5,800 and the estimated value of an avoided turtle/vehicle collision is between $1,260 and $4,100.
- Responses to motivation questions suggest that concern for animal well-being was a stronger motivation for supporting collision mitigation programs than was concern for personal safety or avoiding vehicle damage.
- The final survey responses were clearly biased towards higher income, higher education level, and less ethnically diverse than the overall population of MN.
- To adjust for bias in demographics, estimated WTP values were adjusted using the most conservative set of assumptions—assigning all non-respondents a zero WTP to support the collision avoidance program. This assumption likely understates true mean household WTP but does provide a strongly defensible conservative estimate.
- A preliminary estimate of the complete benefits (direct collision costs plus passive use costs) of an avoided deer/vehicle collision in MN is $13,277. For this estimate, direct collision costs (from Huijser et al. 2009, Table 2) account for 63% of the loss of a deer collision and passive use values account for 37%.
- In the case of vehicle/turtle collisions, direct vehicle and human injury costs are generally low to zero. Therefore, the estimated passive use values from this study (an average of estimates from the 2 valuation question formats of $3,070) represent the per collision loss to MN residents from such collisions.

Overall, this pilot study was successful in achieving a broad range of objectives. The mail survey methodology chosen proved appropriate and effective. The valuation formats used were well accepted by respondents and yielded statistically significant value estimates for deer and turtles. The survey responses showed strong support for collision mitigation projects including exclusionary fencing and passage structures and revealed that a strong motivation for this support was concern for animal welfare. These bottom-line results suggest that the methods developed and implemented are appropriate for estimating an important component of benefits associated with animal collision avoidance.

CHAPTER 1

Introduction

Purpose and Need:

Wildlife-vehicle collisions and the associated damage and economic costs that result have been increasing in recent years (Huijser et al. 2009). Damage caused by collisions with large ungulates (deer, elk, and moose) represent substantial costs in terms of vehicle damage as well as human injury and death. In ongoing efforts to mitigate these collision-caused damages and costs, there has been significant research aimed at identifying and estimating the extent of these collision costs in recent years (see Huijser et al. 2009 for a review of this literature). Associated with understanding the scale and costs of the wildlife-collision problem has been research on the effectiveness, and specifically the cost-effectiveness of collision mitigation measures. While the costs of adopting or constructing collision mitigation structures is generally easily measured, estimating the benefits of successful mitigation measures is less so. Factors necessary to understand the benefits of collision mitigation include considerations of the type of animal(s) involved in collisions, average costs associated with vehicle damage, human injury and death, as well as any lost value of the animal killed. These benefit-cost estimations have been presented and discussed both in a generalized example (Huijser, et al. 2009) and in relation to specific road sections and mitigation projects (Huijser et al. 2016).

In past studies the values associated with collision avoidance related to the injured/killed animals has been limited to easily identifiable direct use values of the animals, such as the value of the animal as hunted species. A second component of wildlife value heretofore omitted from the cost-benefit analysis of the cost-effectiveness of mitigation measures is passive use value for the animals.

A review of the current literature on this new value component for collision mitigation, wildlife passive use values, was completed in June 2019 (Duffield and Neher 2019). These prior studies of wildlife passive use were generally for endangered species such as wolves or threatened fish species. There are no prior studies where passive use values have been specifically estimated in the context of direct road mortality of wildlife. It is possible that additional previously unmeasured values associated with collision reduction may be in play, such as those related to humanitarian concerns for wildlife safety or habitat connectivity for wildlife including for species such as deer that are not necessarily threatened or in danger of extinction. The current work takes the literature review as a starting point and develops and implements a household survey designed to measure passive use values associated with preventing animal-vehicle collisions.

This pilot research study focuses on two specific species groups within the state of Minnesota: deer and turtles. Deer and turtles provide a potentially informative contrast in terms of passive use values for this study. Deer-vehicle collisions cause both property damage and potentially morbidity or mortality to both deer and humans. By contrast, vehicle-turtle collisions are less likely to significantly impact cars and their drivers, but still incur morbidity/mortality for the turtles.

Minnesota was identified as a state providing a site with both widespread aquatic habitat and turtles, as well as being one of the states with the highest rate of damage from deer-vehicle collisions.

Conservation and other advocacy organizations demonstrate that individuals in the economy attach an economic value to such things as preserving endangered species, open space, wild rivers, and wilderness areas. This economic value is demonstrated through the simple fact that individuals are willing to donate money to organizations working toward these goals. Some of this demonstrated value is due to the fact that people want the possibility of "using" the resources they are paying to help preserve through direct use activities such as hiking, hunting, or wildlife viewing. Some people, however, may never intend to make any direct use of a given resource, but still attach a value to the preservation of that resource. They may hold this value for a number of reasons: 1) they may want to preserve the resource for future generations (bequest value); 2) they may want to hold open the option to use the resource in some way in the future (option value); or 3) they may simply feel that preservation of a resource or species is the right thing to do, and thus attach a value to its existence or viability (existence value). The term passive use values as used in this paper includes any or all of these possible motives. The general concept of passive use and these various motives and the possible importance of these values for conservation were described in a seminal paper by Krutilla (1967).

People demonstrate their passive use value in the marketplace by contributing to organizations such as the Nature Conservancy, Ducks Unlimited, or Defenders of Wildlife. When an individual contributes to the World Wildlife Fund to protect pandas in China, which they themselves almost certainly may never see, it is evidence of passive use values. However, whether people enjoy existence values of resources is not contingent upon whether they donate money to support a cause. The fact that some people are willing to donate money is just the most obvious manifestation of these passive use values.

Given that passive use values exist, the problem facing economists is how to measure these values without actually collecting the monetary equivalent from the relevant human population. The primary technique used in this analysis, contingent valuation (which essentially amounts to conducting surveys and asking people what they are willing to pay for something), is the only method available to economists to measure passive use values directly. This method has been used in hundreds of applications in the last several decades. Contingent valuation is recognized by governmental regulatory agencies such as the Department of Interior, U.S. Fish and Wildlife Service, National Park Service, and National Oceanic and Atmospheric Administration as the appropriate tool for use in measuring passive use values.

This study utilizes two variants of the widely accepted contingent valuation methodology (discrete choice modeling and payment card solicitation) in a survey of Minnesota households designed to place a passive use value on the avoidance of vehicle/deer or turtle collisions in the state.

Report Organization

The report is organized in four main sections: 1) Discussion of the theory and methods and literature associated with wildlife valuation along with a description of the methods used in the current valuation study; 2) Description of data collection and survey development methods; 3) Presentation of survey and modeling results; and 4) Conclusions drawn from this pilot study.

CHAPTER 2

Theory, Methods, and Literature

2.1 Wildlife Valuation Concepts and Methods

There is a deep and rich literature in the natural resource economics field related to valuation of wildlife. Estimated values associated with wildlife species fall into several classifications. Figure *1* diagrams this generic flow of ecosystem services (including those associated with wildlife species).

As can be seen in Figure *1*, several kinds of services, or uses, derive from natural systems. One dichotomy is between direct use values and passive use values. Direct use includes viewing or hunting a wildlife species. However, individuals who have no expectation to ever see or hunt may still place a value on knowing certain species are present in the ecosystem. This has been demonstrated in numerous studies and is exemplified by the donations that support wildlife conservation organizations, such as the World Wildlife Fund, for the protection of species, such as pandas in China that the donor will likely never see. Such values are termed passive use values and are not dependent on direct on-site use. Several of the possible motives for nonuse values were first described by Weisbrod (1964) and Krutilla (1967) and include existence and bequest values. Existence values can derive from merely knowing that a given natural environment or population exists in a viable condition. These values would be expected to be greatest for species and populations that are in danger of extinction. Bequest values derive from the interest in protecting wildlife species and associated natural environments for use and enjoyment by future generations. A hybrid category "option value" can have characteristics of both use value (the option to directly use it in the future) or passive use value (the option for it to be available for future generations or for society).

While direct use services may or may not have associated developed markets for them, passive use services are exclusively non-market services. When passive use and direct use values are estimated together, the estimate is referred to as total valuation. This concept was first introduced by Randall and Stoll (1983) and has been further developed by Hoehn and Randall (1989).

2.1.1 Consideration of Passive Use Values in Public Policy Decisions

In the past several decades the concept of passive use value has played an ever-increasing role in decision-making on a broad range of public policy decisions and plans for use and operation of public infrastructure.

Benefit-cost analysis as a field of economics was first developed in the context of water resource development. The Flood Control Act of 1916 was the first instance of a requirement that a proposed federal project must pass a benefit-cost test. The earliest examples where passive use values played a clear and decisive role in benefit-cost decision making for a court or government agency are found in the context of proposed construction of, operation of, or removal of dams on western rivers. Benefit-cost analysis has a long history and many applications, and a positive benefit-cost ratio is still a required value for the Federal Energy Regulatory Act (formerly the Federal Power Act). Beginning in the 1950s recreation values were

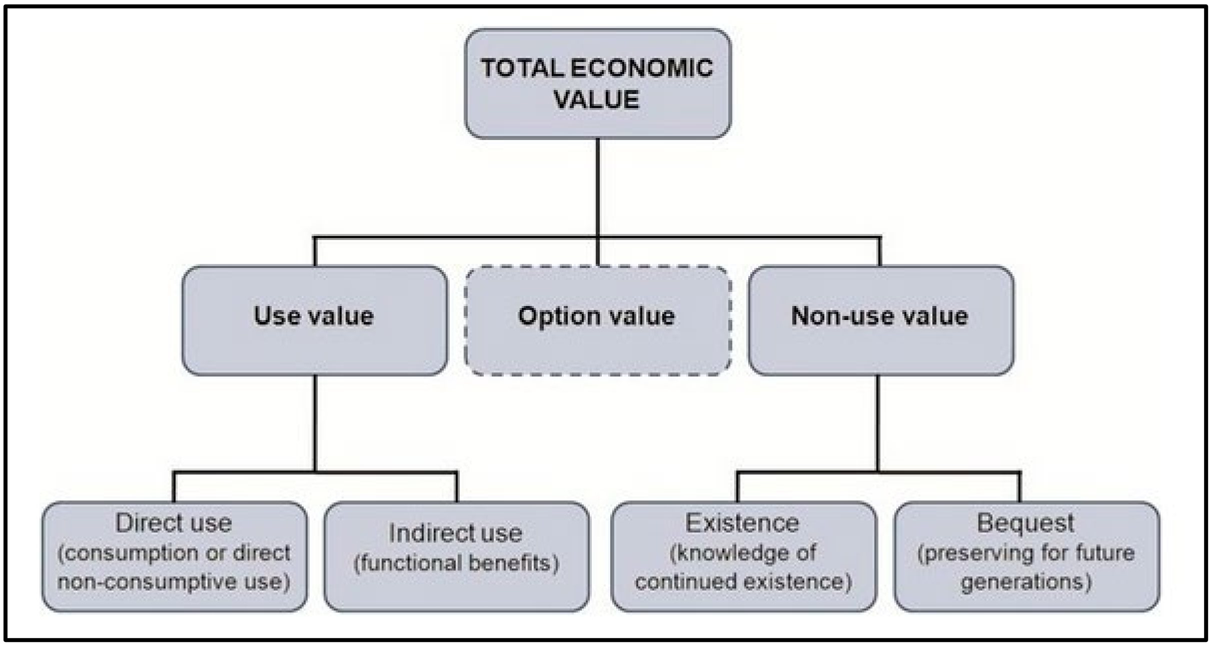


Figure 1. Flows of Ecosystem Services

beginning to be utilized in benefit-cost decision making (Clawson 1959; Krutilla 1968). Passive use values began to be incorporated in this context in the early 1980s. Huijser et al. (2009) introduced the use of this tool to the application in road ecology.

While the benefits of hydropower are principally the provision of a marketed commodity at a cost lower than the next best alternative source of power, the potential foregone values provided by flooding riparian and whitewater rivers and unblocked fish passage and other impacts on wildlife and natural environments are often not priced and must be evaluated through other means. This is aside from some natural resource industries like commercial fishing. These values include both direct on-site use, such as sportfishing, boating and wildlife observation, but also passive use, which, as noted previously, includes the value associated with the existence of natural environments and related biota and the desire to bequest these resources to future generations, independent of one's own direct use (Krutilla, 1967). Dams such as Grand Coulee on the Columbia River led to the extinction of the huge "June hogs" salmon on the Columbia. As noted, the fact that individuals will donate money for the protection of species such as pandas or tigers, which they have no expectation of ever even seeing, is evidence of these values. The methods for measuring these values have come to be known as non- market valuation and had their origin in the development of the travel cost model (Wood and Trice, 1958; Clawson, 1959; Clawson and Knetsch, 1966) and the contingent valuation method (Davis, 1963; Knetsch and Davis, 1966). The travel cost model is a type of revealed preference model where estimates are derived from observed behavior; contingent value is a type of stated preference and relies on survey research. Passive use values can only be estimated through stated preference methods.

