Three Essays on Behavior, Incentives, Environmental Valuation, and Contributions to Conservation

by

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Abstract

Understanding how human behavior influences and is influenced by environmental resources that are outside of markets is challenging but crucial for policy evaluation and regulatory decisions. This thesis presents three studies that examine non-market behavior associated with environmental resources and recreational activities. The empirical application of the thesis is to study the behavioral and welfare impacts of the presence of a potentially zoonotic wildlife disease on recreational hunters and to design incentive programs that engage recreational hunters in curbing the wildlife disease. The first paper focuses on individuals' spatial and temporal recreation decisions and their responses to incentives that provide temporal flexibility. I extend a discrete-continuous recreation demand model that explicitly combines spatial (where to go) and temporal (when to go) decisions at intensive and extensive margins. The incentives of longer recreation seasons, with the intent to support wildlife disease management by providing individuals with the flexibility of choosing the time of activities, are found to encourage more recreation trips, induce spatial and temporal substitution behavior, and generate welfare benefits. The second paper studies the effectiveness of incentives and information framing on contributions to impure public goods in an experimental setting. Based on a theoretical framework within the concept of motivational crowding, I examine students' and recreational hunters' decisions on increasing recreation trips in response to incentives and pro-social information in a multiple threshold impure public goods game. Pro-social information is found to encourage more contributions from students and recreational hunters. Monetary rewards generate different behavioral outcomes in the two samples, depending on whether they are given in fixed amounts or as a lottery. Students and recreational hunters also behave differently after incentives are removed. The third paper tests the temporal reliability of estimates from discrete-continuous recreation demand models with contingent behavior data – a type of stated preference data. The contingent behavior data, collected from online surveys over three years, elicit individuals' intended decisions on recreation trips with hypothetical incentive programs. I estimate three separate models, construct welfare estimates of closing recreation sites, and test consistency of coefficient and welfare estimates. I find most coefficient and welfare estimates are consistent or temporally reliable across years. Together, these studies provide economic insights into designing incentives and engaging humans in managing potentially zoonotic wildlife diseases and other similar health risk situations, as contributions to the ongoing research effort to improve knowledge of human behavior and inform policy decisions.

Preface

All the research in this thesis received research ethics approval from the University of Alberta Research Ethics Board:

- Chapter 2: "Incentive programs for Chronic Wasting Disease management by hunters in Alberta – Focus Group and Primary Survey", No. Pro00077042
- Chapter 3: "Hunter Game", No. Pro00086132
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Chapter 2 is coauthored with Wiktor Adamowicz (Department of Resource Economics & Environmental Sociology, University of Alberta) and Patrick Lloyd-Smith (Department of Agricultural & Resource Economics, University of Saskatchewan). Chapter 3 is coauthored with Wiktor Adamowicz and Maik Kecinski (Department of Applied Economics & Statistics, University of Delaware). Chapter 4 is coauthored with Wiktor Adamowicz.

To my parents

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Chapter 1

Introduction

The year 2020 will be remembered as a remarkable year in human history. Triggered by the COVID-19 pandemic, the interactions between human decisions and disease transmission have again called for attention from researchers, policy makers, and a majority of people. The whole world is working "non-stop" to compete with COVID-19: virologists are studying the virus, developing treatments and vaccines, social scientists and policy makers are working to identify socio-economic factors that are affected by and affect disease transmission, and a majority of people are changing behaviors in response to rapidly-developed policy tools. Although the policy tools, regardless of "carrot" or "stick", share the same objective to intervene in virus transmission, they have different impacts on human behavior. However, the effectiveness of the same policy tools varies across regions/countries, partially due to the heterogeneity of individual behavioral responses across space and time. This heterogeneity has also urged researchers to use various approaches to collect data, from actual behavior recorded by mobile phones (e.g. Dimke et al. 2020) to intended/recalled behavior elicited on Internet surveys (e.g. Thunström et al. 2020), to advance the understanding of individual behavior – a key to assessing the efficacy of policy tools on combating the spread of COVID-19.

In environmental and resource economics, understanding human behavior in relation to nature has been critical in developing policy tools to address issues such as public good provision and resource allocation. As policy tools have market and non-market impacts on people, depending on the existence of markets, human behavior is categorized into market and non-market behavior. Non-market behavior, involving the natural assets that are not traded on the market and do not have market prices, is mostly studied by non-market valuation approaches. These approaches measure the economic values of natural assets by employing individuals' actual behavior to reveal their values (i.e. revealed preference methods, RP) or asking individuals' intended behavior to measure values (i.e. stated preference methods, SP) through surveys. Although RP and SP methods are widely applied to measure preferences and value natural resources, concerns around modeling techniques and criticisms of data collection methods continue to motivate research to increase our knowledge of individuals' behavior and create more accurate estimates of associated benefits and costs of environmental regulations and policies.

This thesis consists of three papers that aim to better understand human decisions that involve environmental resources. Each paper examines different aspects of non-market behavior: how people choose the location and time periods of non-market activities when receiving incentives associated with time choices, whether and how people would provide more to public goods through non-market activities with material incentives and behavioral nudges, whether approaches to examine individuals' non-market behavior provide stable or consistent measures over time. The empirical application of the three papers is to study how the presence of a potentially zoonotic wildlife disease affects recreational hunting activities and to design effective incentive programs to engage recreational hunters in disease control.

The disease examined in the empirical application is Chronic Wasting Disease (CWD), a fatal and infectious wildlife disease. Caused by misfolded proteins called prions, CWD has been found to affect the deer family including mule deer, white-tailed deer, elk, caribou (reindeer), and moose. CWD is present in 3 Canadian provinces and 26 states in the United States, South Korea, Norway, Finland, and Sweden.[1] Although CWD progresses slowly, it

[1] http://cwd-info.org/faq/#:~:text=Chronic%20Wasting%20Disease%20(CWD)%20is, of%20bodily%20functions%20and%20death.https://www.usgs.gov/centers/nwhc/science/chronic-wasting-disease?qt-science_center_objects=0#qt-science_center_objects

is difficult to control due to various transmission routes, e.g. direct contact with infected animals and indirect contact with contaminated environments (Williams, 2005), and strong resilience in local environments (e.g. soil). Given the increased prevalence and spread of CWD in regions like Alberta,[2] two main concerns call for CWD management: first, the potential threat to wildlife populations as CWD prevalence increases (DeVivo et al., 2017); and second, potential zoonotic risks. While there is no evidence of humans being infected by the CWD prion, there are concerns about the zoonotic potential of CWD (Czub et al., 2017; Barria et al., 2018; Nemani et al., 2020; Schaetzl, 2020). Health agencies advise precautions when contacting and consuming infected animals.

Wildlife agencies around the world have implemented or are considering various CWD surveillance and control programs to monitor and slow the progression of the disease. Given a lack of vaccines and treatments, hunter harvest in disease-affected areas is likely the most desirable approach to depopulate infected animals for CWD control in Alberta and other areas of western North America. Although recreational hunters obtain use and non-use values from wildlife populations and hunting activities, they might be adversely affected by CWD and CWD surveillance programs. Hunting satisfaction might decrease if CWD reduces wildlife population densities and hence require more search effort during hunting. Given the potential impact of CWD on wildlife populations, hunters are encouraged, or required in some areas, to submit harvested animals for CWD testing. Although CWD testing facilitates the surveillance of the disease, the lengthy testing process can result in delays in processing and consumption of meat and adversely affects the satisfaction of the overall experience. Therefore, recreational hunters might change locations or reduce hunting effort.

Given the development of CWD, some wildlife agencies have piloted a set of incentive programs that provide additional hunting opportunities to encourage hunter harvest for CWD control (Western Association of Fish and Wildlife

[2] https://www.usgs.gov/media/images/distribution-chronic-wasting-disease-north-america-0 https://www.alberta.ca/chronic-wasting-disease-updates.aspx

Agencies, 2017). With the assumption that hunters favor these incentives and would increase hunting, epidemiological models have shown that these incentive programs could be effective in CWD control based on deer activities and disease transmission dynamics (Mysterud et al., 2020; Jennelle et al., 2014; Wasserberg et al., 2009). However, it is not clear whether these incentive programs would actually encourage hunting effort because the behavioral and welfare impacts of these incentives on recreational hunters have not been examined from an economic perspective. For recreational hunters, although hunting for CWD control may increase private costs and perhaps perceived human health risks, it generates benefits of reduced CWD prevalence and healthy wildlife populations in the future. In addition, these benefits are not exclusive to hunter communities: the general public would enjoy the non-use values of wildlife populations that are free from CWD (especially caribou, a threatened species); producers and consumers of livestock would benefit from the reduced potential risks of CWD transmitting to livestock; and Indigenous people would have access to healthy and sufficient wild game as a food source. As such, recreational hunters' behavioral responses to incentives for CWD management involve trade-offs between private benefits, public benefits, and private costs. With the focus on non-market behavior in recreational hunting activities, this thesis aims to examine these trade-offs and provide insights into better design of incentives for CWD control by recreational hunters.

Although the behavior examined in this thesis is specific to recreational activities and wildlife disease management, it shares similarities with other economic activities associated with the use of environmental resources and the transmission of infectious diseases. With primary data collected from RP and SP surveys and economic experiments, the papers present results and findings that offer economic insights into designing incentive programs, encouraging private provision of public goods, as well as managing wildlife diseases and pandemics.

The first paper focuses on individuals' spatial and temporal decisions on recreation trips and the impacts of non-monetary incentives that provide them with more flexibility in choosing the time of activities. While it is common to see people decide on locations and time periods in recreational activities, particularly in response to external shocks such as lockdown or reopening policies (e.g. Nguyen et al. 2020), recreation demand models focus largely on the location decisions rather than both. To capture spatial and temporal substitution behavior, my co-authors and I extend a discrete-continuous recreation demand model (Kuhn-Tucker or KT model) that combines spatial (where to take trips) and temporal (when to take trips) choices. With the novelty of combining spatial and temporal choices in one model, we examine the behavioral and welfare impacts of extended recreation seasons that intend to encourage hunting activities to curb a wildlife disease. The data we use are from an online RP and SP survey administered to recreational hunters in Alberta, Canada. The results show that individuals substitute activities spatially and temporally, increase trips, and gain welfare benefits when they can more flexibly choose the time of activities with an extended recreation season. These actions will aid in control of the wildlife disease by increasing hunter harvest in CWD-infected areas. Two major contributions of the study are: first, building on Lloyd-Smith et al. (2019, 2020) that focus only on temporal decisions, this study develops a flexible econometric model that explicitly incorporates spatial *and* temporal decisions in a demand system; and second, it shows that incentives associated with time choices can be a unique type of incentive to change behavior. This paper also has direct policy implications on using extended hunting seasons to encourage hunting to control CWD.

Economists and policy makers have put substantial effort into designing incentives and behavioral nudges to induce beneficial behavior (e.g. DellaVigna and Pope 2017; Brownback and Sadoff 2020; Goette and Stutzer 2020; Mellström and Johannesson 2008; Allcott 2011). Yet we have a limited understanding of when and how they are effective in achieving beneficial behavioral outcomes, especially when incentives and nudges interact with individual motivations that drive beneficial behavior for public good contributions. For example, stay-at-home orders might crowd out voluntary decisions of staying at home to reduce COVID-19 transmission in public space (Yan et al., 2020). Moral suasion has different impacts on intentions to practice hand washing and social distancing as contributions to public health (Bos et al., 2020). To gain insight in the area of public good provision, the second paper focuses on comparing the effectiveness of incentives and information framing to encourage contributions to impure public goods. I work with my co-authors to develop a theoretical framework within the concept of motivational crowding. Using experimental methods, specifically a multiple threshold impure public goods (PG) game, we test how incentives and information affect behavior for students and recreational hunters, in the context of recreational hunting to curb CWD. Treatments in the experiments include non-monetary incentives, pro-social information, as well as fixed and lottery monetary rewards that are stylized versions of actual policy options. We find that both students and recreational hunters contribute more hunting trips with pro-social information that encourages hunting for wildlife disease management, but respond differently to monetary rewards and removal of incentives. Fixed monetary rewards are found to induce behavioral outcomes in the hunter sample as expected by the theoretical framework while lottery monetary rewards encourage more contributions from students than from hunters. With the different behavioral responses from students and recreational hunters, this paper contributes to the experimental economics literature by raising concerns about using experimental findings with student samples when the experiments are framed in a specific context. The paper advances the knowledge of the relationship between incentives, information, motivational crowding, and the appropriateness of some types of experiments. It also shows the importance of information framing in combination with incentives for wildlife disease management.

Given a relatively controlled environment and potential selection bias arising from small samples, the generalizability of experimental findings from the second paper is limited compared to studies that use field surveys with random yet representative samples. Furthermore, season expansion explored in the first paper, monetary rewards, and pro-social information examined in the second paper are all considered as policy options for CWD management (Western Association of Fish and Wildlife Agencies, 2017).

To give a full picture of the impacts of these different incentives and potentially address the issue on generalizability of the second paper, the third paper looks at how incentives affect individuals' decisions on recreation hunting sites over time using three SP surveys. In addition to its practical goal of evaluating the incentives for CWD management, the third paper tests the temporal reliability of estimates from Kuhn-Tucker (KT) recreation demand models with contingent behavior (CB) trip data – a type of SP data. Although CB trip data, by eliciting individuals' intended trip decisions with hypothetical scenarios, has been widely used with RP data in recreation demand models, its temporal reliability – a measure of credibility/accuracy – has not been studied. Together with limited applications of KT recreation demand models, little is known about the temporal reliability of estimates from KT models with CB data. In this paper, I estimate three separate KT models, construct welfare estimates of site closures, and test consistency of estimates from the three models. Three CB datasets used in this paper were collected in surveys from 2018 to 2020 that asked recreational hunters about intended trip decisions with proposed incentives for wildlife disease management. I find that most coefficient and welfare estimates from the three models are not significantly different – indicating that estimates are temporally reliable. This paper contributes to the literature on non-market valuation by showing that CB data are a reliable SP data source. For recreation demand studies, the findings in this paper show the potential for a broader application of KT models. Moreover, this paper increases wildlife managers' confidence in assessing impacts of incentives on hunting trips to curb CWD that is slowly progressing over time. This study also emphasizes the importance of temporal reliability of findings using surveys that collect information about expectations (Aucejo et al., 2020) and/or data with hypothetical scenarios (Bos et al., 2020), in time periods such as during the COVID-19 pandemic.

These three papers tackle distinct problems but share important themes. Each paper examines individuals' decisions in non-market recreational activities in response to external factors, in particular incentives, albeit with different approaches. In the first paper (KT model), the focus is on how individuals allocate recreational activities across space and time. The incentives studied are non-monetary incentives that give individuals longer periods of time for recreational activities. The linkage between human behavior and incentives studied is the extended recreation demand model. People are found to substitute locations and time periods of recreation activities and gain welfare benefits from the incentives. This paper provides an example of using advanced models to flexibly capture individuals' decisions and welfare impacts that might be missed in traditional repeated discrete choice models. In the second paper (PG game), the emphasis is on whether individuals increase the intensity of recreational activities (e.g. take additional trips). The external factors are material incentives (monetary and non-monetary) and behavioral nudges. The interplay between individuals' decisions and external factors is characterized in an impure public goods game. Different findings with students and non-students highlight the heterogeneity of individual behavior in response to incentive programs. In the third paper (KT reliability), the attention is on whether measurement of individual preference and welfare using KT models with CB data is reliable or consistent as time goes by. Incentives examined in this paper include incentives from the other two papers. Using a KT model similar to that in the first paper but without the temporal choices, this paper captures the spatially varying impacts of incentives on individuals' decisions across three years. By finding temporally reliable individuals' decisions, this paper increases confidence in the evaluation of the impacts of incentive programs that sometimes take years to be in place.

The second theme is that all three papers evaluate approaches to motivate private provision of public goods. As the empirical application is to encourage recreational hunting trips for controlling a wildlife disease, recreation trips in all three papers are impure public goods: individuals obtain private benefits and pay private costs of trips, while generating public benefits of controlled wildlife disease and healthy wildlife populations. The trade-offs between private benefits, private costs, and public benefits are mostly evident in the PG game paper where the feedbacks among individual decisions, incentives, and the nature (wildlife populations) are characterized in the experiments. With the motivational crowding framework, this paper suggests that it is important to understand the interactions between incentives and motivations that drive behavior to encourage contributions to public goods. In the KT model paper, since it is possible that longer recreation seasons only induce substitution activities without increasing the total number of trips, it is not clear whether non-monetary incentives of this kind would increase trips, and potentially harvests, to generate public benefits. With the existence of substitution behavior, increased trips and welfare benefits found in the paper show that individuals might contribute more to impure public goods when they are flexible in choosing the time of contributions. The KT reliability paper indicates that KT models and CB data used to measure individual contributions to the public goods provide temporally reliable insights.

The last common theme of the papers is that they all provide insights into the use of economic incentives for managing potentially zoonotic wildlife diseases, and perhaps more broadly pandemics, because humans play a key role in the progression of diseases. Even though the wildlife disease (CWD) in the empirical application of the papers is slowly progressive and it has not been found to transmit to humans, humans and nature are already affecting each other due to the unavailability of treatments and vaccines as well as potential human health risks. Together with ongoing scientific research, economic insights in the three papers provide important policy advice for wildlife managers on engaging humans in controlling the disease by employing various incentives. Generally, the three papers offer lessons for designing more effective policy interventions to combat situations like the COVID-19 pandemic so that there are smaller and fewer holes in the policy "Swiss cheese slices".[3] The KT model paper demonstrates an option to characterize the behavioral and welfare impacts of lockdown/reopening policies or longer opening hours for grocery stores because individuals might substitute activities across locations and time periods given the COVID-19 risks. The PG game paper inspires the use of incentives and pro-social information for people to take actions that reduce

[3] https://globalnews.ca/news/7393839/coronavirus-swiss-cheese-model/?utm_source=GlobalNews&utm_medium=Facebook&fbclid=IwAR0tSV8ZzoP6Ucn9mVte1EU_i5we8gxxGKtcOBmGQ_k_7DVXBwM6oOIzLOs

the spread of the disease, by considering their own and group benefits and costs/risks. It also draws the attention to heterogeneous behavioral responses to the same incentives and nudges. The KT reliability paper indicates that same approaches to evaluate the impacts of policies on human behavior could result in consistent findings over time. Correspondingly, policy makers, when designing policies, not only have to account for the temporal progression of the COVID-19 but also have to consider consistently assessing impacts on human behavior. Similar to the data collection efforts observed during the pandemic, the papers apply online surveys, laboratory and framed field experiments to collect RP and SP data – an indication that a variety of data collection approaches is critical for gathering information to understand human behavior.

In a world with an ongoing risk of pandemics and growing environmental problems, economists continue to contribute to important and policy-relevant research. Understanding human behavior is central to the design of incentives and to address policy problems. With the focus on non-market activities, the research in this thesis contributes to the ongoing efforts to improve knowledge of human behavior and incentives in a fast-changing world.

Chapter 2

Spatial and Temporal Responses to Incentives: An Application to Wildlife Disease Management

Individuals decide on where to go (locations) and when to participate (time periods) in activities such as recreation, and respond to changes in external factors (e.g. incentives). In examining economic decision-making, economists focus mostly on location choices, thus the behavioral and welfare impacts of the incentives associated with time choices are largely unknown. In this paper we develop and estimate a flexible econometric model that combines spatial and temporal choices. The model is applied to examine individuals' location and time choices of their recreation trips in response to extended recreation seasons that are proposed to encourage hunting for wildlife disease management. The data are from an online revealed and stated preference survey of recreational hunters in Alberta, Canada. We find that individuals substitute activities spatially and temporally and take more hunting trips and gain welfare benefits when they can more flexibly choose the time of activities. Our findings show that increases in time flexibility can be used as an incentive to encourage socially desirable outcomes.

2.1 Introduction

Location (where to go) and time (when to go) are common components in economic decision-making, such as restaurant visits (Athey et al., 2018), leisure activities (Bhat and Gossen, 2004; Sener et al., 2008), livelihood choices (Barrett et al., 2001), and recreational activities (Dundas and von Haefen, 2019). Accordingly, individuals change behavior spatially and/or temporally in response to external shocks, regulations, and incentives. For example, commuters adjust their departure time according to different toll regimes (Arnott et al., 1993). When facing spatial closures, fishers substitute fishing locations to seek economic returns (Smith and Wilen, 2003). Recreationists change the location and time of beach visits due to temporary closures of beaches caused by oil spills (English et al., 2018; Glasgow and Train, 2018). In these cases, understanding how individuals choose location and time, and substitute activities spatially and temporally, is important for predicting demand (e.g. restaurants, recreation) and evaluating effectiveness of policy tools (e.g. regulations or incentives).

When participating in activities (e.g. outdoor recreation activities) to benefit from the natural environment, individuals choose locations and time periods of these activities (e.g. where and when to hike) to maximize utility. At the same time, policy makers can provide incentives to induce behavioral changes for improving environmental conditions (e.g. protect wildlife populations). These behavioral changes may come at the cost of individuals. As a result, individuals' decisions reflect trade-offs among improved environment, incentives, and private cost. Environmental economists have widely studied individuals' spatial decisions in response to changes in environmental conditions (e.g. wildfires, "red tide" outbreaks) with relatively few studies have focused on individuals' temporal decisions or both temporal and spatial decisions. Moreover, economists and policy makers have largely examined the behavioral and welfare impacts of material incentives (e.g. financial incentives to increase the purchase of energy-efficient vehicles in Clinton and Steinberg, 2019). Yet few studies have discussed the impact of incentives that do not offer direct monetary value but allow for a more flexible time period of activities (e.g.

a year round fishing season in Abbott et al., 2018, flexible working time in Eriksson and Kristensen, 2014).

In this study, we examine how individuals make spatial and temporal decisions in response to the provision of non-monetary incentives associated with time choices in the context of recreational activities. We extend a discrete-continuous (often called the Kuhn-Tucker, KT) recreation demand model in a multiple discrete-continuous extreme value specification, with a focus on spatial and temporal substitution behavior in recreation trips, as well as the welfare benefits from the incentives involving time choices, which are seldom discussed in recreation demand models (Freeman et al., 2014). Building on previous work that focuses on the temporal dimension in KT recreation demand models (Lloyd-Smith et al., 2019, 2020), the proposed model in this study captures both spatial *and* temporal choices by recasting choice sets from alternative locations or time periods to alternative locations in each time period, at extensive and intensive margins.

The empirical application of the model is used to study recreational hunters' behavioral responses to the presence of a wildlife disease – Chronic Wasting Disease, CWD (Williams, 2005), and the season expansion program for disease management. CWD is an infectious wildlife disease that imposes risks to wildlife populations and affects recreational and wildlife harvesting activities, especially in places where recreationists harvest animals for meat consumption. Given its various transmission routes, lack of vaccinations and treatments, increasing hunter harvest in CWD-infected areas has been considered as an effective and publicly accepted option to control CWD (Pattison-Williams et al., 2020). Although extending hunting seasons based on animal activities has been proposed as an incentive program to increase and direct hunter harvest in disease-affected areas, the impacts of season expansion programs on recreation hunting activity and economic value are not well examined and understood. In this study, we advance the understanding of recreational hunters' behavior and welfare benefits of season expansion programs by estimating our proposed model with the data from a revealed and stated preference survey of recreational hunters in Alberta, Canada.

Our results show that individuals change recreation location and time when they receive the incentive of the season expansions. We find spatial and temporal substitution behavior caused by the incentives and this behavior is not captured if only the spatial or temporal dimension is examined. An extended season is an effective incentive to engage recreational hunters for disease management because it increases hunting trips and generates welfare benefits for individuals. Also, we find that the wildlife disease does not appear to affect individuals' behavior which increases the merit of the season expansions as a wildlife conservation policy tool. In general, the findings in this study suggest incentives that increase the flexibility for individuals to choose the time of activities are effective in encouraging beneficial outcomes when these activities involve location and time.

This study makes two contributions to the environmental valuation and general economics literature. First, from a methodological perspective, this study develops a flexible econometric model to capture individuals' choice behavior by explicitly incorporating spatial and temporal decisions in a demand system. Different from previous studies that mostly capture one dimension of individual decision making (e.g. spatial or temporal choices), the proposed model in this study captures spatial and temporal dimensions. As such, this study presents a better behaviorally consistent model for demand estimation of individual behavior. The associated welfare measures also derive more accurate values of the natural environment. Second, from conceptual and policy perspective, this study provides insights into the use of non-monetary incentives associated with time choices. Compared to the majority of the economics research that examines material incentives (e.g. financial rewards, commodities) that could be converted into monetary values, in this study, we discuss a unique type of incentive: the incentive that offers time flexibility for individuals to obtain utility. For individuals, this type of incentive could increase welfare by increasing the choice set in the temporal dimension (e.g. relaxing working and shopping time constraints). For incentive providers such as policy makers or private companies, this type of incentive could be effective in achieving desirable outcomes at a relatively low cost. For example, companies could increase employees' productivity by adding working-time flexibility arrangements without increasing incentive pay (Eriksson and Kristensen, 2014).

The remainder of the paper is organized as follows. Section 2.2 provides a brief review of relevant literature in recreation demand models and welfare measures. Section 2.3 describes the conceptual model that is used to develop the empirical model. Section 2.4 introduces the empirical application. Section 2.5 describes the data used for the empirical analysis. Section 2.6 provides details on the empirical model and analysis. Section 2.7 reports results on estimation, spatial and temporal substitution as well as welfare estimates. This is followed with conclusions and the discussion on policy implications in Section 2.8.

2.2 Relevant Literature

Economics literature has applied various choice models to examine individuals' economic decisions such as purchasing decisions. Among these economic decisions, decisions on outdoor recreational activities have motivated environmental economists to model recreation demand to value the natural environment. This section presents a summary of common recreation demand models regarding assumptions and welfare measures.

Recreation demand models apply micro-econometric frameworks to analyze recreation choices in space and time, as well as trip frequencies of recreational activities. Based on the decision to participate in a recreational activity, recreation trips can be divided into the participation decision and the frequency decision. The participation decision is whether to take a trip to a site during one time period and the frequency decision is the number of trips to take based on the participation decision. Two common approaches to model this decision-making process are discrete choice models (DCM) and the discrete-continuous (often called the Kuhn-Tucker, KT) models. These two approaches explicitly incorporate spatial substitution among multiple sites or temporal substitution across different time periods. However, most studies either focus on the spatial decisions or temporal choices without combining the two dimensions.

Discrete choice models (DCM) that focus on the participation decision in site/time choice are often extended to the repeated DCM for the frequency decision. Among repeated DCM models, the repeated nested logit (Morey et al., 1993) and repeated random parameter logit (Train, 1998) models are widely applied to examine spatial substitution through different assumptions on error term structures. However, as the assumptions restrict the estimates of seasonal benefits (Phaneuf and Smith, 2005), few studies use repeated DCM to capture temporal substitution, together with spatial substitution. Herriges and Phaneuf (2002) use repeated nested/mixed logit models to model spatial and temporal choices by introducing error complexity. They find richer patterns of cross-site (i.e. spatial) correlation and cross-choice occasion (i.e. temporal) correlation compared to a nested logit specification. Swait et al. (2004) incorporate temporal dependence into a multinomial panel data model through a meta-utility framework with consideration of prior behavior and past attribute perceptions. By applying this dynamic model in the context of recreational fishing, they find differences regarding behavioral choices compared to static models. Yet challenges associated with using repeated DCM in the temporal context such as assumptions on the number of choice occasions, error term structures, and a constant marginal utility of trips (Lloyd-Smith et al., 2020), remain for modeling spatial and temporal decisions.

The Kuhn-Tucker (KT) approach tackles each of the challenges above in a structural utility-consistent framework (Lloyd-Smith et al., 2020). Combining the participation and frequency decisions, the KT approach is more behaviorally consistent because it considers multiple discreteness in consumption patterns by modeling which good to consume and how many goods, while allowing for zero consumption levels (i.e. corner solutions). Currently there are two main specifications in KT approach: Linear Expenditure System (LES) by von Haefen and Phaneuf (2005) and multiple discrete-continuous extreme value (MDCEV) by Bhat (2008). The former is mainly used in environmental economics and focuses on site choices of recreational activities such as moose hunting (von Haefen and Phaneuf, 2005), and fishing (Ji et al., 2020) whereas the latter is mostly used in the transportation literature to examine decisions such as transportation modes (Bhat, 2008), and leisure activities (Sener et al., 2008).

Even though the MDCEV specification outperforms the LES specification regarding weak complementarity, the utility component of the outside good, as well as the structure of the Jacobian in empirical specification Bhat (2008), only a few recreation demand studies apply the MDCEV model given its computational challenges. Abbott and Fenichel (2013) apply the MDCEV model to simulate anglers' behavior in the spatial dimension under alternative policy scenarios by incorporating the anglers' adaptive behavior. Lloyd-Smith et al. (2019, 2020) and Abbott et al. (2018) modify the MDCEV model by recasting the choice set into when to visit and incorporating time constraints on behavior. Using revealed preference (RP) and stated preference (SP) data from an online survey with recreational anglers, they compare the estimates with stated values of travel time and income-based measures (Lloyd-Smith et al., 2019) and examine intertemporal substitution behavior (Lloyd-Smith et al., 2020). Kuriyama et al. (2020) incorporate spatial and temporal decisions in a MDCEV specification with triple constraints to examine substitution behavior between weekends and long holidays by accounting for heterogeneous values of leisure time and trip predictions. But they focus on temporal substitution behavior rather than both dimensions. Table 2.1 provides a summary of recreation demand models discussed.

Although researchers have put effort into building better behaviorally consistent models to examine demand in different contexts, most have not focused attention on the associated welfare measure in both spatial and temporal dimensions. In non-market valuation, welfare measures are usually used to monetize economic gain or loss from external changes (e.g. pollution) and policy programs (e.g. site/season closures). When a recreational site or season is closed, individuals might stop recreational activities that are affected by the closure or display substitution behavior (i.e. recreate in other sites nearby or during other seasons) (Parsons et al., 2009). The associated welfare measures indicate the use value of recreational sites or seasons. Since welfare estimates have been found to be affected by how substitution behavior (Swait et al., 2004;

Table 2.1: A Summary of Recreation Demand Models

	Choice	Model examples	Assumptions
Repeated Discrete Choice Models (DCM)	Participation decision	**Spatial choices:** Repeated nested logit (e.g. Morey et al., 1993), repeated random parameter logit (e.g. Train, 1998) **Temporal choices:** Repeated logit models (e.g. Herriges and Phaneuf, 2002), multinomial panel data models (e.g. Swait et al., 2004)	*Fixed* number of choice occasions, specific error term structures, and a *constant* marginal utility of trips
Kuhn-Tucker Models (KT)	Participation and frequency decisions	**Spatial choices:** LES utility specification (e.g. von Haefen and Phaneuf, 2005), MDCEV utility specification (e.g. Abbott and Fenichel, 2013) **Temporal choices:** MDCEV utility specification (e.g. Lloyd-Smith et al., 2020)	*Flexible* number of choice occasions, specific error term structures, and a *diminishing* marginal utility of trips

Train, 1998) is captured, accounting for substitution behavior is important for constructing more accurate welfare measures. Most recreation demand studies estimate the lost values caused by site and season closures as they are often used to advise damage assessment. Recently, several studies have examined the lost recreational use values due to the 2010 Deepwater Horizon oil spill in the Gulf of Mexico by considering cancelled trips (Whitehead et al., 2018), reduced visitation (Glasgow and Train, 2018; Tourangeau et al., 2017) and lost recreation days (English et al., 2018).

While the welfare loss of site and season closures has been discussed widely, the welfare gain of new recreation seasons or season expansions has not drawn much attention from researchers and policy makers. For recreational activities such as fishing and hunting that are often restricted by shorter seasons, a longer recreation season could generate welfare benefits for hunters and anglers. Abbott et al. (2018) find economic benefits from a flexible fishing management with a longer fishing season than the current management scheme with relatively short seasons. Schwabe et al. (2001) find that hunters benefit from one extra day of deer hunting season in Ohio. Although these two studies show that a longer season could bring potential welfare benefits to recreationists, they do not discuss whether it could serve as an incentive to change recreation behavior for policy use (e.g. fish or wildlife population management).

To evaluate whether policies that allow for a more flexible time period of activities could be used as an effective incentive to change spatial and temporal choices in the context of recreational activities, we need a more flexible recreation demand model that combines spatial and temporal decisions and assesses welfare gain. Building on the work by Lloyd-Smith et al. (2019, 2020) that focuses on temporal choices and value of travel time, we modify the KT model with the MDCEV specification to combine spatial and temporal decisions so that the proposed model can capture substitution behavior in spatial and temporal dimensions. Employing RP and SP survey data, we assess whether extended recreation seasons in specific areas could be effective incentives in two ways: first, whether the extended recreation seasons result in additional trips given the potential for substitution between the regular and extended recreation seasons; and second, whether the extended seasons generate welfare benefits.

2.3 Conceptual Model

In order to model when and where to take recreation trips, the choice sets in the proposed model are recast from "what good to consume" (e.g. number of site visits in all time periods as in von Haefen and Phaneuf, 2005) or "when to consume" (e.g. number of recreation days in one site as in Lloyd-Smith et al., 2019) to "what good and when to consume" (e.g. number of site visits in different recreation seasons). Decisions on trip length are ignored for simplification.[4] The modified choice sets allow us to study spatial and temporal substitution in one model. One key assumption is that the location and timing of the trips are decided at the beginning of all recreation periods so that the choice sets are consistent throughout the entire recreational time period. This assumption is reasonable when the recreation season is within a short period (e.g. hunting season within one to two months). However, the assumption has to be modified if the recreation season is throughout the whole year (e.g. hiking trips).

A conceptual model is developed for the empirical analysis. Each individual is assumed to maximize utility by choosing recreation trips and consumption of a numeraire good subject to a monetary budget constraint and a time constraint. The individual's problem is

$$\max_{x_{km},z} U(x_{km}, Q_{km}, z) \tag{2.1}$$

$$\text{subject to} \sum_k \sum_m p_{km} x_{km} + z \leq \overline{y} + t_w w \tag{2.2}$$

$$\sum_k \sum_m t_{km} x_{km} + t_w \leq \overline{T} \tag{2.3}$$

where:

[4]As it is difficult to model the decisions on trip length, most studies avoid the issue by assuming the exogenous or constant on-site time (Phaneuf and Smith, 2005). This assumption can be relaxed by extending the model to consider single and multiple-day trips as discussed in English et al. (2018).

x_{km} is the number of recreation trips to site k at time m,

Q_{km} is a vector of quality characteristics for recreation at site k at time m,

z is the numeraire good with price normalized to one,

p_{km} is the monetary cost of a recreation trip,

$\overline{y}$ is exogenous (non-wage) income,

t_w is the time spent working at parametric wage,

w is the parametric wage,

t_{km} is the travel time of a recreation trip,[5]

$\overline{T}$ is total available time to the individual.

As choice sets involve different time periods, we need to decide how to incorporate the time constraint into the model. The common practice in most recreation demand studies is to collapse the time constraint into the money constraint by converting the value of time into a constant fraction of the individual's wage rate with the assumption that the individual can allocate his/her time between work and leisure (Bockstael and McConnell, 2007). There are two other alternatives to incorporate the time constraint into the KT model, depending on the activities and the time horizon considered. Castro et al. (2012) discuss an activity-based approach to incorporate time constraints into the KT model where individuals' decisions on activity/travel patterns are based on their time-use decisions. Lloyd-Smith et al. (2019) include an annual constraint on leisure days to reflect individual valuation of the leisure time. As this study focuses on the time and money allocation of the same type of recreation trips rather than time and money allocation among different activities, the recreational activities in this study fall into the trip-based approach instead of the activity-based approach as discussed in Castro et al. (2012). As this study focuses on the case where individuals allocate recreation time within a relatively short period (i.e. not across the whole year), leisure time constraints are likely to be valued similarly in the time horizon considered. Furthermore, while the value of time is different across time periods, it is relatively difficult

[5] t_{km} does not include on-site time in the empirical analysis due to the results (e.g. issues of endogeneity) of McConnell (1992).

to identify the differences within a short period.[6] Therefore, the proposed model follows the common practice and collapses the time constraint into the money constraint, and assume monetary and time costs are the same for each trip to the same alternative location over the time periods. The constraints (2) and (3) can be combined into one and be rewritten as follows:

$$\sum_k \sum_m (p_{km} + t_{km}w)x_{km} + z = \overline{y} + w\overline{T} \tag{2.4}$$

Assuming that the consumption of the numeraire z is strictly positive (Phaneuf and Smith, 2005), the final Kuhn-Tucker conditions that define the optimal number of recreation trips to take at each site k at time m are given as follows (see details in Appendix 2.A):

$$\frac{U_{x_{km}}}{U_z} \leq p_{km} + t_{km}w, \text{ k = 1,...K, m =1,...M} \tag{2.5}$$

$$x_{km}\Big[\frac{U_{x_{km}}}{U_z} - p_{km} - t_{km}w\Big] = 0, \text{ k = 1,...K, m =1,...M} \tag{2.6}$$

In the first equation, the left-hand side is the marginal rate of substitution between recreation trips and the consumption of the numeraire good, or marginal willingness-to-pay (MWTP) for trips to site k at time m. The right-hand side is the corresponding travel cost for x_{km}, which consists of the out-of-pocket monetary expenses and opportunity cost of the time measured in wage rate for each trip. Together with the first equation, the second equation (i.e. complementary slackness condition) represents the conditions for optimal number of recreation trips. The optimal number of recreation trips is positive when MWTP for trips to site k at time m is equal to the travel cost. The optimal number of recreation trip is zero (i.e. no trips are taken) when MWTP for trips to site k at time m is strictly smaller than the travel cost. These two KT conditions are used for empirical estimation in Section 2.6.