One of the first instances of the use of passive use values to inform public policy decisions on approval of a proposed hydroelectric dam was in the case of the proposed Kootenai Falls hydroelectric project in northwest Montana in 1978. This case is of interest in that: (1) it was a legal case decided initially by an administrative law judge, (2) a site-specific total valuation study (including direct recreation and passive use values) was undertaken, (3) contingent valuation estimates were accepted into evidence, (4) a subset of the contingent valuation estimates of direct recreational values (but not indirect or 'passive use' values) in this case were introduced and were deemed credible despite opposing testimony, and (5) the license application was denied both by the Administrative Law Judge (ALJ) in the initial decision (FERC, 1984) and by Commission order (FERC, 1987) pursuant to the 1986 amendments to the Federal Power Act.

Within the context of informing public decisions on operation of existing dams, passive use values are an indication of the national significance of resources like the river and river corridor through the Grand Canyon (Harpman et al., 1995). These values are associated with knowing that these resources are in a viable condition and with wanting future generations to also be able to enjoy this heritage. Welsh et al. (1995) applied dichotomous choice contingent valuation methods to estimate willingness-to-pay to improve native vegetation, native fishes, game fish (such as trout), river recreation and cultural sites in Glen Canyon National Recreation Area downstream of Glen Canyon Dam and in Grand Canyon National Park.

This social cost–benefit analysis shows a significant net benefit of modifying Glen Canyon Dam water releases from the procedures used since the dam was constructed to a more moderate fluctuating flows scenario. While the non-use study for the Colorado River corridor in Grand Canyon National Park (Welsh et al., 1995) was completed too late to be fully utilized in the 1995 EIS, the study findings did have an influence on the EIS outcome and were favorably reviewed by a National Research Council panel:

> The GCES [Glen Canyon Environmental Studies] nonuse value studies are one of the most comprehensive efforts to date to measure nonuse values and apply the results to policy decisions. . .. While not completed in time to be reported in the final EIS, the nonuse value results are an important contribution of GCES and deserve full attention as decisions are made regarding dam operations (National Research Council, 1996, p. 135).

When certain guidelines are followed, such studies as the Welsh et al. (1995) study are recommended for use in natural resource damage. Willingness-to-pay analyses have also been upheld in court and specifically endorsed by a NOAA-appointed blue-ribbon panel (led by several Nobel laureates in economics). These methods are widely used in determining economic losses in the context of natural resource damage assessment (CERCLA, NOAA). They are also used in regulatory settings (EPA guidelines) and, as noted, benefit-cost analyses are required for all significant Federal actions by Executive Order 12866.

U.S. Governmental agencies also recognize the importance of including accounting for changes in passive use values in agency decision-making. In 1996, then Secretary of the Interior, Bruce Babbitt signed the Record of Decision on operations of Glen Canyon Dam. Included in this decision was an explicit recognition that the non-use (passive use) values of one alternative outweighed the predicted financial benefits of another alternative.

In 2016, the operation of Glen Canyon Dam was once again examined in the Long-Term Environmental Management Plan (LTEMP) FEIS. This large NEPA analysis included results of a replication study of the original Welsh et al. (1995) passive use value study (Duffield et al. 2016). The estimates of passive use values associated with expectations for improvements or stabilization in beach size and number, and in humpback chub populations (an ESA-listed species), played a significant role in informing the economic costs and benefits associated with the seven FEIS alternatives considered for water release from the dam.

Final dam-related examples of the use of passive use values in public policy decisions is in recent dam removal decisions. Two dams have been removed on the Elwah River to restore historic anadromous fisheries; this is a case where passive use values were estimated and appear to have influenced the decision (Loomis, 1996). Another significant restoration effort is also underway on the Rogue River, where four major federal dams, Gold Ray, Elk Creek, Savage Rapids and Gold Hill Dam, have been or are in the process of being removed (Preusch, 2008). On the Klamath River in Northern California and Southern Oregon four dams are under consideration for removal (J.C. Boyle, Irongate, and Copco 1 and 2). A large agency-sponsored passive use survey was undertaken to estimate the values residents and the public at large attribute to restoring and supporting traditional anadromous fish runs in the river through dam removal.

The examples given of passive use values informing public investment decisions have largely been driven by ESA considerations—listed fish species in the case of operation of Glen Canyon Dam, and listed salmon and steelhead in the case of the Oregon and California dams. Given that ESA listed species are also at risk for wildlife-vehicle collisions, the passive use values associated with protection of these species should play a role in the cost-benefit calculations associated with evaluating proposed collision mitigation projects.

2.2 Types of Wildlife Economic Values

In the context of incorporating direct use and passive use values associated with wildlife into the benefit cost analysis of wildlife collision mitigation spending, it is important to recognize that different species have different measures of economic value associated with their protection. This distinction is based, at least partially, in differences in "accounting frameworks" used to measure the values. One distinct framework is regional economic impact. This accounting framework measures distribution changes in income and employment across the larger economy resulting from changes in spending. An associated value (within the context of the regional economic impact framework) might be hunter spending associated with hunting the species in the local area. In this framework, increases in spending by hunters or wildlife watchers in one area are likely largely offset by decreases in another area of the economy. A second accounting framework (which is not generally zero-sum), which has its basis in applied welfare economics, is benefit-cost accounting. Some species, such as ESA-listed small mammals, reptiles, or amphibians might have little to no identifiable direct use value but may nonetheless have passive use value associated with "existence" or "bequest" value to people living far removed from the species.

Incorporation of wildlife direct and passive use values within mitigation structure benefit-cost calculations requires a measure of wildlife value not generally measured and reported in the literature. Most studies of passive use values of wildlife denominate estimates of value in terms of dollars per household per year, or values aggregated over a given resident population associated with protecting a specific wildlife population. However, in terms of mitigation spending benefit-cost analysis, the most useful measure of wildlife value is in terms of per-animal that is, per animal life saved by collision avoidance.

Value per household or total species valuation could be converted to value per individual animal through simple use of total species value divided by species population. The obvious result of this type of conversion is that species with very small populations, such as localized endangered species, could have very large per individual values while some species with widespread populations, such as elk, might have comparatively small values. It is important to recognize that passive use values are not only found for existence of a given species but may also be associated with given populations. This parallels the recognition of "distinct population segments" in the Endangered Species Act. This is important for wildlife mitigation applications since a given road segment may have an impact on a local distinct population segment but a much more modest impact on the entire species.

2.3 Potential Sources for Wildlife Passive Use Values

Given the diversity of potential species impacted by wildlife-vehicle collisions, and the relative scarcity of previously conducted passive-use value studies producing valuation estimates for individual terrestrial species, there are obvious challenges to providing passive use values from current data at the species and location level of detail. In general terms, there are five potential sources of wildlife valuation estimates.

1. Use of a previously estimated passive use value for the species in the setting desired.
2. Benefit transfer: use of an estimate from a different setting, location, or even species as an appropriate proxy for an existing location and species-specific estimate.
3. Meta-analysis: use of a valuation estimate derived from a larger comprehensive meta-analysis of existing species valuation studies.

4. Original valuation study specific to the species/population at issue.
5. Government expenditure decisions that reveal a minimum value for a given resource.

While many different approaches can be used to estimate passive use values of a wildlife species, the most direct and targeted method is to design and undertake an original valuation study specific to the population or species of interest. Generally, the process involves holding focus groups or conducting cognitive interviews, designing survey instruments and sampling plans, implementing a pre-test, administering the final survey, analysis and report writing. These types of original passive use value studies have been conducted in the case of the Exxon Valdez oil spill (Carson et al. 1989), operation of Glen Canyon Dam (Welsh et al. 1995; Duffield et al. 2016), removal of dams on the Klamath river to restore salmon and steelhead runs and estimating national level losses due to the BP Deepwater Horizon oil spill (Bishop et al. 2016).

The current research utilized this original targeted research method in an application of estimating passive use values of deer and turtles in MN.

2.4 Estimating household Willingness-to-Pay (WTP) to prevent vehicle/animal collisions

Two types of stated preference models were included in the MN survey. The first, a discrete choice (DC) (conjoint) model of WTP, and the second, a "payment card" model. The DC model as used in this study has many advantages: 1) the payment vehicle used in the DC questions (increased transportation taxes) are "incentive compatible" in that there is no clear incentive for the respondent to give a strategic (or false) response to the question, and 2) the question format also uses a "referendum style" presentation, asking whether people would "vote" for a program that would raise their taxes and give certain benefits. This type of structure was specifically recommended by the NOAA Blue Ribbon committee examining the validity of contingent valuation for passive use benefits (Arrow et al. 1993).

The second question format used, was a payment card format. This question type is simple to administer and robust in interpretation. However, asking for voluntary donations to a fund without implied consequence for a misleading answer means this method has a weaker "incentive compatibility" structure, thus increasing the odds of strategic responses. Several studies have shown either consistency between payment card WTP estimates and discrete choice question formats, or that DC tends to overstate the payment card results (for example, Danyliv et al. (2012) or Ryan & Watson (2009)). Estimates of the relationship between contingent valuation and actual demonstrated WTP have varied widely in the literature.

The primary question format in this study (discrete choice) used stated preference (SP) data to estimate MN households' total value for potential outcomes associated with alternative collision avoidance programs. To analyze the data from the conjoint/discrete choice experiment questions, we applied a random utility modeling (RUM) framework, which is commonly used to model discrete choice decisions in SP studies. The RUM framework assumes that survey respondents implicitly assign utility to each choice option presented to them. This utility can be expressed as:

$$U_{ij} = V(X_{ij}, Z_i; \beta^i) + e_{ij}$$

- U_{ij} is individual i's utility for a choice option (i.e., restoration option) j
- $V(\cdot)$ is the non-stochastic part of utility, a function of X_{ij}

- X_ij represents a vector of attribute levels for the option *j* (including its cost) presented to the respondent
- Z_i, a vector of personal characteristics
- β^{i}, a vector of attribute-specific preference parameters
- e_{ij} is a stochastic term, which captures elements of the choice option that affect individuals' utility but are not observable to the analyst.

On each choice occasion, respondents are assumed to select the option that provides the highest level of utility. By presenting respondents with a series of choice tasks and options with different values of Xij, the resulting choices reveal information about how to identify preference combinations.

There is a growing body of work that suggests that CV and choice experiments can yield valid measures of Willingness to Pay (see for example, Vossler and Evans 2009 and Vossler et al. 2012).

2.4.1 Conditional Logit Estimation

To estimate the parameters of the conjoint model, we used a standard conditional logit (CL) model (McFadden 1986), which assumes the disturbance term follows a Type I extreme-value error structure and uses maximum-likelihood methods to estimate β1 and β2. The conditional logit is a computationally straightforward estimation approach that can provide useful insights into the general pattern of respondents' preference, trade-offs, and values.

The parameter estimates from the CL model were then used to estimate the average marginal value of each non-cost attribute:

$$MWTP_k = -(\hat{\beta}_{1k}/\hat{\beta}_{2}),$$

where k refers to the kth element of the **X** and **β1** vectors.

The secondary valuation questions used a payment card format. To measure values associated with alternative reductions in deer/turtle collisions, respondents were asked if they would be willing to make a one-time contribution to a conservation fund which would lead to annual reductions in collisions. The estimation of willingness to pay models was implemented using a maximum likelihood interval approach (Welsh and Poe 1998; Cameron and Huppert 1989). Respondents were asked to choose the highest amount he or she was willing to pay from a list of possible amounts. It was inferred that the respondent's true willingness to pay was some amount located in the interval between the amount the respondent chose, and the next highest amount presented. Let XiL be the maximum amount that the ith person would be willing to pay and XiU be the lowest presented amount that person would not pay. Given this, WTP (willingness to pay) must lie in the interval $[X_{iL}, X_{iU}]$.

The STATA Double Bounded Logistic regression module was used to estimate the parametric model of willingness to pay based on the underlying payment card responses.

CHAPTER 3

Data Collection and Survey Design

This study was designed as a pilot study of the feasibility of using discrete choice and another contingent valuation method within a random household survey context to derive values for individual animals protected through use of vehicle/animal collisions avoidance structures. As a household survey, the methodology used was based on current guidance for survey research (Dillman 2009).

The study began with communication between the researchers and individuals both with the Minnesota Department of Transportation (wildlife biologists and transportation hydrologists) regarding our choice of deer and turtles as target species for our pilot survey. Following these conversations, a draft survey was prepared which was first presented to four individuals as a cognitive interview in order test the structure and general wording used in the survey. Following edits, the revised draft survey was reviewed by agency personnel and researchers both in Minnesota and at Montana State University-Western Transportation Institute, to check for errors in issues of fact or understanding of the interface between collision avoidance structures and wildlife. Following edits from this round of professional reviews, a limited pretest of the survey was administered to 200 randomly selected MN households. Following the general Dillman (2009) approach, repeat contacts were used to improve response rates. This pretest included an initial postcard notification followed by the full survey mailing packet including an explanatory letter, the survey instrument and a postage paid addressed return envelope.

The results of the pretest showed that the survey was well understood and there was very minimal item non-response (typically all questions elicited a response). A slight increase in the maximum bid level presented in the discrete choice questions was the only change made between the pretest and the final survey administration.

In the month of June (2021) potential respondents in the final survey sample of 2300 MN households were sequentially mailed a series of survey items: 1) an initial postcard announcing the survey; 2) the full survey packet; and 3) a reminder postcard to send back the survey.

3.1 sample sizes and response rates

As noted, the sample frame for the MN survey was all households with deliverable addresses recognized by the USPS as of April 1, 2021. A total random sample of 2500 names and addresses was drawn from this population. Initially, 200 addresses were randomly selected for the pretest, and the remaining 2300 addresses were used for the final survey mailing. Based on previous household mail surveys in recent years (Duffield et al. 2016) it was anticipated that a repeat contact mail survey would yield in the range of 16% response rate. Overall, the response rate for the MN survey was 20.25% (Table 1) suggesting that either MN respondents found the survey to be of greater interest than a typical household survey, or that MN households are more likely to complete mail surveys than typical US households. Perhaps a combination of these factors led to the better-than-expected response to the survey.

Table 1. Sample statistics and response rates.

Statistic	Pretest	Final sample	Total Sample
Randomly selected Households	200	2300	2500
Non-deliverables	18	181	199
Delivered Surveys	182	2119	2301
Completed and returned	35	431	466
Response Rate	19.2%	20.34%	20.25%

3.2 Survey Design

The mail survey (Appendix A) was organized into three general sections: introductory questions and information on wildlife collision avoidance structures; valuation questions; and demographic questions. Chapter 4 presents statistical results from the non-valuation survey questions. However, design of the discrete choice valuation questions is discussed here. The second valuation method (the payment card method) is described following the discussion of the DC model design and results.

The major objective of this research was to ascertain whether reliable estimates of the total value (including passive use value) of deer and turtles protected from animal vehicle collisions could be estimated through survey research. As noted, passive use values can only be estimated through the use of contingent valuation survey methodology. This method involves asking respondents whether they would pay a set amount to receive a set outcome. In the case of the current research, the payment was framed as an annual increase in transportation taxes paid by the household. The outcomes were specific decreases in deer and turtle/vehicle collisions. The method for reducing these collisions was through funding construction of exclusionary fencing and animal over/underpasses to keep more animals off the roadways. In designing discrete choice surveys, it is important to balance the cognitive burden faced by respondents and the need to include sufficient variation in the values of the included attributes in order to provide statistically meaningful results.

In terms of the goals of discrete choice survey design, this construction of the valuation question had many advantages. First, it uses a real program (wildlife passage and exclusion) as a method to achieve the outcomes. It also uses transportation taxes to fund those wildlife passages. Which is a logical and commonplace funding source based on the "user pays" principle. In short, the valuation questions build on real life programs and funding sources to hypothesize the choice scenarios that are presented. In terms of economic research, this question construction is "incentive compatible", or it induces the respondent to respond in a manner that is optimal in their own view. Further, it is "consequential" as there is a direct, real-life tie between costs and benefits.

The discrete choice question format asks respondents to make A/B choices between two competing scenarios. These scenarios differ in terms of different "attribute levels" associated with them. For the MN survey, attributes chosen to be included were changes in deer/vehicle collisions, changes in common turtle/vehicle collisions, changes in rare or threatened turtle/vehicle collisions, and the cost associated with these changes. Each respondent faced two choices between a status quo (no change) program and a program that had some combination of collision reductions and associated costs (Figure 2).

Q1. Each year in Minnesota, vehicles collide with about 40,000 deer and 100,000 turtles (including around 1,000 rare turtles). Please ask yourself whether the reduced deer and turtle collisions offered under Plan A (below) are worth the cost shown each year to your household in increased taxes for the next 10 years. Please check ONE box at the bottom of the table to indicate whether you prefer Plan A, or no expanded wildlife collision program.

Resources impacted by plans	**PLAN A** Expanded Wildlife-vehicle collision reduction program	**No Expanded Wildlife-vehicle collision reduction program**
Change in Minnesota Deer-vehicle collisions	**50% decrease in collisions**	**No change**
Change in vehicle collisions with COMMON TURTLE SPECIES	**10% decrease in collisions**	**No change**
Change in vehicle collisions with RARE OR THREATENED TURTLE SPECIES	**10% decrease in collisions**	**No Change**
Cost to your household in increased tax DOLLARS PER YEAR	**$60**	**$0**
I would vote for (check only one)	❑	❑

Figure 2. Example Discrete Choice Question Format

The range of attribute levels included in the survey questions is shown in Table 2. Two design issues are overall sample size, and the share of the sample to allocate to each of the possible attribute level sets. Based on the number of attributes included in the discrete choice questions (four) and the number of attribute levels, it was determined that an experimental design using six survey versions with two choice questions per version should adequately capture variation in response probability in a sample of 400 completed surveys. The STATA module **dcreate** was used to create an experimental design of the six survey versions. This module statistically determines the optimal sample allocation that makes the most efficient use of the overall sample and the number of attribute/attribute level combinations. Table 3 shows the final distribution of attribute levels across the six survey versions.

Table 2. Different Attribute Levels used in Experimental Design

Discrete Choice Question Attribute	Attribute Levels
Change in Deer-Vehicle Collisions	No change 10% decrease 50% decrease
Change in Common Turtle-Vehicle Collisions	No change 10% decrease 50% decrease
Change in Rare & Threatened Turtle-Vehicle Collisions	No change 10% decrease 50% decrease
Increase in Annual Household Transportation Taxes	$6 $20 $60 $120

Table 3. Final Experimental Design for Six Survey Versions

SURVEY VERSION	QUESTION	ALTERNATIVE	DEER	TURTLE	T&E TURTLE	COST
V1	1	1	-50%	0	-50%	$20
V1	1	2	0	0	0	0
V1	2	1	0	-50%	-50%	$120
V1	2	2	0	0	0	0
V2	3	1	0	0	-10%	$6
V2	3	2	0	0	0	0
V2	4	1	0	-10%	0	$20
V2	4	2	0	0	0	0
V3	5	1	-50%	0	0	$120
V3	5	2	0	0	0	0
V3	6	1	-10%	-50%	-10%	$20
V3	6	2	0	0	0	0
V4	7	1	-10%	-10%	-10%	$120
V4	7	2	0	0	0	0
V4	8	1	0	-50%	-50%	$60
V4	8	2	0	0	0	0
V5	9	1	-10%	0	0	$6
V5	9	2	0	0	0	0
V5	10	1	-50%	-50%	-10%	$60
V5	10	2	0	0	0	0
V6	11	1	-50%	-10%	-10%	$60
V6	11	2	0	0	0	0
V6	12	1	-10%	-10%	-50%	$20
V6	12	2	0	0	0	0

CHAPTER 4

Survey and Modeling Results

This section outlines the primary statistical results from the MN vehicle collision survey. As noted, the structure of the survey instrument included a number of introductory questions which helped to characterize the respondents. The core of the survey was the explanatory material and associated discrete choice valuation questions along with the alternative valuation questions—the payment card WTP questions. The survey also asked attitude and reasoning questions to help understand the discrete choice and payment card responses. Finally, the survey asked a number of standard demographic questions to help understand how representative the sample of respondents was compared to the overall MN population.

4.1 Introductory Questions on respondent driving and previous collisions

Survey respondents were initially asked a series of questions to gauge their level of experience both with driving and with previously having hit an animal while ether driving or riding in a car. The vast majority (96.72%) of respondents said that they personally drive a vehicle, with 74% saying they drive every day.

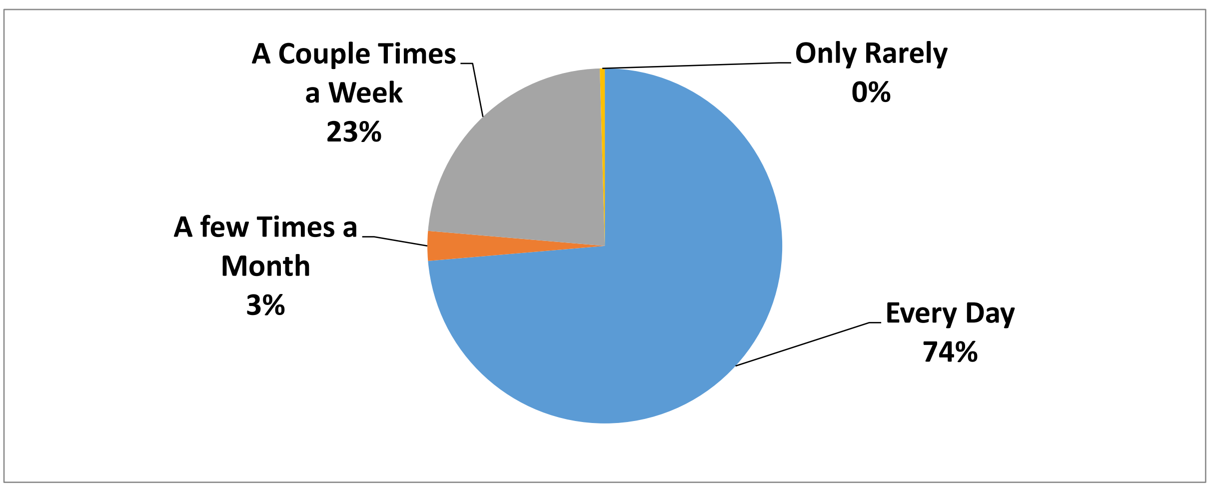


Figure 3. Responses To: About How Often Do You Drive?

We then asked respondents for their experience with animal collisions, whether they had personally been driving or had been a passenger in a vehicle that hit an animal. Significant percentages of respondents reported being in a vehicle that had struck an animal (Table 4). The largest percentage of respondents said they were in a vehicle that hit a deer (52%). The other species of particular concern to this study (turtles) showed 17% reporting hitting them with a vehicle. Other notable species reported to be frequently hit were birds (64%), Raccoons (26%) and skunks (25%).

With regard to the 52% reporting being in a vehicle that hit a deer, it is of interest to look at other available data to determine of this sample overrepresents people who have been in a deer collision. Each year State Farm Insurance reports annual probability of a driver hitting a deer (or other animals). In 2017 Minnesota drivers were estimated to have a 1 in 77 chance of hitting a deer. The average age of respondents to the survey was 59.7. If we assume that the 1 in 77 chance of a deer collision has held steady over the past 20 years in MN, and assume the average driver in the respondent sample has been driving for 40 years (since they were 20) then the odds over those 40 years would be 1 in 1.93 or 52%--exactly the percent reporting being in a deer collision. Based on this average event, back-of-the-envelope calculation, it does not appear that the survey respondents have an "avidity bias" related to experience with vehicle/deer collisions.

Table 4. Percentage of respondents reporting having been in a vehicle/animal collision: by animal type.

Animal	Percent who report being in a vehicle which hit the species
Deer	51.86%
Turtle	16.95%
Raccoon	25.94%
Fox	3.00%
Bear	1.72%
Moose	0.86%
Skunk	25.75%
Bird	63.95%
Porcupine	6.44%
Other	30.04%

4.1.1 Respondent Familiarity and Support of Animal Collision Avoidance Structures

The primary focus of the MN survey measured support for and specifically, willingness to pay for collision avoidance structures designed to reduce vehicle/ animal collisions. Three primary types of avoidance structures were described in the survey: overpasses, underpasses, and fencing and culverts (Figure 5).

Respondents were generally familiar with the described wildlife overpasses, underpasses, fencing and culverts, with 68.83% saying they had heard of these types of structures before, and with 53.44% saying they had seen or were aware of any of these types of structures in Minnesota. Respondents were strongly in favor of these types of structures, with 86% saying they either strongly favored or somewhat favored them.