[6]Given the information is usually collected from surveys, it is difficult to change the value of time for different individuals other than income adjustments when collapsing the time constraint into the money constraint by using the fraction of wage rate. This can be addressed to incorporate individual values of time by asking recreationists willingness-to-accept (WTA) to give up time in different time periods (Lloyd-Smith et al., 2019).

2.4 Empirical Application: Chronic Wasting Disease and Recreational Hunting in Alberta

The empirical application is to study recreational hunters' behavioral responses to the presence of Chronic Wasting Disease (CWD) and the season expansion program to control CWD.

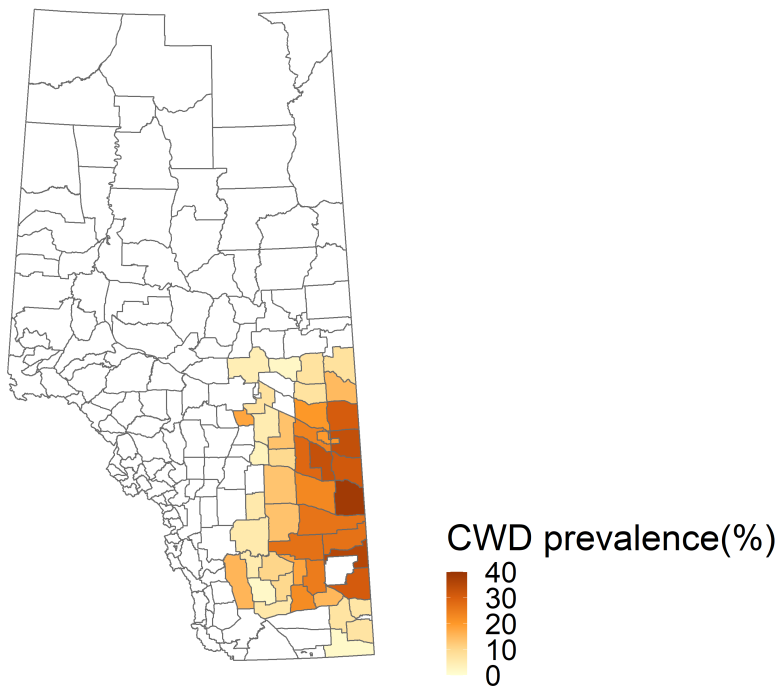
CWD is a prion wildlife disease that is fatal to deer family (e.g. deer, elk, and moose). Transmitting through contacts with animals and contaminated environments, CWD has affected cervid species in North America, South Korea, Norway, Finland, and Sweden. In addition to some parts of the United States, it has been found in Alberta, Saskatchewan, and Quebec in Canada. According to the latest update in 2020 from the Government of Alberta, the number of CWD identified cases annually has increased from 4 in 2005 to 1160 in 2019, among which the majority were mule deer (85%). CWD prevalence was 17.5% for mule deer.[7] Furthermore, the spatial extent of the known presence of infected animals has increased significantly since the first cases were found. Figure 2.1 provides a map of CWD prevalence in Alberta in 2019. While no known CWD cases have been found in humans, precautions such as avoiding consuming meat from CWD positive animals are recommended[8] due to the possibility of the transmission from animals to humans (Williams, 2005).

Since no treatment is available for CWD-infected animals and no vaccine is available to prevent infection, reducing infected deer populations through selective culling (i.e. culling deer within certain geographic areas) and hunter harvests is commonly used to control CWD. As selective culling is not widely supported by hunters and the general public (Pybus, 2012), wildlife managers in Alberta are considering changes to recreational hunting policy to engage hunters in the disease control by offering additional harvesting opportunities to maximize hunting satisfaction and reduce wildlife populations in CWD-infected

[7] https://www.alberta.ca/chronic-wasting-disease-updates.aspx?utm_source=redirector

[8] http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/cwd/fact-sheet/eng/1330189947852/1330190096558

Figure 2.1: CWD Prevalence Map in Alberta (2019)



areas. The expansion of hunting season in areas with CWD presence is under consideration because increasing harvests during or shortly after the breeding season (i.e. outside of the regular hunting season) is likely to reduce prevalence (Western Association of Fish and Wildlife Agencies, 2017). Meanwhile, the expansion of hunting season might increase harvests by providing more options of hunting time periods for hunters and thus be considered as an incentive to hunt more.

CWD and extended seasons could directly influence recreational hunters by changing hunting satisfaction, hunting opportunities, and perceptions of human and wildlife health risks. These changes may, in turn, be reflected in hunting behavioral changes regarding trip decisions, i.e. the choices of hunting sites, time periods, as well as the number of trips.

2.5 Data

Data for the empirical application come from an online survey that collects information on the preferences and behavior of recreational hunters in Alberta, Canada.

2.5.1 Survey Design and Structure

To ensure the questions were understood and interpreted as expected and for a better development of the structure of the survey, we conducted two focus groups with hunters in Alberta in February 2018. The online version of the survey was pre-tested with a subset of the sample in March 2018 to check for technical issues before the survey was sent to the field.

The survey consists of five sections (see Supplementary Materials A for the full survey): background information, hunting trip recall, CWD description, contingent behavior, and demographic information. The section on background information asked questions about hunting practices and hunting attributes. The section on CWD description provided information on CWD and asked questions on hunters' attitudes towards CWD and its management programs, hunters' perceptions of CWD prevalence and wildlife population health risks. The section on demographic information collected information on hunters' socio-demographic background.

The key components of the survey are sections of hunting trip recall and contingent behavior. These two sections collected revealed preference (RP) and stated preference (SP) data. RP data were from the section of hunting trip recall where respondents indicated the sites they went to, the number of trips they took in each site in the previous hunting season – the whole month in November of 2017. We are referring to information provided by respondents on their actual trips as RP data. But we recognize that these data potentially suffer from recall bias and in some cases may be affected by strategic behavior. The contingent behavior section (see an example in Appendix 2.D) collected SP data where respondents indicated the number of trips they would have taken in each site in each season under scenarios with the proposed extended season for CWD management. The hunting season was proposed to be extended into the last week of October or the first 17 days of December from the current regular hunting season in November (entire month) in mandatory CWD testing zones in 2017 and adjacent sites. The areas were chosen because they already have or likely have CWD risks in the future. The extended seasons in October and December were chosen based on the feedback from the focus groups and the consultations with wildlife managers. The extended season in October was shorter to avoid the overlap with other hunting seasons. Licensed hunters are allowed to have one mule deer tag that permits them to harvest one mule deer during the regular season in November. The extended season in December allowed for one additional tag under the existing license while the extended season in October did not allow for it. This is to account for the possibility that recreational hunters would not have taken trips in December after filling the one tag during the regular season in November.

2.5.2 Survey Administration

The target population for the survey was recreational hunters in 2017 who held special licenses [9] for mule deer in hunting sites (i.e. Wildlife Management Unit, WMU, the unit used by the Government of Alberta to manage wildlife resources and hunting activities) from eastern to southeastern Alberta where CWD has existed or was likely to spread to, as in grey in Figure 2.2. The study area is not limited to only CWD-infected areas for following reasons: Hunters who hunt in sites adjacent to CWD-infected areas are likely to be aware of CWD spread and be affected behaviorally; the purpose of CWD control strategies include reduce the prevalence and spread. Hunters who hunt in CWD surrounding areas are the "target" group to help reduce CWD spread by additional harvests. The survey was administered online on Qualtrics from March to May 2018 to 5,000 eligible individuals who were randomly drawn from the license database of Wildlife Allocation Policy Branch, Alberta Environment and Parks.[10] With one invitation and one reminder email, a total of 994 respondents completed the online survey for a response rate of 19.8%. We excluded respondents who either

[9]In Alberta, special licenses apply to specific species in designated areas in a certain time period. Recreational hunters must apply for special licenses through a lottery system and can only buy tags to harvest animals once they win the lottery. Recreational hunters who hold mule deer special license are allowed to have one tag to hunt in the hunting season of November (Alberta Environment and Parks, 2018).

[10]There were around 18851 eligible licensed hunters in the database for 2017 hunting season. https://www.albertarelm.com/cust.drawsummarymuledeer17.page

disagreed to participate the survey or did not provide required information such as RP and SP trips, postal codes for calculating travel costs. As only two policy scenarios included changes of hunting seasons, we use responses from individuals who received at least one of these policy scenarios for this study. A total of 832 observations from 416 respondents are included in the KT estimation because they provided the trip recall data and contingent behavior responses.

2.5.3 Trip Data

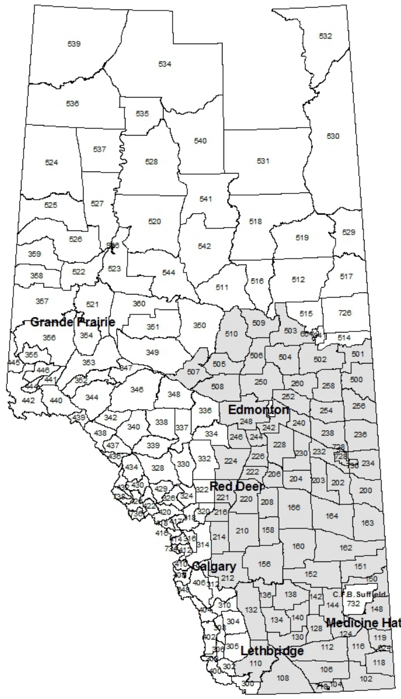
Revealed preference (RP) and stated preference (SP) data include information on trips under different scenarios. Table 2.2 provides a summary of average number of trips per person. In 2017 hunting season, each respondent took around 10 hunting trips on average. With CWD management programs in all SP scenarios provided to respondents, each respondent would have taken around 14 hunting trips on average. With the season expansion program in the SP scenarios, each respondent would have taken around 9 trips on average during the regular season in November. They would have taken around 6 trips on average during the proposed extended season if the hunting season was extended to either October or December – this is more than half of the trips they actually took in 2017.

Table 2.2: Average Number of Trips per Person under Different Scenarios

Scenarios	**Season Length**	**Average Trips per Person**
RP (actual trips)	30 days (entire November)	10.21
SP (regular and extended seasons)	55 days	13.92
SP: regular season	30 days (entire November)	9.39
SP: extended season	25 days (last week of October and first 17 days of December)	6.42

Note: Since some respondents indicated that they would have taken trips only in the regular season or extended season, the numbers of respondents who would have taken trips in two seasons in the SP scenario are different and therefore the average trips per person in the third and fourth rows do not sum up to the one in the second row. Appendix 2.B provides trip distribution table and graphs.

Figure 2.2: Study Area

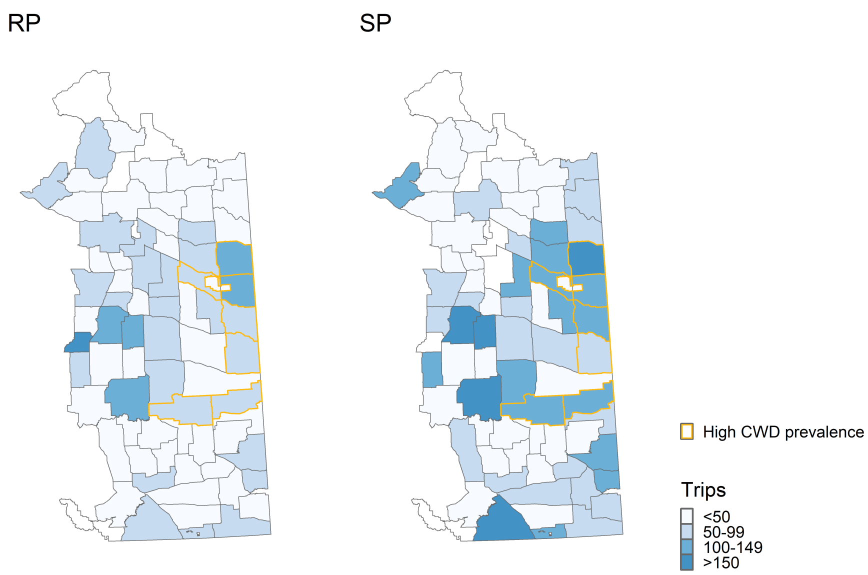


Note: Information on the shapefile used in the figure is available via https://geodiscover.alberta.ca/geoportal/rest/metadata/item/2740033f734b429f987d9331b43d9b8e/html

Figures 2.3 and 2.4 present maps of trips aggregated by hunting sites (i.e. WMUs) under different scenarios. More trips were taken or would have been taken to sites in dark blue than sites in light blue. Hunting sites with CWD prevalence rates higher than 10% in 2017 are marked with the orange boundary.

Figure 2.3 compares the recalled total number of trips (RP) and stated total number of trips in regular and extended seasons. The graph on the right has more darker areas than the one on the left, indicating that respondents would have taken more trips with the proposed season expansion program, especially sites with high CWD prevalence. This can be explained by two underlying reasons. First, studies have found that individuals take more trips in contingent behavior scenarios than the recall scenario (Englin and Cameron, 1996). However, individuals on average take more trips (10.21) during the regular season in the recall scenario than in the contingent behavior scenario (9.39). The insignificant estimate of the contingent behavior dummy variable as shown in Section 2.7.1 provides supporting evidence. Second, individuals

Figure 2.3: Trips under RP and SP (Both Seasons) Scenarios, Aggregated by Hunting Sites



take more trips because the hunting season in the stated preference scenario is around 25 days longer than the recall scenario. Figure 2.4 compares trips during the extended season of October and December in SP scenarios. The patterns are different in the two extended seasons. Sites located in the north would have been visited more in October while sites located south would have been visited more in December. This difference could be mainly driven by temperature since it is usually warmer in October than in December, as indicated in qualitative responses in the survey. There is no obvious pattern that suggests that people are driven away by the high CWD prevalence.

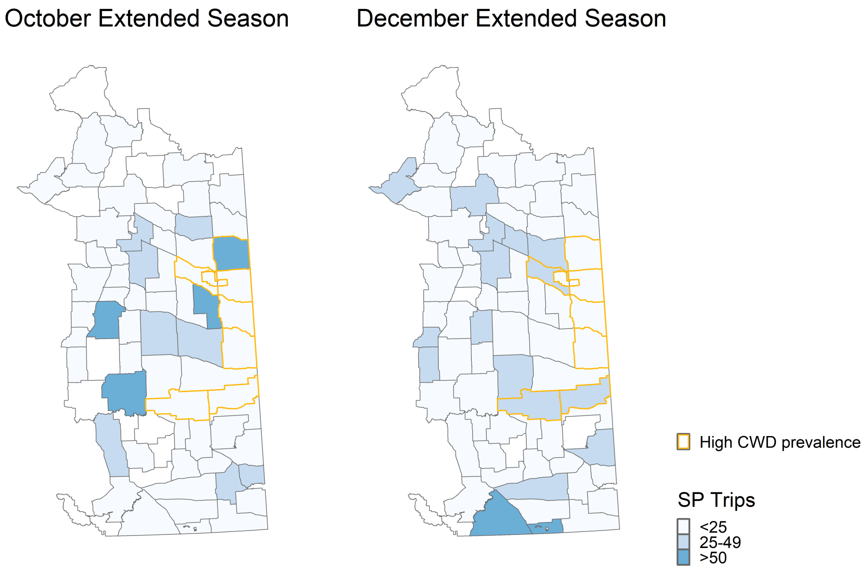
2.6 Empirical Model and Analysis

The KT model is applied for empirical estimation because it makes use of the nature of the count data with potential zero trips collected from hunting activities.

2.6.1 Travel Costs

The first step of the empirical analysis is to calculate travel costs for trips to each location in each time period using relevant information from the survey.

Figure 2.4: SP Trips in the Extended Season (October vs. December), Aggregated by Hunting Sites



As discussed in Section 2.3, the time constraint is collapsed into the money constraint. The formula for travel cost calculation for individual i to travel from dwelling to an alternative site k at time m is given by (Zimmer et al., 2012):

$$TC_{ikm} = \left[DIST_{ikm} \times 2 \times \frac{\text{total cost}}{\text{kilometer}}\right] + \left[\left(\frac{INC_i}{2040} \times \frac{1}{3}\right) \times \left(\frac{DIST_{ikm} \times 2}{\text{average travel speed/hour}}\right)\right] \tag{2.7}$$

The first term is the monetary costs for each round trip and the second term is the value of time for the trip. Monetary costs are the round-way gas expenses for recreation trips. $DIST_{ikm}$ is the driving distance from individual i's residence (approximated by first three digits postal code) to the centroid of each alternative site k. INC_i is the annual household income reported by each individual in the survey. The self-reported annual income is converted to hourly wages by dividing the annual hours worked per individual (i.e. 2040 hours worked per year as in Lloyd-Smith et al. 2019[11]). Each individual is

[11]The average working hours (weighted by gender and age) for full- and part- time employment were around 2080 in Alberta in 2017. Given the average age of sample is 50, a fraction of respondents might be retired. 2040 hours give a lower bound estimate of hours worked. Estimates using 2080 hours are almost the same as estimates using 2040 hours. Detailed statistics is available in https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410004301&pickMembers%5B0%5D=1.10&pickMembers%5B1%5D=3.1&pickMembers%

assumed to value their hourly time at one-third of his/her hourly wage when travelling (English et al., 2015). The one-third of wage rate approach is not universally accepted as empirically valid, it is consistent with the past and recent studies (Lupi et al., 2020). As more than half of the respondents used trucks to access the hunting sites, we use information on trucks to calculate total cost per kilometer and average travel speed per hour.[12]

2.6.2 Kuhn-Tucker Model

The first-order KT conditions (i.e. Equations 2.5 and 2.6) from the conceptual model directly derive the probabilities of observing choices for the likelihood function that is used for estimation in the empirical analysis (Phaneuf and Smith, 2005). Once the right-hand side of Equation (2.5) has been obtained from travel costs calculation, we need to specify the utility function to operationalize the model. We use the translated generalized constant elasticity of substitution (tCES) utility function as in Bhat (2008). This utility function is additively separable across alternative sites and the time periods.[13] The functional form is as follows:

$$U(x_{km}, Q_{km}, z) = \sum_k \sum_m \frac{\gamma_{km}}{\alpha_{km}} \psi_{km} \left[\left(\frac{x_{km}}{\gamma_{km}} + 1 \right)^{\alpha_{km}} - 1 \right] + \frac{\psi_z}{\alpha_z} z^{\alpha_z} \tag{2.8}$$

where $\gamma_{km} \geq 0$ and $\alpha_{km} \leq 1$ for all k and m are required for this function to be consistent with the properties of a utility function (Bhat, 2008). γ_{km} allows for the corner solution (i.e. zero trips) and the rate of satiation (Bhat, 2008). α_{km} represents a satiation parameter by controlling the rate of diminishing marginal utility from additional trips (Lloyd-Smith et al., 2019). ψ_{km} is the baseline marginal utility when no trips are taken. This baseline marginal utility includes a random element that ensures $\psi > 0$ through an exponential form. The model applies the most commonly-used form in the KT approach as follows: $\psi(Q_{km}, \varepsilon_{km}) = \exp(\beta' Q_{km} + \varepsilon_{km})$ for recreation trips and $\psi_z = \exp(\varepsilon_z)$ for the

5B2%5D=5.2&pickMembers%5B3%5D=6.9

[12]These two pieces of information are available on the website of Alberta Motor Association. https://ama.ab.ca/2017/06/12/the-calculated-costs-of-driving-your-vehicle/

[13]The assumption on additive separation is admittedly strict and might not be consistent with actual hunting behavior, but the functional form we chose here is relatively more flexible than other specifications as discussed above.

numeraire good. In our application, variables included in the baseline marginal utility are site attribute variables (e.g. CWD prevalence levels, extended season dummy variable) and individual-specific variables (e.g. urban/rural dummy variable, years of hunting experience, landowner dummy variable), as listed in Table 2.3. The resulting utility form can be written as

$$U(x_{km}, Q_{km}, z) = \sum_k \sum_m \frac{\gamma_{km}}{\alpha_{km}} \exp(\beta' Q_{km} + \varepsilon_{km}) \Big[\Big(\frac{x_{km}}{\gamma_{km}} + 1 \Big)^{\alpha_{km}} - 1 \Big] + \frac{\exp(\varepsilon_z)}{\alpha_z} z^{\alpha_z} \tag{2.9}$$

Since hunting seasons are divided into the regular and extended hunting seasons, $m = 2$ in the application. As 43 groups of sites were visited or would have been visited during the regular season, 38 groups of sites would have been visited during the extended season, the total number of choices is 81 in the final choice set.[14]

We impose two restrictions to address the potential identification problem in estimation and obtain the model specification that fits best for our data based on values of log-likelihood and model convergence. First, since the satiation and the translation parameters both influence the rate of satiation, they cannot be identified and estimated simultaneously. Therefore, we restrict the satiation parameter to be constant across all sites and the numeraire good ($\alpha_{km} = \alpha_z = \alpha$) while allowing the translation parameter (γ_{km}) to vary across trips to each site in two hunting seasons. Second, the satiation parameter (α) is restricted to be between 0 and 1 for convergence considerations (Lloyd-Smith et al., 2019).

As discussed in Section 2.2, the MDCEV specification is flexible in capturing substitution through utility parameters. According to Bhat (2008), the formula of marginal utility of trips taken to site k at time m for the analysis of spatial and temporal substitution in Section 2.7.2 is given by:

$$\frac{\partial U(x_{km}, Q_{km}, z)}{\partial x_{km}} = \exp(\beta' Q_{km} + \varepsilon_{km}) (\frac{x_{km}}{\gamma_{km}} + 1)^{\alpha - 1} \tag{2.10}$$

[14]Sites that were visited less frequently are grouped by using K-means clustering based on geographic and biological attributes for convergence consideration. As we could only sample hunters who held licenses in the study area, some respondents took hunting trips outside of the study area. These sites are grouped into three aggregate sites according to Alberta Hunting Regulation (Alberta Environment and Parks, 2018)

Table 2.3: Summary Statistics of Site Attributes and Socio-demographic Variables (N = 832)

Variable	Description	Mean	Min	Max
CWD	Chronic Wasting Disease infected rate (%) in four categories: 0, 2.5, 7.5, 12.5*	2.65	0	12.5
October scenario	Dummy variable if the decision is made in the scenario where the hunting season is extended into October	0.27	0	1
December scenario	Dummy variable if the decision is made in the scenario where the hunting season is extended into December	0.29	0	1
Extended season	Dummy variable if the trip is taken during the extended hunting seasons	0.47	0	1
Contingent behavior	Dummy variable indicating contingent behavior scenario	0.5	0	1
College	Dummy variable if hold a college degree	0.31	0	1
Urban	Dummy variable if live in urban area (20,000 people or more)	0.52	0	1
Children	Dummy variable if children under 12 in household	0.24	0	1
Yrshunt	Years of hunting experience	25.64	2	65
Landowner	Dummy variable if own land in CWD-infected areas	0.12	0	1
Income	Annual household income ($000s)	98.714	10	150

*CWD testing results come several months after the hunting season and are based on heads submitted by hunters. In other words, hunters only had CWD information from 2016 hunting season when they made trip decisions for 2017 hunting season. Therefore we use CWD information from 2016 hunting season to address potential endogeneity issue. As CWD occurs primarily to mule deer and we sampled mule deer hunters, we chose to calculate the CWD infected rate only for mule deer. The numbers represent the average infected rate in four categories: none (0%), low (1-5%), medium (6-10%), high (10% and above) (Zimmer et al., 2012).

The KT conditions in Equation (2.5) and Equation (2.6) and the utility specification in Equation (2.9) produce the estimating equations, details shown in Appendix 2.A:

$$V_{km} + \varepsilon_{km} = V_z + \varepsilon_z \text{ if } x^*_{km} > 0 \text{ and} \tag{2.11}$$

$$V_{km} + \varepsilon_{km} < V_z + \varepsilon_z \text{ if } x^*_{km} = 0 \text{ where} \tag{2.12}$$

$$V_{km} = \beta' Q_{km} + (\alpha - 1)\ln\left(\frac{x_{km}}{\gamma_{km}} + 1\right) - \ln(p_{km} + t_{km} w) \tag{2.13}$$

$$V_z = (\alpha - 1)\ln(z) \tag{2.14}$$

The error term for each individual is assumed to follow a type 1 extreme value distribution that is independent from other individuals and choice occasions.

2.7 Results

2.7.1 Estimation

Table 2.4 provides parameter estimates for the modified KT model. Baseline marginal utility parameters include site attributes variables, policy dummy variables and socio-demographic variables. CWD prevalence is the only specified site attribute variable. In order to control for unobserved site attributes, we include alternative-specific constants (ASCs) for each site (Murdock 2006). For convergence consideration, we construct the choice set and dummy variables to capture differences in baseline marginal utility ψ_{km} in the following ways. First, as some respondents received either October *or* December SP scenarios, or October *and* December SP scenarios, we pool the SP trip data in October and December into trips in the extended season, to have enough observations for estimation. As such, the temporal dimension of the choice set has a regular season in November and an extended season in October or December, as opposed to a regular season in November and two extended seasons in October and December respectively. Second, although we pool the SP trip data in the extended seasons, we use the dummy variables of October and December scenarios to distinguish the baseline marginal utility associated with the two SP scenarios and RP scenario. Therefore, the dummy variables of October and December scenarios do not capture the baseline marginal utility only in the associated extended seasons – in fact, they do not distinguish whether SP trips are in the regular or extended season. Third, we use a dummy variable of extended season to distinguish the baseline marginal utility of trips during the extended season from the regular season, while assuming that the baseline marginal utility of trips is the same across sites in the extended season. This is to complement with the setup of October and December scenario dummy variables, and the setup of one ASC for each site.

Holding all other variables and travel costs constant, the insignificant CWD coefficient indicates that changes in the disease prevalence levels do not affect individuals' decisions – individuals are not likely to stop hunting in more infected areas. This somewhat surprising result, although different from the findings of Zimmer et al. (2012), is consistent with the qualitative responses in the survey: 74% of respondents in the survey stated CWD did not affect their site choice decisions although more than 90% of them were aware of it. In addition, as the respondents were randomly selected from the hunters who were still hunting in CWD-infected and surrounding areas, the sample does not capture the hunter population who either stopped hunting or did not hunt in these regions any longer due to CWD. From the perspective of disease management, the hunter population that is not captured by the sample is less likely to be interested in the extended season for CWD management and less responsive to the incentives.[15] Nevertheless, this finding is consistent with a study where Pattison-Williams et al. (2020) examine mule deer hunters' responses to the spread and prevalence of CWD at the aggregate level in Alberta. With hunting draw application data across 12 years in each Wildlife Management Unit, they find hunters do not stop applying for mule deer special licenses in the infected areas at the province level.

Individuals are more likely to take trips under the scenario that extends the hunting season into December while the scenario with the extended season in

[15] English et al. (2018) provide approaches to address sample selection/non-response bias. However, we could not apply these approaches due to the lack of information on the hunter population.

October does not significantly affect their utility and trip decisions. However, extended seasons are less preferred than the regular season in November for hunting trips. This might be due to respondents' strong habit of hunting in November. In addition, the extended season in October overlaps with bow hunting season and might be less preferred whereas hunters might be busy with other activities in the extended season in December as it is close to Christmas season.

Most socio-demographic variables do not significantly affect hunting trip decisions except for the landowner dummy variable and the children dummy variable. Individuals who own lands in CWD-infected areas are less likely to go hunting – this might be because hunters do not define hunting activity on their own lands as hunting trips. Individuals who have children are less likely to take hunting trips. The positive and insignificant coefficient for the contingent behavior dummy variable indicates that hypothetical scenarios are not likely to induce a behavioral difference from the recall scenario. Estimates in Table 2.4 are similar to model estimates with RP and SP data separately in Appendix 2.C. In addition, models that account for observed heterogeneity by interacting CWD prevalence levels with socio-demographic variables (e.g. urban) do not largely change parameter estimates and estimated log-likelihood at convergence.

2.7.2 Spatial and Temporal Substitution

With β coefficients of ASCs and the extended season dummy variable in ψ_{km}, estimates of translation parameters γ_{km} and the satiation parameter α, we calculate the marginal utility (MU) of trips for each site using Equation (2.10). For better visual presentation, we take the average of marginal utilities of trips in regular and extended seasons across four site groups, i.e. WMU 100 Series, WMU 200 Series, WMU 300 Series and 400 Series, and WMU 500 Series (Alberta Environment and Parks, 2018).[16] WMU 100 Series and WMU

[16] ASC coefficients that are not significantly different from 0 are converted to 0s in calculating MU for each site. We drop sites with MUs that are not significantly different from 0 when taking average for site groups.

Table 2.4: Parameter Estimates for Kuhn-Tucker Model

	Estimate[a]	z-stat
Baseline marginal utility parameters (β_{km})		
CWD	−0.427	−1.290
Extended season	−0.495***	−13.708
October	0.063	0.654
December	0.233**	2.252
College	−0.039	−0.640
Urban	0.013	0.266
Children	−0.159**	−2.343
Yrshunt[b]	−0.017	−0.933
Landowner	−0.178***	−2.813
Contingent behavior	0.063	0.493
ASC (mean)[c]		
WMU 100 Series&732	−3.239***	−2.362
WMU 200 Series&728&730	−4.814***	−5.480
WMU 300 Series&400 Series	−4.436***	−12.929
WMU 500 Series	−4.943***	−14.225
Mean translation parameters (γ_{km})[d]		
Regular season		
WMU 100 Series&732	4.794***	12.668
WMU 200 Series&728&730	8.072***	10.600
WMU 300 Series&400 Series	5.157***	5.922
WMU 500 Series	6.244***	4.848
Extended season		
WMU 100 Series&732	4.331***	6.954
WMU 200 Series&728&730	5.561***	7.470
WMU 500 Series	5.404**	2.458
Satiation parameter (α)	0.219***	5.090
Scale parameter	0.553***	42.560
N	832	
Log-likelihood (mean)	-11789.17	

Note:
[a]*** and ** denote statistical significance at the 1% and 5% level respectively.
[b]Years of hunt (Yrshunt) index is scaled as the year of hunting experience divided by 10.
[c]One alternative specific constants (ASC) is estimated for each hunting site regardless of hunting seasons. The table presents the average baseline marginal utility estimates for each site group. The grouping follows the hunting season categories in Alberta Guide to Hunting Regulations (Alberta Environment and Parks, 2018).
[d]Translation parameters (81 in total) are estimated for each hunting site during regular and proposed extended hunting seasons. The table presents the average translation parameters for each site group. The extended season was proposed in all WMU 100 Series, 200 Series sites and one site in 500 Series.

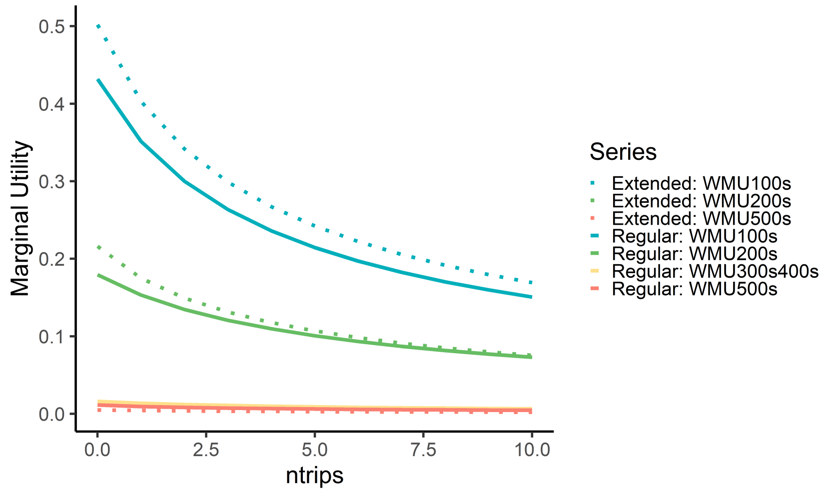
200 Series are areas with CWD risks and mostly covered in our sampling areas. WMU 300 Series and 400 Series are not affected by CWD and therefore ineligible to season expansion program. In addition, we choose the number of trips from 0 to 10 because the MU is the baseline marginal utility when 0 trips are taken (i.e. the exponential of β coefficients) and the average number of trips in RP scenario is around 10 trips.

Figure 2.5 shows the average MU of trips to the four site groups in two seasons. Individuals obtain the highest marginal utility when hunting in WMU 100 Series in both seasons, followed by hunting in WMU 200 Series in both seasons. Marginal utilities of trips to Wildlife Management Unit 300 Series and 400 Series (without the presence of CWD) in the regular season, and Wildlife Management Unit 500 Series (without the presence of CWD) in both seasons remain relatively low. This indicates that individuals might substitute from hunting in these areas (without CWD risks) during the regular season to hunting in WMU 100 Series and 200 Series (with CWD risks) in the regular and extended seasons. This substitution pattern shows the possible effectiveness of directing hunting/harvest with season expansion. One should notice that this substitution pattern can only be captured when spatial and temporal decisions are combined in one model – this is different from the previous studies.

2.7.3 Welfare Impacts of the Extended Season

With the estimated utility parameters, we simulate Hicksian welfare estimates of hunting in extended seasons by following the method described by Lloyd-Smith (2018). Table 2.5 reports the welfare estimates (in Canadian dollars) per individual for hunting in the extended seasons. Individuals are willing to pay around 230 Canadian dollars to hunt in the extended seasons in all sites where the season expansion program is proposed. Individuals obtain the largest welfare benefit (around 152 Canadian dollars) from hunting in Wildlife Management Unit 100 Series in the extended season regardless of the high CWD prevalence in the area. Individuals obtain a smaller welfare benefit (around 76 Canadian dollars) from hunting in the WMU 200 Series in the extended season although this group includes a similar number of sites as WMU 100

Figure 2.5: Marginal Utility of Trips (Spatial and Temporal Substitution)



Note: "Extended" and "Regular" denote MU of trips in the extended and regular seasons respectively. The extended season does not apply to WMU 300s400s. All MU series are significantly different from 0. MU series associated with WMU 100s (regular and extended seasons) are significantly different from MU series associated with WMU 300s (regular season) WMU 500s (regular and extended seasons).

Series. These findings correspond to the insignificant CWD coefficient and the highest marginal utility of hunting in the WMU 100 Series as discussed above. Individuals are only willing to pay around 1.6 Canadian dollars for hunting in the WMU 500 Series in the extended season because the season was proposed to extend only in one site in this group. Figure 2.6 presents the welfare estimates per individual for hunting in the extended seasons in each of the sites in WMU 100 Series and 200 Series. The welfare estimates are heterogeneous across sites, ranging from 0.1 to 30 Canadian dollars. The site where individuals obtain the highest welfare benefit is within the orange boundary with high disease prevalence.