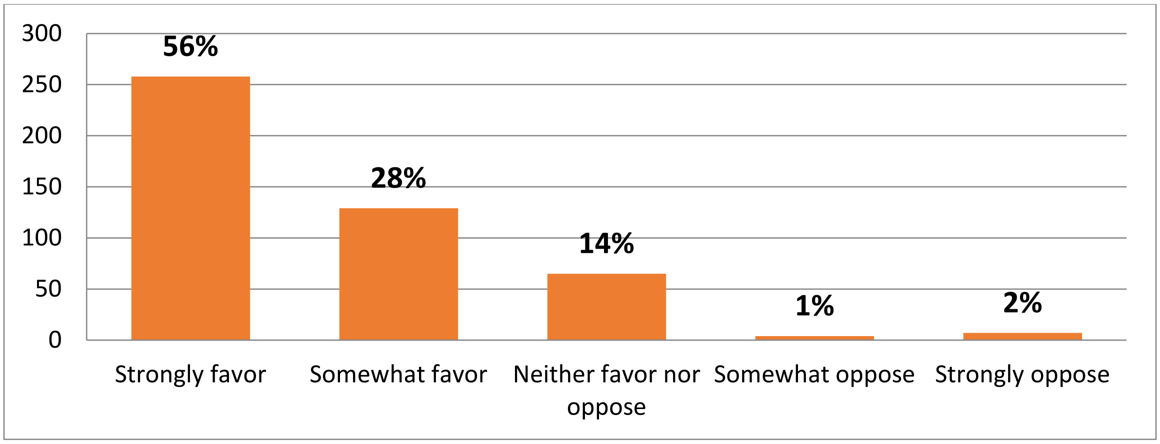


Figure 4. Support For Use of Animal Collision Avoidance Structures

WAYS ROAD DESIGNERS TRY TO REDUCE THE NUMBER OF ANIMAL-VEHICLE COLLISIONS

Wildlife experts and road designers have found several methods that significantly reduce the number of wildlife-car collisions and that allow wildlife to safely get to the other side of the road. Below are three commonly used and effective methods.

OVERPASSES

Wildlife overpasses, with fencing to direct wildlife to the overpass, can provide a crossing that includes natural vegetation and is inviting to deer and other animals.

BRIDGE UNDERPASSES

Wildlife bridge underpasses with accessible shoreline when combined with fencing can be simpler and less expensive to build, but still provide very useful routes for animals to avoid crossing busy roads.

FENCING & CULVERTS

Road fencing which guides small animals such as turtles away from unsafe crossing locations and towards culverts can be cost-effective methods to reduce wildlife-vehicle collisions and provide passage across roadways.

Figure 5. Survey descriptions of collision avoidance structures.

4.2 Collision Prevention Program Valuation Modeling Results

The primary goal of the pilot survey addressing the valuation of avoiding vehicle/animal collisions in Minnesota was to successfully estimate per-animal values for deer and turtles in the state. As noted, the MN survey employed two separate but complimentary contingent valuation questions to collect information sufficient to estimate these per animal values. The first set of stated preference questions used a discrete choice (DC) question format. This format is sometimes referred to as a conjoint question because it allows the simultaneous estimation of values for several independent attributes. The second set of valuation questions presented were two payment card questions (PC) on WTP to prevent animal/vehicle collisions. This PC question format simply asks respondents to choose the highest amount they would be willing to donate to support a collision avoidance program from a list of set donation amounts.

4.2.1 Discrete Choice Cumulative Logit Model of WTP

Much of the MN survey was dedicated to 1) describing the problem of vehicle/animal collisions in the state, 2) describing collision avoidance structures and their use, and 3) describing a potential program in the state to fund and construct collision prevention structures such as exclusionary fencing, and road over and underpasses. These descriptions were followed by two DC questions (Figure 2). The data from the DC question responses were analyzed and modeled using the STATA statistical module **clogit** (StataCorp 2017). The modeling results from the full set of responses is shown in Table 5.

The cumulative logit modeling results show a generally very well-fitting model of WTP with highly significant explanatory coefficients estimated for protecting deer (d), rare turtles (rt), and for the cost variable. Additionally, all estimated coefficients had the expected signs. Protecting all three listed species had positive signs, indicating that protecting a higher percentage of the species from collisions was associated with a higher level of willingness to pay for collision prevention. Additionally, the cost variable had the expected negative sign, indicating that as the cost increased, the chances that the person would pay that cost decreased. This result indicates that the survey responses were consistent with economic theory, specifically the foundational law of demand.

Utilizing the estimated parameters from the cumulative logit model (Table 5) to derive marginal WTP values is a straightforward calculation. Essentially, the marginal value of preservation of any of the species in the model can be calculated as their estimated coefficient divided by the coefficient for cost times negative one, or $MWTP_{species} = -\widehat{(\beta_{species}/\hat{\beta}_{cost})}$.

The changes in vehicle/animal collisions were denominated in percentage reductions in collisions in the DC questions. Therefore, the ratio of the estimated coefficients for deer (d=0.0198) divided by the coefficient for cost (-0.0049) results in a WTP value of $4.00 per household for a 1% reduction in deer/vehicle collisions in MN. Table 6 shows the estimated WTP values for a 1% reduction in collisions with deer (d), common turtles (t), and rare/threatened turtles (RT). While the estimate for common turtles is not statistically significant, the point estimate ($0.80) is substantially less than the estimated value for rare/threatened turtles ($2.29). This is consistent with the concept of the marginal value associated with scarcity. It should be noted that while the estimates of $4.00 and $2.29 per household for a 1% reduction in deer and turtle collisions, respectively are highly statistically significant, a 2-tailed t-test shows that these means are not statistically different at a 95% level of confidence (p=0.215).

Table 5. Estimated Cumulative Logit Model of WTP for Animal/Vehicle Collision Avoidance

```
Conditional (fixed-effects) logistic regression

                                                Number of obs     =      1,824
                                                Wald chi2(4)      =      69.59
                                                Prob > chi2       =     0.0000
Log pseudolikelihood = -585.45476               Pseudo R2         =     0.0739

                                   (Std. Err. adjusted for 459 clusters in id)
------------------------------------------------------------------------------
             |               Robust
      choice |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           d |   .0197791   .0032642     6.06   0.000     .0133813    .0261768
           t |    .003946     .00325     1.21   0.225    -.0024239    .0103159
          rt |   .0113089   .0032856     3.44   0.001     .0048693    .0177485
        cost |  -.0049378   .0015076    -3.28   0.001    -.0078927    -.001983
------------------------------------------------------------------------------
```

d=deer; t=turtle; rt=rare/threatened turtle; cost=cost per household per year

Table 6. Estimated WTP values for collision avoidance: by Species.

Impacted species	WTP per household for a 1% reduction in collisions	Standard Error[1]	WTP Lower 95% Confidence Interval	WTP Upper 95% Confidence Interval
Deer	$4.00	0.997***	$2.05	$5.96
Common Turtle Species	$0.80	0.63	$ 0	$2.04
Rare or Threatened Turtle Species	$2.29	0.951**	$0.42	$4.16

1 ** indicates estimate is statistically significant at the 95% level of confidence; *** indicates 99% level of significance.

A number of additional permutations of the cumulative logit model of WTP were estimated to test the robustness of the results and the *a priori* consistency of values associated with subgroups. Table 7 shows WTP values estimated both for those respondents who had reported being in a vehicle that had hit an animal, and those who said they had not been in such a collision. For the modeling results that were statistically significant, the results were consistent with expectations. Those who had been in animal/vehicle collisions valued preventing those collisions more highly than did those who had not been in an animal/vehicle collision.

Table 7. Difference between WTP for Collision Avoidance: by whether the respondent reported having collided with an animal in the past.

Impacted Species	**Willingness to Pay /household /year for a 1% reduction in animal-vehicle collisions**	
	Respondents who HAD been in a vehicle that hit an animal	**Respondents who HAD NOT been in a vehicle that hit an animal**
Deer	$4.75***	$1.96***
Common Turtles	$0.82	$0.97
Rare/threatened turtles	$2.63**	$1.05

** indicates estimate is statistically significant at the 95% level of confidence; *** indicates 99% level of significance.

An additional test was conducted to see if modeling results were significantly changed if those survey respondents who indicated they were "not at all certain" about their answers to the DC questions were excluded from the analysis. This exclusion did not substantially change the modeling results.

4.2.2 Payment Card Models of WTP

The second set of questions related to estimating WTP to prevent animal/vehicle collision utilized the payment card question format. While the payment card WTP elicitation format like the DC format discussed above is a type of stated preference contingent valuation question, as noted previously, it differs from DC in several aspects. First, it relies on a stated voluntary donation payment mechanism. This format has been shown to lack the strong "incentive compatibility" of the referendum vote format and tax increase payment vehicle used in the DC questions. There is a substantial literature on hypothetical bias in contingent valuation studies and the convergent validity between stated WTP and actual demonstrated WTP. These studies have shown wide divergence in the degree of potential bias (overstatement) of WTP derived from stated preference studies such as payment card analysis. In the current analysis, no specific adjustment for potential hypothetical bias is used due to a lack of what (if any) that adjustment should be in the current setting. Rather, the WTP estimates from the payment card analysis are presented (and compared with the WTP estimates from the DC models), unadjusted with the caveat that further research could indicate a potential bias in the estimates.

An example of the payment card format questions asked is shown in Figure 6. In this instance, the respondent is asked for the maximum one-time donation they would make to fund a program that would prevent 1,000 deer/vehicle collisions per year into the future.

Q13. Rather than paying for wildlife fences and crossing structures with increased taxes, another possible method of financing the structures would be through voluntary donations to a wildlife crossing conservation fund in Minnesota. If such a conservation fund existed, what is the largest amount you be willing to give in a one-time donation to fund a crossing structure that would be predicted to prevent 1,000 deer-vehicle collisions per year?

(circle the largest one-time donation you would be willing to make)

$0 (No donation)	**$5**	**$10**
$25	**$50**	**$100**
$250	**$500**	**$1,000 or more**

Figure 6. Example Payment Card WTP Survey questions.

A version of the payment card question was asked specific to preventing deer collisions and one specific to preventing turtle collisions. Unlike with the DC questions previously, no distinction was made between common and rare/threatened turtles in the payment card question. The responses to the payment card questions were modeled parametrically using a double-bounded logistic regression model. The estimated WTP values per household to prevent 1,000 deer and 1,000 turtle collisions annually are shown in Table 8. The models show that responding households were willing to donate $69.88 to prevent deer collisions and $59.12 to prevent turtle collisions. Both these estimates were highly statistically significant. Although the estimates were individually highly statistically significant, a two-tailed t-test of differences in the two mean values returned a p value of 0.12 indicating the means were not significantly different at the 95% level of confidence.

Table 8. Estimated Mean Lump Sum WTP to prevent 1000 animal/vehicle collisions per year.

Valued Species	Mean WTP/household	Std. Error	WTP Lower 95% C.I.	WTP Upper 95% C.I.
Deer	$69.88	5.12***	$59.83	$79.92
Turtles	$59.12	4.81***	$49.69	$68.55

*** indicates 99% level of significance.

As with the DC models, several specifications of the logistic regression models from the PC data were tested for consistency with economic theory. Models showed that higher income respondents were willing to pay more to prevent collisions than those reporting lower incomes. This result is consistent with theory. A second model included an indicator variable for respondents who marked that they "strongly agreed" with the statement "I voted for Plan A or Plan B (the collision prevention plans in the DC questions) mainly to protect deer and turtles from vehicle collisions." These people indicated a strong desire to protect species. These models showed that the motivation to protect animals from collisions played a highly significant role in determining total WTP for the protection program described.

4.2.3 Comparison of Discrete Choice Model and Payment Card Model WTP Estimates.

In order to compare the "per household" WTP values from both the DC and the PC models, it is necessary to convert these results to "per household/per animal" values. In the case of the DC results this is as simple as dividing the per household value ($4.00 for a 1% decrease in collisions with deer) by the number of deer collisions avoided (1% of 40,000 annual collisions is 400 deer protected). Therefore, the value per deer protected per household implied by the DC model is $0.01 (Table 9). For common turtles this value is $0.001, and for rare/threatened turtles $0.229. The implied combined value for both common and rare/threatened turtles is $0.003 per turtle per household.

Making the same conversion for the PC results requires an additional step and assumption. In the PC question the animals being protected are 1,000 deer or turtles **per year** into an undefined future. In the case of considering the value of a future stream of benefits, standard practice is to *discount* future benefits. This is consistent with the concept in banking that a dollar received in the future is worth less to an individual than a dollar received today. Thus, the value of collisions avoided in future years are valued less than avoided collision this year. The choice of an appropriate discount rate to employ is largely one of art. However, personal discount rates in the range of 20% are consistent with several careful empirical analyses of the issue (for example, Hausman 1979).

Using the 20% personal discount rate, the implied value of saved deer and turtles from the PC responses are $0.014 and $0.012, respectively.

Comparing the results from the DC and the PC models shows generally comparable estimates. For deer, the WTP value range from 1 cent to 1.4 cents per household per deer. For turtles these values range from 0.3 cents to 1.2 cents per household per turtle.

Table 9. Estimated WTP values per animal, per household.