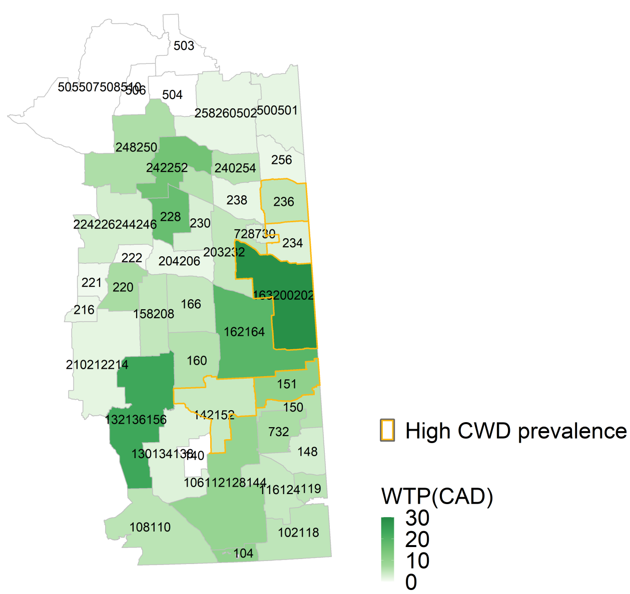
Table 2.5 and Figure 2.6 show that individuals are better off from hunting in the extended seasons but the welfare gains vary by hunting areas. From an economics standpoint, season expansion increases welfare benefits by increasing individuals' choice set. In our case, an extended season increases individuals' choice set from 43 alternatives to 81 alternatives. From a policy/management standpoint, season expansion is less costly to increase harvests for wildlife management than material incentives (e.g. extra hunting tags, monetary

Table 2.5: Welfare Estimates for Hunting in the Extended Season

Series	**Mean (CAD/person)**	**Standard Error**
All hunting sites	229.62***	13.23
WMU 100 Series (18 sites)	151.78***	10.67
WMU 200 Series (19 sites)	76.28***	4.83
WMU 500 Series (1 site)	1.56***	0.26

Note:
*** denotes statistical significance at the 1% level. WMU refers to Wildlife Management Unit. Welfare estimates for each site group are calculated by taking difference of welfare loss (negative willingness-to-pay) of closing extended seasons. For example, the welfare estimate for WMU 100s is the difference between welfare loss of closing the extended season in all sites and welfare loss of closing the extended season sites other than WMU 100s.

Figure 2.6: Willingness-To-Pay Per Person for Hunting in the Extended Season



Note: Labels are hunting site names: the starting number of the name indicates the series of the hunting site, e.g. 104 belongs to WMU 100 Series. WTPs in all WMUs are significantly different from 0.

rewards).[17] As the extended seasons could have generated 6 additional trips on average, a back-of-envelope calculation that multiplies additional trips by estimated harvest rate (around 50% from the Government of Alberta,[18]) gives us around 2 or 3 additional harvest per person on average in areas with CWD in the extended seasons. As such, extended seasons could be an effective incentive to engage individuals in the disease management by generating additional trips and harvests in CWD-infected areas and increasing welfare gains at a relatively low cost.

2.8 Conclusion

In this paper, we explore individuals' spatial and temporal responses to non-monetary incentives that extend time periods in the context of recreational activities. We develop a modified KT model by combining spatial and temporal choices into one model and incorporating spatial and temporal substitution behavior. The empirical application of the proposed model is implemented using revealed and stated preference data from an online survey of recreational hunters in Alberta, with a focus on the impacts of a wildlife disease (Chronic Wasting Disease) and its management using season expansions on hunting activities and value. We find that individuals do not appear to avoid hunting in the disease infected areas. Individuals like the proposed season expansion scenarios that encourage harvesting animals. We find that individuals are likely to substitute from hunting in areas with lower disease risks in the regular season to hunting in the most infected areas in both the regular and extended seasons. We assess the welfare impacts of the extended seasons by accounting for spatial and temporal substitution behavior. We find that individuals gain welfare

[17] We simulate WTP for a monetary reward of CAD 50 with the same dataset in the same model. Although individuals are willing to pay higher for the monetary reward than the extended season, the net benefit (WTP less the monetary cost) is negative. Compared to monetary rewards that directly cost money from the wildlife management agency, the cost of non-monetary incentives is more from administration. Regarding the monitoring procedure, season expansion might cost less than extra hunting tags that require checks on hunting license and number of tags.

[18] https://mywildalberta.ca/hunting/documents/MuleDeer-2017HunterHarvest-Mar2018.pdf

from an extended season for disease management, especially in areas with high disease prevalence. The welfare benefits are heterogeneous across hunting areas. Our findings suggest that extended seasons, by increasing individuals' choice sets and allowing them to more flexibly choose the time of activities, could be used as an effective incentive for disease management.

This research provides insights for studies on recreation demand and economic decisions in general. For non-market valuation studies on recreation demand, the proposed model can be applied to recreationists' decisions on trip locations and time periods as well as frequency in outdoor recreational activities (e.g. fishing, rock/ice climbing) that are often affected by environmental conditions and relevant policies. The flexible framework will also provide more realistic implications for policy makers on managing natural resources and associated recreational activities. This study shows the importance of incorporating human behavior into the management of natural resources. For other economic decisions with multiple dimensions, the proposed model can be easily extended or modified to fit the context such as livelihood choices within households (e.g. allocating household members to local farm activities and migratory off-farm activities in the dry season) and restaurant visits (e.g. time, location and frequency of eating out). By applying the model, these studies could explore the behavioral and welfare impacts of the incentives associated with temporal dimensions of choice.

Future research could address several limitations and extend the model from this study. Although the proposed model is the main contribution of this study, it has two limitations that are worth noting. First, the assumption of additive separability in our proposed model restricts the ability of the model to flexibly capture substitution behavior. As a result, the substitution patterns found in this study should be interpreted as a lower bound – more effort should be made to relax this assumption for generalizing the substitution patterns (Lavín and Hanemann, 2008). Second, since we use ASCs to control for unobserved attributes, it is possible that some unobserved attributes are not fully captured by ASCs and may correlate with CWD – this could bias the coefficient and welfare estimates. In addition, while we find season expansion could be used as an incentive to change recreation behavior, we are not able to argue if it is actually cost-effective through a benefit-cost analysis or a benefit-cost ratio for the season expansion program due to the lack of information on program costs. As the data are collected from a RP and SP survey, this study may suffer from issues such as data collection challenges (e.g. response bias, recall bias) and the potential for hypothetical bias like other stated preference studies. The limited number of observations used to estimate a model with many parameters restrict the further extension of the model due to convergence considerations. A larger sample would be preferable when collecting data for the application of the model in the future. Moreover, since the direct implication of the empirical application is for wildlife disease management, this study could be incorporated into epidemiological models (e.g. Potapov et al., 2016) and bioeconomic models as in Horan et al. (2011).

Appendix 2.A Derivations

Lagrangian function and first-order conditions for conceptual model

The Lagrangian for the optimization problem defined in Equations (2.1) to (2.4) is given by

$$L = \sum_k \sum_m U(x_{km}, Q_{km}, z) + \lambda[\overline{y} + w\overline{T} - \sum_k \sum_m (p_{km} + t_{km}w)x_{km} - z]$$

We assume that the numeraire good have positive demand so that the constraint is always binding and the Lagrangian multiplier is positive (i.e. positive marginal utility of money). The resulting first-order conditions are

$$\frac{\partial L}{\partial x_{km}} = \frac{\partial U}{\partial x_{km}} - \lambda(p_{km} + t_{km}w) \leq 0, x_{km} \geq 0, x_{km}\frac{\partial L}{\partial x_{km}} = 0, \text{, k = 1,...K, m =1,...M}$$

$$\frac{\partial L}{\partial z} = \frac{\partial U}{\partial z} - \lambda = 0$$

$$\frac{\partial L}{\partial \lambda} = \overline{y} + w\overline{T} - \sum_k \sum_m (p_{km} + t_{km}w)x_{km} - z = 0$$

From the second first-order condition we get $\lambda = \frac{\partial U}{\partial z}$. Dividing the first first-order condition by λ, we have

$$\frac{\partial U/\partial x_{km}}{\partial U/\partial z} \leq p_{km} + t_{km}w, \text{, k = 1,...K, m =1,...M}$$

$$x_{km}[\frac{\partial U/\partial x_{km}}{\partial U/\partial z} - p_{km} - t_{km}w] = 0, \text{, k = 1,...K, m =1,...M}$$

Derivation of the estimation equations in Section 2.6.2

From equation 2.10, we have the partial derivative of the utility function in Equation (2.9) with respect to a recreation trip is

$$U_{x_{km}} = \exp(\beta' Q_{km} + \varepsilon_{km})(\frac{x_{km}}{\gamma_{km}} + 1)^{\alpha - 1}$$

The partial derivative of the utility with respect to the numeraire good is equal to

$$U_z = \exp(\varepsilon_z) z^{\alpha - 1}$$

Substituting these two equations into Equation (2.5), we have

$$\frac{\exp(\beta' Q_{km} + \varepsilon_{km})(\frac{x_{km}}{\gamma_{km}} + 1)^{\alpha - 1}}{\exp(\varepsilon_z) z^{\alpha - 1}} \leq p_{km} + t_{km}w, \text{, k = 1,...K, m =1,...M}$$

Taking logarithms of both sides yield the estimating Equations (2.11) to (2.14):

$$V_{km} + \varepsilon_{km} = V_z + \varepsilon_z \text{ if } x^*_{km} > 0 \text{ and}$$

$$V_{km} + \varepsilon_{km} \leq V_z + \varepsilon_z \text{ if } x^*_{km} = 0 \text{ where}$$

$$V_{km} = \beta' Q_{km} + (\alpha - 1) \ln\left(\frac{x_{km}}{\gamma_{km}} + 1\right) - \ln(p_{km} + t_{km} w)$$

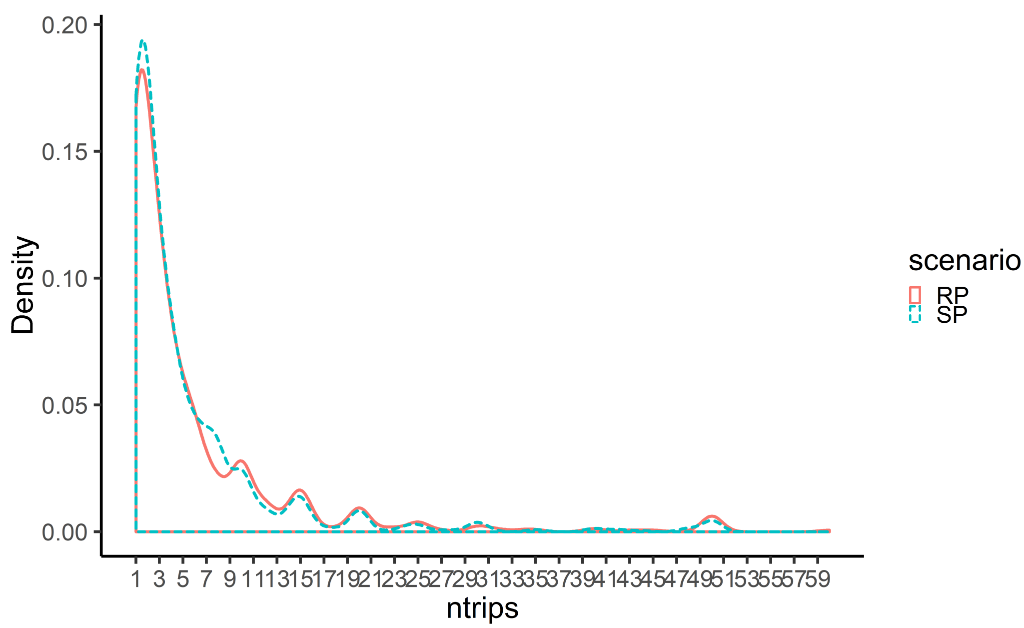
$$V_z = (\alpha - 1) \ln(z)$$

Appendix 2.B Trip Frequency

Table 2.B.1: Trip Frequency Distribution Table

Trip	Frequency	Percent	Trip	Frequency	Percent
1	480	26.39%	22	1	0.05%
2	341	18.75%	23	3	0.16%
3	209	11.49%	24	3	0.16%
4	152	8.36%	25	11	0.60%
5	98	5.39%	27	2	0.11%
6	90	4.95%	28	1	0.05%
7	57	3.13%	30	11	0.60%
8	73	4.01%	31	2	0.11%
9	13	0.71%	32	1	0.05%
10	83	4.56%	34	1	0.05%
11	10	0.55%	35	3	0.16%
12	28	1.54%	40	5	0.27%
13	5	0.27%	42	2	0.11%
14	14	0.77%	43	1	0.05%
15	48	2.64%	44	1	0.05%
16	5	0.27%	45	1	0.05%
17	2	0.11%	48	3	0.16%
18	4	0.22%	50	20	1.10%
20	34	1.87%	60	1	0.05%

Figure 2.B.1: Trip Frequency Density (RP vs. SP)



Appendix 2.C Robustness Checks

Table 2.C.1: Parameter Estimates for Kuhn-Tucker Model (RP and SP Data Respectively)

	RP data		SP data	
	Estimate	z-stat	Estimate	z-stat
Baseline marginal utility parameters (β_{km})				
CWD	−0.422	−1.340	−0.441	−1.410
Extended season			−0.061*	−1.750
October			0.062	0.570
December			0.234**	2.090
College	−0.025	−0.320	−0.025	−0.340
Urban	0.059	0.780	−0.033	−0.480
Children	−0.137	−1.480	−0.199***	−2.340
Yrshunt	−0.013	−0.480	−0.019	−0.760
Landowner	−0.158	−1.370	−0.217**	−2.030
ASC (mean)				
WMU 100 Series&732	−2.900**	−2.014	−3.170***	−2.508
WMU 200 Series&728&730	−4.350***	−4.522	−4.662***	−5.491
WMU 300 Series&400 Series	−3.787***	−7.638	−4.350***	−10.427
WMU 500 Series	−4.339***	−8.541	−4.875***	−10.807
Mean translation parameters (γ_{km})				
Regular season				
WMU 100 Series&732	5.281***	7.365	5.190***	7.619
WMU 200 Series&728&730	6.894***	7.759	7.477***	7.893
WMU 300 Series&400 Series	4.592***	3.416	6.614***	3.363
WMU 500 Series	3.468***	4.933	6.004***	4.263
Extended season				
WMU 100 Series&732			4.226***	7.502
WMU 200 Series&728&730			5.363***	7.276
WMU 500 Series			4.614**	2.126
Satiation parameter (α)	0.254***	4.530	0.244***	4.990
Scale parameter	0.555***	27.760	0.536***	33.500
N	416		416	
N of "goods" in choice set	43		81	
Log-likelihood (mean)	-4585.83		-6868.54	

Note: There is only one season (i.e. regular season) in the recall scenario, therefore estimation with RP data do not have variables of extended season, October and December – this is different from the estimation with SP data where two seasons (i.e. regular and extended seasons) are proposed in the contingent behavior scenario.

Appendix 2.D Contingent Behavior Scenario Examples

Figure 2.D.1: Contingent Behavior Scenario: Proposed Extended Season in October

Potential Hunting Policy Scenario

Expanding the hunting seasons for one week into October:

- Prairie WMUs 100 Series (except 162, 163, 164, 166), marked in dark green on the map:

  Wednesday to Saturday in **the last week of October** and November (**Oct.25** – Nov.30)

- Parkland WMUs 200 Series; WMU 162, 163, 164, 166; WMU 500, marked in light green on the map:

  Oct.23 – Nov.30

Figure 2.D.2: Contingent Behavior Scenario: Responses Entry Table

EXTENDED HUNTING SEASON TRIPS (OCTOBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during *the extended hunting season (i.e. October) in 2017* under the scenario above.

		Number of trips you would have taken in *October* of 2017 under the scenario above	Average number of days you would have spent in *October* of 2017 under the scenario above	Number of deer you would have harvested in *October* of 2017 under the scenario above
WMU				
WMU				
WMU				
WMU				
WMU				

REGULAR HUNTING SEASON TRIPS (NOVEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *regular hunting season (i.e. November) in 2017* under the scenario above.

		Number of trips you would have taken in 2017 under the scenario above	Average number of days per trip you would have spent in 2017 under the scenario above	Number of deer you would have harvested in 2017 under the scenario above
WMU				
WMU				
WMU				
WMU				
WMU				

Chapter 3

Incentives for Impure Public Good Contributions and Motivational Crowding: Evidence from Laboratory and Framed Field Experiments

Incentives and behavioral nudges are widely used to induce beneficial behavior. When these incentives are used in specific contexts such as environmental conservation, individual knowledge, experience, and attitudes can lead to motivational crowding and may limit the efficacy of incentives. We use theory and experimental methods to compare how incentives and information affect behavior for highly specialized target groups and non-specialized audiences. Specifically, we use a multiple threshold public goods game to examine the effectiveness of policy instruments designed to curb a wildlife disease. Controlled laboratory and framed field experiments were conducted with students and recreational hunters. We find that pro-social information results in desirable outcomes for both groups. However, hunters and students respond differently to fixed and lottery monetary rewards as well as the removal of incentives. This research advances knowledge on how nudges and incentives can lead to motivational crowding and provides meaningful policy implications for wildlife management.

3.1 Introduction

Incentives and behavioral nudges have long been used to improve behavioral outcomes associated with private and public goods/services in various contexts: to induce costly effort (DellaVigna and Pope, 2017), to improve college instruction (Brownback and Sadoff, 2020) and performance on standardized tests (List et al., 2018), to increase airline captains' productivity (Gosnell et al., 2020), to increase blood donations (Goette and Stutzer, 2020; Mellström and Johannesson, 2008), and to encourage energy conservation (Allcott, 2011). However, undesirable outcomes caused by monetary and non-monetary incentives have led to a debate about their efficacy and generated attention to use behavioral nudges (e.g. information framing, social comparisons) to motivate pro-social behavior (Gneezy and Rustichini, 2000a; Gneezy et al., 2011; Thaler, 2018).

Motivational crowding theory offers a potential explanation for the puzzle of ineffective incentives and effective behavioral nudges (Frey and Jegen, 2001). Behavior could be driven by intrinsic motivations (i.e. "inner feeling") that come from within the person and/or extrinsic motivations (e.g. incentives, behavioral nudges) that come from outside of the person (Deci, 1971). When extrinsic motivations undermine existing intrinsic motivations, undesirable behavioral outcomes from a social welfare perspective may occur due to a net loss of total motivation (Kaczan et al., 2017) – called motivational crowding-out. On the contrary, motivational crowding-in arises when desirable outcomes happen because extrinsic motivations reinforce existing intrinsic motivations. Since individuals' intrinsic motivations change with private and public goods, the efficacy of incentives and behavioral nudges depends on the interplay between intrinsic and extrinsic motivations in different contexts (Bénabou and Tirole, 2003; Bowles, 2008; Bowles and Hwang, 2008). This interplay sometimes has a persistent effect even after extrinsic incentives are removed (Gneezy and Rustichini, 2000b; Gneezy et al., 2011; Kaczan et al., 2015).

Although motivational crowding theory (Frey and Jegen, 2001) has been applied to understand behavioral responses to incentives, findings and explanations are sensitive to specific contexts, study areas, recipients of incentives, problems that incentives intend to address, and individual behavior that incentives propose to change. In the context of natural resource management and environmental conservation, it is even more challenging to design effective incentives to overcome market failures, increase contributions to public goods, and internalize externalities (Polasky et al., 2019), partly due to the interactions between humans and nature. A number of studies have examined incentives and tested motivational crowding using framed field experiments in developing countries on land use decisions (e.g. public goods games in Moros et al. 2019 and Narloch et al. 2012, a dictator game in Kaczan et al. 2015), activities to generate forest-conservation payments for ecosystem services (e.g. a voluntary contributions game in Kaczan et al. 2017), overfishing and over-harvesting forest products (e.g. common pool games in Travers et al. 2011 and Reichhuber et al. 2009). These studies, by eliciting induced values in specific contexts, focus only on motivational crowding effect with a sample of target populations who either have field experience or are familiar with the context. No studies, to the best of our knowledge, have compared the different impacts of incentives on participants with and without field experience in the same specific context (Fréchette, 2015). In addition, experimental design in these studies has focused on the relationship between intrinsic and extrinsic motivations, and individual and group behavior, with little attention to the feedback between individual contributions and private or public benefits from the natural system.

In this study, we examine the effectiveness of monetary and non-monetary incentives, as well as information framing, to increase students' and non-students' contributions to impure public goods within the conceptual framework of motivational crowding. We design an innovative multiple thresholds impure public goods game where we characterize the relationship between individual decisions and natural system responses and incorporate this relationship into the interplay between intrinsic and extrinsic motivations, as a theoretical framework to understand behavioral responses to incentives. We test the theorized behavioral predictions in laboratory and framed field experiments with students and recreational hunters in the context of recreational hunting, to understand the effectiveness of incentives in engaging recreational hunters in controlling a wildlife disease, Chronic Wasting Disease (CWD), for conserving wildlife populations in Alberta, Canada.

Chronic Wasting Disease (CWD) imposes risks to wildlife resources and affects recreational activities in countries such as the United States, Canada, and Norway. As a prion disease, CWD kills members of deer family and is highly infectious with potential zoonotic risks. In Canada, the spread and prevalence of CWD has increasingly affected deer in the provinces of Alberta and Saskatchewan since the first confirmed cases.[19] As CWD has complicated causes and transmission routes, it is challenging for scientists to develop vaccines and treatments and hard for wildlife managers to control CWD. The current available approach to control CWD is to depopulate infected animals by direct herd reduction and hunter harvests. The opposition to direct herd reduction from the general public and stakeholders have increased the desire of using hunter harvest for CWD control (Pybus, 2012). Although recreational hunters obtain satisfaction from harvesting animals, they tend to harvest less than the optimal level for CWD control, in part, due to the regulations and large private cost associated with hunting activities. While epidemiological models have proposed various harvesting strategies to control the disease, these models do not discuss the incentives required to increase hunter harvest (Jennelle et al., 2014; Potapov et al., 2016; Uehlinger et al., 2016).

Various incentive programs, including non-monetary incentives of hunting season expansion, additional hunting tags, and financial rewards in fixed amounts or in a lottery, have been implemented to encourage hunting in North America (Cooney and Holsman, 2010; Holsman and Petchenik, 2006; Holsman et al., 2010). The mixed findings on the success of these incentives, together with the increased spread and prevalence of CWD, have urged wildlife managers to consider adaptive incentive programs to achieve the dual goal of controlling CWD and increasing hunting satisfaction (Western Association of Fish and Wildlife Agencies, 2017). However, discussions on these incentive

[19] https://www.usgs.gov/centers/nwhc/science/expanding-distribution-chronic-wasting-disease?qt-science_center_objects=0#qt-science_center_objectshttps://www.alberta.ca/chronic-wasting-disease-updates.aspx?utm_source=redirector

programs focus on the epidemiological perspective or are based on evidence from qualitative surveys – economics insights are missing from the examination of the effectiveness of the different incentive programs.

Designing effective incentives to increase recreational hunting for CWD control is an important economics problem and policy issue. Harvesting animals in an infected region is an impure public good because it generates the private benefit of hunting satisfaction and the public benefit of healthy wildlife populations, and these benefits reflect the feedback between humans and wildlife. Using the framework of motivational crowding, whether to harvest more infected animals with various incentives is a behavioral outcome of the interactions between the intrinsic motivations of obtaining private and public benefits and extrinsic incentives. Furthermore, a better understanding of the relationship between private and public benefits, and the interplay between intrinsic and extrinsic motivations, provides direct policy advice for wildlife managers in designing the most effective CWD management programs.

Our theoretical model and experiments presented in this research, explore behavioral responses of both a student sample as well as a smaller recreational hunter sample to a multiple thresholds impure public goods game where individuals choose quantities of contributions (framed as recreation trips). In the payoff function, we use non-linear private benefits to reflect the impacts of nature on humans. The public benefits are generated by multiple thresholds based on epidemiological models to capture the impacts of individual decisions on wildlife populations. As such, the payoffs characterize the interactions between individual decisions and natural system responses. Several behavioral treatments are designed to mimic actual CWD policy programs and include a non-monetary reward, a non-monetary reward with pro-social information, a fixed monetary reward, and a lottery monetary reward. We use Poisson difference-in-differences regressions and non-parametric tests to examine behavioral differences in the treatment groups, persistent treatment effects, and existence of motivational crowding effect.

We find that pro-social information has a motivational crowding-in effect for both students and recreational hunters, resulting in increasing contributions to the public good. On the other hand, different forms of monetary reward lead to divergent behaviors in students and hunter samples. Depending on whether monetary rewards are given as a fixed amount or a lottery, our results suggest that students do not respond to fixed monetary rewards while hunters do not respond to lottery monetary rewards, indicating that crowding-out effects are affected by framing. Removing these incentives after they have been established, i.e. testing their persistence, also leads to different behaviors between students and hunters. Students reduce contributions after pro-social information is removed and hunters increase contributions after fixed monetary rewards are removed.

This study makes several contributions to the literature and policy design. First, we compare behavioral responses of non-specialized groups (i.e. students without field experience) and highly specialized target groups (i.e. recreational hunters with field experience) using framed field experiments. This is different from laboratory experiments in previous studies where students and random samples of the general public make decisions without specific contexts (e.g. Exadaktylos et al. 2013; Belot et al. 2015). This is also different from other motivational crowding studies that mostly focus on the behavior of a sample of target populations in framed field experiments. In finding different behavioral responses from students and non-students, we show that researchers should be cautious about generalizing experiment findings with student samples, especially when experiments have a specific background and framing. Second, compared to most public goods games where participants contribute money, we design an innovative multiple threshold impure public goods game in the quantity space, which can be applied to various contexts, not just recreational hunting. The quantity contribution approach applies to decisions such as recreation trips, purchase decisions of organic/green foods, land use/conservation acreage decisions, pesticide use, and hours of volunteer work. In addition, by using multiple thresholds to link individual contributions with public benefits, we provide an example that captures the impacts of human behavior on natural systems (i.e. wildlife population dynamics) within epidemiological models. This example could inspire experimental economics studies to address other interdisciplinary environmental issues. Third, since the specific frame and treatments that are stylized versions of actual policy options, this study provides direct policy advice for wildlife managers who are tasked with designing incentives for wildlife disease management.

The remainder of the paper is organized as follows. Section 3.2 presents a theoretical framework that is used for experimental design. Section 3.3 describes empirical approach that includes experimental design and procedure as well as analysis methods. Section 3.4 presents key findings. This is followed by a conclusion in Sections 3.5.

3.2 Theoretical Framework

This section provides the theoretical framework for the subsequent experimental design. We first characterize the non-monetary and monetary returns to individual decisions on contributing impure public goods in quantities. We then discuss the interactions between incentives and non-monetary returns in a utility framework to link the impacts of incentives and motivational crowding. Based on the utility framework, we specify and parameterize the monetary return component as the payoff function framed in the context of recreational hunting in the experiment.

3.2.1 Utility Function

Following an additive utility function with monetary and non-monetary components from Levitt and List (2007), each individual i obtains utility U_i that consists of non-monetary returns $m(x_i)$ and monetary returns $\pi(x_i)$ through their decisions over x_i as quantities/numbers of goods to contribute:

$$U_i = m(x_i) + \pi(x_i) \tag{3.1}$$

where $m(x_i)$ is not observed by the researchers and $\pi(x_i)$ can be characterized as an experimental payoff function. In a standard public goods game, the setup of $\pi(x_i)$ follows a voluntary contribution mechanism (VCM) where individual decisions x_i are the amount of money contributed. As such, x_i could directly enter the monetary returns $\pi(x_i)$ (Moffatt, 2016). When individual decisions are quantities, i.e. individuals contribute quantities of goods, x_i needs to be translated to money/value by functions to generate the monetary returns $\pi(x_i)$. Moreover, to capture the "impure public goods" characteristics of the quantity contributions, the monetary returns $\pi(x_i)$ consist of private benefits $B_{pri}(x_i)$, public benefits $B_p(x_i)$, and private costs $C(x_i)$ of contributions as follows:

$$\pi(x_i) = B_{pri}(x_i) + B_p(x_i) - C(x_i) \tag{3.2}$$

When receiving incentives, individuals' private benefits $B_{pri}(x_i)$ have two components: the monetized individual benefits from quantity contributions $B_I(x_i)$ and the monetized benefits from incentives to encourage contributions $B_E(x_i)$. Using the framework of motivational crowding, one can think of $B_I(x_i)$ as the part of intrinsic motivations that affects monetary returns whereas $B_E(x_i)$ is the extrinsic motivations (e.g. material incentives) that offer monetary returns. $B_p(x_i)$ captures the public benefits from individuals' contributions. The usual approach to specify $B_p(x_i)$ in a public goods game in money/value space is converting the total group contributions to individual payoffs through the marginal per capita return. This is not suitable when individuals contribute quantities. Consequently, $B_p(x_i)$ is a function that transfers group quantity contributions to monetary returns by setting threshold levels that, if met, result in larger public benefits (Narloch et al., 2012). The individual's utility function can be described as:

$$U_i = m(x_i) + B_I(x_i) + B_E(x_i) + B_p(x_i) - C(x_i) \tag{3.3}$$

Individuals choose the optimal number to contribute to satisfy the following first order condition that takes derivative of the utility function with respect to x_i:

$$m'(x_i) + B'_I(x_i) + B'_E(x_i) + B'_p(x_i) = C'(x_i) \tag{3.4}$$

Given that $m'(x_i)$ is unobservable by researchers, the first order condition sets monetized marginal benefits equal to the costs of contribution.

Since motivational crowding effects occur when the interactions of intrinsic and extrinsic motivations affect non-monetary returns, $m(x_i)$ are extended as

$m(x_i, B_E(x_i)) = m(x_i) + \lambda_T B_E(x_i)$. As such, individual decisions could directly affect non-monetary returns through $m(x_i)$ and indirectly affect non-monetary returns through incentives in the term $\lambda_T B_E(x_i)$, where λ_T measures how incentives affect non-monetary returns and varies by incentives T (Bowles and Hwang 2008). If $m'(B_E) < 0$, incentives reduce non-monetary returns $m(x_i, B_E(x_i))$ for $\forall x_i > 0$. If $m'(B_E) > 0$, incentives increase non-monetary returns $m(x_i, B_E(x_i))$ for $\forall x_i > 0$ (Bowles and Hwang, 2008). Thus, the utility function is further extended to

$$U_i = m(x_i) + \lambda_T B_E(x_i) + B_I(x_i) + B_E(x_i) + B_p(x_i) - C(x_i) \tag{3.5}$$

The associated first order condition that determines the optimal contribution is

$$m'(x_i) + B_I'(x_i) + B_p'(x_i) = C'(x_i) - (1 + \lambda_T)B_E'(x_i) \tag{3.6}$$

In Equation (3.6), the impacts of incentives on individual decisions x_i are captured by the term $(1 + \lambda_T)B_E'(x_i)$. If $B_E'(x_i) = 0$, incentives do not change individual decisions. One could think of B_E as a behavioral nudge that does not affect monetary returns. If $B_E'(x_i) \neq 0$ and $\lambda_T = 0$, incentives do not interact with non-monetary returns, Equation (3.6) is reduced to Equation (3.4), i.e. motivational crowding effect does not exist. If $B_E'(x_i) \neq 0$ and $\lambda_T \neq 0$, individual decisions are affected by monetary returns of incentives and the interactions between incentives and non-monetary returns – motivational crowding exists and the crowding effect (in or out) depends on the value of λ_T as compared to -1.

Since non-monetary returns $m(x_i, B_E(x_i))$ are not directly observed, we use monetary returns $\pi(x_i)$ from the utility function to specify payoffs in the experiments and predict behaviors of rational agents. Treatments that include material incentives only, i.e. those that change experimental payoffs, are predicted to change individual decisions $B_E'(x_i) \neq 0$ and $\lambda_T = 0$, and motivational crowding does not exist. On the other hand, treatments with behavioral nudges only do not change the payoff function and are theoretically predicted to not change behavior, $B_E'(x_i) = 0$. Experimentally, we identify crowding-in effects through the quantity choice of individuals, that is, any individual who contributes more than predicted by theory when extrinsic motivations reinforce intrinsic motivations. For treatments that are designed to increase contributions by including material incentives, an increase in contribution does not necessarily indicate a crowding-in effect – a crowding-in effect exists only when the increased contributions are more than theoretically predicted. Crowding-out effects exist if individuals do not change behavior or contribute less than predicted because extrinsic motivations undermine intrinsic motivations.

3.2.2 Payoff Function

We further specify the monetary returns $\pi(x_i)$ in the utility function, i.e. $B_I(x_i)$, $B_E(x_i)$, $B_p(x_i)$, and $C(x_i)$ in Equation (3.3), to construct a meaningful payoff function framed in the context of recreational hunting.

Regarding hunting activities, decisions x_i are the number of hunting trips each individual decides to take. $B_I(x_i)$ is the direct individual benefit from hunting trips. Since $B_I(x_i)$ characterizes the part of intrinsic motivations that affects monetary returns, one can think of $B_I(x_i)$ as capturing the use value of hunting: hunting satisfaction and material benefits from hunting trips and harvesting.[20] We choose a non-linear functional form for $B_I(x_i)$ so that hunting trips (or animals harvested) increase the utility at a decreasing rate (i.e. $B_I(x_i)$ is concave in x_i) – this is to capture the impact of "animals" on hunting utility: hunters are more satisfied with the first harvested animal than the second. $B_E(x_i)$ is the benefit from incentives to encourage more hunting trips for Chronic Wasting Disease (CWD) control. As incentives are provided by wildlife managers, $B_E(x_i)$ is the extrinsic motivation for individuals to hunt more in CWD-infected areas and is increasing in x_i (i.e. $B'_E(x_i) > 0$). $B_p(x_i)$ captures the public benefits from reduced animals in CWD-infected areas and increased healthy wildlife populations, that are shared with other hunters and the general public. Costs C_I are the travel costs for hunting trips. For simplicity, $B_E(x_i)$, and $C(x_i)$ are linear in x_i. As hunting trips affect private

[20] The use value of recreational hunting and other recreational activities are mostly uncovered through recreation demand models (Adamowicz et al., 1997; Segerson, 2017). Accordingly, we monetize the use value in the private benefits $B_I(x_i)$ to capture hunting satisfaction and reduced expenses on meat consumption of other sources. Another intrinsic motivation of hunting, especially hunting to curb CWD, is for wildlife/environmental conservation – this is not related to the use value of hunting and is included in the non-monetary returns $m(x_i)$.

and public benefits through harvesting, a harvest rate h_i is added to mimic the expected number of animals harvested $E(x_i) = h_i x_i$ when individuals make hunting trip decisions. The resulting payoff function is

$$\pi(x_i) = a(h_i x_i)^2 + b h_i x_i + B_e h_i x_i + B_p(x_i) - c x_i \tag{3.7}$$

Where $a < 0$ and $b > 0$ are parameters in $B_I(h_i x_i)$, B_e captures the difference among incentives in $B_E(h_i x_i)$, $c > 0$ is the unit travel cost in $C(x_i)$.

In order to translate group hunting trips into monetary values in $B_p(x_i)$, we specify a function that links hunting trips with reduced animals in CWD-infected areas that will lead to healthier wildlife populations in the longer term. According to epidemiological models (Wasserberg et al., 2009; Potapov et al., 2016; Jennelle et al., 2014), the impact of harvesting infected animals on CWD prevalence and wildlife populations depends on harvest efforts and changes over time. Intense harvesting is effective in curbing CWD by removing infected wildlife populations at the beginning, but the effect decreases as the harvesting intensity increases due to wildlife population dynamics, especially because harvest potentially affects healthy wildlife populations. In other words, public benefits generated by harvesting are associated with multiple thresholds at diminishing rates, whereas harvest effort generates the largest public benefit when it reaches the first threshold relatively to no effort and continues to generate public benefits when it reaches the next thresholds, albeit at diminished benefits. Therefore, we specify the public benefit $B_p(x_i)$ as $B_p\theta$ that is determined by total number of animals harvested by hunter groups. We choose three thresholds and $\boldsymbol{B_p}$ is a vector of the multipliers B_{p1}, B_{p2}, B_{p3} ($B_{p1} > B_{p2} > B_{p3}$) that depend on the threshold vector $\boldsymbol{\theta} = \{\theta_1, \theta_2, \theta_3\}$. $\boldsymbol{\theta}$ creates four intervals of $\boldsymbol{B_p \theta}$ as showed in Table 3.1.

To maintain the consistency with different harvest rates, the thresholds $\boldsymbol{\theta}$ increase with harvest rates proportionally – this also mimics how various harvest strategies affect CWD prevalence given a specific time period (Wasserberg et al., 2009; Potapov et al., 2016; Jennelle et al., 2014). $\boldsymbol{B_p}$ is the same for all harvest rates but decreases as $\boldsymbol{\theta}$ increases – this is to reflect the increasing impact at a decreasing rate of harvesting on populations over time given a

Table 3.1: Public Benefit at Each Harvest Threshold

Total number of harvested animals, $\sum_i \boldsymbol{h_i x_i}$	$\boldsymbol{B_p \theta}$
$\sum_i h_i x_i < \theta_1$	0
$\sum_i h_i x_i \in [\theta_1, \theta_2)$	$B_{p1}\theta_1$
$\sum_i h_i x_i \in [\theta_2, \theta_3)$	$B_{p2}\theta_2$
$\sum_i h_i x_i \geq \theta_3$	$B_{p3}\theta_3$

Note: $B_{p1} > B_{p2} > B_{p3}$ and $\theta_1 < \theta_2 < \theta_3$

harvest rate (Wasserberg et al., 2009; Jennelle et al., 2014).

With each component of the payoff function specified, we can derive the optimal number of trips. Without considering the public benefits, individuals choose their private optimal number of trips x_i^{NE} (i.e. Nash equilibria) to maximize net private benefits when the marginal benefit is equal to the marginal cost of a trip:

$$2ah_i^2 x_i + bh_i + B_e h_i = c \tag{3.8}$$

Although public benefits drive participants to take more trips than the private optimal number of trips, the cost of trips is not shared with others and the public benefits do not increase with the number of trips within a given interval (e.g. between θ_1 and θ_2). Assuming perfect information and symmetry, each individual perceives others to take the same number of trips at the equilibrium. Rational individuals would only contribute the individual share of the group harvest to reach the lower bound of each threshold interval (Cadsby and Maynes, 1999). As such, when considering the private and public benefits as well as private costs, the optimal number of trips (i.e. social optima) to maximize the total payoff is

$$x_i^* = \frac{\boldsymbol{\theta}}{nh_i} \tag{3.9}$$

where n is the number of individuals in the group, and $\boldsymbol{\theta} \in \{\theta_1, \theta_2, \theta_3\}$.

3.2.3 Parameterization

In the experiment, the parameterized payoff for each participant i is given by:

$$\pi(x_i) = -50(h_i x_i)^2 + 400h_i x_i + B_e h_i x_i + B_p \theta - 100x_i \tag{3.10}$$

Table 3.2: Public Benefit by Harvest Rate and Thresholds

Harvest rate	**Threshold intervals ($\boldsymbol{\theta}$) for group harvested animals**	**Public benefit for each individual ($\boldsymbol{B_p\theta}$)**
30%	$[0, 6)$	0
	$[6, 7.2)$	70
	$[7.2, 8.4)$	86
	$[8.4, 12)$	104
40%	$[0, 8)$	0
	$[8, 9.6)$	94
	$[9.6, 11.2)$	115
	$[11.2, 16)$	138
50%	$[0, 10)$	0
	$[10, 12)$	117
	$[12, 14)$	144
	$[14, 20)$	173
60%	$[0, 12)$	0
	$[12, 14.4)$	140
	$[14.4, 16.8)$	173
	$[16.8, 24)$	208

The parameters are chosen to generate sensible payoff for the experiments. The number of hunting trips x_i is an integer between 0 and 10, a range based on findings from a recent survey to recreational hunters in Alberta (Xie et al., 2020). The harvest rate h_i is drawn from the set of 30%, 40%, 50%, 60%.[21] Since the thresholds for public benefit change with harvest rates, in experiments with multiple decision rounds, the harvest rate is the same for all participants within the same round but is different across rounds. The private benefits from hunting trips $B_I(x_i)$ are $-50h_i^2x_i^2 + 400h_ix_i$. The private costs are $100x_i$. $B_p\theta$ is the public benefits from hunting trips that are determined by total number of expected harvest in each group in each round. Setting four individuals in one group (i.e. $n = 4$ in Equation 3.9), we specify $B_p\theta$ at each harvest rate in Table 3.2. $B_eh_ix_i$ is the private benefit from incentives that differs among treatment groups and will be discussed in Section 3.3.2. The associated Nash equilibria and social optima for each treatment groups are also discussed in Section 3.3.2.

[21]This is based on deer harvest reports https://mywildalberta.ca/hunting/documents/MuleDeer-2017HunterHarvest-Mar2018.pdf

3.3 Empirical Approach

To provide empirical evidence for the theoretical framework and test the effectiveness of various incentives, we conducted laboratory and framed field experiments with students and recreational hunters. This section describes the experimental design and associated methods to analyze experimental data.

3.3.1 Experimental Procedure

The experiment was conducted in three parts using Z-tree (Fischbacher, 2007) as shown in Figure 3.1. All decisions were made on personal computers that ensured privacy. Participants were first provided an overview of the experiment, and information on CWD. In Part A, participants were asked to answer an open-ended question. The question asked for a participant's opinions concerning hunters' roles in CWD management. This question is to help inform researchers of their pre-existing intrinsic motivations that is missing in most studies on motivational crowding (Rode et al., 2015).

In Part B (decision rounds), participants were presented with experimental instructions (Appendix 3.D) and completed practice questions.[22] All participants were randomly assigned to a group of four and remained in this configuration for one decision only. Groups do not interact in the experiments. Participants made a total of 15 decisions, one decision per round – thus facing new randomly assigned group members in all 15 rounds. Rounds were evenly divided into three stages. Each participant was randomly assigned to either a control group or one of four treatment groups (between-subject design), further explained in Section 3.3.2. In the first stage all participants made 5 decisions in pre-treatment control rounds. In the second stage, all participants received a new set of instructions containing either treatment information or control information and made another 5 decisions. Instructions for participants in

[22] To ensure participants carefully read and understand the instructions, we distributed paper copies of instructions along with a voiceover to read the instructions. We also used slides to familiarize participants with the computer program. To avoid the end effect (Selten and Stoecker, 1986), participants were told they would play at least 15 paid rounds (15 decisions plus 1 risk task). The pre-registration plan is available upon request.

the four treatment groups provided new information and associated payoff while instructions for participants in the control group provided the same information as in the first stage. In the third stage, i.e. post-treatment control rounds, all participants received the same instructions as in the first stage and made 5 more decisions. In each round, participants had to decide how many hunting trips to CWD areas they wanted to take. To help participants with their decisions, the instructions provided them with information sheets, which included the number of trips they could take, the chances of harvesting deer (randomly selected harvest rate h_i as explained in Section 3.2.3), the number of deer that could be harvested by them and their group, and the associated private and public payoffs (see instructions in Appendix 3.D). At the end of each round, participants were informed about the randomly drawn harvest rate, the number of animals harvested by themselves, their private benefits, the number of animals harvested by their group, their shares of public benefits, and their total payoff. Additionally, after participants had completed all 15 decision rounds, we elicited their risk preferences at Stage 4 (risk task) following Dave et al. (2010).

Lastly, in Part C, participants filled out a short debriefing survey including socio-demographic information, their attitudes towards incentives to engage hunters in CWD management and the same open-ended question as in Part A (Appendix 3.D). At the end of the experiment all participants received payoff for the randomly determined rounds. Each session lasted just over one hour. The average payoff was 13 Canadian dollars that did not include participants' show-up compensation (10 or 35 Canadian dollars).

3.3.2 Treatments

In addition to a control group (T0) , the following four treatments (T1-4) were tested in the experiments:

T1: Participants were given two extra hunting tags for a maximum harvest of six deer.

T2: T1 plus pro-social information adapted from the Wisconsin Hunting Regulation (Appendix 3.D).

Figure 3.1: Overview of the Experiment Procedure

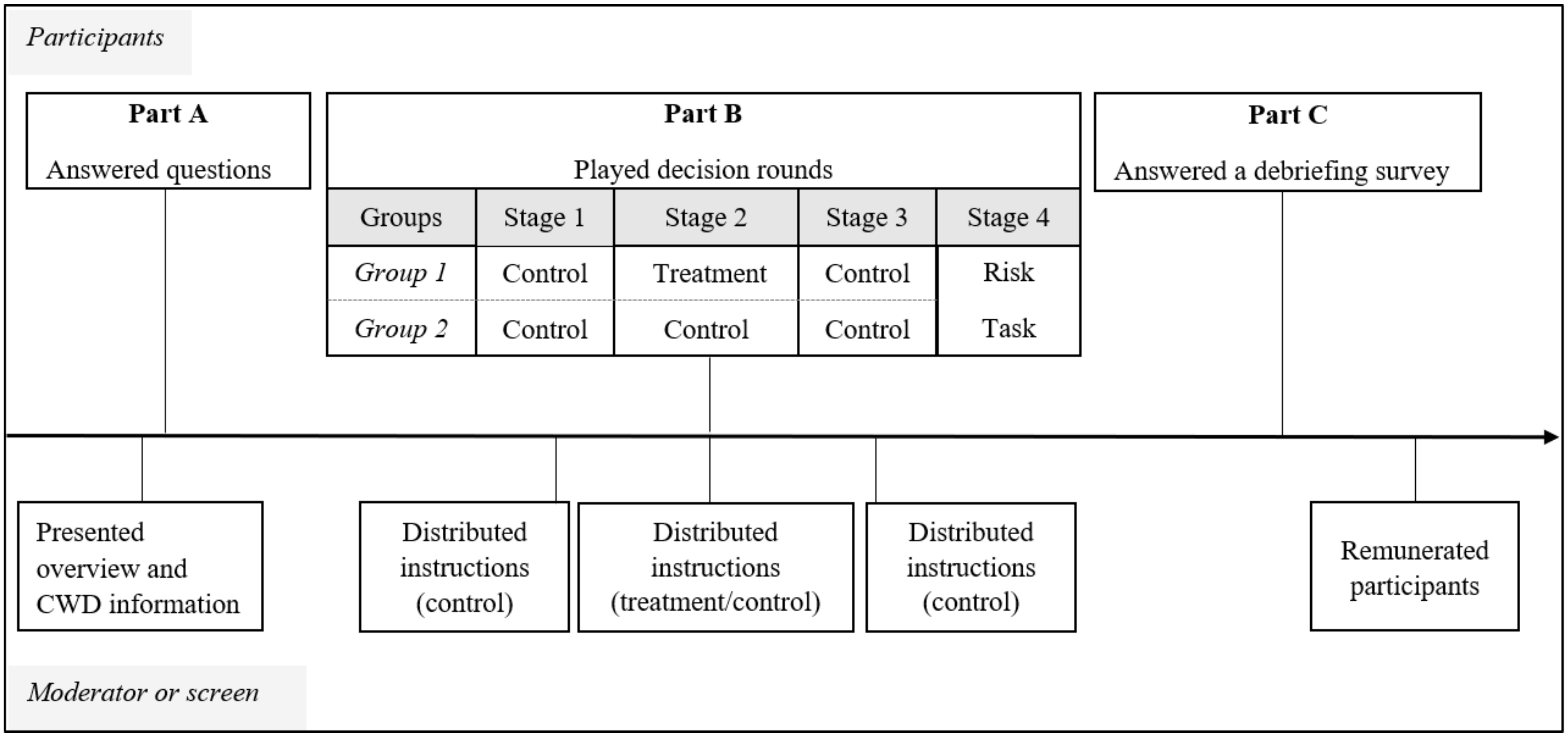


Table 3.3: Treatments in the Experiment

Treatment	**Incentive Type**	**Description**	$\boldsymbol{B_e}$	**Value**
Control (T0)	N/A	No incentives	0	0
Treatment 1 (T1)	Non-monetary incentives	Extra tags	B_T	50
Treatment 2 (T2)	Non-monetary incentives and pro-social framing	Extra tags + pro-social information	B_T	50
Treatment 3 (T3)	Non-monetary and fixed monetary incentives	Extra tags + fixed monetary rewards	$B_T + B_M$	100 $(= 50 + 50)$
Treatment 4 (T4)	Non-monetary and lottery-based monetary incentives	Extra tags + lottery monetary rewards	$B_T + dB_D$ $(dB_D = B_M)$	100 (=50+ 25% $\times$ 200)

T3: T1 plus a fixed monetary reward, which were awarded based on the number of deer harvested.
T4: T1 plus enrollment in a monetary reward lottery (25% odds); with an expected payoff equivalent to T3.

All four treatments are chosen based on real-world applicability to test these specific policy interventions for CWD management. These treatments use stylized settings and mirror policy programs that are either under consideration or were implemented in other areas (Western Association of Fish and Wildlife Agencies, 2017; Holsman and Petchenik, 2006; Holsman et al., 2010). Although the incentives characterized by treatments in the experiments are not the same as the ones in reality, real monetary payments that link behavior and analogous incentives in the experiments increase incentive compatibility of the experiments. Table 3.3 lists four treatments and associated parameter B_e in the experiments.

All treatments include two extra hunting tags to relax harvesting restrictions. As such, one could think of T1 as a baseline treatment group for T2-4. In Alberta, hunters are typically restricted by hunting licenses and tags, such that hunting licenses specify time, location, and species that can be harvested; whereas tags limit the number of animals one can harvest. Without extra hunting tags, hunters cannot increase the number of harvested animals and are, thus, unlikely to take more hunting trips. However, in reality extra hunting tags do not necessarily increase the number of trips because hunters could harvest more animals in the same trip – this possibility is taken into account by adding the payoff associated with extra tags, as other incentives. In addition, although extra hunting tags are non-monetary incentives (i.e. do not provide direct monetary benefits), they are material incentives and therefore monetized in the payoff function – this is different from behavioral nudges that do not affect monetary returns.

The provision of pro-social information in T2 does not change an individual's payoff function (i.e. $B'_E(x_i) = 0$ as discussed in Section 3.2.1) but has previously been shown increase voluntary contributions (see for example Cialdini et al. 2006). The pro-social information script is adapted from the 2011 Wisconsin Deer Hunting Regulation where wildlife managers encouraged additional harvest in CWD-infected areas (see Appendix 3.D for the script).[23] Monetary rewards in T3-4 add payoff to benefits from extra tags in T1. Fixed monetary rewards are set so that participants receive 50 more payoff points from monetary rewards for every additional hunting trip. Lottery monetary rewards are set such that participants have the chance to win a lottery of 200 more payoff points for every additional hunting trip. The chance of winning a lottery is 25% (one winner per group). The lottery is to test whether framing a fixed monetary reward as a lottery with the same expected value would encourage more hunting trips than a fixed monetary reward, as a lottery has been found to change behavior in List and Price (2009).

With the parameterized payoff function in Section 3.2.3 and Table 3.3, we derive Nash equilibria and social optima for each treatment in control and treatment rounds, as well as trip differences across treatment groups as in Table 3.4. The differences between Nash equilibria and social optima within and across treatments are rather small (one to two trips). This is mainly because hunting trips are costly in reality and recreational hunters are more likely to take one or two additional hunting trips when receiving incentives.

[23]The original 2011 Wisconsin Deer Hunting Regulation was available online when we designed the experiments but is no longer available online now. A digital copy of the regulation will be provided upon request.

Table 3.4: Nash Equilibria and Social Optima in Number of Recreation Trips for Each Treatment at Control and Treatment Rounds

	Treatments	Stage 1 & 3: Pre- and post-treatment control rounds	Stage 2: Treatment rounds
Nash Equilibria (NE)	T0 (control)	4	4
	T1 (extra tags) & T2 (extra tags + pro-social information)	4	5
	T3 (extra tag + fixed rewards) & T4 (extra tag + lottery rewards)	4	6
Social Optima (SO)	T0 (control)	5	5
	T1 (extra tags) & T2 (extra tags + pro-social information)	5	6
	T3 (extra tag + fixed rewards) & T4 (extra tag + lottery rewards)	5	7

Note: By taking difference of NE or SO across treatments, we can find the predicted differences between treatment groups in treatment rounds are: 1 trip between T1/T2 and T0, 1 trip between T3/T4 and T1.

3.3.3 Participants

Based on a power analysis (Appendix 3.C), a total of 130 participants (one sample of 100 students and one sample of 30 recreational hunters) took part in the experiments. The student sample was recruited from the Online Recruitment System for Economic Experiments (ORSEE) at our university. Sessions with students were conducted between October 7 and October 22, 2019. The recreational hunter sample was recruited through various approaches, including hunting stores, online hunter forums, Facebook hunting groups, and word-of-mouth recruitments. Substantial efforts went into the recruitment of recreational hunters. Nonetheless, as many hunters live in rural areas, for some as far as a two-hour drive from our campus, they were deterred by the fact that they had to come to the campus. This and in our experience a general lack of interest in participating in economic experiments made it challenging to produce a larger sample from hunters. Sessions with hunters were conducted between January 16 and February 8, 2020. Another session had to be cancelled due to the COVID-19 pandemic. Nonetheless, we are not aware of any research that has previously tested policy programs with recreational hunters in incentive compatible economic experiments, and though small, we feel rather strongly about the importance of this data subset.

All participants were invited to an experimental laboratory at our university to participate in the sessions with the same hunting context, instructions, computer program, and payoffs. Debriefing surveys in Part C were slightly different for the two samples (Appendix 3.D). To account for expenses and time from long-distance drive, recreational hunters were paid 25 Canadian dollars more than students.

Table 3.5 provides summary statistics of socio-demographics variables of the student and hunter samples. We can see that the hunter sample has more variation in almost all demographic variables such as age, urban, and risk preference – this is not surprising and similar to other studies (Harrison and List 2004). In the student sample, there are slightly fewer male than female participants overall. The average age is around 25 for most of the treatments. The risk task reveals that around 40% of participants are risk loving. In the hunter sample, 80% of participants are male – most hunters in Alberta are male. The average age is 38 but different across treatment groups – this is very different from the student sample with a more concentrated age distribution. Fewer participants live in urban areas and are risk loving compared to the student sample. Although we randomly assigned treatments to participants, socio-demographic variables are not balanced across treatment groups due to the small sample of participants for each treatment group in both student and hunter samples. The summary statistics and a balance check indicate the statistical differences in socio-demographics between the student and hunter samples. The differences should be interpreted and generalized cautiously given the unequal sample sizes (100 students and 30 hunters) and recruitment/self-selection mechanisms: we expect that students interested in or having previous experience were more likely to participate the experiments while hunters with CWD concerns were more likely to participate the experiments.

Table 3.5: Summary Statistics for Socio-demographic Variables by Sample and Treatment

Variable	Description	***Student Sample***						***Hunter Sample***				
		All	**T0**	**T1**	**T2**	**T3**	**T4**	**All**	**T1**	**T2**	**T3**	**T4**
Male	Dummy variable	**0.41**	**0.40**	**0.25**	**0.50**	**0.35**	**0.55**	**0.80**	**0.86**	**0.62**	**0.71**	**1.00**
	indicating male	(0.49)	(0.49)	(0.43)	(0.50)	(0.48)	(0.50)	(0.4)	(0.35)	(0.49)	(0.45)	(0.00)
Age	Age of participants	**25.40**	**24.65**	**24.55**	**28.05**	**23.75**	**26.20**	**37.70**	**35.00**	**28.88**	**43.30**	**44.00**
		(6.15)	(3.62)	(4.74)	(9.57)	(4.21)	(5.74)	(15.30)	(14.67)	(9.66)	(16.86)	(14.35)
Urban	Dummy variable	**0.91**	**0.95**	**0.95**	**0.95**	**0.90**	**0.80**	**0.60**	**0.71**	**0.50**	**0.43**	**0.75**
	indicating areas of living	(0.29)	(0.22)	(0.22)	(0.22)	(0.30)	(0.40)	(0.49)	(0.45)	(0.50)	(0.50)	(0.43)
Risk	Dummy variable	**0.41**	**0.40**	**0.45**	**0.35**	**0.40**	**0.45**	**0.27**	**0.57**	**0.00**	**0.43**	**0.12**
loving	indicating risk loving	(0.49)	(0.49)	(0.50)	(0.48)	(0.49)	(0.50)	(0.44)	(0.50)	(0.00)	(0.50)	(0.33)
N	Number of participants	100	20	20	20	20	20	30	7	8	7	8

Note:
Mean values are in bold. Standard deviations are in parentheses.
Variables are not balanced across all groups in student sample according to pairwise t-tests and joint orthogonality tests. Variables are not balanced between the student and hunter samples according to a joint orthogonality test.
Riskloving variable is constructed using data from the risk task following Dave et al. (2010)

3.3.4 Analysis

Our analysis mainly relies on regression analyses, supported by non-parametric analyses. When the randomization in the experiments perfectly eliminates the selection bias (Rubin, 1974), non-parametric analyses for between- and within-group comparisons are sufficient to identify average treatment effect (ATE) and average treatment effect on the treated (ATT), and inform the motivational crowding effect. Nevertheless, the assumption of a perfect randomized experiment does not hold in our experiments given unbalanced socio-demographic variables across treatment groups as discussed in the previous section and shown in Table 3.5. As such, we use regressions to control for observed and unobserved selection biases and identify the magnitude of treatment effects.

As trip data are integers, a Poisson or negative binomial regression is most suitable for these count data – the main difference being that the Poisson regression assumes the equality of conditional mean and variance whereas the negative binomial regression allows for greater variance than the conditional mean (i.e. overdispersion) (Greene, 2012). Since we do not find overdispersion using a negative binomial regression, we choose to use a Poisson regression, which assumes the number of hunting trips x_{it} individual i chooses at round t is drawn from a Poisson distribution with mean γ_{it} (Greene, 2012):

$$Prob(X = x_{it}|\boldsymbol{S}, \boldsymbol{T}, \boldsymbol{D}) = \frac{e^{-\gamma_{it}}\gamma_{it}^{x_{it}}}{x_{it}!}, x_{it} = 0, 1, 2, ... \quad (3.11)$$

We apply a difference-in-differences (DID) approach to make use of the three stages of the experiments as in the following log-linear specification for γ_{it}:

$$ln\gamma_{it} = \alpha_0 + \alpha_1 S_2 + \alpha_2 S_3 + \beta_1 S_2 T + \beta_2 S_3 T + \boldsymbol{\delta D} + \epsilon_{it} \quad (3.12)$$

where S_2 is a dummy variable of Stage 2 (i.e. treatment rounds), S_3 is a dummy variable of Stage 3 (i.e. post-treatment control rounds). T is a treatment dummy indicator that captures possible differences between 1) the control and treatment groups; 2) the baseline treatment group (T1) and other treatment groups (T2-4) prior to treatment rounds. One key assumption in the DID approach is the common trend assumption: the average outcomes of the treatment groups and control group would have experienced the same trend/variation over time (rounds in our experiments) in the absence of the treatments (Abadie and Cattaneo, 2018). Our experimental design of pre-treatment control rounds in Stage 1 satisfies this assumption and allows us to flexibly use either the control group (T0) or the baseline treatment group (T1) as the "control". Our variables of interest are two DID coefficients: S_2T with a focus on treatment rounds; and S_3T with a focus on post-treatment control rounds. S_2T measures the average treatment effect on the treated (ATT) for each treatment group (T1-4) when we use the control group (T0) as the "control". It measures the ATT "premium" for T2-T4 in addition to the ATT of T1 when we use the baseline treatment group (T1) as the "control". S_3T indicates the persistence of treatment effects for each treatment group (T1-4) after the treatments are removed with the control group as the "control". $\boldsymbol{D}$ is a vector of socio-demographic variables that are not balanced across treatment groups, including gender (male = 1), age, areas of living (urban=1), risk preference (risk loving = 1). To account for unobserved confounders within each individual, the regression is estimated with robust standard errors clustered at individual level.

The regression analyses identify individual behavioral changes through the magnitude and direction of average treatment effects (relative to the control group), treatment effect premiums (relative to the baseline treatment group), and persistent treatment effects for treatment groups. However, regression analyses cannot fully untangle the cause of behavioral changes, the average treatment effects, or treatment effect premiums. As discussed in Section 3.2.1, individual decisions are affected by 1) treatments that are designed to induce behavioral changes by changing payoffs, as all treatments are to increase the number of hunting trips in the experiments (see Nash equilibria and social optima for treatment groups in Table 3.4), assuming no motivational crowding effect exists; and 2) motivational crowding effect that is not directly modeled in the theoretical framework or observed in the experiments.[24] As such, treatment

[24] We admit that there could be other reasons that cannot explained by the treatments or motivational crowding effects. To align our analysis with the theoretical model, we do not

effects identified by regression analyses could be explained by treatments and/or motivational crowding effects. To better understand and link regression findings with the theoretical model, we conduct non-parametric analyses (e.g. Mann-Whitney U-test, as trips do not follow a normal distribution according to Shapiro–Wilk tests) that compare observed behavior from the experiments with predicted behavior from the theoretical model. Noting that our theoretical model does not indicate whether the observed number of trips should be larger or smaller than predicted number of trips, we leave non-parametric tests as two-tailed to test whether they are significantly different. Insignificant differences between observed and predicted behaviors indicate that participants behaved no different than predicted by the theoretical model whereas significantly different observed and predicted behaviors suggest the existence of motivational crowding. Based on the two-tailed testing results and comparing the observed average number of trips with the predicted trips, we infer the motivational crowding-in (more observed trips than predicted) or crowding-out (fewer observed trips than predicted) effects. In light of the theoretical model in Section 3.2, by combining the regression and non-parametric analyses, motivational crowding effect can be identified and categorized as follows:

- Crowding-out effect: when treatments that should have positive effects are found to have no or negative treatment effects per DID coefficients in regressions, *and/or* observed number of trips are fewer than predicted number of trips per non-parametric tests.
- Crowding-in effect: when treatments are found to have positive treatment effects per DID coefficients in regressions, *and* observed number of trips are more than the predicted number of trips per non-parametric tests.
- No effect: when treatments are found to have positive treatment effects per DID coefficients in regressions, *and* observed number of trips are the same as predicted number of trips per non-parametric tests.

Given a small hunter sample relatively to the student sample (i.e. 30 versus 100 participants), we compare hunters' and students' behaviors by

consider these reasons.

various approaches. First, we present summary statistics and trip descriptive graphs for student and hunter samples respectively. Second, we estimate regressions with the student sample only and with pooled student and hunter samples including a dummy variable for hunters. As such, the difference between students and recreational hunters can be identified by the coefficient of the hunter dummy variable and/or different DID coefficients estimated by regressions with different samples. Third, we conduct non-parametric analyses for hunter sample separately to better understand regression findings with pooled student and hunter samples.

3.4 Results

This section presents key findings from our analysis. We first report three findings on incentives and motivational crowding effect with the student sample only, then we compare findings with students and hunters. In the discussion of each finding, we refer to Table 3.6 that presents the average number of trips in each stage by treatment, and Figures 3.2 and 3.3 that show the average number of trips in each round by treatment for student and hunter samples. Results from difference-in-differences (DID) Poisson regressions are reported in Table 3.7 with T0 (control) as the baseline group and Table 3.8 with T1 (extra tags) as the baseline group respectively. The same specification using Ordinary Least Squares regressions are reported in Appendix 3.B as robustness checks. Results from non-parametric analyses are discussed in this section with the full results presented in Table 3.A.1 of Appendix 3.A.

3.4.1 Pro-social Information Has a Crowding-in Effect for Students

To identify the impacts of pro-social information on individual decisions for contributing public goods, we focus on results associated with treatment 2 (T2) that includes pro-social information and extra tags (T1) in our experiments.

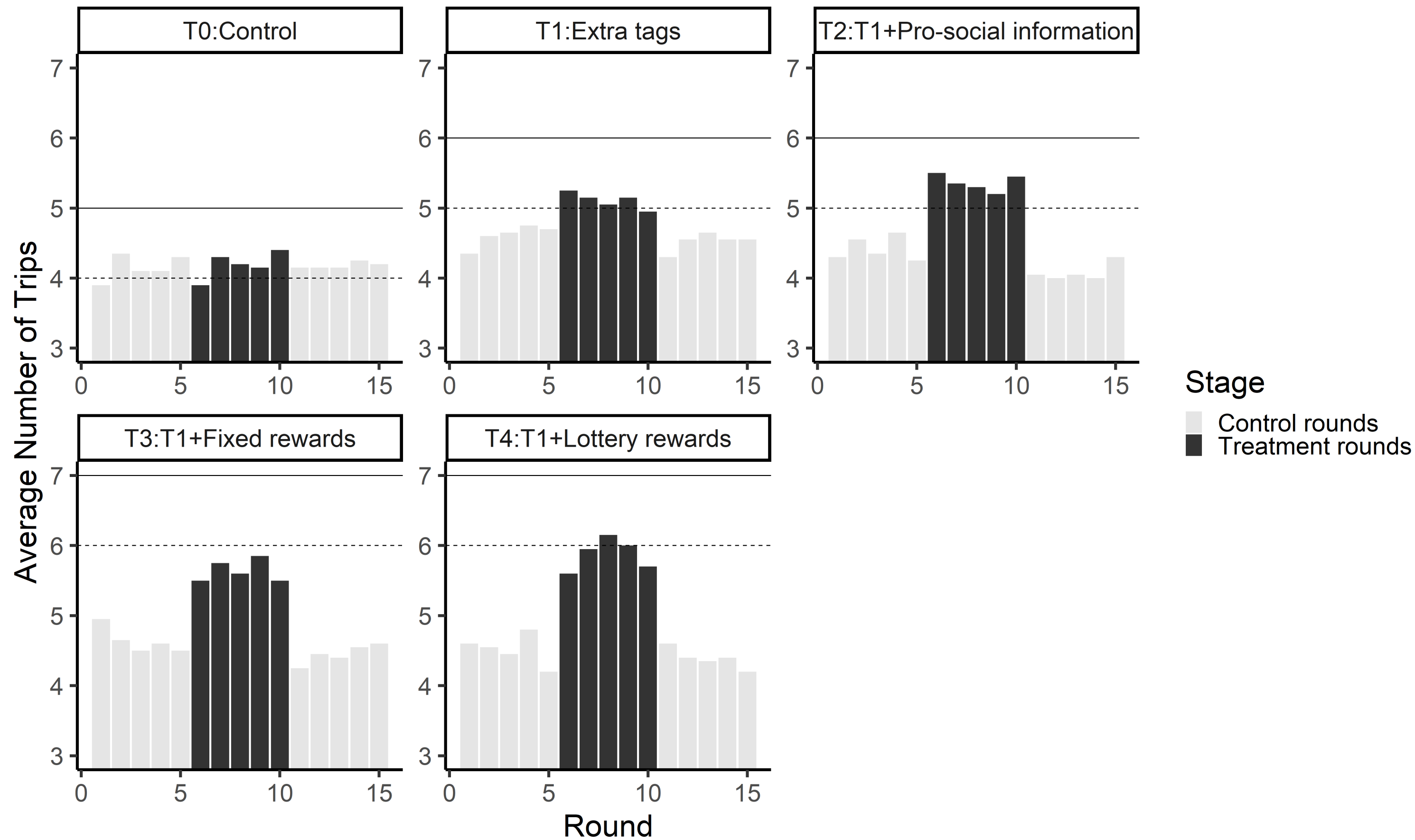
Since pro-social information in T2 does not change payoff compared to the extra tags only in T1, our theoretical model predicts that observed behaviors

Table 3.6: Average Number of Trips by Treatment at Control and Treatment Rounds

Treatments	***Student Sample***			***Hunter Sample***		
	Stage 1 Pre-treatment control rounds	**Stage 2 Treatment rounds**	**Stage 3 Post-treatment control rounds**	**Stage 1 Pre-treatment control rounds**	**Stage 2 Treatment rounds**	**Stage 3 Post-treatment control rounds**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
T0 (control)	**4.15**	**4.19**	**4.18**			
	(0.74)	(0.90)	(0.88)			
T1 (extra tags)	**4.61**	**5.11**	**4.52**	**4.83**	**5.51**	**4.60**
	(0.99)	(1.33)	(1.04)	(0.99)	(1.77)	(1.01)
T2 (extra tags +	**4.42**	**5.36**	**4.08**	**4.75**	**6.12**	**4.55**
pro-social information)	(0.81)	(0.87)	(0.58)	(0.87)	(1.54)	(0.82)
T3 (extra tags +	**4.64**	**5.64**	**4.45**	**4.14**	**6.43**	**4.83**
fixed rewards)	(1.20)	(1.67)	(1.08)	(1.29)	(1.74)	(0.79)
T4 (extra tags +	**4.52**	**5.88**	**4.39**	**4.70**	**5.58**	**4.40**
lottery rewards)	(0.98)	(1.34)	(0.84)	(1.09)	(1.72)	(1.08)

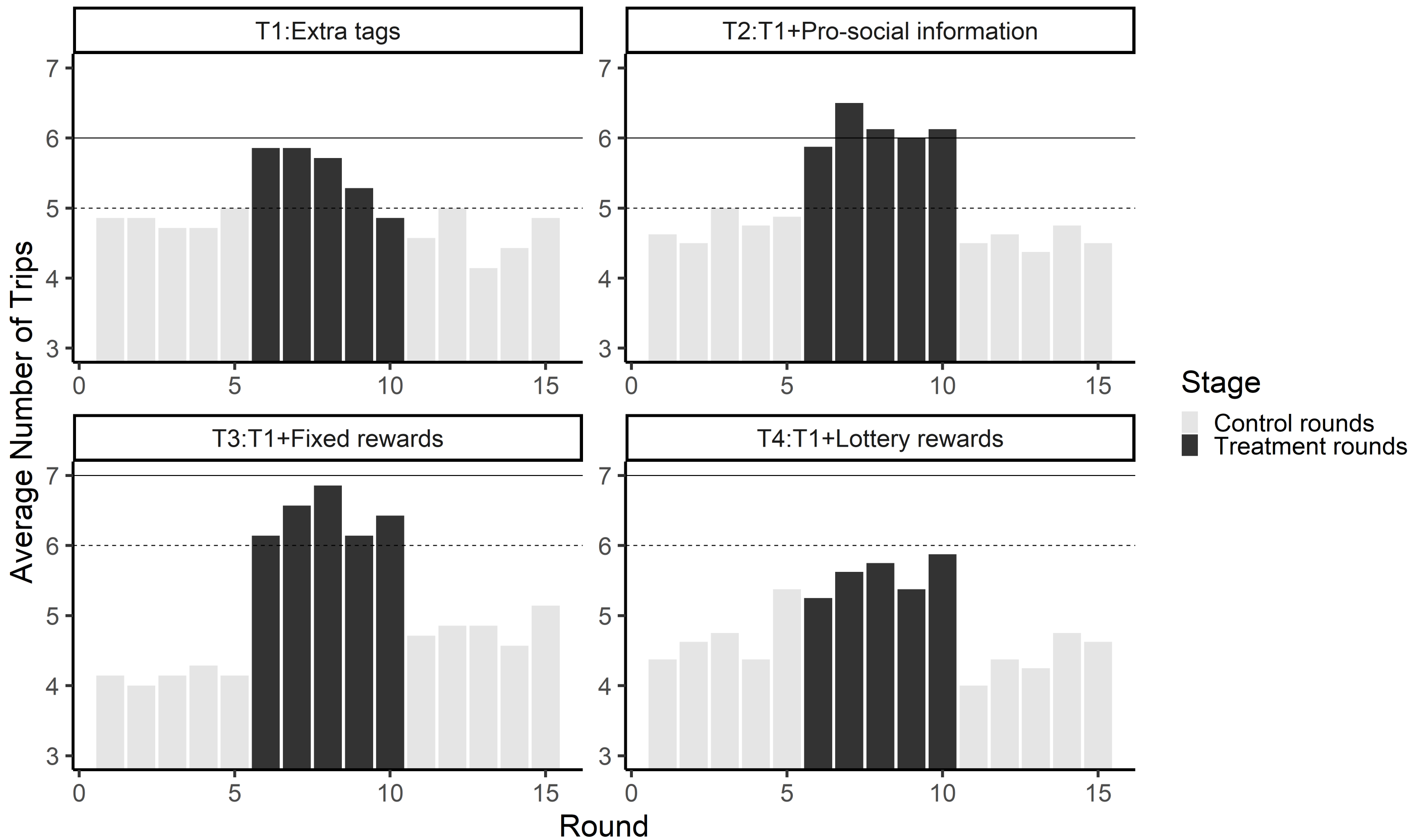
Note:
Mean values are in bold. Standard deviations are in parentheses.
Theoretical predictions from Table 3.4: Nash Equilibria and social optima at control rounds and T0 are 4 and 5 trips respectively.
Nash Equilibria for T1/T2 and T3/T4 at treatment rounds are 5 and 6 trips respectively. Social optima for T1/T2 and T3/T4 at treatment rounds are 6 and 7 trips.
The T0 is missing for the hunter sample because the associated session was cancelled due to the COVID-19 pandemic.