Question format/Impacted Species	WTP	Number of animal collisions avoided	Assumed Discount Rate for Payment Card	WTP per animal/ household
WTP Estimates from Payment Card Responses				
PC DEER	$ 69.88	1,000/yr	20%	$ 0.014
PC TURTLES	$ 59.12	1,000/yr	20%	$ 0.012
WTP Estimates from Discrete Choice Model Responses				
DC DEER	$ 4.01	400		$ 0.010
DC TURTLES	$ 0.80	1,000		$ 0.001
DC RARE TURTLES	$ 2.29	10		$ 0.229
WEIGHTED COMBINED COMMON AND RARE TURTLES		1,010		$ 0.003

Range of WTP Estimates per animal per household across Methods

Species	**Discrete Choice Model WTP**	**Payment Card Model WTP**
Deer	$0.01	$0.014
Turtles (all species)	$0.003	$0.012

4.3 Aggregating WTP across Households

In theory, the process of aggregating estimated values per animal protected from a vehicle/animal collision to statewide (MN) values involves simply multiplying the estimated value per animal per household times the number of households in the state. This straight-ahead method makes the assumption that those randomly selected households that did not respond to the survey have the same opinions and values as those who did complete and return the survey. One way to test the plausibility of this assumption is to compare information collected from the sample respondents to information that is available for the entire statewide population. The most reliable way to make this comparison is to compare responses to the demographic questions in the survey (discussed in the previous section) to this same information for the entire state as collected by the US Census in their Annual Community Survey.

Making these comparisons shows some clear differences between the survey respondents and the entire MN statewide population. The survey sample is more male (55.9% vs 49.3% for the US Census), significantly more Caucasian (96.5% vs 63.8% for the US Census), and more highly educated (56% with a college degree or above vs 35% for the US Census) than is the average Minnesota resident.

In terms of Income levels, the current survey respondents have generally higher incomes on average than the average MN household (38.8% vs 27.8% for the US Census reporting household incomes over $100K) (Table 10**).**

Table 10. Comparison of Survey Sample and US Census reported MN Household total income levels.

Pre-tax household income	Current survey responses	US American Community Survey
under 25k	11.8%	18.0%
25k-35k	5.3%	8.7%
35k-50k	12.7%	12.7%
50k-75k	15.1%	18.7%
75k-100k	16.3%	14.1%
100k-200k	27.6%	22.0%
over 200k	11.1%	5.8%

One method of adjusting or correcting for these differences in the survey sample and the entire MN population would be to reweight the survey observations to align with their proportions in the population (for example, place higher weights on non-white respondents, or lower weights on high income individuals). This method was examined for the sample, but very small numbers of respondents in some underrepresented groups made the re-estimation of weighted models unstable, and unreliable.

As an alternative, a robust and very conservative adjustment is to make the assumption that those not returning a survey place a zero value on the collision avoidance program (Haefele, Loomis, and Bilmes 2016). Thus, total statewide estimated values per animal protected were multiplied by 0.2024 to adjust for survey non-respondents. It should be noted there is no evidence non-respondents to the survey truly have a "zero" value for collision avoidance programs. Therefore, use of the assumption of a zero value for non-respondents in the current study provides a very conservative estimate of total value.

Table 11 shows the final estimates of total value (including passive use value) of both deer and turtles for the two valuation methods employed. Based on this pilot study of total value associated with preventing deer and turtle deaths through collision avoidance structures in MN, the estimated conservative value of an avoided deer collision is between $4,100 and $5,800. And the estimated value of an avoided turtle/vehicle collision is between $1,260 and $4,100.

Table 11. Estimated Total MN Statewide value per protected animal.

Species / Valuation Method	Value per animal per household	Total unadjusted MN Value per animal*	Non-response adjusted Conservative value per animal**
PC DEER	$ 0.014	$ 28,369	**$ 5,770**
DC DEER	$ 0.010	$ 20,327	**$ 4,135**
PC TURTLES	$ 0.012	$ 24,001	**$ 4,882**
DC COMBINED TURTLES	$ 0.003	$ 6,210	**$ 1,263**

* Based on 2021 households of 2,185,000 and 7.1% of households without vehicles. Thus, 2,030,000 total households were multiplied by the per animal per household values.

** Total MN Value per animal multiplied by 20.24% to adjust for potential non-response bias.

4.4 Attitudinal Question Responses

Following the DC valuation questions, a number of survey questions probed respondents' motivations for the way they answered the DC questions. Immediately following the second DC question respondents were asked "how certain do you feel about your choices in Q7 and Q8 above?" This "certainty" question is often asked in order to test whether the responses of those who were less certain in their responses significantly bias the survey results. As noted, excluding those who responded that they were "not at all certain" about their responses had no substantial impact on the DC modeling results. This is as expected from the observed distribution of responses to this question (Figure 7) where 94% of respondents said they were either "very certain" (53%) or "somewhat certain" (41%).

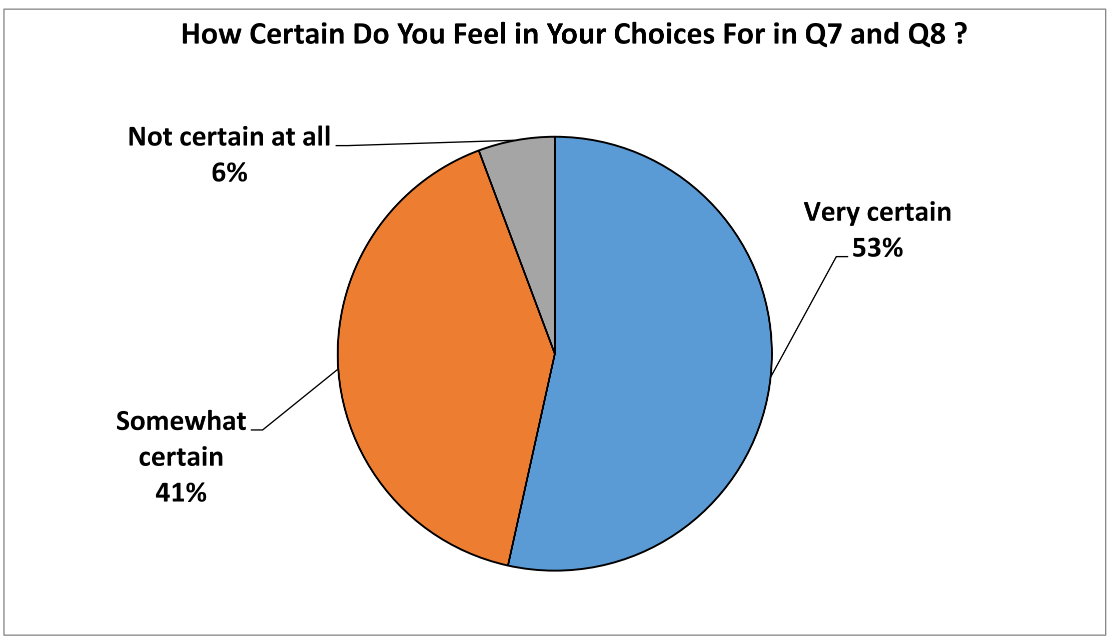


Figure 7. Respondent certainty about their Discrete Choice Question Responses

Additional attitude question probed reasons for either supporting or opposing the collision mitigation programs in the DC questions. Among those who voted “not to expand” the wildlife-vehicle collision reduction program in either of the DC questions, 64% said they did so “because I believe my taxes are already too high.”

A question for those who voted to support the expanded wildlife-vehicle collision reduction program in either of the two DC questions asked for their level of agreement with two statements regarding motivations (Figure 8). Interestingly, a higher percentage of respondents indicated they were more motivated to support the program due to concern for animals (81% either agreed or strongly agreed) than due to concern for protecting themselves or their families from collisions (72% either agreed or strongly agreed).

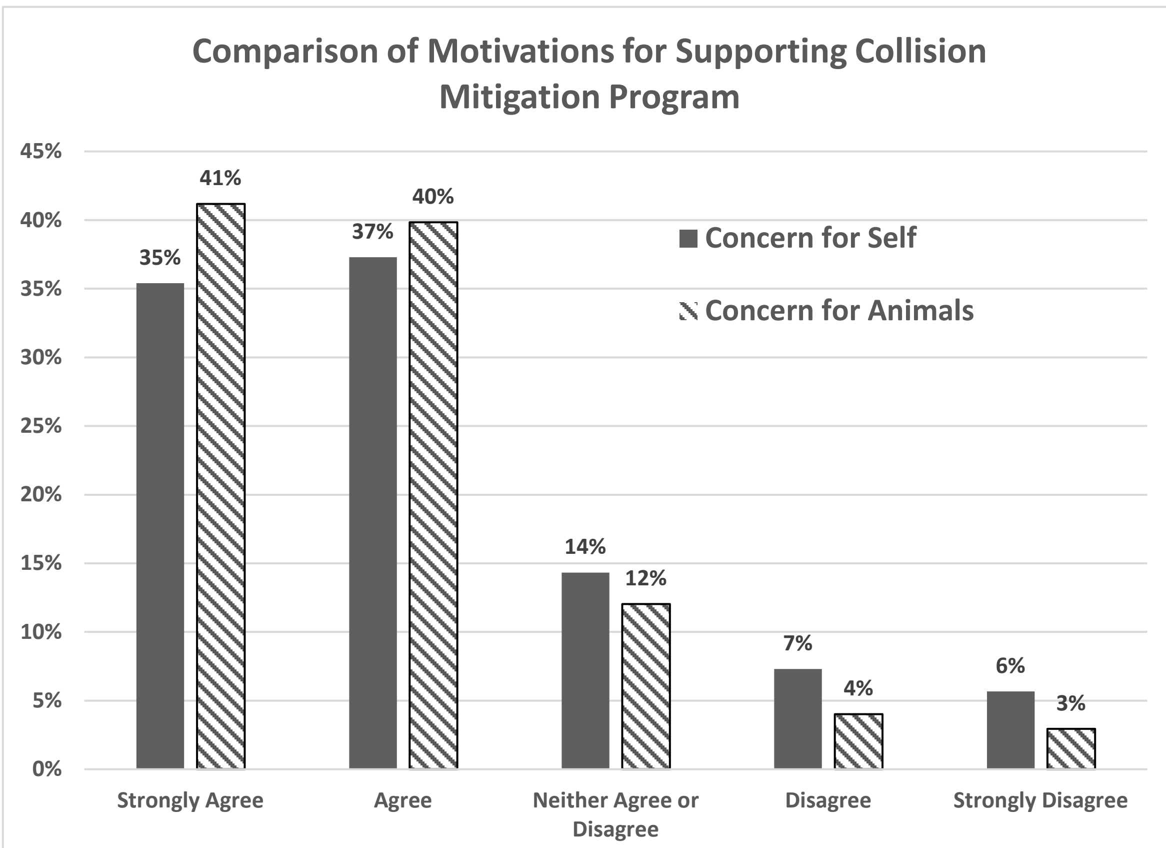


Figure 8. Comparison of motivations for supporting collision mitigation program.

Table 12 shows the response percentages of respondents concerning level of agreement with a set of four statements on wildlife and wildlife protection. Overall, respondents expressed a strong level of agreement with motives concerning protection of wildlife and concern about wildlife being hit in road collisions. This is consistent with the substantial values estimated for protecting deer and turtles in MN from collisions.

Table 12. Respondent Agreement to Statements on Wildlife and Wildlife Protection.

Statement	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
I have a great deal of concern for protecting wildlife.	40.0%	44.8%	12.4%	2.2%	0.7%
Wildlife species must be beneficial to humans to deserve protection.	13.3%	20.7%	18.6%	26.6%	20.7%
It is important to protect rare plants and animals to maintain genetic diversity.	39.3%	41.1%	16.8%	2.2%	0.7%
I am concerned about animals getting hit by vehicles on Minnesota roads.	37.5%	46.7%	11.8%	2.2%	1.8%

4.5 Socioeconomics and Demographics

Several aspects of the demographic characteristics of the survey respondents were discussed in Section 4.3 pertaining to the representativeness of the sample to the overall MN household populations. As noted, the sample was 44% female, 98.9% non-Hispanic, 96.6% white, and had higher income levels than the overall MN population.

Figure 9 sows the distribution of reported education levels for the respondents to the survey. As noted previously, those responding had higher education levels than is found on average in the state of MN.