Figure 3.2: Average Number of Trips by Round (Student Sample)



Note: Black dashed lines are Nash Equilibria in treatment rounds for each group from Table 3.4. Black lines are social optima in treatment rounds for each group from Table 3.4.

Figure 3.3: Average Number of Trips by Round (Hunter Sample)



Note: Black dashed lines are Nash Equilibria in treatment rounds for each group from Table 3.4. Black lines are social optima in treatment rounds for each group from Table 3.4.

in the two treatments are the same (see Table 3.4 for reference). However, our experimental findings do not support this theoretical prediction. As shown in the column (2) of Table 3.6 where we average the number of trips over Stage 2 that consists of five treatment rounds, the average number of trips is 5.36, which is larger than the 5.11 trips in T1. Breaking the average number of trips to rounds as in Figure 3.2, we can also see that T2 has a larger average number of trips in each round than T1.

With the indication from descriptive graphs, we estimate three DID Poisson regressions to explore whether the difference associated with pro-social information is statistically significant. In Table 3.7 (results from DID Poisson regressions with T0 control group as the baseline group), the DID coefficients (S_2T_i) of T1 in column (1) and T2 in column (2) are positive and significant at 10% and 1% respectively, showing that treatments 1 and 2 induce positive behavioral changes comparing to the control group. This indicates that neither treatment induces a crowding-out effect. Although we see a larger coefficient S_2T_2 of treatment 2 than the coefficient S_2T_1 of treatment 1, as it indicates a potential crowding-in effect of T2, it is not clear whether T2 has a significantly larger treatment effect than T1. Therefore, we estimate another DID Poisson regression with T1 as the baseline group for treatment 2. In column (1) of Table 3.8, a positive and significant DID coefficient S_2T_2 shows that the prosocial information has a treatment "premium" on average in addition to extra tags. Mann-Whitney U-tests find that the observed trip difference between treatment 2 and treatment 0 (control) is significantly (at 10% level) different from the predicted difference of 1 trip (see Table 3.4 for calculation) whereas the trip difference between treatments 1 and 0 is not significantly different from the theoretical prediction. As these results show that extra tags, when combined with pro-social information, encourage more hunting trips than we predicted, we can conclude that pro-social information has a crowding-in effect for students.

Aligning with other studies (e.g. Ferraro and Price, 2013), our finding supports that pro-social information, as a type of behavioral nudge, could change behavior without offering monetary benefits. Noting that in our treatment, pro-social information is combined with the non-monetary incentives as opposed to a stand-alone behavioral nudge, the crowding-in effect for students shows that pro-social information can be used in addition to material non-monetary incentives for a better behavioral outcome that increases public good contributions.

3.4.2 Fixed Monetary Rewards Have a Crowding-out Effect but Lottery Rewards Do Not Have a Motivational Crowding Effect for Students

To identify and compare the impacts of monetary rewards on contributions to public goods, we turn our attention to treatments 3 and 4 that include fixed and lottery monetary rewards respectively in addition to extra tags (T1).

As treatments 3 and 4 have both non-monetary incentives of extra tags and monetary rewards that increase payoffs, we expect to see more contributions, i.e. 1 more hunting trip in addition to the extra tags of T1 (see Table 3.4 for calculation). Interested in the treatment effect premium of monetary rewards, we estimate two DID Poisson regressions that capture the treatment effect "premium" by setting T1 as the baseline group. In column (2) of Table 3.8, we see that the DID coefficient S_2T_3 of treatment 3 is positive but insignificant, indicating that fixed monetary rewards do not induce additional behavioral changes relative to extra tags, contrary to the theoretical prediction. This is a strong indication that fixed monetary rewards have a crowding-out effect. As in the column (2) of Table 3.6, treatment 3 only increases by 0.56 (5.64-5.11) additional trips on average compared to treatment 1 and this is significantly different (at the 5% level) from the predicted 1 trip according to a Mann-Whitney U-test. These results together suggest that fixed monetary rewards have a crowding-out effect for students.

As treatment 4 has the same expected payoff as treatment 3, the theoretical model predicts that individual decisions in treatment 4 should be the same as in treatment 3 – this does not appear in Figure 3.2 where more trips are taken on average in each treatment round in treatment 4 compared to treatment 3. In column (3) of Table 3.8, we see that the DID coefficient S_2T_4 of treatment 4 is positive and significant at the 1% level, showing a positive treatment effect

Table 3.7: DID Poisson Regression Results with T0 as Baseline Group (Treatments 1 and 2)

Variables	*Students*		*Students & Hunters*	
	T1: Extra Tags	**T2: Extra Tags +Pro-social Information**	**T1: Extra Tags**	**T2: Extra Tags +Pro-social Information**
	(1)	**(2)**	**(3)**	**(4)**
$\boldsymbol{T_i}$ **(Treatment)**	0.089^{*}	0.090^{**}	0.089^{*}	0.075^{*}
	(0.048)	(0.041)	(0.049)	(0.039)
$\boldsymbol{S_2}$ **(Treatment rounds)**	0.010	0.010	0.010	0.010
	(0.035)	(0.035)	(0.035)	(0.035)
$\boldsymbol{S_2T_i}$ **(Treatment × Treatment rounds)**	$\mathbf{0.093}^{*}$	$\mathbf{0.183}^{***}$	$\mathbf{0.101}^{**}$	$\mathbf{0.202}^{***}$
	(0.049)	**(0.049)**	**(0.050)**	**(0.045)**
$\boldsymbol{S_3}$ **(Post-treatment rounds)**	0.007	0.007	0.007	0.0072
	(0.039)	(0.039)	(0.039)	(0.039)
$\boldsymbol{S_3T_i}$ **(Treatment × Post-treatment rounds)**	**−0.027**	$\mathbf{-0.087}^{*}$	**−0.035**	$\mathbf{-0.076}^{*}$
	(0.049)	**(0.047)**	**(0.048)**	**(0.045)**
Hunter			0.112	0.157^{**}
			(0.096)	(0.077)
Male	−0.073	−0.048	−0.084	−0.038
	(0.058)	(0.042)	(0.062)	(0.042)
Age	0.000	-0.005^{***}	0.000	-0.004^{*}
	(0.008)	(0.002)	(0.003)	(0.002)
Urban	0.142^{***}	0.095^{*}	0.083	0.000
	(0.047)	(0.051)	(0.063)	(0.071)
Riskloving	0.087	0.132^{***}	0.055	0.120^{**}
	(0.068)	(0.046)	(0.056)	(0.047)
Constant	1.293^{***}	1.415^{***}	1.354^{***}	1.482^{***}
	(0.229)	(0.056)	(0.080)	(0.078)
N	600	600	705	720
LL	-1066.16	-1038.74	-1263.85	-1261.49

Note:
Robust standard errors clustered at individual level are in parentheses.
***, **, and * denote statistical significance at the 1%, 5%, and 10% level respectively.
The baseline group when $T_i = 0$ is T0 (i.e. treatment 0, control group). S_2T_i captures the difference between the control and treatment groups in treatment rounds. S_3T_i captures the persistent treatment effect.
Same specification is estimated for T3 and T4, see Appendix 3.A for details.

premium on top of the extra tags in T1– this result indicates that lottery monetary rewards do not have the crowding-out effect as we found with fixed monetary rewards. A Mann-Whitney U-test finds that the average additional 0.77 (5.88-5.11, in column 2 of Table 3.6) trips taken in treatment 4 (compared to treatment 1) are not significantly different from the theoretical prediction. We conclude that in our experiments, lottery monetary rewards do not have a motivational crowding effect (in or out)for students.

Monetary rewards are widely discussed and used by economists and policy makers (DellaVigna and Pope, 2017; Brownback and Sadoff, 2020). Our findings with the student sample show that the effectiveness of monetary rewards in increasing contributions to public goods depends on how monetary rewards are provided, i.e. whether they are given as fixed amounts or lottery. For policy makers, it is important to choose the most effective approach to offer monetary rewards because fixed and lottery monetary rewards incur the same expected costs.

3.4.3 Removal of Pro-social Information Has a Crowding-out Effect for Students

Following the studies that have found persistent motivational crowding effects after incentives were removed (e.g. Gneezy and Rustichini 2000b; Gneezy et al. 2011; Kaczan et al. 2015), we examine the persistent motivational crowding effects by focusing on individual decisions in the post-treatment control rounds.

As incentives that increase payoffs or pro-social information are all removed in the post-treatment control rounds, i.e. Stage 3, we expect to see the same individual decisions as in the pre-treatment control rounds, i.e. Stage 1. Comparing columns (1) and (3) of Table 3.6, we find that the average numbers of trips in Stage 3 are slightly less (ranging from 0.09 to 0.19 trips) than those in Stage 1 for treatments 1, 3 and 4, and these differences are not significant from 0 according to within-group Wilcoxon signed rank tests. For treatment 2, there are 0.34 fewer trips in Stage 3 than Stage 1 and the difference is significantly from 0 at the 1% level. In the DID Poisson regression with the control group as the baseline, we find a negative and significant (at the 10% level) DID coefficient S_3T_2 of treatment 2 in column (2) of Table 3.7. Recall that we find a crowding-in effect of pro-social information, however, the negative post-treatment effect indicates that the crowding-in effect of pro-social information is not persistent after being removed. Rather, the removal of pro-social information has a surprising crowding-out effect. We do not find persistent treatment or crowding out effects for extra tags, fixed or lottery monetary rewards even though they have different effects during treatment rounds from regression analyses (see Appendix 3.A for details).[25]

Although pro-social information, as a behavioral nudge, could increase contributions to public goods without additional costs, the crowding-out effect of removing pro-social information we find with students suggests that one should be cautious about removing pro-social information once it is given. In order to avoid the crowding-out effect, policy makers may consider providing pro-social information on a continuous basis in addition to non-monetary rewards.

3.4.4 Students and Non-students Respond to Incentives Differently

Given the specific hunting context of our experiments, we compare students and non-students regarding the three findings above. Some studies have criticized experiments that draw conclusions based on experiments conducted with student participants as non-representativeness of the target populations on at least two issues: endogenous sample selection and informing behavior of the population (Harrison and List, 2004). Findings with students are less informative on the target population's behavior especially when students do not have experience with the field context (Harrison and List, 2004). However, framed field experiments with a sample of target populations can face the sample selection issue and challenges on recruitment (Harrison and List, 2004). In our experiments, the sample selection issue is likely to be worse for recreational

[25] Although a within-group Wilcoxon signed rank test indicates a crowding-out effect of removing lottery rewards (at 10% significance level), it does not show up in the regression after we control for observed and unobserved selection bias (see Tables 3.A.1 and 3.A.2 in Appendix 3.A for details).

Table 3.8: DID Poisson Regression Results with T1 as Baseline Group

Variables	***Students***			***Students & Hunters***		
	T2: Extra Tags +Pro-social Information	**T3: Extra Tags +Fixed Rewards**	**T4: Extra Tags +Lottery Rewards**	**T2: Extra Tags +Pro-social Information**	**T3: Extra Tags +Fixed Rewards**	**T4: Extra Tags +Lottery Rewards**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
T_i	−0.036	−0.010	−0.009	−0.029	−0.029	−0.001
(Treatment)	(0.058)	(0.055)	(0.054)	(0.047)	(0.048)	(0.042)
S_2	0.103^{***}	0.103^{***}	0.103^{***}	0.111^{***}	0.111^{***}	0.111^{***}
(Treatment rounds)	(0.035)	(0.035)	(0.035)	(0.036)	(0.036)	(0.036)
S_2T_i	$\mathbf{0.090}^{*}$	**0.092**	$\mathbf{0.160}^{***}$	$\mathbf{0.101}^{**}$	$\mathbf{0.148}^{***}$	$\mathbf{0.126}^{***}$
(Treatment × Treatment rounds)	**(0.049)**	**(0.060)**	**(0.052)**	**(0.046)**	**(0.057)**	**(0.044)**
S_3	−0.020	−0.020	−0.020	−0.027	−0.027	−0.027
(Post-treatment rounds)	(0.030)	(0.030)	(0.030)	(0.028)	(0.028)	(0.029)
S_3T_i	−0.060	−0.022	−0.010	−0.041	0.036	−0.013
(Treatment × Post-treatment rounds)	(0.040)	(0.062)	(0.037)	(0.036)	(0.058)	(0.037)
Hunter				0.099^{*}	0.065	0.033
				(0.055)	(0.063)	(0.064)
Male	0.015	0.095	−0.060	−0.034	0.007	−0.078
	(0.069)	(0.073)	(0.055)	(0.056)	(0.061)	(0.056)
Age	−0.003	−0.012	0.009^{*}	0.000	−0.002	0.0026
	(0.002)	(0.010)	(0.005)	(0.002)	(0.002)	(0.002)
Urban	0.131^{**}	0.059	0.068^{*}	0.014	−0.010	0.023
	(0.064)	(0.067)	(0.038)	(0.066)	(0.063)	(0.049)
Riskloving	0.011	−0.022	0.036	0.005	0.041	0.066
	(0.059)	(0.070)	(0.051)	(0.052)	(0.051)	(0.053)
Constant	1.455^{***}	1.744^{***}	1.247^{***}	1.524^{***}	1.562^{***}	1.441^{***}
	(0.075)	(0.258)	(0.138)	(0.076)	(0.088)	(0.078)
N	600	600	600	825	810	825
LL	-1077.00	-1116.92	-1095.44	-1497.66	-1516.26	-1520.23

Note: Robust standard errors clustered at individual level are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level respectively. The baseline group when $T_i = 0$ is T1 (i.e. treatment 1, extra tags). S_2T_i captures the difference between the T1 and other treatment groups in treatment rounds. S_3T_i captures the difference between T1 and other treatment groups in post-treatment control rounds.

hunters than for students, especially given various recruitment approaches and the small sample of hunters. As it is difficult to address the sample selection issue in analyses, and experimental payoff functions, instructions, and randomization are identical for both samples, here we focus on comparing students' and hunters' decisions assuming no corrections for sample selection issues.

We first compare the average numbers of trips of the two samples. Table 3.6 shows that hunters take more trips than students in almost all treatments and all stages, especially in Stage 2 with treatments in columns (2) and (5). Comparing Figure 3.3 with Figure 3.2, we find that hunters take more trips in each round. In treatment rounds, the average numbers of trips are all above the Nash equilibria and closer to, if not above, the social optima for treatments 1-3. We estimate a supplementary Poisson regression with pooled student and hunter samples by including interaction terms of treatment dummy variables and treatment round dummy variables, a hunter dummy variable and socio-demographic variables (see Table 3.A.3 in Appendix 3.A). The regression shows hunters take significantly more trips than students. Two possible explanations for this difference are: our sample of hunters are more concerned about CWD, while students are more selfish and rational (Belot et al., 2015).

Second, we look at whether pro-social information also has a crowding-in effect for hunters. Recall that as we have a relatively small sample of hunters, we conduct regression analyses by pooling student and hunter samples, and use non-parametric analyses for hunters only as a supplement. From Table 3.7, we see that the DID coefficients S_2T_1 and S_2T_2 (columns 3 and 4) of treatments 1 and 2 are larger for both treatments and more significant for treatment 1 with the pooled student and hunter sample. In Table 3.8, comparing to the DID coefficient S_2T_2 in column (1), the DID coefficient for treatment 2 in column (4) becomes slightly larger and more significant (at 1% level), showing a larger treatment "premium" of pro-social information after we add the hunter sample to the student sample. However, the DID coefficients in columns (1) and (4) are not significantly different. Mann-Whitney U-tests with pooled samples find a more significant (at the 1% level) difference between the observed trip difference (treatment 2 and treatment 0) and the predicted difference while the result is the same for treatment 1.[26] These results show that pro-social information also has a crowding-in effect, and to some extent the effect is stronger, for hunters.

Then we examine motivational crowding effects associated with monetary rewards for hunters. Comparing DID coefficients S_2T_3 in columns (5) and (2) of Table 3.8, we see that the coefficient is larger and changes from insignificant to significant at 1% level, indicating that fixed monetary rewards have a treatment effect "premium" in addition to extra tags with the pooled sample. This shows that the crowding-out effect of fixed monetary rewards found in the student sample does not exist for the pooled sample – this is mainly because hunters take additional 0.92 (6.43-5.51, as column 5 in Table 3.6) trips with fixed monetary rewards. The Mann-Whitney U-test with the hunter sample independently indicates that the observed trip difference between treatments 3 and 1 are not significantly different from the predicted 1 trip. Therefore, we can say that fixed monetary rewards do not have motivational crowding (in or out) effects for hunters. For lottery monetary rewards, a smaller and significant DID coefficient S_2T_4 in column (6) compared to the one in column (3) of Table 3.8 shows that the treatment effect premium still exists but is smaller after adding hunter observations. As we do not find crowding-in effects of lottery rewards for students, a smaller DID coefficient provides stronger evidence of no crowding-in effect for hunters. In fact, column (5) of Table 3.6 and Figure 3.3 show the average number of trips in treatment rounds for T4 is smaller than those for treatments 2 and 3 with the hunter sample. The observed trip difference between treatments 4 and 1 for hunters is 0.07 and is significantly (at 1% level) different from the predicted 1 trip from a Mann-Whitney U-test. These results indicate that lottery monetary rewards are likely to have a crowding-out effect for hunters. Different from students, we find that hunters respond as expected to fixed monetary rewards but do not respond to lottery monetary rewards as

[26]As we were not able to conduct a T0 session for hunters due to the COVID-19 pandemic, we conduct Mann-Whitney U-tests by pooling student and hunter samples for comparisons with T0, without controlling for the difference between students and hunters.

lottery potentially induces a crowding-out effect.

We also examine whether treatments have persistent effects after being removed for the pooled student and hunter sample. The regression analyses do not indicate a big difference from results with student sample only, as shown by the DID coefficients S_3T_i in columns (3) and (4) of Table 3.7 and columns (4)-(6) of Table 3.8, except for a slightly smaller, negative and significant coefficient S_3T_2 for treatment 2 (comparing column 4 with column 2 of Table 3.7). However, a closer look at the descriptive statistics indicates differences between student and hunter samples. Comparing columns (4) and (6) in Table 3.6, we find the average numbers of trips in Stage 3 are smaller than those in Stage 1 for treatments 1, 2 and 4 but they are not significantly different according to the within-group Wilcoxon signed rank tests. However, the average number of trips in Stage 3 is more than the one in Stage 1 for treatment 3 and the 0.69 (4.83-4.14) additional trips are significantly (at 5% level) different from 0 (details in Table 3.A.1 of Appendix 3.A). These findings indicate that removal of pro-social information does not have a crowding-out effect for hunters as it does for students. Moreover, removal of fixed monetary rewards has a crowding-in effect for hunters even though it does not have the crowding-in effect for hunters when being provided (in the treatment stage).

We summarize the above comparisons in Table 3.9. From Table 3.9, we see that students and hunters have the same response to pro-social information, i.e. a crowding-in effect. We find opposite behavioral responses to monetary incentives and different responses to removal of incentives. However, these findings should be interpreted and generalized carefully given unequal and unbalanced sample sizes.

In addition to different sample sizes, different demographic background and experience with hunting could also explain the different responses we see in Table 3.9. Different experience with hunting activities between student and hunter samples might be an important factor that results in different behavioral responses we see in the experiments. As recreational hunters have more experience with hunting (i.e. they had around 18 years of hunting experience on average), they are more familiar with the hunting context we

Table 3.9: Summary of Comparison Findings on Motivational Crowding Effects

Treatment	**Students**	**Hunters**	**Students & Hunters**
Provision of treatments:			
T2: Pro-social information	Crowding-in	Crowding-in	Crowding-in
T3: Fixed monetary rewards	Crowding-out	No effect	No effect
T4: Lottery monetary rewards	No effect	Crowding-out	No effect
Removal of treatments:			
T2: Pro-social information	Crowding-out	No effect	Crowding-out
T3: Fixed monetary rewards	No effect	Crowding-in	No effect

Note: Findings for students only are drawn from regression and non-parametric analyses, findings for hunters only are indicated by non-parametric analyses, findings for students & hunters are mostly drawn from regression analyses.

use in the framed field experiments and more responsive to extra hunting tags that are included in all treatments. Our hunter sample, given their interest in CWD management by participating the experiments, might also be more responsive to pro-social information. With the stronger emotional connection to hunting and concern about CWD, hunters might feel more serious about hunting for CWD management when receiving fixed rewards rather than lottery rewards that they could associate with gambling. Since most of students in our sample do not have hunting experience (only 7% of students hunted before with mostly 1 or 2 years of hunting experience), they might not have a deep connection with the hunting context. For some students, hunting tags might be abstract, pro-social information might be alien, and CWD might seem to be scary, therefore they tend to link hunting tags and pro-social information more with payoffs as in other laboratory experiments rather than the hunting context. In addition, 41% of students in our sample are risk loving while only 27% of hunters are risk loving – this might explain why students respond more to the lottery monetary rewards. At the same time, students might have learned more about hunting for CWD management and adjusted their attitudes during the decision rounds: as suggested by a sentiment analysis of students' text responses to the open-ended question "*How do you feel about engaging hunters in Chronic Wasting Disease surveillance and management?*" being asked before and after decision rounds, we find more positive sentiments and less negative sentiments in responses after decision rounds than responses before decision rounds (see Figure 3.A.1 in Appendix 3.A). Although changes in attitudes are not captured in our quantitative analysis, they could be seen as an indication of learning and interactions between intrinsic and extrinsic motivations.

Studies comparing students' and non-students' social preferences have found mixed evidence in classic experiments such as public goods games and dictator games (Exadaktylos et al., 2013; Goeschl et al., 2020; Belot et al., 2015). Different from these studies that randomly drew non-student samples from the general public and did not include specific contexts, we sampled the non-students from a specific target population (i.e. recreational hunters) and used the hunting context in the experiments. As such, our findings provide direct policy advice for CWD management as well as general implications for public goods contributions. In our experiments, we find that hunters are willing to contribute more by taking more trips for CWD management than students. As a result, we could expect to see more hunting trips to CWD-infected areas if incentives are implemented in the field. With the consistent crowding-in effect of pro-social information with students and hunters from the experiments, we could expect that extra hunting tags and pro-social information, when being provided in a long time horizon of multiple years, would be effective to encourage hunting trips for CWD management. While inconsistent results between students and hunters impose challenges in generalizing our findings for policy, we suggest relying on findings with the hunter sample given the hunting context in the experiments. That is, if wildlife managers are to use monetary incentives to encourage hunting for CWD management, they might consider providing fixed monetary rewards in one hunting season. However, more similar framed field experiments and pilot tests with hunters should be conducted before providing monetary incentives in the field. In general, regarding the use of incentives to increase contributions to public goods, our study is consistent with other studies and suggests that students' pro-social behavior can be seen as a lower bound of the behavior of general populations as students are found to be more selfish (Exadaktylos et al., 2013; Belot et al., 2015). For monetary rewards, how they are provided (in fixed or lottery format), to which target populations they are provided, and for how long they are provided could all affect their effectiveness on increasing contributions to public goods.

3.5 Conclusion

In this paper, we evaluate the effectiveness of non-monetary and monetary incentives, and information framing on increasing contributions to impure public goods, with the framework of motivational crowding. We first design an impure public goods game in quantity space where individuals contribute quantities of goods to obtain monetary benefits and link the game with incentives and motivational crowding in a generic utility framework. We then use the context of recreational hunting and wildlife disease (Chronic Wasting Disease, CWD) management to specify a payoff function for a multiple-threshold impure public goods game that translates individual hunting trip decisions to private and public benefits. The public benefits are generated by multiple thresholds that are constructed based on epidemiological models. Based on the theoretical framework, we employ laboratory and framed field experiments with students and recreational hunters as an empirical approach. We design stylized treatments to test the effectiveness of extra hunting tags, pro-social information, fixed and lottery monetary rewards to encourage hunting for CWD management. We analyze the experimental data with DID Poisson regressions and non-parametric tests to identify the impacts of incentives and motivational crowding effects.

We find the evidence of motivational crowding and different treatment effects of incentives for students and hunters. Pro-social information can increase contributions to public goods without changing monetary returns and thus has a crowding-in effect for students and hunters. For CWD management, the non-monetary incentives of extra tags, when combined with a pro-social information script, are more effective in encouraging hunting trips than extra tags only. Students and hunters respond to monetary rewards in an opposite direction. For students, fixed monetary rewards are found to be ineffective in increasing contributions – this could be attributed to a crowding-out effect; whereas lottery monetary rewards with the equivalent expected monetary values are effective as expected. However, fixed monetary rewards are effective while lottery monetary rewards are found to have a crowding-out effect on our small sample of hunters. Regarding persistent treatment effects of incentives, we find that removing pro-social information has a crowding-out effect for students, i.e. students contribute less than before after pro-social information is removed. While we do not find the same crowding-out effect of removing pro-social information for hunters, hunters contribute more than before after the fixed monetary rewards are removed, indicating the existence of a crowding-in effect. These findings are meaningful for CWD management: first, offering monetary rewards is important for individual decisions concerning hunting trips to curb CWD. Here, fixed monetary rewards might work better than lottery rewards given hunters' responsiveness; second, among hunters, fixed monetary rewards can produce crowding-in effects after they are removed, while policy makers should aim to keep pro-social information around to avoid a decrease in contributions. Inconsistent findings with student and hunter samples require more experimentation with hunters or pilot tests of incentives in the field to better understand their effectiveness in encouraging hunting for CWD management. This, however, will prove challenging given sampling difficulties and hunters' willingness to participate in research.

Overall, this research provides insights for experimental studies using public goods games. In our experimental design of an impure public goods game, we provide an example of contributions in quantity space as opposed to in value space, and ways to convert quantity contributions to private and public benefits. This design can be generalized to other decisions in quantity space (e.g. land use decisions to generate ecosystem services, time spent in volunteer activities), or to study areas where cash incomes are too low and are replaced by labor contributions (Gibson et al. 2016). The setup of multiple thresholds to generate public benefits based on epidemiological models can be applied to other contexts where individual contributions generate non-linear public benefits, such as invasive species management, as a way to capture the interactions between human behavior and animal population dynamics. Students' and non-students' different behavioral responses to incentives in our framed field experiments indicate that researchers should be cautious when rely on student samples to draw conclusions in framed contexts with target populations.

This study also provides implications into the use of incentives to encourage public goods contributions, with the consideration of motivational crowding. Our findings highlight the importance of information framing to increase contributions but also notice the undesirable outcomes after information framing is removed. We also show that combining material (i.e. non-monetary and monetary) incentives could be effective if they are provided properly to the target population. The waning impacts of incentives on behavior provides implications of choosing an appropriate time horizon of giving incentives to achieve ideal outcomes. For designing policy programs to engage recreational hunters in CWD management, we provide empirical evidence that extra hunting tags and pro-social information could encourage hunting trips to CWD-infected areas. Fixed monetary rewards could be combined with extra hunting tags to encourage harvesting of animals in CWD-infected areas.

Future research could address several limitations and provide evidence in the field for actual policy design. The gap between the treatments used in this study and incentive programs proposed to be implemented in the field imposes a threat to the external validity of this study. Although we design the experiment and treatments to closely resemble the actual policy programs, we frame these programs and examine their effects in a laboratory experiment through payoff functions. We do not provide actual hunting tags and monetary rewards that are discussed and used for the actual policy implementations for CWD management. Furthermore, we are trying to understand hunters' behavior through the experiments. However, due to the challenge of recruiting hunters, the majority observations of the data in this study are from a standard student sample. As hunters are a unique group with special interest in incentive programs for CWD management, student samples may not be as informative as we would like them to be in other policy relevant contexts. Nevertheless, this study provides a first indication of potential hunter behavior in response to incentive programs for CWD management in the experimental setting. Future research could address the issue of external validity and obtain findings that could be generalized to hunter population in the following aspects. First, continuing the experiment with more hunters from the field to compare findings with those obtained from the student sample. Second, comparing the findings from the laboratory experiment with findings from field surveys that propose parallel incentive programs. Third, based on the first two steps, testing incentive programs with actual policy tools (e.g. hunting tags) at a small scale. Forth, implementing large scale randomized controlled trials over a relatively long period of time to identify hunters' actual behavioral responses and their impacts on the spread and prevalence of Chronic Wasting Disease. Last but not least, preference heterogeneity could be incorporated into the theoretical framework (e.g. in light of Jacobsen et al., 2017) and empirical approaches, to better understand heterogeneous motivational crowding effect of incentives used for the private provisions of public goods.

Appendix 3.A Results from Supplementary Analyses

Table 3.A.1: Non-parametric Analysis Results

	Student Sample	**Hunter Sample**	**Students & Hunters**
Between-group Mann-Whitney U-tests			
H_0: observed trip difference is equal to predicted trip difference			
Difference between T1 and T0	**1493**		**2793.5**
(Predicted difference: 1)	(0.876)		(0.83)
Difference between T2 and T0	**1763***		**4050****
(Predicted difference: 1)	(0.094)		(0.01)
Difference between T3 and T1	**1126.5****	**213.5**	**2291.5****
(Predicted difference: 1)	(0.016)	(0.7)	(0.02)
Difference between T4 and T1	**1249.5**	**29*****	**2036.5****
(Predicted difference: 1)	(0.193)	(0.001)	(0.015)
Within-group Wilcoxon signed rank tests			
H_0: trips in pre-treatment and post-treatment control rounds are equal			
T1	**730.5**	**145**	
	(0.507)	(0.298)	
T2	**1432*****	**158.5**	
	(0.000)	(0.260)	
T3	**898**	**83.5****	
	(0.401)	(0.018)	
T4	**801.5***	**132.5**	
	(0.090)	(0.121)	

Note:
Test statistics is in bold. P values are in parentheses.
***, **, and * denote statistical significance at the 1%, 5%, and 10% level respectively.

Table 3.A.2: DID Poisson Regression Results with T0 as Baseline Group (Treatments 3 and 4)

Variables	*Students*		*Students & Hunters*	
	T3: Extra Tags +Fixed Rewards	**T4: Extra Tags +Lottery Rewards**	**T3: Extra Tags +Fixed Rewards**	**T4: Extra Tags +Lottery Rewards**
	(1)	**(2)**	**(3)**	**(4)**
T_i	0.103**	0.091**	0.067	0.101***
(Treatment)	(0.047)	(0.040)	(0.050)	(0.037)
S_2	0.010	0.010	0.010	0.010
(Treatment rounds)	(0.035)	(0.035)	(0.035)	(0.035)
S_2T_i	**0.186*****	**0.253*****	**0.249*****	**0.227*****
(Treatment × Treatment rounds)	**(0.061)**	**(0.052)**	**(0.056)**	**(0.047)**
S_3	0.007	0.007	0.007	0.007
(Post-treatment rounds)	(0.039)	(0.039)	(0.039)	(0.039)
S_3T_i	**−0.049**	**−0.036**	**0.001**	**−0.047**
(Treatment × Post-treatment rounds)	**(0.067)**	**(0.044)**	**(0.064)**	**(0.043)**
Hunter			0.108	0.045
			(0.069)	(0.077)
Male	0.027	−0.074*	0.023	−0.081**
	(0.060)	(0.040)	(0.057)	(0.039)
Age	−0.012**	0.003	−0.005*	0.002
	(0.006)	(0.004)	(0.003)	(0.002)
Urban	0.036	0.048	−0.035	0.019
	(0.054)	(0.039)	(0.049)	(0.043)
Riskloving	0.077	0.139***	0.108**	0.158***
	(0.061)	(0.046)	(0.053)	(0.040)
Constant	1.650***	1.287***	1.521***	1.317***
	(0.148)	(0.108)	(0.097)	(0.085)
N	600	600	705	720
LL	-1079.722	-1058.293	-1277.895	-1282.332

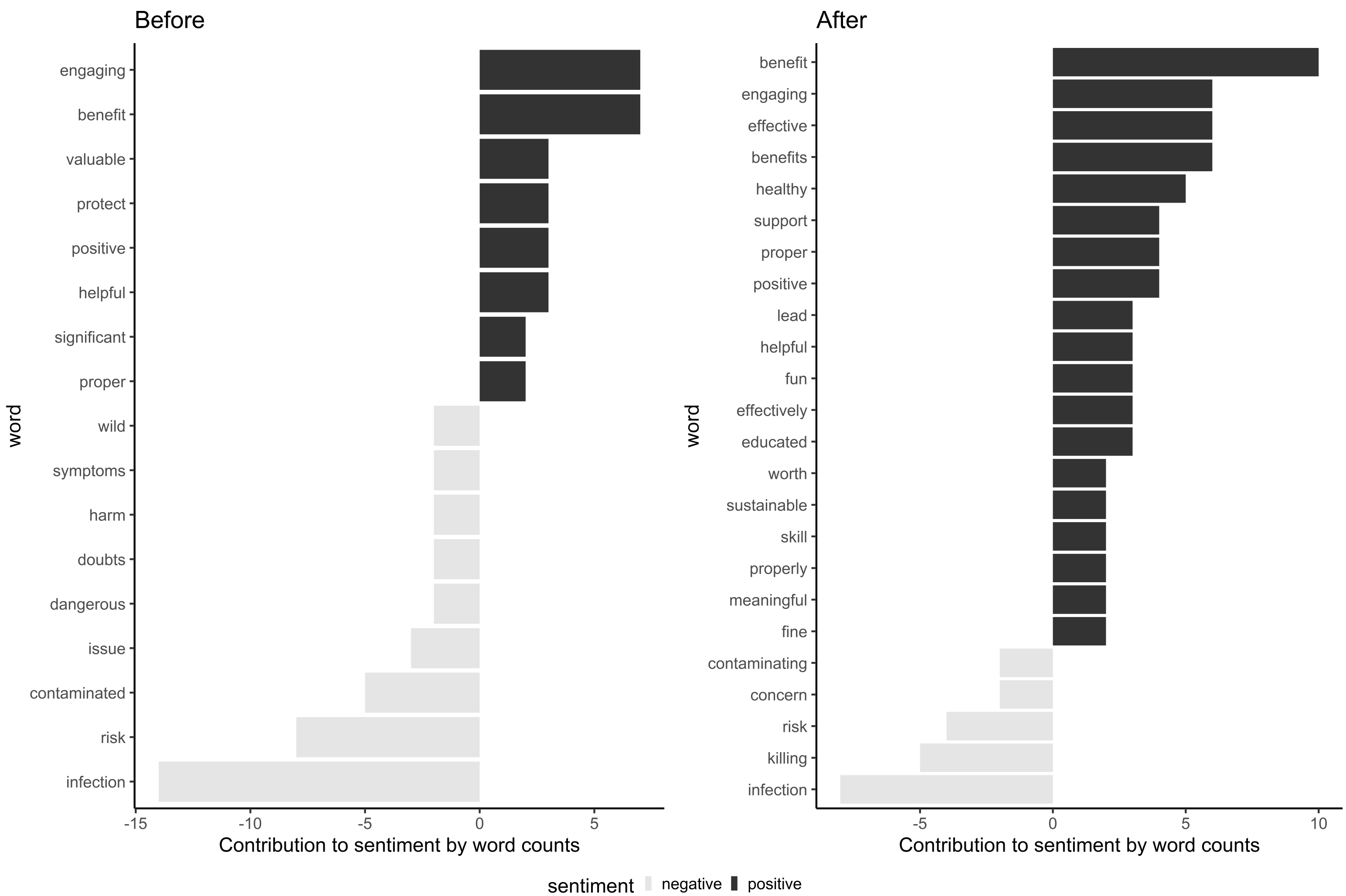
Note:
Robust standard errors clustered at individual level are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level respectively.
The baseline group when $T_i = 0$ is T0 (i.e. treatment 0, control group). S_2T_i captures the difference between the control and treatment groups in treatment rounds. S_3T_i captures the persistent treatment effect.

Table 3.A.3: Poisson Regression Comparing Trips of Students and Hunters

Treatment dummy variables		***Demographic variables***	
Variables	**Estimates**	**Variables**	**Estimates**
$\boldsymbol{T_1}$	0.073	**Hunter**	**0.080***
(Treatment 1)	(0.045)		**(0.045)**
$\boldsymbol{T_2}$	0.046	**Male**	−0.039
(Treatment 2)	(0.035)		(0.033)
$\boldsymbol{T_3}$	0.065	**Age**	−0.001
(Treatment 3)	(0.041)		(0.002)
$\boldsymbol{T_4}$	0.069*	**Urban**	−0.013
(Treatment 4)	(0.036)		(0.034)
$\boldsymbol{S_2}$	0.0060	**Riskloving**	0.080*
(Treatment rounds)	(0.023)		(0.045)
$\boldsymbol{S_2T_1}$	0.119***	**Constant**	1.450***
(Treatment 1 × Treatment rounds)	(0.044)		(0.065)
$\boldsymbol{S_2T_2}$	0.239***		
(Treatment 2 × Treatment rounds)	(0.037)		
$\boldsymbol{S_2T_3}$	0.249***		
(Treatment 3 × Treatment rounds)	(0.044)		
$\boldsymbol{S_2T_4}$	0.251***		
(Treatment 4 × Treatment rounds)	(0.040)		
N			1950
LL			-3553.038

Note:
Robust standard errors clustered at individual level are in parentheses.
***, **, and * denote statistical significance at the 1%, 5%, and 10% level respectively.

Figure 3.A.1: Sentiments of Text Responses (Before and After Decision Rounds, Student Sample)



Appendix 3.B Robustness Checks with DID OLS Regressions

Table 3.B.1: DID OLS Regression Results with T0 as Baseline Group (Treatments 1 and 2)

Variables	*Students*		*Students & Hunters*	
	T1: Extra Tags	**T2: Extra Tags +Pro-social Information**	**T1: Extra Tags**	**T2: Extra Tags +Pro-social Information**
	(1)	**(2)**	**(3)**	**(4)**
$\boldsymbol{T_i}$	0.392*	0.391**	0.387*	0.319*
(Treatment)	(0.212)	(0.179)	(0.219)	(0.173)
S2	0.040	0.040	0.040	0.040
(Treatment rounds)	(0.148)	(0.148)	(0.147)	(0.147)
$\boldsymbol{S_2T_i}$	**0.460***	**0.900*****	**0.508****	**1.024*****
Treatment × Treatment rounds)	**(0.235)**	**(0.228)**	**(0.241)**	**(0.218)**
$\boldsymbol{S_3}$	0.030	0.030	0.030	0.030
(Post-treatment rounds)	(0.163)	(0.163)	(0.163)	(0.163)
$\boldsymbol{S_3T_i}$	**−0.120**	**−0.370***	**−0.156**	**−0.330***
(Treatment × Post-treatment rounds)	**(0.213)**	**(0.202)**	**(0.209)**	**(0.190)**
Hunter			0.521	0.750*
			(0.452)	(0.387)
Male	−0.323	−0.209	−0.375	−0.172
	(0.252)	(0.179)	(0.270)	(0.189)
Age	−0.003	−0.021***	0.000	−0.018***
	(0.036)	(0.008)	(0.015)	(0.010)
Urban	0.626***	0.426*	0.386	0.010
	(0.217)	(0.222)	(0.285)	(0.345)
Riskloving	0.393	0.582***	0.254	0.537**
	(0.305)	(0.206)	(0.256)	(0.213)
Constant	3.603***	4.114***	3.828***	4.427***
	(1.022)	(0.237)	(0.380)	(0.371)
N	600	600	705	720
R-squared	0.148	0.322	0.152	0.354

Note:
Robust standard errors clustered at individual level are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level respectively.
The baseline group when $T_i = 0$ is T0 (i.e. treatment 0, control group). S_2T_i captures the difference between the control and treatment groups in treatment rounds. S_3T_i captures the persistent treatment effect.

Table 3.B.2: DID OLS Regression Results with T1 as Baseline Group

Variables	***Student Sample***			***Student & Hunter Sample***		
	T2: Extra Tags +Pro-social Information	**T3: Extra Tags +Fixed Rewards**	**T4: Extra Tags +Lottery Rewards**	**T2: Extra Tags +Pro-social Information**	**T3: Extra Tags +Fixed Rewards**	**T4: Extra Tags +Lottery Rewards**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$\boldsymbol{T_i}$	−0.162	−0.053	−0.024	−0.132	−0.133	0.003
(Treatment)	(0.270)	(0.259)	(0.258)	(0.220)	(0.235)	(0.222)
$\boldsymbol{S_2}$	0.500***	0.500***	0.500***	0.548***	0.548***	0.548***
(Treatment rounds)	(0.182)	(0.182)	(0.182)	(0.190)	(0.190)	(0.190)
$\boldsymbol{S_2T_i}$	**0.440***	**0.500**	**0.860*****	**0.516****	**0.785****	**0.673****
(Treatment × Treatment rounds)	**(0.252)**	**(0.335)**	**(0.287)**	**(0.249)**	**(0.316)**	**(0.262)**
$\boldsymbol{S_3}$	−0.090	−0.090	−0.090	−0.126	−0.126	−0.126
(Post-treatment rounds)	(0.137)	(0.137)	(0.137)	(0.131)	(0.131)	(0.131)
$\boldsymbol{S_3T_i}$	−0.250	−0.100	−0.040	−0.174	0.163	−0.053
(Treatment × Post-treatment rounds)	(0.182)	(0.282)	(0.168)	(0.163)	(0.268)	(0.155)
Hunter				0.479*	0.323	0.159
				(0.270)	(0.306)	(0.350)
Male	0.070	0.468	−0.303	−0.162	0.031	−0.378
	(0.328)	(0.374)	(0.271)	(0.273)	(0.307)	(0.266)
Age	−0.011	−0.057	0.044*	−0.002	−0.009	0.013
	(0.011)	(0.046)	(0.025)	(0.010)	(0.012)	(0.011)
Urban	0.588*	0.291	0.322*	0.067	−0.050	0.108
	(0.303)	(0.322)	(0.177)	(0.326)	(0.294)	(0.215)
Riskloving	0.055	−0.109	0.180	0.023	0.200	0.323
	(0.278)	(0.349)	(0.247)	(0.250)	(0.252)	(0.238)
Constant	4.287***	5.656***	3.213***	4.589***	4.775***	4.181***
	(0.340)	(1.255)	(0.698)	(0.365)	(0.454)	(0.372)
N	600	600	600	825	810	825
R-squared	0.183	0.130	0.246	0.193	0.145	0.186

Note: Robust standard errors clustered at individual level are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level respectively. The baseline group when $T_i = 0$ is T1 (i.e. treatment 1, extra tags). S_2T_i captures the difference between the T1 and other treatment groups in treatment rounds. S_3T_i captures the difference between T1 and other treatment groups in post-treatment control rounds.

Appendix 3.C Power Analysis and Sample Size

We conducted an ex-ante power analysis to choose a reasonable sample size before actual data collection. In order to choose a sample size for treatment tests, we need to determine the following parameters: effect size, standard deviations of control and treatment groups, the significance level (i.e. size of the test, or the probability of a type 1 error) and the power of the test (Duflo et al., 2007).

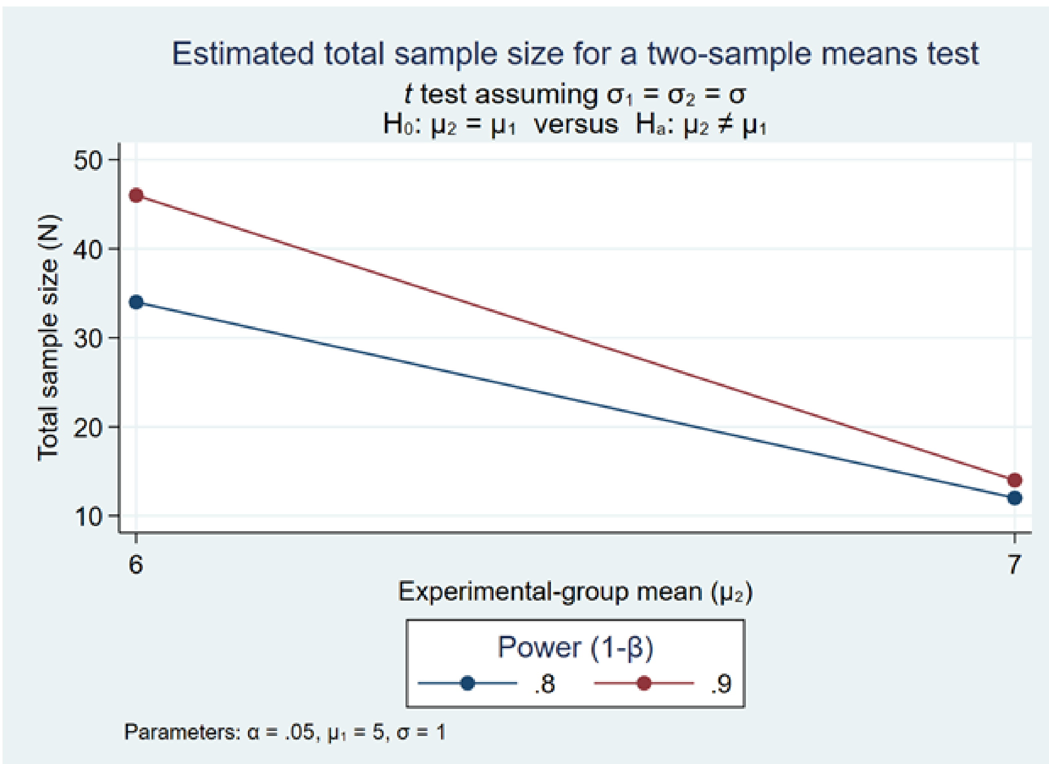
We use Nash Equilibria and social optima presented in Table 3.4 from the parameterized payoff function to obtain the effect size of 1 or 2 for between-group differences in the treatment rounds. We assume an equal standard deviation of 1 in control and treatment groups – this is close to actual trip data's average standard deviations of the control and treatment groups as in Table 3.6. We choose 0.05 as the significance level, 0.8 or 0.9 as the power of the test (Moffatt, 2016), and equal sample size of control and treatment groups. Following Moffatt (2016), we estimate total sample size for a two-sample means t-test on Stata. The results are presented in 3.C.1 and 3.C.1.

Table 3.C.1: Total Sample Size Calculation Results

$\boldsymbol{\alpha}$ **(significance level)**	$\mathbf{1-\beta}$ **(power)**	**Effect size**	**Standard deviation**	**Control N**	**Treatment N**
0.05	0.8	1	1	17	17
0.05	0.9	1	1	23	23
0.05	0.8	2	1	6	6
0.05	0.9	2	1	7	7

Since we require a group of 4 participants, we chose 20 as the sample size per treatment group so that the power is between 0.8 and 0.9. As we have 1 control group and 4 treatment groups, multiplying 20 by 5 yields to a sample size of 100 participants. This power analysis does not account for repeated rounds and within-group comparisons to reduce the bias in assuming parameters.

Figure 3.C.1: Power Analysis Results



Appendix 3.D Experimental Instructions

Part A

1. **Have you heard of Chronic Wasting Disease (CWD) before today?** Yes No

2. **How do you feel about engaging hunters in Chronic Wasting Disease surveillance and management?**

____

____

____

Main instructions in Part B

Part B (Decision-making)

- In what follows, you will take on the role of a hunter and make a number of decisions.
- For each decision, you will be randomly assigned to a group of 4 hunters (you plus 3 others). You will stay in this group for only one decision.
- For each new decision, you will be randomly assigned to a new group of 4 hunters.
- All members of your group receive the same instructions.
- You and the other members of your group will make decisions in a number of rounds.
- In each round you and the other hunters decide how many hunting trips to take to Chronic Wasting Disease (CWD) affected areas to hunt deer.
- The more trips you take to CWD areas, the more infected deer you are likely to harvest, and therefore the healthier the deer population will be in the future.
- In each round, you will have an opportunity to earn benefit points.
- At the end of Part B, we will randomly select one of the rounds to be paid out. So, the more benefit points you have in the selected round, the more money you will earn at an exchange rate of 20 benefit points = 1 Canadian Dollars.

The number of benefit points you can earn in each round depend on:
(1) Individual benefit points – these benefit points depend on how many deer you harvest (the more trips you take the more deer you will likely harvest). The more deer you harvest the more benefit points you receive, but the first deer you harvest will give you more points than the second, the second more than the third, and the third more than the fourth. Taking a trip is also costly (for example gas expenses for your vehicle) and the more trips you take, the higher the cost.
(2) Share of group benefit points – these are benefit points you receive from curbing Chronic Wasting Disease. The amount of points depends on how many deer you and the other members in your group harvest (the more deer are harvested by all members of the groups - the healthier the deer population).

More details on individual benefit points

- In each round, you can choose any number of trips from zero (0) to ten (10).

- It is not certain that you will harvest deer on each trip.
    - In every round, after all hunters in your group have made their decisions, the computer will randomly determine your chances of harvesting deer, which are either 30%, 40%, 50%, or 60%.
    - The number of deer you harvest equals the chances of harvesting deer (so 30%, 40%, 50%, or 60%) times the number of trips you choose.
    - For example, if you choose to take 5 trips, and the chances of harvesting deer is randomly selected to be 40%, then you will harvest 2 deer; if you take 3 trips and the chances of harvesting deer is 60%, then you will harvest 1.8 deer.
- Your individual benefit is based on the number of deer you harvest, we call this "**Your harvest**." In the examples above your harvest is 2 or 1.8 deer.
- It is easy to imagine harvesting 2 deer but how do you harvest 1.8 deer? Think of it like this, it is not certain that you harvest a deer when you take a trip (this is determined by the chances of harvesting deer we explained above) – sometimes you will go home without a deer and sometimes you will do really well, so the number 1.8 is just an average number of deer you can expect to harvest.
- The chances of harvesting deer are the same for everyone in your group and will be revealed at the end of each round after you make your decision.
- No matter the chances, at most, you can harvest 4 deer during each decision round.
- Your individual benefit is summarized on Information Sheet 1.
- Remember, the more deer you harvest the more individual benefit points you receive, but the first deer you harvest will give you more points than the second, the second more than the third, and the third more than the fourth. Taking a trip is also costly (for example gas expenses for your vehicle) and the more trips you take, the higher the cost.

Now please turn over **Information Sheet 1** on your desk.

Information Sheet 1: Individual Benefit

Number of trips you decide to take	Chances of harvesting deer	Your harvest	Your individual benefit points	Number of trips you decide to take	Chances of harvesting deer	Your harvest	Your individual benefit points
0	30%	0	0	0	50%	0	0
1	30%	0.3	16	1	50%	0.5	88
2	30%	0.6	22	2	50%	1	150
3	30%	0.9	20	3	50%	1.5	188
4	30%	1.2	8	4	50%	2	200
5	30%	1.5	-13	5	50%	2.5	188
6	30%	1.8	-42	6	50%	3	150
7	30%	2.1	-81	7	50%	3.5	88
8	30%	2.4	-128	8	50%	4	0
9	30%	2.7	-185	9	50%	4.5	-113
10	30%	3	-250	10	50%	5	-250
0	40%	0	0	0	60%	0	0
1	40%	0.4	52	1	60%	0.6	122
2	40%	0.8	88	2	60%	1.2	208
3	40%	1.2	108	3	60%	1.8	258
4	40%	1.6	112	4	60%	2.4	272
5	40%	2	100	5	60%	3	250
6	40%	2.4	72	6	60%	3.6	192
7	40%	2.8	28	7	60%	4.2	98
8	40%	3.2	-32	8	60%	4.8	-32
9	40%	3.6	-108	9	60%	5.4	-198
10	40%	4	-200	10	60%	6	-400

Example 1: If you choose to take **5** *trips* and the computer randomly determines the *chances of harvesting deer* to be 4**0%**, then *your harvest* is **2** deer and you will receive **100** *individual benefit points*.

Example 2: If you choose to take **0** *trips* and the computer randomly determines the *chances of harvesting deer* to be **50%**, then *your harvest* is **0** deer and you will receive **0** *individual benefit points*.

Example 3: If you choose to take **10** *trips* and the computer randomly determines the *chances of harvesting deer* to be **60%**, then *your harvest* is **6** deer and you will receive **negative 400** *individual benefit points* (if you take 10 trips and the chances of harvesting deer are 60%, then your harvest is 6 deer – but you cannot harvest more than 4 deer, so the extra trips would only cost you money, but you cannot harvest additional deer).

Note: A negative number means your show-up compensation will be reduced by the amount of money converted from the negative points.

More details on your share of group benefit points

- Your share of the group benefit is also based on the total number of deer your group will harvest. We call this "**Group harvest.**"
- In order to receive a share of group benefit, the group harvest must be greater than a certain minimum of harvested deer.
- If the group harvest is smaller than this minimum, no one in your group (including you) will receive any group benefit.
    - Think of it like this, in order to receive a share of group benefit your group must harvest enough deer to make a positive contribution to curb Chronic Wasting Disease. If that number is not reached then there is no benefit to be had.
    - You will also see that the group benefit come in ranges, for example "Between 6 (including 6) and 7.2 (not including 7.2)." You can think of these as ranges of different levels of effectiveness to curb chronic wasting disease.
- The share of group benefit you receive in each round is summarized in Information Sheet 2.
- Now please turn over **Information Sheet 2** <u>on your desk</u>.

Information Sheet 2: Share of Group Benefit

Group harvest	Chances of harvesting deer	Your share of group benefit points
Below 6	30%	0
Between 6 (including 6) and 7.2 (not including 7.2)	30%	70
Between 7.2 (including 7.2) and 8.4 (not including 8.4)	30%	86
Above 8.4 (including 8.4)	30%	104
Below 8	40%	0
Between 8 (including 8) and 9.6 (not including 9.6)	40%	94
Between 9.6 (including 9.6) and 11.2 (not including 11.2)	40%	115
Above 11.2 (including 11.2)	40%	138
Below 10	50%	0
Between 10 (including 10) and 12 (not including 12)	50%	117
Between 12 (including 12) and 14 (not including 14)	50%	144
Above 14 (including 14)	50%	173
Below 12	60%	0
Between 12 (including 12) and 14.4 (not including 14.4)	60%	140
Between 14.4 (including 14.4) and 16.8 (not including 16.8)	60%	173
Above 16.8 (including 16.8)	60%	208

Example 4: If the *group harvest* is **between 14.4 and 16.8** (for example 15 deer) and the computer randomly determines the *chances of harvesting deer* to be **60%**, then you will receive **173** points from the *shared group benefit* in addition to your individual benefit points.

Example 5: If the *group harvest* is **below 6** (for example 5 deer) and the computer randomly determines the *chances of harvesting deer* to be **30%**, then you will receive **0** points from the *shared group benefit* in addition to your individual benefit points.

Summary Examples:

The following examples are a summary of both Information Sheets 1 and 2.

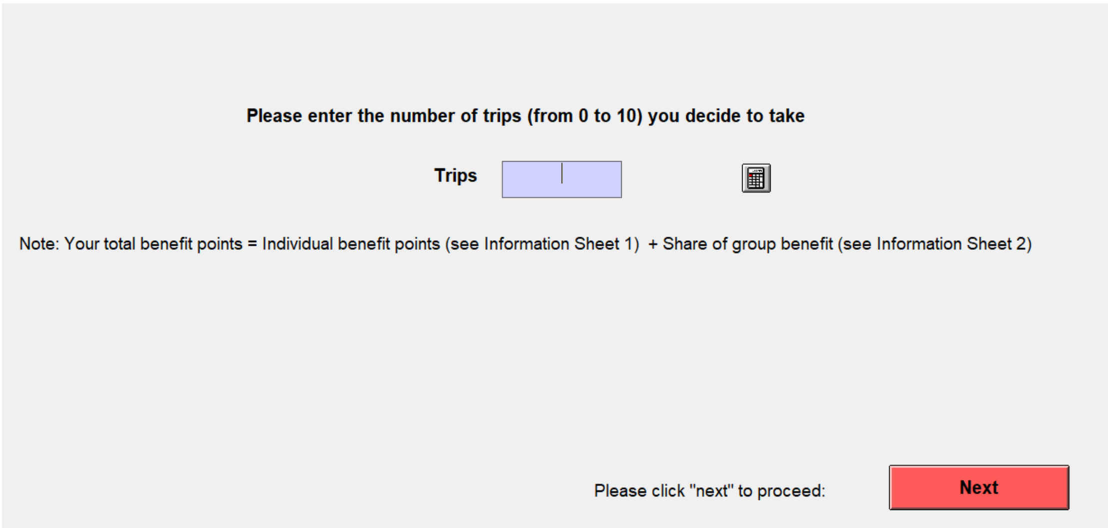
Example 6: If you choose to take **2** *trips* and the computer randomly determines the *chances of harvesting de*er to be **50%**, and the *group harvest* is **13**, then you will receive **150** *individual benefit points* and **144** *group benefit points*. So, your *total points* in this example are **294 (150+144)**.

Example 7: If you choose to take **0** *trips* and the computer randomly determines the *chances of harvesting deer* to be **40%**, and the *group harvest* is **9**, then you will receive **0** *individual benefit points* and **94** *group benefit points*. So, your *total points* in this example are **94 (0+94)**.

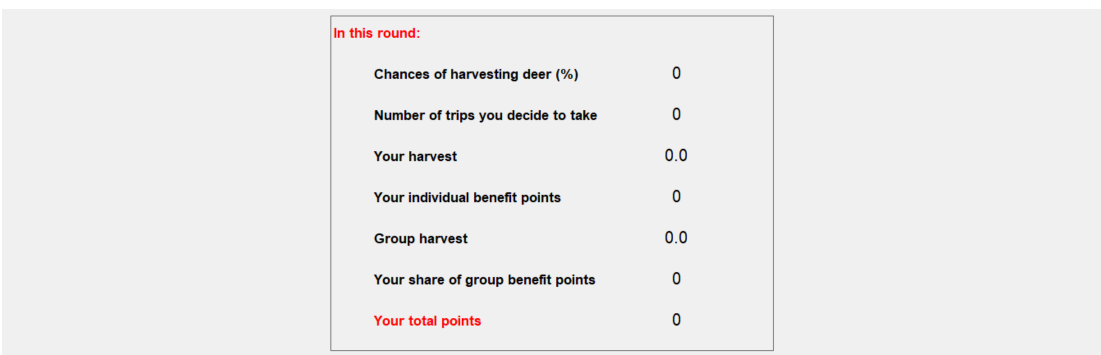
Example 8: If you choose to take **8** *trips* and the computer randomly determines the *chances of harvesting deer* to be **30%**, and the *group harvest* is **4**, then you will receive **negative128** *individual benefit points* and **0** *group benefit points*. So, your *total points* in this example are **-128 (-128+0)**.

Example 9: If you choose to take **4** *trips* and the computer randomly determines the *chances of harvesting deer* to be **60%**, and the *group harvest* is **11**, then you will receive **272** *individual benefit points* and **0** *group benefit points*. So, your *total points* in this example are **272 (272+0)**.

Decision making screen on Z-tree



Payoff display screen on Z-tree



<u>Instructions in treatment rounds</u>

Treatment 0: Control Group

The next few decision rounds are like the ones you started with.

- Your total benefit points in each decision round depend on:

(1) Individual benefit points (see Information Sheet 3)
+
(2) Share of group benefit (see Information Sheet 4)

- You can harvest at most **4** deer during each decision round.

Note: For each new decision, you will be randomly assigned to a new group of 4 hunters. Remember, at the end of Part B, we will randomly select one of the rounds to be paid out.

Treatment 1: Extra Tags

- The next few decision rounds are similar to the previous ones, with the exception that

  (1) you and the other members of your group are given 2 extra tags to hunt in Chronic Wasting Disease areas, which means you can now harvest up to **6** deer in each decision round; and

  (2) you will receive additional benefit points (called program benefit points) on top of the individual and group benefit points.

- Your total benefit points in each decision round depend on:

  (1) Individual benefit points (see Information Sheet 3)
  +
  (2) Program benefit points (see Information Sheet 3)
  +
  (3) Share of group benefit (see Information Sheet 4)

- You can harvest at most **6** deer during each decision round.

Note: For each new decision, you will be randomly assigned to a new group of 4 hunters. Remember, at the end of Part B, we will randomly select one of the rounds to be paid out.

Treatment 2: Extra Tags + Pro-social Information

- The next few decision rounds are similar to the previous ones, with the exception that

  (3) you and the other members of your group are given 2 extra tags to hunt in Chronic Wasting Disease areas, which means you can now harvest up to **6** deer in each decision round; and

  (4) you will receive additional benefit points (called program benefit points) on top of the individual and group benefit points.

- Your total benefit points in each decision round depend on:

  (4) Individual benefit points (see Information Sheet 3)
  +
  (5) Program benefit points (see Information Sheet 3)
  +
  (6) Share of group benefit (see Information Sheet 4)

- You can harvest at most **6** deer during each decision round.

Note: For each new decision, you will be randomly assigned to a new group of 4 hunters. Remember, at the end of Part B, we will randomly select one of the rounds to be paid out.

Before making your decision also consider the following:

Help – Beyond the fun (the hunt) and the treasures (the harvest and memories), deer hunters are partners in managing the deer herd on behalf of all citizens. We all know that the deer herd does need to be managed. In some cases, an overabundance of deer can cause problems for farmers or cause long-term damage to forests. Unfortunately, we've also learned that our deer herd is not immune to disease issues and hunters can help slow the spread of disease, such as Chronic Wasting Disease. In short, deer hunters play a vital role in keeping a healthy herd, and …we can't do this without you! If you are hunting in a Chronic Wasting Disease area, please consider harvesting the extra deer among your hunting party. You play an important role in keeping healthier deer populations and wildlife conservation for all Albertans.

Information Sheet 3: Individual and Program Benefit Points

Number of trips you decide to take	Chances of harvesting deer	Your harvest	Your individual benefit points	Program benefit points	Number of trips you decide to take	Chances of harvesting deer	Your harvest	Your individual benefit points	Program benefit points
0	30%	0	0	0	0	50%	0	0	0
1	30%	0.3	16	15	1	50%	0.5	88	25
2	30%	0.6	22	30	2	50%	1	150	50
3	30%	0.9	20	45	3	50%	1.5	188	75
4	30%	1.2	8	60	4	50%	2	200	100
5	30%	1.5	-13	75	5	50%	2.5	188	125
6	30%	1.8	-42	90	6	50%	3	150	150
7	30%	2.1	-81	105	7	50%	3.5	88	175
8	30%	2.4	-128	120	8	50%	4	0	200
9	30%	2.7	-185	135	9	50%	4.5	-113	225
10	30%	3	-250	150	10	50%	5	-250	250
0	40%	0	0	0	0	60%	0	0	0
1	40%	0.4	52	20	1	60%	0.6	122	30
2	40%	0.8	88	40	2	60%	1.2	208	60
3	40%	1.2	108	60	3	60%	1.8	258	90
4	40%	1.6	112	80	4	60%	2.4	272	120
5	40%	2	100	100	5	60%	3	250	150
6	40%	2.4	72	120	6	60%	3.6	192	180
7	40%	2.8	28	140	7	60%	4.2	98	210
8	40%	3.2	-32	160	8	60%	4.8	-32	240
9	40%	3.6	-108	180	9	60%	5.4	-198	270
10	40%	4	-200	200	10	60%	6	-400	300

Example 10: If you choose to take **5** *trips* and the computer randomly determines the *chances of harvesting deer* to be 4**0%**, then *your harvest* is **2** deer and you will receive **200** points (**100** *individual benefit points* plus **100** *program benefit points*). See Information Sheet 4 for the group benefit points in addition to your individual benefit points.

Example 11: If you choose to take **0** *trips* and the computer randomly determines the *chances of harvesting deer* to be **50%**, then *your harvest* is **0** deer and you will receive **0** points (**0** *individual benefit points* plus **0** *program benefit points*). See Information Sheet 4 for the group benefit points in addition to your individual benefit points.

Note: A negative number means your show-up compensation will be reduced by the amount of money converted from the negative points.

Information Sheet 4: Share of Group Benefit

Group harvest	Chances of harvesting deer	Your share of group benefit points
Below 6	30%	0
Between 6 (including 6) and 7.2 (not including 7.2)	30%	70
Between 7.2 (including 7.2) and 8.4 (not including 8.4)	30%	86
Above 8.4 (including 8.4)	30%	104
Below 8	40%	0
Between 8 (including 8) and 9.6 (not including 9.6)	40%	94
Between 9.6 (including 9.6) and 11.2 (not including 11.2)	40%	115
Above 11.2 (including 11.2)	40%	138
Below 10	50%	0
Between 10 (including 10) and 12 (not including 12)	50%	117
Between 12 (including 12) and 14 (not including 14)	50%	144
Above 14 (including 14)	50%	173
Below 12	60%	0
Between 12 (including 12) and 14.4 (not including 14.4)	60%	140
Between 14.4 (including 14.4) and 16.8 (not including 16.8)	60%	173
Above 16.8 (including 16.8)	60%	208

Example 12: If the *group harvest* is **between 14.4 and 16.8** (for example 15 deer) and the computer randomly determines the *chances of harvesting deer* to be **60%**, then you will receive **173** points from the *shared group benefit* in addition to your individual benefit points.

Example 13: If the *group harvest* is **below 6** (for example 5 deer) and the computer randomly determines the *chances of harvesting deer* to be **30%**, then you will receive **0** points from the *shared group benefit* in addition to your individual benefit points.

Treatment 3: Extra Tags + Fixed Rewards

- The next few decision rounds are similar to the previous ones, with the exception that

  (1) you and the other members of your group are given 2 extra tags to hunt in Chronic Wasting Disease areas, which means you can now harvest up to **6** deer in each decision round; and

  (2) you will receive additional benefit points (called program benefit points) on top of the individual and group benefit points; and

  (3) you will now have an opportunity to earn bonus points. The number of bonus points you receive depend on "Your harvest." The more deer you harvest the higher the bonus points you receive. The bonus points are summarized in Column "Bonus points" of Information Sheet 3.

- Your total benefit points in each decision round depend on:

  (1) Individual benefit points (see Information Sheet 3)
  +
  (2) Program benefit points (see Information Sheet 3)
  +
  (3) Bonus points (see Information Sheet 3)
  +
  (4) Share of group benefit (see Information Sheet 4)

- You can harvest at most **6** deer during each decision round.

Note: For each new decision, you will be randomly assigned to a new group of 4 hunters. Remember, at the end of Part B, we will randomly select one of the rounds to be paid out.

Information Sheet 3: Individual and Program Benefit Points, and Bonus Points

Number of trips you decide to take	Chances of harvesting deer	Your harvest	Your individual benefit points	Program benefit points	Bonus points	Number of trips you decide to take	Chances of harvesting deer	Your harvest	Your individual benefit points	Program benefit points	Bonus points
0	30%	0	0	0	0	0	50%	0	0	0	0
1	30%	0.3	16	15	15	1	50%	0.5	88	25	25
2	30%	0.6	22	30	30	2	50%	1	150	50	50
3	30%	0.9	20	45	45	3	50%	1.5	188	75	75
4	30%	1.2	8	60	60	4	50%	2	200	100	100
5	30%	1.5	-13	75	75	5	50%	2.5	188	125	125
6	30%	1.8	-42	90	90	6	50%	3	150	150	150
7	30%	2.1	-81	105	105	7	50%	3.5	88	175	175
8	30%	2.4	-128	120	120	8	50%	4	0	200	200
9	30%	2.7	-185	135	135	9	50%	4.5	-113	225	225
10	30%	3	-250	150	150	10	50%	5	-250	250	250
0	40%	0	0	0	0	0	60%	0	0	0	0
1	40%	0.4	52	20	20	1	60%	0.6	122	30	30
2	40%	0.8	88	40	40	2	60%	1.2	208	60	60
3	40%	1.2	108	60	60	3	60%	1.8	258	90	90
4	40%	1.6	112	80	80	4	60%	2.4	272	120	120
5	40%	2	100	100	100	5	60%	3	250	150	150
6	40%	2.4	72	120	120	6	60%	3.6	192	180	180
7	40%	2.8	28	140	140	7	60%	4.2	98	210	210
8	40%	3.2	-32	160	160	8	60%	4.8	-32	240	240
9	40%	3.6	-108	180	180	9	60%	5.4	-198	270	270
10	40%	4	-200	200	200	10	60%	6	-400	300	300

Example 10: If you choose to take **5** *trips* and the computer randomly determines the *chances of harvesting deer* to be 4**0%**, then *your harvest* is **2** deer and you will receive **300** points (**100** *individual benefit points* plus **100** *program benefit points* plus **100** *bonus points*). See Information Sheet 4 for the group benefit points in addition to your individual benefit points.

Example 11: If you choose to take **0** *trips* and the computer randomly determines the *chances of harvesting deer* to be **50%**, then *your harvest* is **0** deer and you will receive **0** points (**0** *individual benefit points* plus **0** *program benefit points* plus **0** *bonus points*). See Information Sheet 4 for the group benefit points in addition to your individual benefit points.

Note: A negative number means your show-up compensation will be reduced by the amount of money converted from the negative points.

Information Sheet 4: Share of Group Benefit

Group harvest	Chances of harvesting deer	Your share of group benefit points
Below 6	30%	0
Between 6 (including 6) and 7.2 (not including 7.2)	30%	70
Between 7.2 (including 7.2) and 8.4 (not including 8.4)	30%	86
Above 8.4 (including 8.4)	30%	104
Below 8	40%	0
Between 8 (including 8) and 9.6 (not including 9.6)	40%	94
Between 9.6 (including 9.6) and 11.2 (not including 11.2)	40%	115
Above 11.2 (including 11.2)	40%	138
Below 10	50%	0
Between 10 (including 10) and 12 (not including 12)	50%	117
Between 12 (including 12) and 14 (not including 14)	50%	144
Above 14 (including 14)	50%	173
Below 12	60%	0
Between 12 (including 12) and 14.4 (not including 14.4)	60%	140
Between 14.4 (including 14.4) and 16.8 (not including 16.8)	60%	173
Above 16.8 (including 16.8)	60%	208

Example 12: If the *group harvest* is **between 14.4 and 16.8** (for example 15 deer) and the computer randomly determines the *chances of harvesting deer* to be **60%**, then you will receive **173** points from the *shared group benefit* in addition to your individual benefit points.

Example 13: If the *group harvest* is **below 6** (for example 5 deer) and the computer randomly determines the *chances of harvesting deer* to be **30%**, then you will receive **0** points from the *shared group benefit* in addition to your individual benefit points.

Treatment 4: Extra Tags + Lottery Rewards

- The next few decision rounds are similar to the previous ones, with the exception that

  (1) you and the other members of your group are given 2 extra tags to hunt in Chronic Wasting Disease areas, which means you can now harvest up to **6** deer in each decision round; and

  (2) you will receive additional benefit points (called program benefit points) on top of the individual and group benefit points; and

  (3) you will now have an opportunity to earn bonus points. The number of bonus points you receive depend on a lottery you will be enrolled in and "Your harvest." The chances of winning the lottery are 25%. The more deer you harvest the higher the bonus points you can receive from the lottery. The bonus points are summarized in Column "Bonus points" of Information Sheet 3.

- Your total benefit points in each decision round depend on:

  (1) Individual benefit points (see Information Sheet 3)
  +
  (2) Program benefit points (see Information Sheet 3)
  +
  (3) Bonus points (see Information Sheet 3)
  +
  (4) Share of group benefit (see Information Sheet 4)

- You can harvest at most **6** deer during each decision round.

Note: For each new decision, you will be randomly assigned to a new group of 4 hunters. Remember, at the end of Part B, we will randomly select one of the rounds to be paid out.