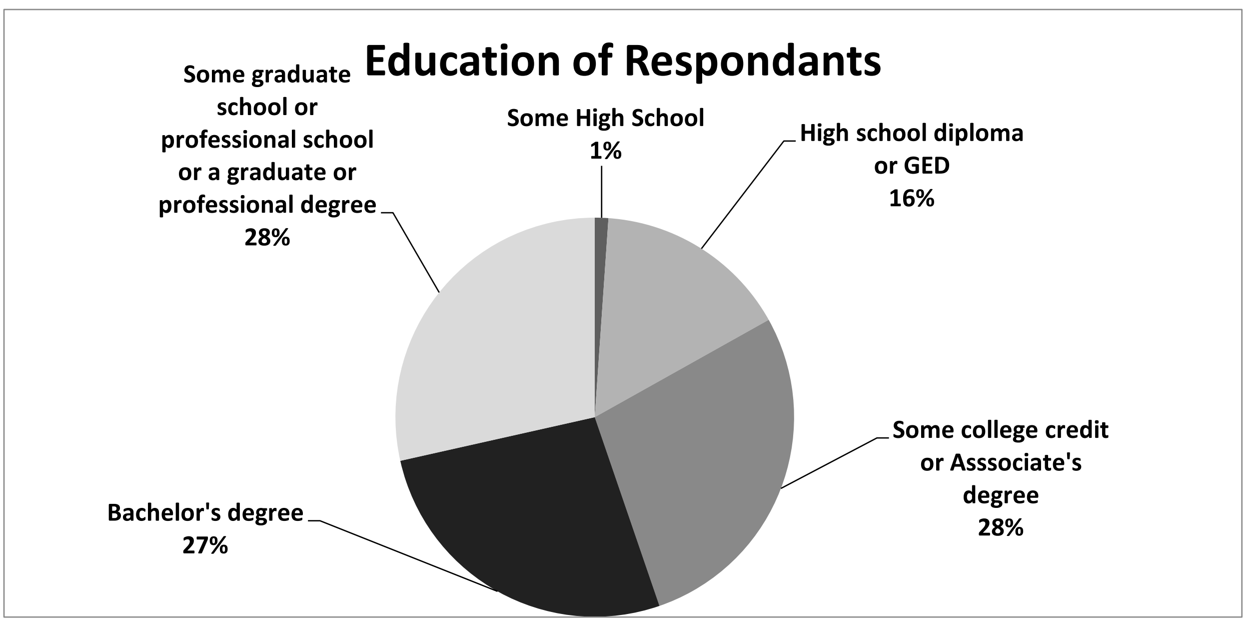


Figure 9. Respondent Education Levels.

Figure 10 Shows that 51% of respondent were employed full time and 40% reported being retired,

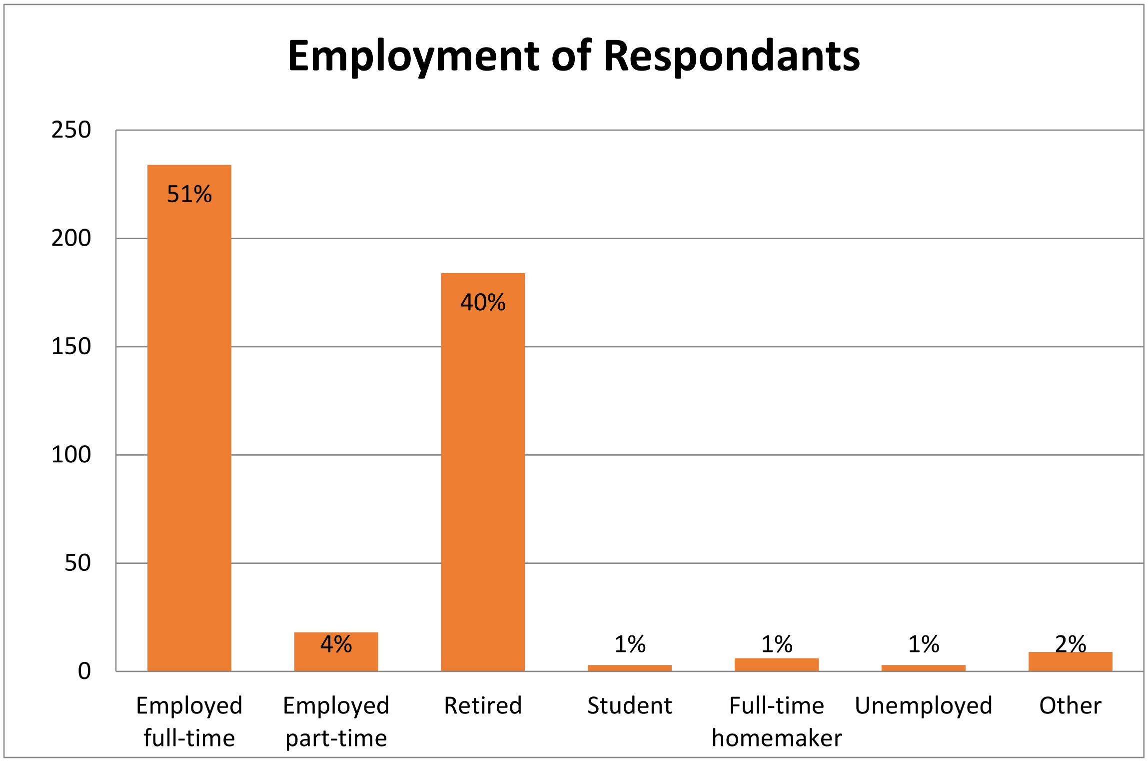


Figure 10. Respondent reported Employment Status.

4.6 Passive Use Values in the Context of Mitigation Analysis

An overall analytic framework for evaluating the benefit-cost balance associated with alternative collision mitigation measures is detailed by Huijser et al. (2009). They outline the calculations of estimated mitigation costs as:

$$A_j = \left[\sum_{t=1}^{n} \frac{c_{tj}}{(1+d)^t}\right]\left[\frac{(1+d)^n \cdot d}{(1+d)^n - 1}\right]$$

Where the first term is the present value of costs over the period t equals 1 to *n* with discount rate d and annual costs (ctj) in year t for mitigation measure j. The second term is an amortization factor (the share that yields the annual equivalent of a fixed sum over some time period, as in the annual payments on a 30-year mortgage); the product of the two terms equals Aj, which is the amortized real annual cost over period n for technology j.

The current study is focused on a portion of economic benefits associated with collision avoidance and mitigation. The benefits associated with mitigation are defined as:

$$B_j = r_j k \sum_{i=1}^{m} \alpha_i c_i + \sum_{i=1}^{m} v_{ij}$$

Where annual benefits are the sum of the reduction in direct collision costs for species i (equals 1 to m) and any annual nonuse or passive-use values vij for these species. Huijser et al. provide a detailed description of the analytic framework needed to utilize estimated costs and benefits within a breakeven analysis intended to provide a decision framework for choosing and funding potential collision mitigation measures/structures. The Huijser article also provides data and estimates on the benefits (avoided costs) associated with the first term of the benefits equation. Specifically, the benefits of avoided direct collision costs. They estimated the average deer/vehicle collision had a direct cost in 2007 dollars of $6,617 associated with vehicle damage, injury/death, and loss/removal of the animal. In current (June 2021) dollars this inflation-adjusted estimate is $8,325 per deer collision.

Table 13. Summary of estimated costs (in 2007 US$) for the average deer–vehicle collision

Cost per collision	**Deer**
Vehicle repair costs per collision	$2,622
Human injuries per collision	$2,702
Human fatalities per collision	$1,002
Towing, accident attendance, and investigation	$125
Hunting value animal per collision	$116
Carcass removal and disposal per collision	$50
Total	**$6,617 (2007 $)** **$8,325 (2021 $)**

Source: Huijser et al. 2009, Table 2.

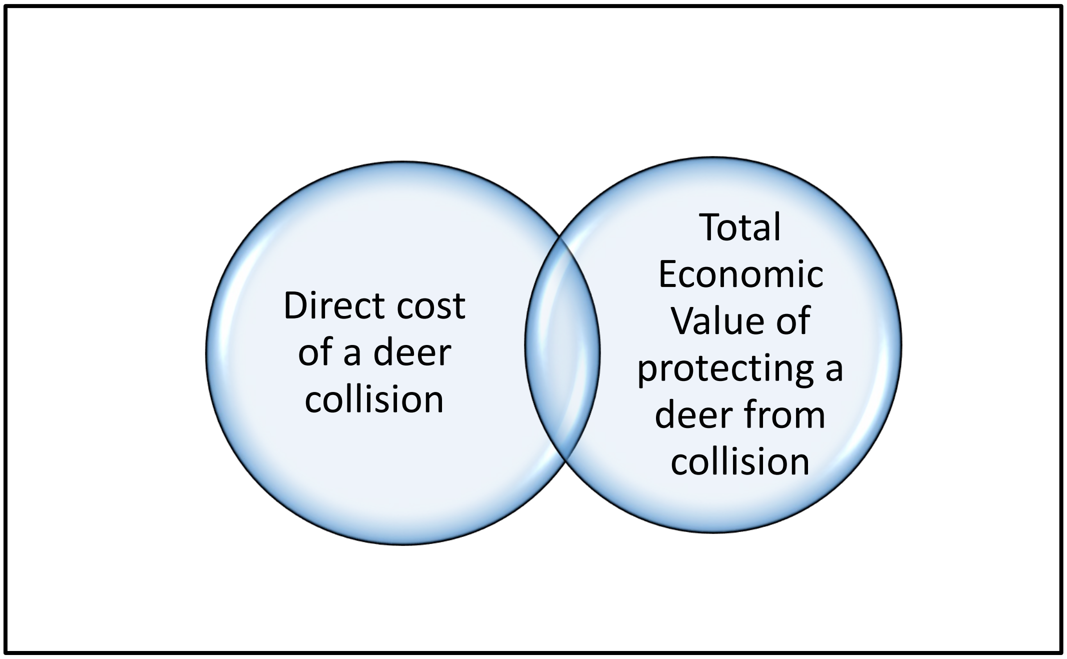


Figure 11. Visual relationship between direct costs of deer/vehicle collision and total value per deer protected from collision.

The direct collision costs estimated and reported by Huijser of $8,835 notably exclude any nonuse or passive-use values for deer. The primary motivation for the current research was to provide an empirically based estimate for this missing benefit component associated with prevention of animal/vehicle collisions.

Based on the Table 11 estimates for passive use protection values per MN deer, which range from $4,135 for the DC valuation model to $5,770 for the PC model, a simple average passive use deer value would be $4,952. This is a generally separate category of value from the collision costs (reported in Table 13) by Huijser et al. and is to a large degree additive to their estimates. An exception to this additivity might be the argument that the hunting value per animal is included in the passive use value estimate, or that the collision costs weighted by the low probability of a deer/vehicle collision might be duplicative. However, these costs would likely represent a very small share of direct collision costs. The Ven diagram shown in Figure 11 shows the conceptual relationship between the total value estimate for the current study which includes passive/nonuse values, and the direct collision costs estimated by Huijser et al. The "unknown" in this diagram is the size of the overlap between the two estimates.

As a test of the relative importance of the two primary motivations for contributing to a conservation fund to protect deer, a double-bounded logistic regression model of WTP (with a linear specification) was estimated using the payment card response data that included two additional covariates. These covariates were coded as indicator variables (coded 1=yes and 0=no) and were based on responses to the two Likert-scaled statements in Question 11 of the survey. These statements were,

- "I voted for the Plan A or B mainly to protect myself or my family from animal collisions", and
- "I voted for the Plan A or B mainly to protect deer and turtles from vehicle collisions."

If a respondent answered the first statement as "strongly agree" then a new variable (PROTECTSELF) was coded as a 1. Otherwise, it was coded as a zero. If the respondent answered the second statement as "strongly agree" then a new variable (PROTECTANIMALS) was coded as 1, and otherwise as zero. Table 14 Show the estimated multivariate model results.

Table 14. Estimated Double Bounded Logistic Model of WTP to Prevent Deer Collisions.

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Beta						
PROTSELF	.9477659	12.3039	0.08	0.939	-23.16744	25.06297
PROTANIMALS	61.3885	11.68443	5.25	0.000	38.48744	84.28956
_cons	49.23294	6.237572	7.89	0.000	37.00753	61.45836

The interpretation of these coefficients is straightforward given the linear specification of the model. Essentially, there are four possible groups (and their associated WTP) that can be parsed from this model:

1. Respondents who did not answer "very important" to either PROTSELF or PROTANIMALS (0,0)
2. Respondents answered "very important" to PROTSELF but not to PROTANIMALS (1,0)
3. Respondents who answered "very important" to PROTANIMALS but not to PROTSELF (0,1)
4. Respondents who answered "very important" to both PROTSELF and PROTANIMALS (1,1)

The estimated WTP values for the four groups (Table 15) are simple aggregations of the estimated coefficients from Table 14.

Table 15. Estimated differential WTP values based on motivations.

Respondent group	Aggregation	WTP value
Group 1 (0,0)	_cons	$49.23
Group 2 (1,0)	_cons + PROTSELF	$50.18
Group 3 (0,1)	_cons + PROTANIMALS	$110.62
Group 4 (1,1)	_cons + PROTSELF + PROTANIMALS	$111.57

There are several conclusions from this modeling exercise. First, while the constant term (_cons) and PROTANIMALS are both highly statistically significant (at the 99% level of confidence or higher), The estimated coefficient for PROTSELF is very imprecise and in fact nearly perfectly brackets zero in its 95% confidence interval. This result shows that PROTSELF, which is the motivation most closely tied to the direct costs estimated by Huijser et al. is not at all significant in predicting WTP. A second finding is that while concern for protecting animals (PROTANIMALS=1) leads to significantly higher WTP than the constant only model ($110.62 vs. $49.23), concern only for self and family only increases WTP slightly ($50.18 vs. $49.23). The conclusions based on this limited modeling suggests that animal welfare concerns (and associated passive use values) are the predominant drivers of estimated WTP from the model rather than concerns associated with protecting against the direct personal costs of hitting a deer.