Information Sheet 3: Individual and Program Benefit Points, and Bonus Points

Number of trips you decide to take	Chances of harvesting deer	Your harvest	Your individual benefit points	Program benefit points	Bonus points	Number of trips you decide to take	Chances of harvesting deer	Your harvest	Your individual benefit points	Program benefit points	Bonus points
0	30%	0	0	0	0	0	50%	0	0	0	0
1	30%	0.3	16	15	A 25% chance to get 60 points	1	50%	0.5	88	25	A 25% chance to get 100 points
2	30%	0.6	22	30	A 25% chance to get 120 points	2	50%	1	150	50	A 25% chance to get 200 points
3	30%	0.9	20	45	A 25% chance to get 180 points	3	50%	1.5	188	75	A 25% chance to get 300 points
4	30%	1.2	8	60	A 25% chance to get 240 points	4	50%	2	200	100	A 25% chance to get 400 points
5	30%	1.5	-13	75	A 25% chance to get 300 points	5	50%	2.5	188	125	A 25% chance to get 500 points
6	30%	1.8	-42	90	A 25% chance to get 360 points	6	50%	3	150	150	A 25% chance to get 600 points
7	30%	2.1	-81	105	A 25% chance to get 420 points	7	50%	3.5	88	175	A 25% chance to get 700 points
8	30%	2.4	-128	120	A 25% chance to get 480 points	8	50%	4	0	200	A 25% chance to get 800 points
9	30%	2.7	-185	135	A 25% chance to get 540 points	9	50%	4.5	-113	225	A 25% chance to get 900 points
10	30%	3	-250	150	A 25% chance to get 600 points	10	50%	5	-250	250	A 25% chance to get 1000 points
0	40%	0	0	0	0	0	60%	0	0	0	0
1	40%	0.4	52	20	A 25% chance to get 80 points	1	60%	0.6	122	30	A 25% chance to get 120 points
2	40%	0.8	88	40	A 25% chance to get 160 points	2	60%	1.2	208	60	A 25% chance to get 240 points
3	40%	1.2	108	60	A 25% chance to get 240 points	3	60%	1.8	258	90	A 25% chance to get 360 points
4	40%	1.6	112	80	A 25% chance to get 320 points	4	60%	2.4	272	120	A 25% chance to get 480 points
5	40%	2	100	100	A 25% chance to get 400 points	5	60%	3	250	150	A 25% chance to get 600 points
6	40%	2.4	72	120	A 25% chance to get 480 points	6	60%	3.6	192	180	A 25% chance to get 720 points
7	40%	2.8	28	140	A 25% chance to get 560 points	7	60%	4.2	98	210	A 25% chance to get 840 points
8	40%	3.2	-32	160	A 25% chance to get 640 points	8	60%	4.8	-32	240	A 25% chance to get 960 points
9	40%	3.6	-108	180	A 25% chance to get 720 points	9	60%	5.4	-198	270	A 25% chance to get 1080 points
10	40%	4	-200	200	A 25% chance to get 800 points	10	60%	6	-400	300	A 25% chance to get 1200 points

Example 10: If you choose to take **5** *trips* and the computer randomly determines the *chances of harvesting deer* to be 4**0%**, then *your harvest* is **2** deer and you will receive **200** points (**100** *individual benefit points* plus **100** *program benefit points*) and *a 25% chance* to get **400** points. See Information Sheet 4 for the group benefit points in addition to your individual benefit points.

Example 11: If you choose to take **0** *trips* and the computer randomly determines the *chances of harvesting deer* to be **50%**, then *your harvest* is **0** deer and you will receive **0** points (**0** *individual benefit points* plus **0** *program benefit points* plus **0** *bonus points*). See Information Sheet 4 for the group benefit points in addition to your individual benefit points.

Note: A negative number means your show-up compensation will be reduced by the amount of money converted from the negative points.

Information Sheet 4: Share of Group Benefit

Group harvest	Chances of harvesting deer	Your share of group benefit points
Below 6	30%	0
Between 6 (including 6) and 7.2 (not including 7.2)	30%	70
Between 7.2 (including 7.2) and 8.4 (not including 8.4)	30%	86
Above 8.4 (including 8.4)	30%	104
Below 8	40%	0
Between 8 (including 8) and 9.6 (not including 9.6)	40%	94
Between 9.6 (including 9.6) and 11.2 (not including 11.2)	40%	115
Above 11.2 (including 11.2)	40%	138
Below 10	50%	0
Between 10 (including 10) and 12 (not including 12)	50%	117
Between 12 (including 12) and 14 (not including 14)	50%	144
Above 14 (including 14)	50%	173
Below 12	60%	0
Between 12 (including 12) and 14.4 (not including 14.4)	60%	140
Between 14.4 (including 14.4) and 16.8 (not including 16.8)	60%	173
Above 16.8 (including 16.8)	60%	208

Example 12: If the *group harvest* is **between 14.4 and 16.8** (for example 15 deer) and the computer randomly determines the *chances of harvesting deer* to be **60%**, then you will receive **173** points from the *shared group benefit* in addition to your individual benefit points.

Example 13: If the *group harvest* is **below 6** (for example 5 deer) and the computer randomly determines the *chances of harvesting deer* to be **30%**, then you will receive **0** points from the *shared group benefit* in addition to your individual benefit points.

Risk task

In this section we ask you to select **one gamble** that you would like to play from a total of 6 different gambles. The points you receive from this gamble will be added to the points from the previous decision rounds. The 6 different gambles are presented below.

- You must select **one** and only one of these gambles
- To select a gamble, click the appropriate box

Each gamble has 2 possible outcomes: roll low or roll high. Each outcome has a 50% probability of occurring. The payout for each gamble is determined by:

- Which of the 6 gambles you choose; and
- Which of the 2 possible payouts occur

For example, if you choose Gamble 4 and roll high occurs will earn 30 points. If roll low occurs, you would be paid 7.5 points.

For every gamble, each roll has a 50% chance of occurring.

Mark the gamble that you would prefer to make in the last box across from your favorite gamble.

	Roll	Points	Chances	Your Selection: **Mark Only One**
Gamble 1	Low	15 points	50%	
	High	15 points	50%	
Gamble 2	High	20 points	50%	
	Low	12.5 points	50%	
Gamble 3	High	25 points	50%	
	Low	10 points	50%	
Gamble 4	Low	7.5 points	50%	
	High	30 points	50%	
Gamble 5	Low	5 points	50%	
	High	35 points	50%	
Gamble 6	Low	0 points	50%	
	High	37 points	50%	

Part C: Debriefing survey (student sample)

Please answer the following questions.

1. **Do you go hunting now or have you hunted in the past?** Yes No

2. **If you go hunting, how many years have you been hunting?** ______________

3. **Are you, in general, supportive of recreational hunting activities?** Yes No

4. **Do you support wildlife conservation programs?** Yes No

5. **The following are some statements regarding risks associated with CWD. Please indicate using the scale of 1 (Strongly Disagree) to 5 (Strongly Agree) your agreement with the statement.**

	Strongly Disagree		Indifferent		Strongly Agree
CWD is a threat to wildlife herd health in Alberta.	**1**	**2**	**3**	**4**	**5**
CWD is a threat to human health.	**1**	**2**	**3**	**4**	**5**

6. **The following are some statements regarding CWD management programs. Please indicate using on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree) your agreement with the statement.**

	Strongly Disagree		Indifferent		Strongly Agree
Hunters can play a role in CWD management through additional harvest.	**1**	**2**	**3**	**4**	**5**
Hunters should be paid to help control CWD by additional harvest.	**1**	**2**	**3**	**4**	**5**

7. **Do you think hunters will help control CWD effectively? Yes No**

8. How do you feel about engaging hunters in CWD surveillance and management? (i.e. providing rewards for head submissions and/or additional harvest for CWD management)

____
____
____
____
____

Socio-demographics

9. Are you:

Male Female Other Prefer not to say

10. In what year were you born? (enter 4-digit birth year; for example, 1970) ______________

11. What is the highest level of schooling you have completed?

Some high school or less

High school diploma

Some university, college, or technical school

Technical school graduate

University/College graduate

Some graduate school

Graduate degree

12. Please indicate your household income before taxes in 2018.

Less than 10,000	50,000 to 59,999
10,000 to 19,999	60,000 to 79,999
20,000 to 29,999	80,000 to 99,999
30,000 to 39,999	100,000 to 149,999
40,000 to 49,999	Greater than 150,000

13. Please indicate, by circling the most appropriate category, where you grew up.

Large urban setting (100 000 people or more)

Small urban setting (20 000 to 99 999 people)

Town or village (1 000 to 19 999 people)

Rural setting (999 people or less)

14. Are there any children under 12 in your household? Yes No

15. In which of the following activities have you participated in the past 12 months? Please select all that apply.

Hiking

Canoeing, kayaking, rafting or sailing

Cross-country or downhill skiing

Bird-watching

Fishing

Wildlife viewing

Mountain biking

Hunting

Photographing nature

None of the above

Part C: Debriefing survey (hunter sample)

Please answer the following questions

1. **Do you hunt cervids (i.e. deer, elk, moose)?** Yes No

2. **If yes (to Question 1) how many years have you been cervids hunting?** ____________________

3. **What cervid species do you usually hunt? Please select all that apply.**

a) Mule deer

b) White-tailed deer

c) Moose

d) Elk

4. **Do you own land in any of these Wildlife Management Units where Chronic Wasting Disease (CWD) occurs (see the map below)?** Yes No

Prairie WMUs (100 Series & 732): 116, 118, 119, 142, 144, 148, 150, 151, 152, 158, 160, 162, 163, 164, 166, 732
Parkland WMU Series (200 Series & 728, 730) & 500: 200, 202, 203, 230, 232, 234, 236, 238, 242, 250, 254, 256, 500, 728, 730

5. **The following are some statements regarding risks associated with CWD. Please indicate using the scale of 1 (Strongly Disagree) to 5 (Strongly Agree) your agreement with the statement.**

	Strongly Disagree		Indifferent		Strongly Agree
CWD is a threat to wildlife herd health in Alberta.	**1**	**2**	**3**	**4**	**5**
CWD is a threat to human health.	**1**	**2**	**3**	**4**	**5**

6. **Have you considered the role of hunters in CWD control?** Yes No

7. **The following are some statements regarding CWD management programs. Please indicate using on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree) your agreement with the statement.**

	Strongly Disagree		Indifferent		Strongly Agree
Hunters can play a role in CWD management through additional harvest.	**1**	**2**	**3**	**4**	**5**
Hunters should be paid to help control CWD by additional harvest.	**1**	**2**	**3**	**4**	**5**

8. **Alberta Fish and Wildlife is currently, or has in the past, conducted a variety of programs to address CWD in the province of Alberta. Please indicate your opinions on the use of these programs on a scale of 1 (Strongly Disagreed) to 5 (Strongly Agreed).**

	Strongly Disagreed		Indifferent		Strongly Agreed
Reducing local deer herds in the areas where CWD is most concentrated.	**1**	**2**	**3**	**4**	**5**
Mandatory submission of heads for CWD testing in certain WMUs.	**1**	**2**	**3**	**4**	**5**
Voluntary submission of heads for the province.	**1**	**2**	**3**	**4**	**5**
Providing freezers for deer head submission.	**1**	**2**	**3**	**4**	**5**
Providing additional hunting opportunities (e.g. extra tags) in CWD high-risk areas	**1**	**2**	**3**	**4**	**5**

9. **In the rounds you just made decisions, if you chose to take additional trips when receiving benefit from CWD management programs, why did you do so?**

a) Because I think hunters would help control CWD effectively.

b) Because I would have more hunting opportunities.

10. **In the rounds you just made decisions, if you didn’t choose to take additional trips when receiving benefit from CWD management programs, why not?**

a) Because hunters are not effective in helping CWD management.

b) Because these programs may be too costly and time consuming for me.

11. How do you feel about engaging hunters in CWD surveillance and management? (i.e. providing rewards for head submissions and/or additional harvest for CWD management)

____
____
____
____
____

Socio-demographics

12. Are you:

Male Female Other Prefer not to say

13. In what year were you born? (enter 4-digit birth year; for example, 1970) ____________

14. What is the highest level of schooling you have completed?

Some high school or less

High school diploma

Some university, college, or technical school

Technical school graduate

University/College graduate

Some graduate school

Graduate degree

15. Please indicate your household income before taxes in 2018.

Less than 10,000

10,000 to 19,999

50,000 to 59,999

60,000 to 79,999

20,000 to 29,999	80,000 to 99,999
30,000 to 39,999	100,000 to 149,999
40,000 to 49,999	Greater than 150,000

16. Please indicate, by circling the most appropriate category, where you currently live.

Large urban setting (100 000 people or more)

Small urban setting (20 000 to 99 999 people)

Town or village (1 000 to 19 999 people)

Rural setting (999 people or less)

17. **Are there any children under 12 in your household?** Yes No

Chapter 4

Temporal Reliability of Contingent Behavior Trip Data in Kuhn-Tucker Recreation Demand Models

Contingent behavior (CB) trip data, eliciting intended trip decisions with hypothetical scenarios, has been popular in recreation demand models. Unlike other stated preference methods, the temporal reliability – a measurement of accuracy – of CB trip data has not been examined in recreation demand models, especially in a Kuhn-Tucker (KT) framework. This paper assesses the temporal reliability of coefficient and welfare estimates from KT models with CB trip data collected over three years. We find that coefficient and welfare estimates are largely reliable over time. Our findings add confidence in using CB trip data to model demands within and beyond recreation contexts and provide insight into the broader application of KT models.

4.1 Introduction

Travel cost recreation demand models analyze individuals' decisions in outdoor recreation activities using micro-econometric frameworks and revealed preference (RP) data. As one of the non-market valuation methods, recreation demand models provide measures of economic values (i.e. use values) for the environmental amenities of recreation sites and inform policy evaluation, resource management, and damage assessment (Phaneuf and Smith, 2005). To address some challenges with RP data, researchers have sought out new data sources, in particular forms of stated preference (SP) surveys (Adamowicz et al., 1994; Bertram et al., 2020). Originally proposed by Englin and Cameron (1996), contingent behavior (CB) trip data, have become a popular type of SP data that complement RP data in recreation demand models (Bertram et al., 2020; Nobel et al., 2020; Yi and Herriges, 2017; Abbott et al., 2018). As a type of SP data, CB data are usually collected by surveys where respondents indicate intended behavior in quantities or frequencies (e.g. units of products to purchase, number of recreational trips to take) under hypothetical scenarios. Different from other SP methods such as contingent valuation (CV) and choice experiment (CE) methods that focus on value elicitation, CB methods focus on eliciting behavior. Nevertheless, due to their hypothetical nature, the accuracy of CB data and estimates from models that use CB data requires investigation.

Given that "true values" are unobserved, the accuracy of the estimates from a non-market valuation method is usually measured by validity (unbiasedness) and reliability (minimum standard errors) (Bishop and Boyle, 2017). In recreation demand studies, the reliability of coefficient and welfare estimates is usually examined with RP data or combined RP-CB data over several time periods. Ji et al. (2020) test the reliability of welfare estimates in repeated discrete choice models (DCM) with a five-year panel of RP trip data. They find welfare estimates associated with changes in water quality are not reliable across all time periods while welfare estimates of site closures are more reliable. Using the same data, Yi and Herriges (2017) examine and find reliability (i.e. convergent validity) of estimates in DCM with RP data from two consecutive years. Meanwhile, with combined RP and CB trip data,Yi and Herriges (2017) and others (e.g. Jeon and Herriges 2010; Whitehead et al. 2010; Grijalva et al. 2002) examine temporal convergent validity of estimates following the same reliability concept. Although findings on temporal reliability or convergent validity in these studies vary by data collection approaches (e.g. time intervals, RP and/or CB data) and model specifications (e.g. whether to include Alternative Specific Constants, ASC), temporal reliability of estimates from recreation demand models with only CB trip data has not been examined to the best of our knowledge. In addition, model specifications used in the existing studies mostly focus on discrete choice models.

The objective of this study is to assess the temporal reliability of estimates in Kuhn-Tucker (KT) recreation demand models with contingent behavior (CB) data. By adding variation through randomly assigning changes to recreation site attributes, CB data potentially address identification issues that arise in model estimation with only RP data (von Haefen and Phaneuf, 2008; Yi and Herriges, 2017), and therefore have been mostly combined with RP data. Unreliable CB data would cast doubt on estimates from models that combine RP and CB data or studies on convergent validity of RP and CB data, and raise concerns about CB question design. At the same time, by collecting intended behavior with hypothetical policy scenarios, CB data can help construct ex-ante welfare estimates for policy analysis. Reliable welfare estimates with CB data can shed light on policies that may take several years to be in place. Compared to the commonly used repeated DCM (Lupi et al., 2020), the KT recreation demand model with a multiple discrete-continuous extreme value (MDCEV) specification (Bhat, 2008) has several advantages such as assumptions on choice occasions, error term structure and parameters to capture substitution behavior (Bhat, 2008; Lloyd-Smith et al., 2020).[27] However, its application is limited due to computational challenges. Applications of KT models with MDCEV

[27]In Bhat (2008) and other literature in transportation, the KT model with a multiple discrete-continuous extreme value (MDCEV) specification is usually called "MDCEV". In this paper, we call it as Kuhn-Tucker model to follow the literature in environmental economics. However, one should note our KT model specification is different from another KT model specification by von Haefen and Phaneuf (2005).

specifications have focused on predicting behaviors, recasting choice sets, and capturing seasonal and substitution behavior (e.g. Abbott and Fenichel 2013; Lloyd-Smith et al. 2020). Yet no studies that we are aware of have evaluated the temporal reliability of estimates from KT models in a MDCEV specification with datasets from multiple years.[28] As such, this paper focuses on the temporal reliability of estimates from KT models with CB data.

The contingent behavior data in this study are collected from three surveys in 2018, 2019, and 2020. Three distinct samples of recreational hunters in Alberta, Canada indicate intended trip decisions (where to take hunting trips and how many trips) with hypothetical scenarios that propose policy programs to encourage hunting for controlling a wildlife disease, Chronic Wasting Disease (CWD). Utilizing the discrete and continuous characteristics of the trip data, we estimate separate KT models in the same MDCEV specification with the three CB datasets. We construct welfare estimates of site closures with parameter estimates and underlying data in a simulation-based approach. We test the temporal reliability of parameter and welfare estimates over the survey periods of 2018 to 2020 (annual comparisons of 2018 and 2019, 2018 and 2020, and 2019 and 2020).

The results show that more than half of the coefficient estimates, including coefficients capturing individuals' preferences towards the wildlife disease and policy programs, are temporally reliable across the survey years. Welfare estimates of site closures for individuals who take trips to the corresponding sites are largely temporally reliable. The mostly reliable estimates indicate that individuals would be more likely to take hunting trips to help control the wildlife disease when responding to policy programs in targeted areas with high disease prevalence. These areas also have a larger use value on average for individuals. Robustness checks with the same KT models using combined RP and CB data also support these findings.

This study contributes to the literature of non-market valuation and recre-

[28] Ji et al. (2020) is the closest study to ours as they examine the temporal reliability of estimates from KT models in the von Haefen and Phaneuf (2005) Linear Expenditure System specification with RP data as a robustness check in their analysis of DCM reliability.

ation demand in the following aspects. Our estimates with CB trip data suggest that CB trip data are a reliable data source in non-market valuation to construct use values, and to compare and combine with RP data in recreation demand models. By evaluating the temporal reliability of estimates from KT models with a MDCEV specification, we provide insights into a broader application of this particular KT model. Previous recreation demand studies focus largely on advancing repeated DCM with few studies on KT models (Lupi et al., 2020; von Haefen and Phaneuf, 2005). The KT model with MDCEV specification has not been widely used and the temporal reliability of its estimates has not been examined due to computational challenges. This study shows that it is promising to apply KT models with multiple years of data at different sample sizes. Our study also provides implications for policy decisions that use estimates from recreation demand models. In general, reliability tests of estimates with CB data share the same significance for benefit transfer over time in policy analysis as the reliability tests of RP estimates discussed in Ji et al. (2020). In particular, the temporal reliability of estimates in our empirical application provides confidence in policy advice for wildlife managers on managing a wildlife disease that is slowly progressive and requires management efforts over a long time period.

In the following sections of the paper, we first introduce the background of the empirical application in Section 4.2. Then we describe the datasets from three surveys we use in Section 4.3. In Section 4.4, we introduce the Kuhn-Tucker recreation demand model and reliability tests in the analysis. In Section 4.5, we report parameter and welfare estimates from the Kuhn-Tucker model as well as results of reliability tests. This is followed by conclusions in Section 4.6.

4.2 Background: Chronic Wasting Disease and Recreational Hunting

Testing temporal reliability of estimates with contingent behavior data in this study not only has its importance in the recreation demand literature but also has direct policy implications for management of a wildlife disease – Chronic Wasting Disease.

Chronic Wasting Disease (CWD) is a fatal prion disease that is infectious among farmed and wild deer populations. CWD has affected 3 Canadian provinces, 26 states in the United States, 3 European countries, and in South Korea. While CWD has not been found to transmit from animals to humans, health agencies raise the concern of this potential and recommend avoiding using and consuming infected animals.[29] In Alberta, CWD has affected wild deer, especially mule deer, for about 15 years. While the CWD prevalence remains relatively low, CWD has become more prevalent and spread to a larger geographic area over the recent years (Pattison-Williams et al., 2020) – this raises the concern about the reduction in wildlife populations if the prevalence is high enough in areas like Wyoming (DeVivo et al., 2017).

Although CWD is challenging to control, wildlife agencies have designed different CWD surveillance and management programs. Currently, the only feasible control approach is reducing animal populations in infected regions. Over the past few years, engaging recreational hunters in depopulation has become desirable and wildlife agencies in western North America have implemented or proposed some incentive programs to increase hunter harvests in CWD-infected areas (Cooney and Holsman, 2010; Holsman and Petchenik, 2006; Holsman et al., 2010; Western Association of Fish and Wildlife Agencies, 2017). As recreational hunters obtain use values by taking hunting trips and harvesting animals, incentive programs could increase their hunting opportunities in CWD-infected areas. On the other hand, recreational hunters who consume meat from harvested animals and perceive CWD as a risky disease might be less satisfied if some harvested animals are CWD-positive. Therefore, it is important to examine hunters' responses to incentive programs and use values associated with hunting activities before incentive programs are implemented. CB responses provide an ideal data source for modeling hunters' intended trip decisions with proposed incentive programs.

[29]https://www.inspection.gc.ca/animal-health/terrestrial-animals/diseases/reportable/cwd/fact-sheet/eng/1330189947852/1330190096558

Limited effort has been made to understand hunting behavior over time, although it is important and even required for engaging hunters in CWD management. Since CWD is a slowly progressive disease, sustained efforts are required to reduce the prevalence and slow the spread for CWD control. Accordingly, from an epidemiological perspective, the effectiveness of CWD management programs can only be evaluated when the programs are implemented persistently for a certain time period, e.g. a minimum of 5 years as recommended by Western Association of Fish and Wildlife Agencies (2017). However, most previous CWD management programs were implemented for a short period of two to three years or were not implemented continuously in a longer time period (Conner et al., 2007; Western Association of Fish and Wildlife Agencies, 2017) – this limits the understanding of whether these management programs could control the disease over the long time. Moreover, hunters' opinions and behavioral responses to CWD and associated incentive programs might change as CWD evolves over time. Yet researchers and policy makers have not paid much attention to continuously collecting data from hunters to evaluate the impacts of CWD and programs on hunters (Vaske and Lyon, 2011; Cooney and Holsman, 2010; Holsman and Petchenik, 2006), regardless of the status of incentive programs (e.g. whether the programs have been discontinued, are being implemented, or are under discussion). As such, it is not clear whether and how incentive programs could encourage hunter harvests to control CWD over time.

In Alberta, CWD prevalence and spread are slowly increasing (i.e. CWD is not newly discovered and is familiar to hunters); hunter population sizes are relatively stable; and wildlife managers are increasingly interested in designing incentive programs for CWD control. As a result, we have the opportunity to assess the temporal reliability of estimates from modeling hunting behavior to provide policy advice.

4.3 Data

To test the temporal reliability of estimates, we use a pseudo panel dataset from three surveys administered to distinct samples from 2018 to 2020. In this section, we describe these surveys and contingent behavior questions, as well as summary statistics of the data.

4.3.1 Surveys and Contingent Behavior Questions

We administered three surveys to distinct samples of recreational hunters in Alberta on Qualtrics in 2018, 2019, and 2020 respectively. The surveys were sent out roughly at the same time period (between February and May) that is after the hunting season in November of the previous year (2017, 2018, 2019). The target population for the surveys was recreational hunters who held special licenses for mule deer in CWD-infected and surrounding areas as with the grey boundaries in Figure 4.1. For each survey, 5,000 eligible individuals were randomly drawn from the license database of Alberta Environment and Parks. In 2018 and 2020, one invitation and one reminder were sent out to eligible participants by Alberta Environment and Parks on our behalf. In 2019, only one invitation email was sent out because the reminder email was cancelled due to the provincial election in Alberta. After excluding respondents who did not agree to participate in the survey, did not take hunting trips in the previous year, or did not provide required information (e.g. hunting trips, postal codes for travel cost calculation), we construct a pseudo panel dataset that consists of data from 636, 330, and 873 respondents in each year. As we did not collect unique identifiers from respondents (i.e. Wildlife Identification Number), we are not able to identify if we have same individuals across years.

Following a section that collects RP data, the three surveys include a section that consists of four contingent behavior scenarios as summarized in Table 4.1. These CB scenarios are identical across year. Each CB scenario proposes an incentive program that aims to increase hunting trips for CWD management. Incentive programs proposed in the scenarios are based on policy recommendations in Western Association of Fish and Wildlife Agencies (2017) and discussions with wildlife managers and biologists from the Government of Alberta. Two scenarios propose to extend hunting seasons in October or December from the regular season in November in sampling areas of 65 hunting sites. Season expansion programs are recommended to reduce prevalence and slow the spread of CWD and thus apply to CWD-infected and surrounding areas (Western Association of Fish and Wildlife Agencies, 2017). The other two scenarios provide material incentives of either extra tags or monetary rewards in gift cards in the regular season of November in 11 high CWD prevalence hunting sites. Extra tags or gift cards are to provide incentives to increase harvest at targeted areas where CWD prevalence is higher than 10% as of 2016 (Western Association of Fish and Wildlife Agencies, 2017). Season expansion and extra tags/gift cards, either being implemented independently or together, are considered to be effective to curb CWD (Western Association of Fish and Wildlife Agencies, 2017). As such, we design four scenarios that cover all aspects of recommended policy programs.

Each respondent randomly received two CB scenarios in the three surveys. Some respondents in the 2018 survey received two season expansion scenarios whereas all respondents in the 2019 and 2020 surveys received one scenario with season expansion (either October or December) and one scenario without season expansion (either extra hunting tags or gift cards). After presenting CB scenarios to respondents, the surveys asked how many trips they would have taken in the previous hunting season (and extended seasons with October and December scenarios) – the same time as their actual hunting trips (see Appendix 4.E for screenshots of CB scenarios in the surveys). We asked the questions in a retrospective manner (i.e. what they would have done) rather than in a forward-looking manner (i.e. what they will do) so that respondents would be more likely to hold all other factors constant when responding.

As discussed in Ji et al. (2020), one cause of unreliable coefficient and welfare estimates over time is changing preferences (i.e. unstable preferences) that could be captured by utility parameters. Changes in preferences might arise from external shocks, such as policy changes, financial crises and pandemics. In Alberta, there was a policy change on hunting licenses associated with

Table 4.1: Contingent Behavior Scenarios

Scenario	Description	Eligible areas[a]	Season Length	Material Incentives
October season expansion	Extend the hunting season from the entire month of November to include the last week of October	Sampling areas (65 sites)	37 days	NA
December season expansion	Extend the hunting season from the entire month of November to include the first 17 days of December	Sampling areas (65 sites)	47 days	1 extra tag if hunting in December
Extra tags	Add one extra hunting tag in November	High CWD prevalence areas (11 sites)	30 days	1 extra tag[b]
Gift cards	Offer gift cards from a popular hunting store for animals harvested in November	High CWD prevalence areas (11 sites)	30 days	1 gift card (valued at $30 or $50)

Note:
[a] Appendix 4.A provides maps of eligible areas under each scenario.
[b] The extra tag in December season expansion scenario only applies to the extended season. This is to make the scenario more feasible: as the number of animals harvested is restricted by hunting tags in Alberta, recreational hunters would not have taken more trips in December if they already used up the hunting tags in November.

CWD between 2018 and 2019 surveys. Prior to 2018, recreational hunters could obtain a free replacement license if they chose not to consume meat from CWD-infected animals. This program was discontinued from the 2018 hunting season and therefore potentially affected trip decisions collected in 2019 and 2020 surveys.[30] Although the 2020 survey was implemented in March 2020, during the COVID-19 pandemic, the primary data collection after the initial invitation happened before the first 30 cases were found in Alberta. In addition, there were no stringent stay-at-home or lockdown orders in place when the 2020 survey was in the field. As such, we are not aware of external shocks that could affect preferences from 2018 to 2020 surveys except for the discontinued replacement license program.

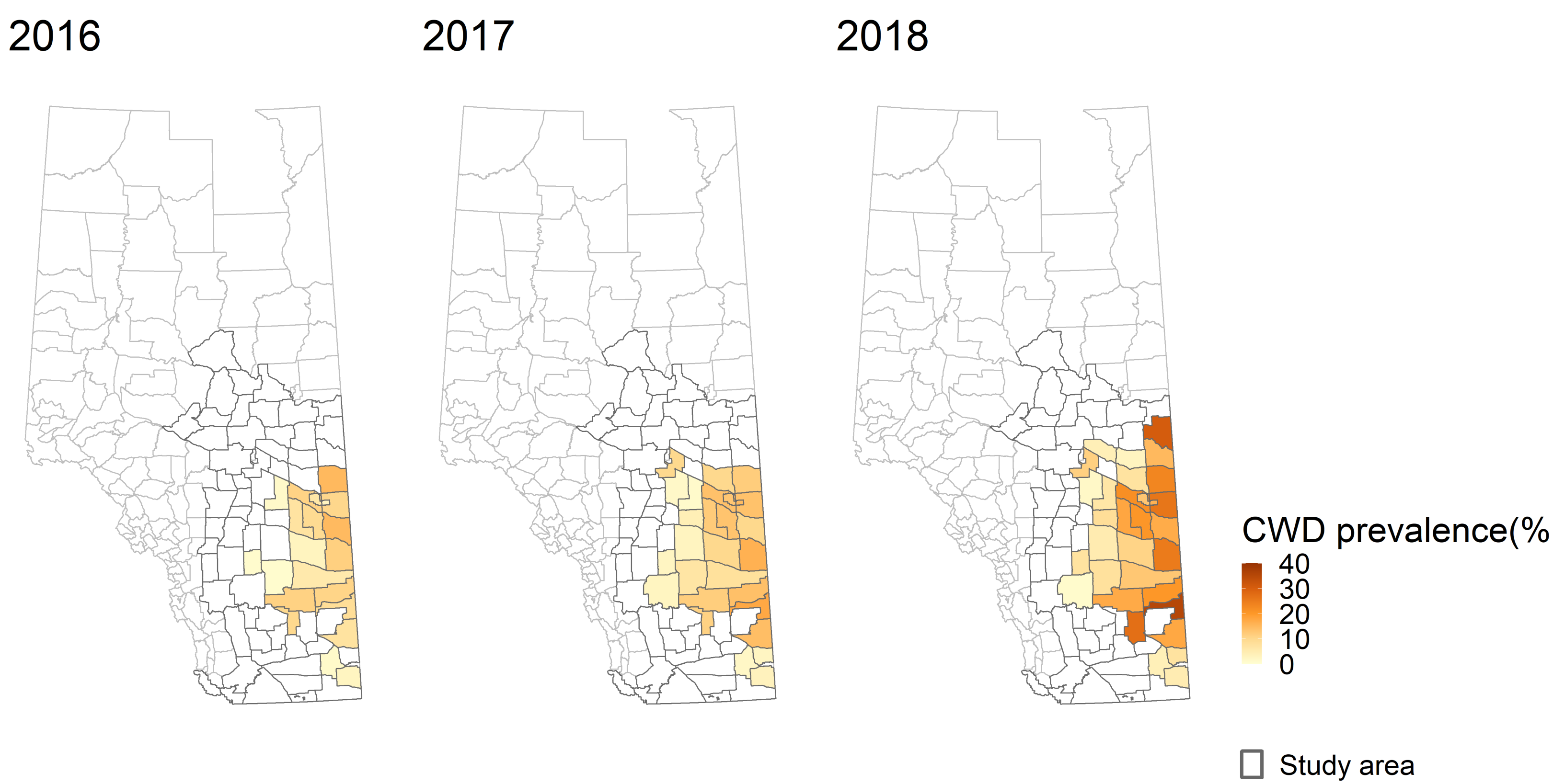
4.3.2 Descriptive Statistics and Trip Data

Table 4.2 present descriptions and mean values of main variables in three surveys. The only site attribute is CWD prevalence rate that is calculated as the percentage of positive CWD cases in mule deer over the total number of mule deer heads submitted for testing from hunters. As CWD testing results usually come after the hunting season, recreational hunters only have CWD information from the previous hunting season when they make hunting trip decisions. Therefore, we use the CWD prevalence rate from the previous hunting seasons in 2016, 2017, and 2018. As we can see, CWD prevalence has increased on average over the survey period. Moreover, CWD has spread to a larger area, i.e. from west to the east in Alberta, as shown in Figure 4.1. Since CWD prevalence is the only available attribute that varies by site and year, we use the actual prevalence rate rather than converting it to a categorical measure as in Zimmer et al. (2012) and Xie et al. (2020) where they only use cross-sectional data in one year.

CB scenario dummy variables identify the impacts of policy programs that vary by sites and individuals. As shown in the third column of Table 4.1

[30]https://open.alberta.ca/dataset/d850792e-cd0c-4bb5-b10e-8e84eae0d764/resource/3b69d983-8dee-45bd-8924-c52d8d2707db/download/cwd-positivedeer-infosheet-sep2018.pdf

Figure 4.1: CWD Spread and Prevalence (2016 – 2018) in Alberta



Note: We implemented surveys in 2018, 2019 and 2020 respectively to collect CB hunting trip decisions in the previous hunting season in 2017, 2018 and 2019. As hunters only had information on CWD prevalence from the previous hunting season (i.e. 2016, 2017 and 2018) when they decided on trips in 2017, 2018 and 2019, we present and use CWD prevalence rate with one year lag in our model.

Table 4.2: Mean Values of Site Attributes, Contingent Behavior Scenario and Socio-demographic Variables

Variable[a]	**Description**	**2018**	**2019**	**2020**
Site attributes				
CWD	Chronic Wasting Disease (CWD) prevalence rate (%) available from the hunting season of 2016, 2017, and 2018[b]	1.927	3.680	5.990
CB scenario dummy variables[c]				
October scenario	Dummy variable if the October season expansion scenario is proposed in eligible areas	0.263	0.289	0.286
December scenario	Dummy variable if the December season expansion scenario is proposed in eligible areas	0.292	0.318	0.304
Extra tags scenario	Dummy variable if the extra tags scenario is proposed in eligible areas	0.023	0.023	0.019
Gift cards scenario	Dummy variable if the gift cards scenario is proposed in eligible areas	0.022	0.022	0.021
Extended season	Dummy variable if the trip is taken during the extended hunting seasons	0.336	0.352	0.358
Socio-demographic variables				
College	Dummy variable if hold a college degree	0.328	0.430	0.337
Urban	Dummy variable if live in urban area (20,000 people or more)	0.501	0.531	0.475
Children	Dummy variable if children under 12 in household	0.240	0.238	0.216
Years of hunt	Years of hunting experience	25.033	28.769	28.491
Income	Annual household income	99,202	105,232	104,012
Travel cost	Travel cost in 2017 Canadian dollars	270.365	316.546	284.529
N	Number of respondents	627	330	873

Note:
[a] Not all variables are balanced across years according to two-sample t-tests and joint orthogonality tests.
[b] The surveys were conducted in 2018, 2019, and 2020 to collect RP and CB trip data in the previous hunting season in 2017, 2018, and 2019. However, as CWD testing results came after the hunting season, hunters only had CWD information from the previous season (i.e. 2016, 2017, and 2018) when making trip decisions in 2017, 2018, and 2019.
[c] Dummy variables of October scenario, December scenario, Extra tags scenario, Gift cards scenario are 0 when these scenarios do not apply (e.g. either in ineligible areas, or an individual did not receive the scenarios).

and the early discussion, the four scenarios do not apply to the same areas: October and December season expansion programs apply to sampling areas while extra tags and gift cards programs only apply to areas with high CWD prevalence. Although respondents were not restricted to indicate intended trips only to eligible areas, the CB scenario dummy variables are defined to distinguish the different impacts of policy programs by sites. At the same time, respondents randomly received two scenarios out of four, CB scenario dummy variables also identify who received what scenarios and therefore are different across individuals. Given the definitions of these dummy variables, one should be cautious about interpreting these variables because the reference category when dummy variables are equal to 0 is not a specific policy program, but an indication when and where associated policy program does not apply – either a site is not in the eligible area of the policy program or an individual did not receive the scenario.[31] The extended season dummy variable is to distinguish trip decisions during the regular season in November with trip decisions during the extended season in October or December.