This result is also consistent with statistics showing that the odds of a driver in MN hitting a deer in a given year are in the range of around 1:77 or 1.3%. Based on this, and given the uncertainty associated with the passive use estimates, we conclude that there is very little overlap between the direct cost and passive cost estimates. Therefore, a preliminary estimate of the complete benefits (direct collision costs plus passive use costs) of an avoided deer/vehicle collision in MN is $8,325 + $4,952 = $13,277. For this estimate, direct collision costs (Table 13) account for 63% of the loss of a deer collision and passive use values account for 37%.

In the case of vehicle/turtle collisions, direct costs are generally low to zero. Therefore, the estimate of passive use values from this study (and average between the 2 valuation question formats of $3,070) represent the loss to MN from such collisions.

CHAPTER 5

Conclusions

The research described in this report was designed as a pilot study with the primary goal of developing and implementing survey methods that were appropriate to the task of gathering statistically reliable data which could be used to construct accepted statistical models to derive estimates of the value associated with individual animals often involved in vehicle/animal collisions. These estimated animal values are a currently largely missing component of cost/benefit calculations related to the construction of exclusionary fencing and dedicated animal road crossings.

While there is a large literature of economic value estimates for wildlife within the natural resource economics literature, the currently available estimates almost entirely focus on either entire population value, threshold values, or values associated with significant changes in population sizes. Values for individual animals within a species have generally not been a focus of previous valuation work. Within this context of the literature on wildlife values, the current study had several objectives:

1) develop a reproducible survey instrument for a test location and species appropriate for eliciting survey responses which could be used to estimate total value estimates (including passive use values) on an individual animal basis;
2) test a draft version of the survey to determine its acceptance by respondents;
3) finalize the survey and conduct a full-scale random household survey in a test location on selected species;
4) analyze the survey data using accepted statistical modeling methods;
5) report the findings, including limitations of the analysis and suggestions for future research.

The research was conducted as designed with the site chosen being the State of Minnesota, and the species of interest being deer and turtles. Both species are of particular concern in MN with regard to vehicle/animal collisions.

The framing of the questions regarding valuation of protecting deer and turtles from vehicle collisions used collision avoidance structures (fencing, culverts, and bridges) as a means of protecting animals from collisions, and willingness to pay "transportation tax" increases to fund these structures as a general proxy for the value of the protected animals.

5.1 Primary Study Findings

The repeat contact mail survey was sent to a random sample of 2500 MN households in May and June of 2021. Based on previous general population household surveys (Duffield et al. 2016; Haeffle et al. 2016) a target response rate of 16% of deliverable surveys was anticipated. The actual response rate from the MN sample was just under 21%. This indicates that the survey was of interest to respondents and engaged a greater than expected share of recipients. Key findings from the survey responses were,

- A significant share of respondents had previously heard of collision avoidance structures as described in the survey (69%).

- A very large majority of respondents were supportive of the use of these types of structures to reduce animal/vehicle collisions (56% strongly favored and 28% favored).
- Both valuation methodologies used in the survey (discrete choice and payment card question formats) yielded data which when analyzed allowed the estimation of statistically significant estimates of total value of preventing collisions with deer and turtles.
- A large motivating factor in support for funding collision avoidance structures was concern for animal welfare.

5.2 Study Limitations

While this pilot study was successful in reaching the goals of the study design, like any study, there remain limitations to the interpretation and broad application of the study results. One limitation concerns the possibility of non-response bias in the survey results. The respondents to the survey had an overall higher income, had more formal education, and were more heavily Caucasian than the general MN population. Because factors such as income and education are positively correlated with WTP to protect animals from collision, relying on a household sample that over-weights these attributes in respondents will lead to upwardly biased WTP estimates. To compensate for this bias, the analysis adopted the very conservative assumption that all nonrespondents had a zero WTP to fund collision avoidance structures. This assumption likely understates true mean household WTP but does provide a strongly defensible conservative estimate.

The Discrete Choice model questions in the survey included attributes for both common turtles and rare/threatened turtles. While the rare/threatened turtle estimated coefficient was statistically significant and was larger than the not-significant coefficient for common turtles (as expected), the lack of a significant estimate for protecting common turtles raises questions. It may be the case that the design of the range of attribute levels for common turtle protection (10% reduction to 50% reduction) did not sufficiently capture the economic tradeoffs households are willing to make to protect these species. However, it also may be that inclusion of two groups of turtle species in the same question format posed a difficult cognitive burden on respondents to parse their concern for the two groups. In any event, any reliance on WTP estimate for common turtles from the DC model should recognize the lack of statistical significance of those estimates.

5.3 Direction for Future Research

The pilot survey and associated analysis described in this report was largely successful in developing and implementing procedures appropriate for estimating individual animal values which can be used as an input to benefit-cost decision making in prioritizing collision avoidance structure funding. One clear improvement on this research would be to include funding and design for a follow up non-response survey which would allow weighting of responses and use of a less conservative approach to non-response bias correction than that used in the current analysis. Additionally, a larger sample size than employed in the current pilot study could result in more precise WTP estimates.

Another possible research direction would be to conduct a survey using the payment card format which explores through either a split sample or multiple PC questions differences in WTP associated with protecting one vs. multiple species in a collision mitigation program.

A final note is that the state of MN ranks as the state with the 10th highest probability of a driver hitting wildlife (primarily deer) in a given year. While modeling collisions with deer and turtles in MN was successful, further research could examine collision avoidance scenarios such as moose in Maine or elk in the Western US. These larger ungulates tend to cause much greater damage and death to drivers, and thus

WTP to reduce the chances of these collisions might also be larger than those found for deer. Further case studies focusing on other states and species could increase the scope of the findings in the current study as well as act as a validation or calibration exercise.

References

Arrow, K., Solow, R., Portney, P. R., Leamer, E. E., Radner, R., & Schuman, H. (1993). Report of the NOAA panel on contingent valuation. Federal register, 58(10), 4601-4614.

Bishop, R. C., Boyle, K. J., Carson, R. T., Chapman, D., Hanemann, W. M., Kanninen, B., ... & Scherer, N. (2017). Putting a value on injuries to natural assets: The BP oil spill. Science, 356(6335), 253-254.

Cameron, Trudy and Huppert, Daniel D., (1989), OLS versus ML estimation of non-market resource values with payment card interval data, Journal of Environmental Economics and Management, 17, issue 3, p. 230-246.

Carson, R. T., Mitchell, R. C., Hanemann, M., Kopp, R. J., Presser, S., & Ruud, P. A. (2003). Contingent valuation and lost passive use: damages from the Exxon Valdez oil spill. Environmental and resource economics, 25(3), 257-286.

Clawson, M. 1959. Methods of Measuring the Demand for and the Value of Outdoor Recreation, reprint no. 10, Washington DC: Resources for the Future.

Clawson, M. and J. Knetsch. 1966. Economics of Outdoor Recreation, Baltimore: John Hopkins Press

Danyliv, A., Pavlova, M., Gryga, I., & Groot, W. (2012). Willingness to pay for physician services: Comparing estimates from a discrete choice experiment and contingent valuation. Society and Economy, 34(2), 339-357.

Davis, R. 1963. 'Big game hunting in the Maine woods', Natural Resources Journal, 3, 329–49.

Dillman, D., Smyth, J. & Christian, L. (2009). Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method, New York: Wiley.

Duffield, J. and C. Neher (2019). "Incorporating passive use values in collision mitigation benefit-cost calculations." Prepared for: Western Transportation Institute, College of Engineering, Montana State University and Nevada Department of Transportation NAS-NRC.

Duffield J, C Neher, and D Patterson. 2016. "Colorado River Total Value Study." Report for the National Park Service. August 2016. Fort Collins, CO.

Federal Energy Regulatory Commission (FERC). 1984. initial decision, Northern Lights, Inc. Project no. 2752–000, 23 April.

Federal Energy Regulatory Commission (FERC). 1987. "Opinion no. 276, Northern Lights, Inc. Project No. 2752-000, order and opinion affirming initial decision denying license for Kootenai Falls development."

Haefele, M., Loomis, J. B., & Bilmes, L. (2016). Total economic valuation of the National Park Service lands and programs: Results of a survey of the American public.

Harpman, D.A., M.P. Welsh and R.C. Bishop. 1995. "Non-use economic value: emerging policy analysis tool." Rivers, 4(4), 280–91.

Hausman, J. A. (1979). Individual discount rates and the purchase and utilization of energy-using durables. The Bell Journal of Economics, 33-54.

Hoehn, J., and A. Randall. 1989. "Too Many Proposals Pass the Benefit Cost Test." American Economic Review. Pp.544-551.

Huijser M, J Duffield, A Clevenger, R Ament, and P McGowen. 2009. "Cost–Benefit Analyses of Mitigation Measures Aimed at Reducing Collisions with Large Ungulates in the United States and Canada: A Decision Support Tool." Ecology and Society 14(2).

Huijser, M.P., W. Camel-Means, E.R. Fairbank, J.P. Purdum, T.D.H. Allen, A.R. Hardy, J. Graham, J.S. Begley, P. Basting & D. Becker. 2016. US 93 North post-construction wildlife-vehicle collision and wildlife crossing monitoring on the Flathead Indian Reservation between Evaro and Polson, Montana. FHWA/MT-16-009/8208. Western Transportation Institute – Montana State University, Bozeman, Montana, USA

Knetsch, J. and R. Davis. 1966. "Comparison of methods for recreation evaluation" in Allen V. Kneese and Stephen C. Smith (eds), Water Research, Baltimore: Johns Hopkins Press for Resources for the Future, pp. 125–42.

Krutilla, J. 1967. "Conservation reconsidered." American Economic Review, 57(4), 777–86.

Loomis, J. B., & White, D. S. 1996. Economic benefits of rare and endangered species: summary and meta-analysis. Ecological Economics, 18(3), 197-206.

McFadden, D. (1986) The Choice Theory Approach to Market Research. Marketing Science, 5, 275-297.

National Research Council. 1996. River Resource Management in the Grand Canyon, Washington, DC: National Academy Press.

Preusch, M. 2008. “Rogue River dams to come down.” The Oregonian, 8 June.

Randall, A. and J. Stoll. 1983. “Existence Value in a Total Valuation Framework.” IN Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. (Rowe and Chestnut, Eds. 1983).

Richardson, L., & Loomis, J. 2009. The total economic value of threatened, endangered and rare species: an updated meta-analysis. Ecological Economics, 68(5), 1535-1548.

Ryan, M., & Watson, V. (2009). Comparing welfare estimates from payment card contingent valuation and discrete choice experiments. Health economics, 18(4), 389-401.

StataCorp. 2017. Stata: Release 15. Statistical Software. College Station, TX: StataCorp LLC.

Vossler, Christian A. & Evans, Mary F., 2009. "Bridging the gap between the field and the lab: Environmental goods, policy maker input, and consequentiality," Journal of Environmental Economics and Management, Elsevier, vol. 58(3), pages 338-345, November.

Vossler, C., Doyon, M., & Rondeau, D. (2012). Truth in Consequentiality: Theory and Field Evidence on Discrete Choice Experiments. American Economic Journal: Microeconomics, 4(4), 145-171.

Weisbrod, B. 1964. “Collective Consumption Services of Individual Consumption Goods.” Quarterly Journal of Economics. 78 pp. 471-477.

Welsh, M., R. Bishop, M. Phillips and R. Baumgartner. 1995. Glen Canyon Dam, Colorado River Storage Project, Arizona-nonuse value study final report, Madison.

Welsh, Michael P. and Poe, Gregory, (1998), Elicitation Effects in Contingent Valuation: Comparisons to a Multiple Bounded Discrete Choice Approach, Journal of Environmental Economics and Management, 36, issue 2, p. 170-185.

Wood, S. and A. Trice. 1958. “Measurement of recreation benefits.” Land Economics, 34(3), 195–207.

Appendix A: Minnesota Passive Use Survey Materials

Initial Contact Postcard Text

Dear Minnesota Resident:

You have been selected to receive a survey sponsored by the Western Transportation Institute at Montana State University.

Montana State University is conducting this study to better understand the issue of vehicle collisions with wildlife on Minnesota roads and what can be done to minimize these collisions and protect both wildlife and drivers.

Within the next two weeks, you will receive a questionnaire from the Montana State University Western Transportation Institute. Only a select number of people in Minnesota are being asked to take part in this study, so your participation is very important. The questionnaire should take about 10 minutes to complete. We are asking that you and everyone receiving a survey from us complete and return it as soon as possible.

Thank you in advance for your help!
Chris Neher, Survey Administrator

Contact Letter in Survey Packet

Dear Minnesota Resident:

You have been selected to receive a survey sponsored by the Western Transportation Institute at Montana State University. Montana State University is conducting this study to better understand the issue of vehicle collisions with wildlife on Minnesota roads and what can be done to minimize these collisions and protect both wildlife and drivers.

Your answers to the survey questions will help the Institute better understand how big an issue the risk of wildlife-vehicle collisions is to Minnesota drivers, and what support there may be in the public to take actions to reduce the chances of such collisions.

Inside this packet you will find a short questionnaire and a self-addressed, postage paid envelope. The questionnaire should take less than 10 minutes to complete and it does not require any special knowledge—we just ask that you consider each question and respond to the best of your ability. All information you provide will remain anonymous and will be combined with the answers of others.

Only a select number of people are being asked to take part in this study, so your participation is very important. Once you have completed the survey, please fold it, place it in the enclosed postage paid envelope, and drop it in the mail. Your participation is completely voluntary but would be greatly appreciated!

If you have any questions, please contact me at 406-721-2265.

Sincerely,

Chris Neher, Survey Director

Follow-up Reminder Postcard

Dear Minnesota Resident:

About a week ago you received a questionnaire in the mail from the Montana State University Western Transportation Institute inviting you to participate in a survey on vehicle-animal collisions in Minnesota. If you have already completed and returned the questionnaire, please accept our sincere thanks. We are very grateful for your participation because it will help us to better understand the issue and the opinions of Minnesota drivers.

If you have not completed and returned the survey, we would like to express how important it is that we hear from you soon. You are one of a small number of people selected to receive this survey.

We are anxious to receive your completed survey. I would like to encourage you to complete the questionnaire we sent and return it today. Your survey responses will add to the success of this study and your time is greatly appreciated.

Thank you in advance for your help!
Chris Neher, Survey Administrator

MONTANA STATE UNIVERSITY | Western Transportation Institute

Minnesota Animal-Vehicle Collision Survey

BACKGROUND INFORMATION ABOUT THIS STUDY

Please read this page before you complete the survey.

This survey deals with ways to reduce collisions between wildlife and motor vehicles in Minnesota through installing fences, bridges, and culverts. Fences keep animals off roads and can also direct animals to safer bridge or culvert crossing locations. We are interested in your opinions and thoughts on wildlife protection structures and their use in Minnesota.

Roads fragment the landscape and are significant barriers to wildlife. It is inevitable that most species of wildlife will want or need to cross roads at some point.

While many species of animals are involved in vehicle collisions in Minnesota, *this survey focuses on two general species groups—deer and turtles*. Nationwide, there are 1.5 million vehicle-deer collisions each year. Minnesota has the 7th highest level of vehicle-deer collisions among the states. These collisions, in addition to wounding or killing the deer, damage vehicles and can injure drivers and their passengers.

Minnesota also has *nine species of native turtles, two of which are listed as threatened (the wood turtle and Blanding's turtles)*. Turtles are also routinely involved in vehicle collision in the state.

Q1. Do you personally drive a vehicle (either your own vehicle or one owned by someone else)?

❑ No ❑ Yes

IF YES → about how often do you drive?

❑ Every Day ❑ a couple times a week

❑ A few times a month ❑ only rarely

Q2. What is your best estimate of the number of miles you drive in Minnesota each year?

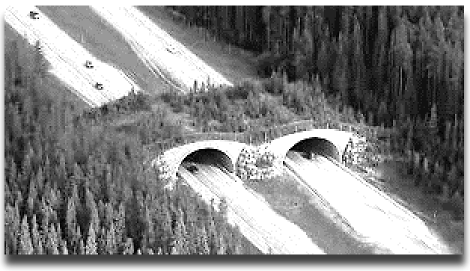
____________________ miles driven in Minnesota per year

Q3. Please look at the following list of animals and for each species check whether you have personally been driving or been a passenger in a vehicle that hit them.

Animal species	Yes	No	Not Sure
Deer	❑	❑	❑
Turtle	❑	❑	❑
Raccoon	❑	❑	❑
Fox	❑	❑	❑
Bear	❑	❑	❑
Moose	❑	❑	❑
Skunk	❑	❑	❑
Bird	❑	❑	❑
Porcupine	❑	❑	❑
Other ______________________	❑	❑	❑
Other ______________________	❑	❑	❑

WAYS ROAD DESIGNERS TRY TO REDUCE THE NUMBER OF ANIMAL-VEHICLE COLLISIONS

Wildlife experts and road designers have found several methods that significantly reduce the number of wildlife-car collisions and that allow wildlife to safely get to the other side of the road. Below are three commonly used and effective methods.



OVERPASSES

Wildlife overpasses, with fencing to direct wildlife to the overpass, can provide a crossing that includes natural vegetation and is inviting to deer and other animals.

BRIDGE UNDERPASSES

Wildlife bridge underpasses with accessible shoreline when combined with fencing can be simpler and less expensive to build, but still provide very useful routes for animals to avoid crossing busy roads.

FENCING & CULVERTS

Road fencing which guides small animals such as turtles away from unsafe crossing locations and towards culverts can be cost-effective methods to reduce wildlife-vehicle collisions and provide passage across roadways.

Q4. Have you heard about these types of collision avoidance structures before reading this survey?

- ❑ No
- ❑ Yes

Q5. Have you seen or are you aware of any of these types of structures in Minnesota?

- ❑ No
- ❑ Yes

Q6. Generally, are you in favor or opposed to use of these types of animal collision avoidance structures?

- ❑ Strongly favor
- ❑ Somewhat favor
- ❑ Neither favor nor oppose
- ❑ Somewhat oppose
- ❑ Strongly oppose

A potential program to reduce wildlife-vehicle collisions in Minnesota

A possible program to build wildlife crossings in the state **could significantly reduce the number of vehicle-animal collisions**. Such a program would use a combination of the structures described on the previous page placed at locations with the highest levels of collisions. ***Such a program would have both benefits and costs.*** **Depending on what type of structures were built, and where they were built, different combinations of reduced collisions could be expected.** Large structures are primarily designed to prevent deer collisions. **Some smaller structures for turtles would benefit different species of turtles to a different extent, depending on where they were built.**

BENEFITS OF THE PROGRAM

- **Saving the costs to drivers in terms of vehicle damage, and human injury**
- **Avoiding killing or injuring deer and turtles**
- **Preserve threatened and endangered turtle species in Minnesota**
- **Provide safe connections and corridors for movement of wildlife populations between areas of the state.**

COSTS OF THE PROGRAM

- **Depending on the location and types of mitigation structures used, the program could have substantial costs. One common method of paying for roadway improvements is through increased transportation taxes.**

The following questions ask you whether you would vote for a program to reduce deer and turtle-vehicle collisions in Minnesota. The programs proposed use different combinations of animal highway crossing types combined with fencing and would have different impacts on wildlife collisions.
Depending on their type and location, collision mitigation structures could be designed to have different impacts on reducing collisions with different animal species. The different programs would also have different costs.
While there are no plans currently to implement such a statewide program or to increase transportation taxes, we would like to know your opinions on such a program should it be considered in the future and how much you would value such a program.

For each of the following two questions, please assume that the animal road fencing and crossing construction program would be funded for 10 years. The estimated cost is increased taxes per year for your household.

Q7. Each year in Minnesota, vehicles collide with about 40,000 deer and 100,000 turtles (including around 1,000 rare turtles). Please ask yourself whether the reduced deer and turtle collisions offered under Plan A (below) are worth the cost shown each year to your household in increased taxes for the next 10 years. Please check ONE box at the bottom of the table to indicate whether you prefer Plan A, or no expanded wildlife collision program.

Resources impacted by plans	**PLAN A** Expanded Wildlife-vehicle collision reduction program	**No Expanded Wildlife-vehicle collision reduction program**
Change in Minnesota Deer-vehicle collisions	**50% decrease in collisions**	**No change**
Change in vehicle collisions with COMMON TURTLE SPECIES	**10% decrease in collisions**	**No change**
Change in vehicle collisions with RARE OR THREATENED TURTLE SPECIES	**10% decrease in collisions**	**No Change**
Cost to your household in increased tax DOLLARS PER YEAR	**$60**	**$0**
I would vote for (check only one)	❑	❑

Now please consider a different choice…

We would now like to know how you would vote if you were presented with a completely different Plan. When making this choice, please imagine that the ONLY two options are Plan B and the Current Plan.

Q8. Each year in Minnesota, vehicles collide with about 40,000 deer and 100,000 turtles (including around 1,000 rare turtles). Please ask yourself whether the improvements offered under Plan B are worth the cost shown each year to your household in increased taxes for the next 10 years. Please check ONE box at the bottom of the table to indicate whether you prefer Plan B, or no expanded wildlife collision program.

Resources impacted by plans	**PLAN B** **Expanded Wildlife-vehicle collision reduction program**	**No Expanded Wildlife-vehicle collision reduction program**
Change in Minnesota Deer-vehicle collisions	**10% decrease in collisions**	**No change**
Change in vehicle collisions with COMMON TURTLE SPECIES	**10% decrease in collisions**	**No change**
Change in vehicle collisions with RARE OR THREATENED TURTLE SPECIES	**50% decrease in collisions**	**No Change**
Cost to your household in increased tax **DOLLARS PER YEAR**	**$20**	**$0**
I would vote for (check only one)	❑	❑

Q9. How certain do you feel about your choices in Q7 and Q8 above?

❑ Very certain ❑ Somewhat certain ❑ Not certain at all

Q10. If you voted for <u>No Expanded Collision Reduction Program</u> in Q7 or Q8, please rate how much you agree or disagree with the following statement. If not, skip to Q11. *(circle one)*

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I voted for No Expanded Program because I believe my taxes are already too high.	1	2	3	4	5

Q11. If you voted for either <u>PLAN A or PLAN B</u>, (or both) please rate how much you agree or disagree with each of the following statements. *(circle one number for each statement)* **If not, skip this question.**

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I voted for the Plan A or B mainly to protect myself or my family from animal collisions	1	2	3	4	5
I voted for the Plan A or B mainly to protect deer and turtles from vehicle collisions	1	2	3	4	5

Q12. We are interested in learning how you feel about wildlife in general and protecting wildlife in particular. On a scale of 1 to 5, with 1 being "strongly agree" and 5 being "strongly disagree," please indicate how you feel about each statement written below. *(Circle one number for each statement)*

Statement	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I have a great deal of concern for protecting wildlife.	1	2	3	4	5
Wildlife species must be beneficial to humans to deserve protection.	1	2	3	4	5
It is important to protect rare plants and animals to maintain genetic diversity.	1	2	3	4	5
I am concerned about animals getting hit by vehicles on Minnesota roads.	1	2	3	4	5

Q13. Rather than paying for wildlife fences and crossing structures with increased taxes, another possible method of financing the structures would be through voluntary donations to a wildlife crossing conservation fund in Minnesota. If such a conservation fund existed, what is the largest amount you be willing to give in a one-time donation to fund a crossing structure that would be predicted to prevent 1,000 deer-vehicle collisions per year?

(circle the largest one-time donation you would be willing to make)

$0 (No donation)	**$5**	**$10**
$25	**$50**	**$100**
$250	**$500**	**$1,000 or more**

Q14. Now please consider a conservation fund to pay for fencing and crossings designed to prevent turtle-vehicle collisions. If such a conservation fund existed, what is the largest amount you be willing to give in a one-time donation to fund a crossing structure that would be predicted to prevent 1,000 turtle-vehicle collisions per year?

(circle the largest one-time donation you would be willing to make)

$0 (No donation)	**$5**	**$10**
$25	**$50**	**$100**
$250	**$500**	**$1,000 or more**

In this last section, we would like to ask you some questions about your background that will help us compare your answers with those of other people.

Q15. Are you male or female?

- ☐ Male
- ☐ Female
- ☐ Other

Q16. What is your age? ________ years old

Q17. What is the highest degree or level of school you have completed?

- ☐ Some high school
- ☐ High school diploma or GED
- ☐ Some college credit or Associate's degree (for example: AA)
- ☐ Bachelor's degree (for example: BA or BS)
- ☐ Some graduate school or professional school or a graduate or professional degree

Q18. Which of the following categories best describes your household employment status? *(Check all that apply)*

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ Retired
- ☐ Student
- ☐ Full-time homemaker
- ☐ Unemployed
- ☐ Other

Q19. Are you Hispanic or Latino?

☐ No ☐ Yes

Q20. Please select the racial category or categories with which you most closely identify by placing an "X" in the appropriate box. *(Check one or more)*

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Pacific Islander
- ☐ White

Q21. What was your total pre-tax household income, including all earners in your household, in 2020?

- ☐ Under $25,000
- ☐ $25,000 to $34,999
- ☐ $35,000 to $49,999
- ☐ $50,000 to $74,999
- ☐ $75,000 to $99,999
- ☐ $100,000 to $199,999
- ☐ $200,000 or more

THANK YOU FOR YOUR HELP!

Please return only this survey booklet in the enclosed, postage-paid envelope

For questions, contact:
Chris Neher (406) 721-2265

V6

Nevada Department of Transportation
Kristina L. Swallow, P.E. Director
Ken Chambers, Research Division Chief
(775) 888-7220
kchambers@dot.nv.gov
1263 South Stewart Street
Carson City, Nevada 89712