Socio-demographic variables are not balanced across surveys. Although the sampling methods were the same for the three surveys, the participation was voluntary and there might have been self-selection bias issues in responses that are similar over the three years. We also calculate the round-trip travel costs that consist of out-of-pocket monetary expenses and opportunity costs of travel time. We convert the travel costs in 2017 Canadian dollars as the first hunting season we have information on was in 2017.

Table 4.3 presents the average number of trips that would have been taken by person with CB scenarios in each survey. As some responses are not eligible based on the criteria listed in Section 4.3.1, the number of respondents in each scenario is not the same. The average number of trips in 2018 survey is slightly lower than those in 2019 and 2020 surveys – this pattern is consistent with their parallel RP trips in the 2017, 2018, and 2019 hunting seasons (see

[31] For example, if an individual received the extra tag scenario, the scenario dummy variable is 1 only for the 11 sites. The dummy variable is 0 in all ineligible sites regardless whether an individual received the scenario or not.

Table 4.3: Average Number of Trips Per Person under CB Scenarios

Scenario	**October**	**December**	**Extra tags**	**Gift cards**
Season length	*37 days*	*47 days*	*30 days*	*30 days*
2018 survey	**9.40**	**11.13**	**7.24**	**6.44**
	(214)	(238)	(208)	(202)
2019 survey	**9.10**	**11.19**	**7.79**	**8.08**
	(148)	(163)	(131)	(130)
2020 survey	**9.71**	**11.93**	**7.40**	**8.00**
	(387)	(413)	(304)	(330)

Note: Average numbers of trips per person are in bold. Numbers of respondents are in brackets. Unrealistic large trip numbers are adjusted to be consistent with the allowable hunting days (with 30 days maximum if trips are in November) in all scenarios.

Table 4.D.1 in Appendix 4.D). Since October and December season expansion programs provide longer hunting seasons, the average numbers of trips in these two scenarios are higher than the average numbers of trips in extra tags and gift cards. The same reason explains a higher average number of trips in December compared to October.

4.4 Analysis

In this section, we outline analysis methods we use to test for reliability. Following the standard practice of reliability tests (Bishop and Boyle, 2017), we first estimate a recreation demand model separately for each survey. Then we construct welfare estimates of site closures. To assess reliability of coefficient and welfare estimates, we will test for 1) differences in the coefficient estimates from the same model across three years; 2) differences in the associated welfare estimates across three years. Given that CB data are usually collected following RP data, the same sets of analyses are conducted with combined RP and CB data as robustness checks.

4.4.1 Model Estimation

As shown in Table 4.3, respondents would have taken more than 5 trips in all scenarios across years. In order to make use of the “continuous” nature of count data while accounting for potential zero trips, we apply a KT model with the multiple discrete-continuous extreme value (MDCEV) specification (Bhat, 2008), for its advantages over a repeated discrete choice model and a traditional Kuhn-Tucker model with an LES specification (Lloyd-Smith et al., 2020; Bhat, 2008).

The conceptual framework for the Kuhn-Tucker model starts from a constrained utility maximization problem. Each recreational hunter is assumed to maximize utility $U(x_j, Q_j, z)$ – a function of recreation hunting trips x_j to hunting site j, vectors of site attributes Q_j at site j and a numeraire good z – by choosing the number of recreation trips and consumption of the numeraire good, subject to their budget and time constraints:

$$\max_{x_j, z} U(x_j, Q_j, z) \tag{4.1}$$

$$\text{subject to} \sum_j p_j x_j + z \leq \overline{y} + t_w w \tag{4.2}$$

$$\sum_j t_j x_j + t_w \leq \overline{T} \tag{4.3}$$

Equation (4.2) is the budget constraint where p_j is the monetary cost of a hunting trip, $\overline{y}$ is the non-wage income, t_w is the time spent on working at parametric wage and w is the wage rate. Equation (4.3) is the time constraint where t_j is the travel time of a hunting trip that does not include on-site time and $\overline{T}$ is the total available time to the hunter. Following the common practice in travel cost recreation demand models (Bockstael and McConnell, 2007), the two constraints are collapsed into one as follows:

$$\sum_j (p_j + t_j w) x_j + z = \overline{y} + w\overline{T} \tag{4.4}$$

The associated first order Kuhn-Tucker conditions of the maximization problem is

$$\frac{U_{x_j}}{U_z} \leq p_j + t_j w, \text{ j = 1,...J} \tag{4.5}$$

$$x_j \left[\frac{U_{x_j}}{U_z} - p_j - t_j w \right] = 0, \text{ j = 1,...J} \tag{4.6}$$

Based on these two conditions, we specify a utility function $U(x_j, Q_j, z)$ and calculate the travel cost $p_j + t_j w$ to derive estimating equations for empirical estimation. The round-trip travel cost, consisting of the monetary expenses and opportunity cost of travel time (measured in hours), is given by

$$\text{Travel cost} = 2 \times \text{travel distance} \times \text{cost per kilometer} + 2 \times \text{travel time} \times \text{wage rate} \times \frac{1}{3} \tag{4.7}$$

For the utility function, we choose the translated generalized constant elasticity of substitution (tCES) specification from Bhat (2008):[32]

$$U(x_j, Q_j, z) = \sum_j \frac{\gamma_j}{\alpha}\psi_j\Big[\Big(\frac{x_j}{\gamma_j} + 1\Big)^{\alpha} - 1\Big] + \frac{\psi_z}{\alpha}z^{\alpha} \tag{4.8}$$

where γ_j, α are utility parameters to allow for the corner solution, satiation effects, and diminishing marginal utility of additional trips or numeraire good as detailed in Bhat (2008). ψ_j is the baseline marginal utility of a recreation trip to site j when no trips are taken. Similarly, ψ_z captures the baseline marginal utility of the numeraire good when it is not consumed. We further specify $\psi(Q_j, \varepsilon_j) = \exp(\beta' Q_j + \varepsilon_j)$ for hunting trips and $\psi_z = \exp(\varepsilon_z)$ for the numeraire good. Q_j includes CWD prevalence, CB scenario dummy variables and socio-demographic variables in Table 4.2 (except for income and travel costs). As CWD is the only available site attribute, we also include year invariant alternative specific constant (ASC) for each site to capture the specific preferences towards certain sites and address potential omitted variable bias (Murdock, 2006). The error terms ε_j and ε_z are to capture unobserved heterogeneity across individuals. The error terms are assumed to follow a type 1 extreme value distribution with a scale parameter σ and are independent across individuals and choice occasions.

The same specification is used to estimate models using data from 2018, 2019, and 2020 surveys. 79 hunting sites would have been visited in CB responses of 2018 and 2020 surveys while only 72 hunting sites would have been visited in CB responses of 2019 survey. Therefore the choice set is slightly

[32] The functional form is chosen over other profiles in Bhat (2008) based on model fit statistics of log-likelihood values.

different across years, i.e. $J = 79$ for 2018 and 2020 surveys, $J = 72$ for 2019 survey. Note although October and December season expansion scenarios have two time periods (i.e. regular and extended seasons) for individuals to take hunting trips and they might substitute across time, we assume they treat the two time periods independently and use the extended season dummy variable to distinguish it from the regular season. We do not combine hunting site and time periods in the choice set as in Xie et al. (2020) that only use RP and CB data associated with season expansion programs from the 2018 survey, to better compare extra tags and gift cards scenarios that do not have the extended seasons.[33] The model is estimated with the R package rmdcev (Lloyd-Smith, 2020a), using Maximum Likelihood technique and 50 multivariate normal draws to compute standard errors.[34]

4.4.2 Welfare Simulation

Following Lloyd-Smith (2018), we construct welfare measures of site closures by using a simulation approach with model estimates and underlying data used in estimation. The approach first simulates Hicksian demand for each site and then uses the Hicksian demand to calculate the Hicksian compensating surplus CS^H. The CS^H for a price change from baseline levels p^0 to new levels p^1 using an expenditure function is given by Lloyd-Smith (2018):

$$CS^H = y - e(p^1, U^0, \boldsymbol{\theta}, \varepsilon) \tag{4.9}$$

where y is the annual income, $\boldsymbol{\theta}$ is the vector of utility parameters $(\psi_j, \alpha, \gamma_j)$, U^0 is the baseline utility level specified as $U^0 = V(p^0, y, \boldsymbol{\theta}, \varepsilon)$, and ε is the error term that captures unobserved heterogeneity by individuals (see Lloyd-Smith 2018 for a full description). In our recreation demand models, p^0 and p^1 are the baseline and new travel costs. In order to simulate CS^H of site closures, p^1 is set to a very large number that essentially has the same effect as site closures.

[33] Differences in the choice set and CB scenarios with Xie et al. (2020) are also explain the reason why we define CB dummy variables of October or December scenarios differently: to capture spatial variation of CB scenarios.

[34] The standard errors can also be computed with the delta method. However, we use multivariate normal draws for consistency as they are required to use for welfare simulation (Lloyd-Smith, 2020a).

We consider closing one site at a time for the three surveys and that gives us 79, 72, and 79 policy scenarios for 2018, 2019, and 2020 surveys respectively. We draw 50 conditional errors per individual in each sample to simulate $E(CS^H)$ in each policy scenario.

The direct output of welfare simulation is $E(CS^H)$ of per individual in each policy scenario. As this does not account for differences in trips and visitation patterns to sites across years (e.g. some sites might be more popular than the other sites in one year but not across years), we further calculate welfare estimates per trip, averaging across all individuals (called "welfare estimates per person") and across only individuals with positive number of trips to sites being closed (called "welfare estimates per participant" as in Lloyd-Smith 2020b) for each policy scenario for each sample in the following steps:

1. For each individual in each simulation, divide the welfare estimates by the positive number of trips or keep the welfare estimates (close to 0) if no trips are taken. This gives us welfare estimates per trip in each simulation.
2. Keep welfare estimates of all individuals for welfare estimates per person while only keeping welfare estimates of individuals with at least one trip for welfare estimates per participant.
3. Calculate the average welfare estimates per trip per person or per participant in each simulation.
4. Obtain the mean, 95% confidence interval (low and high) of the welfare estimates per trip per person or per participant for each policy scenario by taking the average, 2.5% and 97.5% quantiles of the average welfare estimates across simulations.

These steps give us three welfare estimates per trip per person or per participant for each policy scenario in each year: mean, lower and higher bounds of the 95% confidence interval. Welfare estimates per person assume that all sites are valuable to the whole sample, regardless whether they visit the sites or not, whereas welfare estimates per participant focus on respondents who would visit the sites. As such, welfare estimates per participant accounts for different visitation patterns across years.

4.4.3 Reliability Tests

To test the reliability of coefficient and welfare estimates across years, we conduct a non-parametric test of estimate differences. With the matrix of parameter draws from estimation and matrix of welfare estimates in each simulation, we can calculate the differences of coefficient and welfare estimates across each year's model for each draw/simulation as below:

$$\Delta\text{Estimate}_{S,k}^{y_1;y_2} = \text{Estimate}_{S,k}^{y_2} - \text{Estimate}_{S,k}^{y_1} \tag{4.10}$$

Where Estimate is coefficient estimate of each parameter in each draw (i.e. ΔEstimate = ΔCoefficient) or welfare estimate (i.e. ΔEstimate = ΔWelfare) per trip per person or per participant in each simulation. S is the draw number or simulation number. k is the parameter number for coefficient estimates, $k = j$ is the site in choice sets for welfare estimates. y_1, y_2 is one combination from $\{(y_1 = 2018, y_2 = 2019), (y_1 = 2018, y_2 = 2020), (y_1 = 2019, y_2 = 2020)\}$.

We then construct a 90% confidence interval for these differences by deleting values at the top and lowest 5% quantile. If the resulting 90% confidence interval contains 0, the coefficient and welfare estimates are reliable. This non-parametric test is similar to the approach used for testing the reliability of welfare estimates in Ji et al. (2020) where they obtain the differences by bootstrapping procedures. One should note that the maintained hypothesis of the reliability tests in this paper is that preferences are stable because estimates that measure unstable preferences are likely unreliable.

4.5 Results

4.5.1 Model Estimation and Welfare Simulation

Table 4.4 presents the estimates of selected baseline marginal utility parameters (ψ), satiation (α), and scale (σ) parameters from Kuhn-Tucker model for each year. As we estimate one ψ (ASC) and γ parameter for each site, a total of 170 parameters are estimated for 2018 and 2020 surveys and a total of 156 parameters are estimated for 2019 survey.[35] Appendix 4.B reports all estimates of ψ (ASC) and γ parameters. We see that the CWD estimates are negative and insignificant across years – this is consistent with recent findings in Xie et al. (2020) and Pattison-Williams et al. (2020). It indicates recreational hunters are not driven away by the presence of CWD even though CWD has an increased prevalence rate and CWD has spread across these years. The reason could be that hunters' perceived CWD risks have declined over time, given the fact that CWD has existed in Alberta for more than ten years and its prevalence level still remains relatively low (Vaske and Miller, 2019). All estimates of CB scenario dummy variables are positive and mostly significant across years, indicating individuals are more likely to take trips when they receive CB scenarios in certain areas. Comparing the magnitude of CB scenario dummy estimates, the extra tags scenario has the largest impact, followed by the gift cards, December, and October scenarios. The popularity of the extra tags scenario is not surprising and also appears in the qualitative responses in surveys. One additional hunting tag, by allowing additional harvests during the same hunting trips, increases harvesting opportunities without substantially increasing the travel costs. Although qualitative responses in surveys suggest season expansion is more favored than gift cards, our model estimates indicate that gift cards are slightly more preferred than the December season expansion. A plausible explanation could be the gift cards scenario is proposed to a smaller area that is popular among respondents whereas season expansion scenarios are proposed to a larger area that include some less popular sites. As the presence of CWD does not change hunters' trip decisions, gift card scenarios make popular areas more desirable even though these areas have high CWD prevalence. The December scenario is more preferred than the October scenario, mostly due to the overlap of other hunting seasons in October as indicated by open-ended responses in surveys. The negative and significant coefficient of

[35] Different from a repeated choice model where one ASC for a site is omitted as the reference category, we include one ASC for each site and use the numeraire good as the reference category. Although Lloyd-Smith (2020a) proposes an option to leave out one ASC due to identification concerns, we do not use this option in the final model as the log-likelihood at convergence with all ASCs is larger than the one leaving out one ASC.

extended season shows that individuals are less likely to take hunting trips in extended seasons (October or December) compared to the regular season in November. Even though most of the socio-demographic variables are not significantly different from zero, we include them in estimation because they are not all balanced across years.

As CB data were collected after the RP data and respondents were reminded of their actual trips when providing CB responses in the surveys, respondents likely anchored CB responses with RP trips. As such, preferences towards CB scenarios revealed by estimates with CB data only might be confounded with unobserved factors embedded in RP trip decisions. To account for this potential issue, we estimate the same KT models with combined RP and CB data (see results in Table 4.D.2 of Appendix 4.D) as a robustness check. Results are similar to what the CB data alone show based on the signs and significance levels of the estimates, except that the estimate of December scenario coefficients are slightly larger than that of gift card scenario coefficients for 2018 and 2019 surveys. Supported by the robustness check, from the main results of coefficient estimates with CB data, we find that recreational hunters are not affected by CWD prevalence levels and are likely to take more hunting trips when they receive incentive programs, especially the incentive programs targeting areas with high CWD prevalence.

Table 4.5 reports selected welfare estimates per trip per person and per participant of closing sites of our main interest – the 11 sites in areas with high CWD prevalence and where all CB scenarios apply. These sites are also popular among respondents because the average welfare estimates in this area are larger than the average in other areas. We calculate the welfare estimates of closing sites for each site in the choice set and report them in Appendix 4.C. From the first half of the table, we can see that the mean welfare estimates per trip per person are between -\$0.11 and -\$7.4 Canadian dollars across years, with some welfare estimates in 2019 slightly larger than estimates in 2018 and 2020. The biggest welfare loss (i.e. lowest of the low value of welfare estimate) of \$9.83 per trip in Canadian dollars is from closing WMU 200 for the 2019 sample whereas the smallest welfare loss (i.e. highest of the high value of welfare estimate) of

Table 4.4: Selected Kuhn-Tucker Model Parameter Estimates

	2018	**2019**	**2020**
Baseline marginal utility parameters ($\boldsymbol{\beta_j}$)			
CWD	-7.188	-10.291	-11.191
	(8.104)	(8.966)	(7.106)
October scenario	0.204***	0.075	0.087*
	(0.062)	(0.074)	(0.048)
December scenario	0.308***	0.162***	0.154***
	(0.062)	(0.061)	(0.047)
Extra tags scenario	0.614***	0.523***	0.583***
	(0.075)	(0.082)	(0.061)
Gift cards scenario	0.317***	0.182**	0.366***
	(0.088)	(0.089)	(0.056)
Extended season	-0.087**	-0.160***	-0.106***
	(0.044)	(0.052)	(0.031)
College	-0.024	-0.018	-0.028
	(0.054)	(0.051)	(0.033)
Urban	-0.134	-0.112	-0.067*
	(0.061)	(0.065)	(0.037)
Children	0.067**	0.073*	0.049*
	(0.044)	(0.063)	(0.026)
Years of hunt	-0.009	0.020	-0.015
	(0.018)	(0.019)	(0.011)
Satiation parameter ($\boldsymbol{\alpha}$)	0.204***	0.202***	0.265***
	(0.031)	(0.035)	(0.020)
Scale parameter ($\boldsymbol{\sigma}$)	0.560***	0.545***	0.535***
	(0.011)	(0.013)	(0.008)
Number of observations	1285	883	2234
Number of respondents	636	330	873
Log-likelihood	-12843.94	-8503.28	-21005.30

Note:
This table reports selected estimates for KT model parameters. Standard errors computed using 50 multivariate normal draws are in parenthesis. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level respectively.
The CWD variable is used in absolute values rather than in percentage. Years of hunt index is scaled as the year of hunting experience divided by 10.
One alternative specific constant (ASC) in β_j and γ_j parameters are estimated for each hunting site. They are not reported here but included in Appendix 4.B.

\$0.04 Canadian dollars is from closing WMU 730 for the 2020 sample. The magnitude of estimates is more than twenty times larger for those who would have taken trips to these hunting sites as in the second half of the table. The mean welfare estimates have a wider range between -\$42 and -\$130 Canadian dollars across years. The biggest welfare loss of \$241 Canadian dollars is from closing WMU 730 for the 2019 participants and the smallest welfare loss of \$10 Canadian dollars is from closing WMU 728 for the 2019 participants. The different patterns of welfare estimates indicate that the economic significance of site closures depends largely on the variation of visitation patterns (or where respondents would have taken trips to). When we focus on the entire sample (e.g. welfare estimates per trip per person), the welfare loss of site closures is relatively small. However, site closures could result in much larger welfare loss to those who take trips to those sites. For example, WMU 730 might not be very valuable for the entire sample but its value is very high for those who enjoy hunting there or who live nearby. Welfare estimates from the models with joint RP and CB data tell the same story (detailed in Table 4.D.3 of Appendix 4.D). Taken together, these welfare estimates suggest that site closures would result in welfare loss, in particular to individuals who take trips to the closed sites rather than the entire hunter populations.

4.5.2 Reliability Tests

Using the approach described in Section 4.4.3, we construct the 90% confidence intervals for a total number of 482 ΔCoefficient (170 pairs between 2018 and 2020, and 156 pairs each between 2019 and the other two years) and a total number of 223 $\Delta\text{Welfare}_{S,j}^{y_1,y_2}$ per person or per participant (79 pairs between 2018 and 2020, and 72 pairs each between 2019 and the other two years). We focus on Figures 4.2-4.4 that present estimates of CB scenarios in KT model, welfare estimates of closing three sites in different areas, and percentage of temporally reliable estimates across years.

Figure 4.2 visually presents the mean and 95% confidence interval of estimates of CB scenario dummy variables – our variables of interest – in the baseline marginal utility parameters (ψ) from KT model estimation. We can

Table 4.5: Welfare Estimates (CAD$) Per Trip of Closing Selected Sites

Per person

(i.e. averaging over all respondents in each survey)

	2018			2019			2020		
Site	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**
148	-2.46	-3.23	-1.89	-3.79	-4.56	-3.00	-2.37	-2.97	-1.97
150	-3.14	-4.49	-2.46	-3.88	-5.23	-2.81	-2.42	-3.18	-2.03
151	-5.17	-6.40	-3.87	-3.97	-5.27	-3.00	-4.24	-4.89	-3.57
152	-2.86	-3.48	-2.25	-3.60	-4.59	-2.70	-2.10	-2.45	-1.82
163	-3.64	-4.55	-2.64	-4.02	-5.46	-2.84	-3.02	-3.59	-2.44
200	-3.38	-4.26	-2.43	-7.40	-9.83	-5.82	-6.02	-6.63	-5.19
202	-3.05	-3.84	-2.38	-3.37	-4.16	-2.54	-3.33	-3.96	-2.79
234	-3.71	-4.41	-2.99	-3.94	-4.87	-2.98	-5.28	-6.06	-4.50
236	-1.63	-2.06	-1.22	-1.50	-2.10	-0.95	-2.10	-2.45	-1.78
728	-2.05	-2.91	-1.43	-0.28	-0.57	-0.05	-0.78	-1.04	-0.51
730	-1.61	-2.19	-0.97	-0.55	-1.09	-0.17	-0.11	-0.23	-0.04

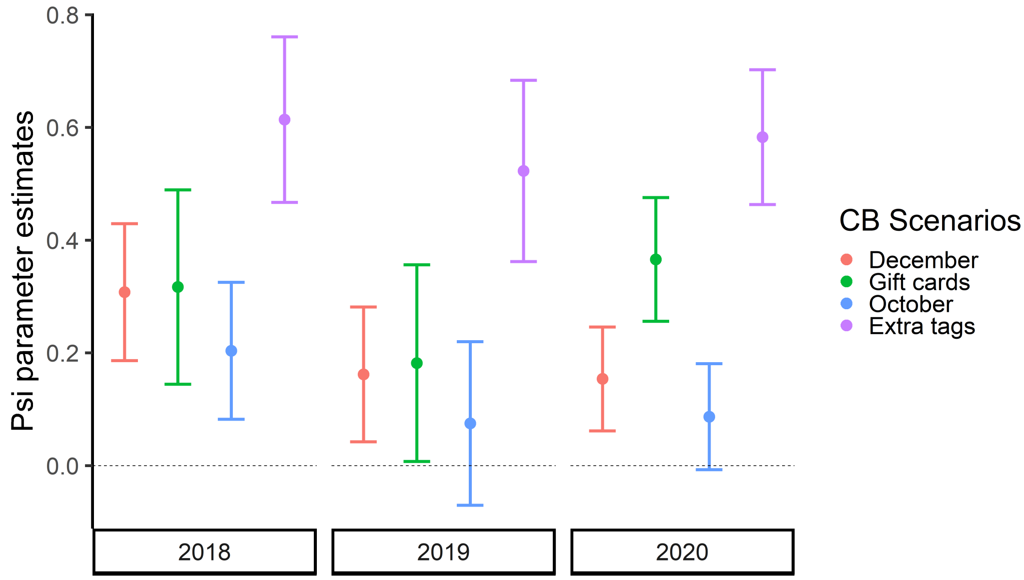
Per participant

(i.e. averaging over respondents who would have taken at least 1 trip to the site in each survey)

	2018			2019			2020		
Site	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**
148	-61	-80	-47	-62	-75	-49	-55	-69	-46
150	-101	-144	-79	-84	-113	-60	-72	-95	-60
151	-98	-121	-73	-100	-133	-76	-91	-105	-77
152	-58	-71	-46	-58	-74	-43	-52	-61	-45
163	-109	-136	-79	-99	-134	-70	-89	-106	-72
200	-89	-112	-64	-96	-128	-76	-91	-100	-78
202	-71	-90	-56	-83	-102	-62	-65	-78	-55
234	-67	-80	-54	-68	-84	-52	-72	-82	-61
236	-42	-53	-31	-74	-103	-46	-54	-63	-46
728	-83	-117	-58	-62	-125	-10	-92	-122	-60
730	-130	-176	-78	-121	-241	-37	-84	-173	-28

Note:
This table reports the average welfare estimates per trip of closing sites (one at a time) with high CWD prevalence and all CB scenarios applied. Appendix 4.C reports the average welfare estimates per trip of closing every site one at a time in choice sets in three years. Welfare estimates per person are calculated by averaging welfare estimates over the whole sample for each survey. Welfare estimates per participant are calculated by averaging welfare estimates over respondents who would have taken at least 1 trip to corresponding sites in each survey. Low and high are 95% confidence intervals of the mean estimates calculated from 30 simulations with 50 individual conditional error draws.

Figure 4.2: KT Model Estimates: ψ Parameters of CB Scenarios

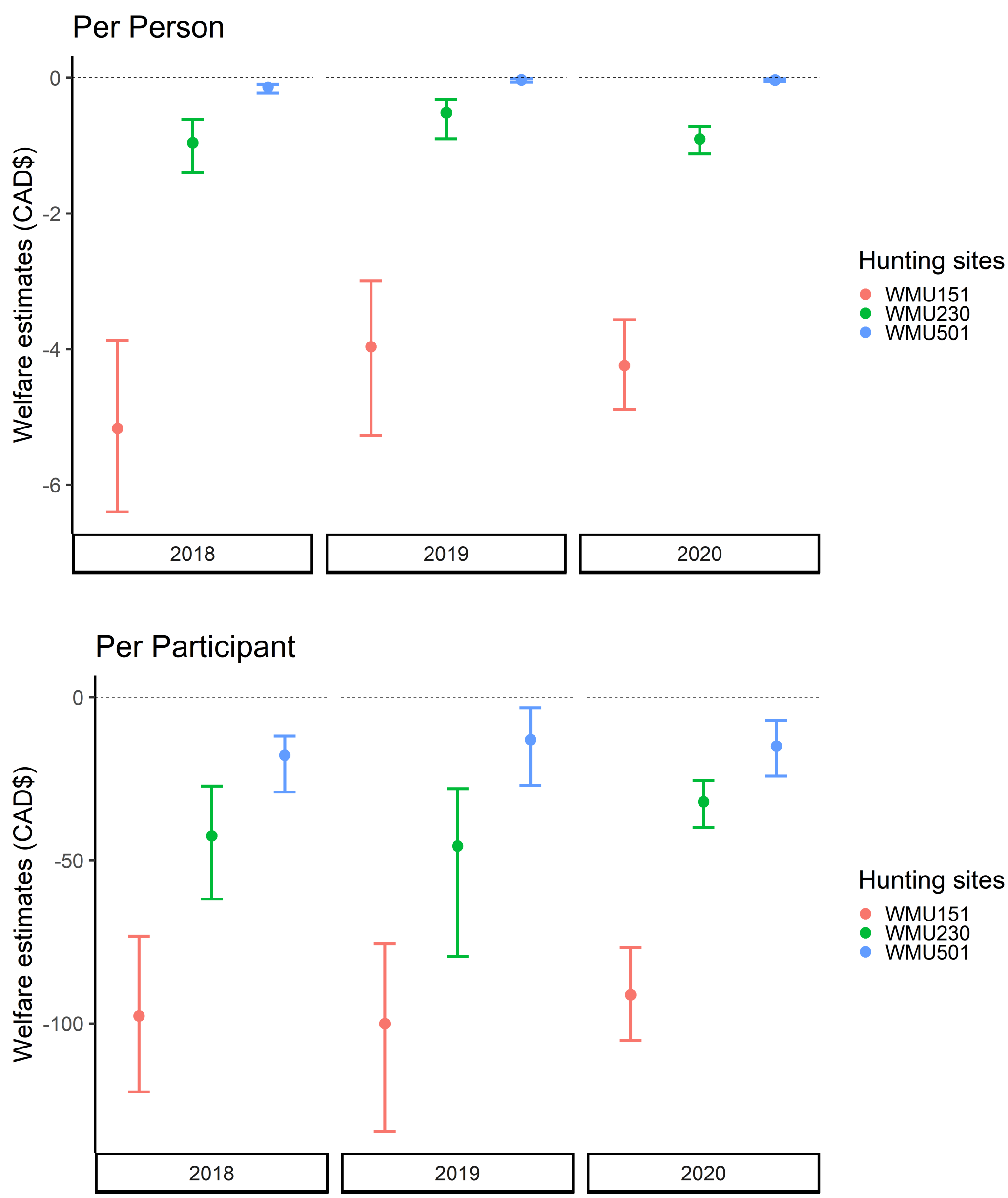


Note: Dots represent the mean estimates of parameters. The dashed horizontal line is the zero reference line. Error bars are in capped vertical lines, representing 95% confidence intervals calculated using 50 multivariate normal draws.

see that the ranking of estimates based on magnitudes are consistent across years, even though the estimate of October is not significantly different from 0 in 2019. 95% confidence intervals of the same coefficient estimate all overlap across years. Our non-parametric tests show that coefficient estimates of extra tags and October are not significantly different (i.e. reliable) across the three years. Coefficient estimates of December and gift cards are not significantly different mostly across two years. The only two pairs that are significantly different (i.e. not reliable) from each other are: the coefficient estimates of December from 2018 and 2020 and those of gift cards from 2019 and 2020. Estimates of ψ parameters including CWD, extended season and most social demographic variables are not significantly different across models. Although our variables of interest in ψ parameters are mostly reliable across years, one should note that these are only a small proportion of all parameters estimated in the models.

After testing the reliability of coefficient estimates, we turn our attention to the reliability of welfare estimates. Figure 4.3 presents welfare estimates of

Figure 4.3: Welfare Estimates of Site Closures

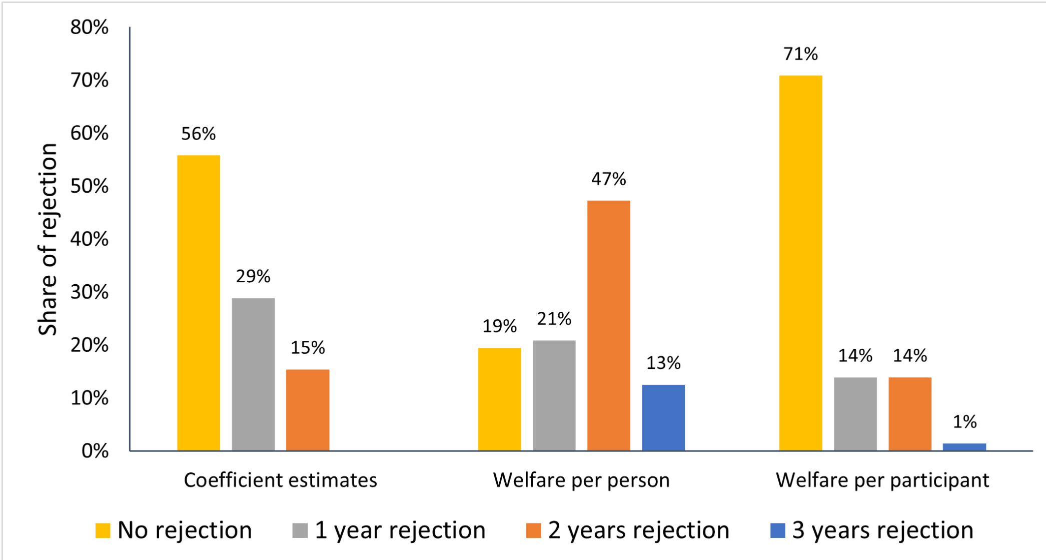


Note: Dots represent the average welfare estimates of closing three hunting sites (i.e. Wildlife Management Units, WMUs): WMUs 151 (with high CWD prevalence and all CB scenarios applied), 230 (with CWD presence and only season expansion scenarios applied) and 501 (without CWD presence and no CB scenarios applied) respectively. The dashed horizontal line is the zero reference line. Error bars are in capped vertical lines, representing 95% confidence intervals calculated from 30 simulations with 50 individual conditional error draws.

closing three sites respectively: WMU 151 has high CWD prevalence and is within the area where all CB scenarios apply, WMU 230 has CWD presence and is within the area where only season expansion scenarios apply to, WMU 501 does not have CWD and is outside of the areas with CB scenarios. We see that welfare estimates are negative for the closures of all sites but closing WMU 151 with high CWD prevalence results in the largest welfare loss and closing WMU 501 without CWD presence has the smallest welfare impact. This pattern is consistent across years for both welfare estimates per person and per participant. According to non-parametric tests, welfare losses per person of closing WMUs 230 and 501 are mostly significantly different (i.e. not reliable) across years whereas welfare loss per person of closing WMU 151 is not significantly (i.e. reliable) across years. Interestingly, welfare loss per participant of closing all three sites are not significantly different across years. This suggests temporal reliability of welfare estimates are affected by whether different visitation patterns are accounted in welfare estimates calculation (i.e. per person vs. per participant) and how sites being closed are affected by CWD and CB scenarios.

Since we test the reliability of a number of coefficient estimates in KT models and welfare estimates of closing one site at a time, we report the percentage of reliability estimates in Figure 4.4. We define years of rejection in a similar manner as in Ji et al. (2020) except that we do not fix a base year for comparisons because we only have three years of estimates. As such, each estimate has three pairs of comparisons: 2018 vs. 2019, 2018 vs. 2020, 2019 vs. 2020, and we have a total of 156 coefficient estimates and 72 welfare estimates available. In our definition, no rejection means estimates are not significantly different across all years, indicating complete temporal reliability; 1 year rejection means that estimates are only significantly different between one pair; 2 years rejection means that estimates are significantly different between two pairs; and 3 years rejection means estimates are not temporally reliable across years. Figure 4.4 shows that more than 50% of coefficient estimates are completely temporally reliable and no coefficient estimates are completely unreliable across three years. Around 47% of welfare estimates per person are

Figure 4.4: Percentage of Temporally Reliable Coefficient and Welfare Estimates



not reliable across two years and 13% are completely unreliable. The pattern changes dramatically for welfare estimates per participant that considers the different visitation patterns in each year: around 71% of welfare estimates per participant are completely temporally reliable, including 9 (out of 11) sites where CB scenarios apply and only 1.4% (1 site) of welfare estimates per participant are completely unreliable across years. Estimates from models with RP and CB data, although slightly less reliable, follow a similar pattern as shown in Figure 4.D.1 of Appendix 4.D: most coefficient estimates (about 50%) and welfare estimates per participant (about 61%) are reliable across three years.

Large proportions of temporally reliable coefficient estimates and welfare estimates per participant reinforce our findings in the previous section that hunters would be more likely to take trips over years when incentives are offered. More importantly, sustained efforts to control CWD to avoid site closures could constantly avoid potential welfare loss to targeted hunters. In general, temporally reliable estimates in this study suggest that researchers could use CB data in KT models to construct reliable welfare measures. Policy makers, especially wildlife managers in Alberta, could rely on findings from one-time data collection to design incentive programs for future implementations.

However, one should note that our findings are affected by our sampling techniques and empirical model specification. Even with the same maintained hypothesis of stable preferences, the same sampling techniques and model specification might yield different findings from reliability tests in a different study context, time period, and study site. Therefore, when applying the methods used in this study to a different study to test the temporal reliability of CB trip data in a KT model, one can borrow lessons from studies (e.g. Bateman et al. 2011) that discuss benefit transfer across study sites.

4.6 Conclusion

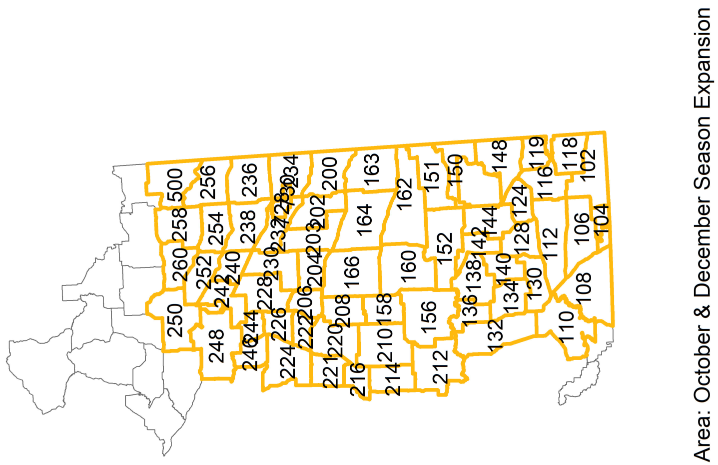
In this paper, we assess the temporal reliability of estimates in Kuhn-Tucker recreation demand models with contingent behavior data. By collecting intended trip decisions in three surveys administered to distinct samples of recreational hunters from 2018 to 2020, we examine how individuals would respond to proposed incentive programs that aim to control a wildlife disease, Chronic Wasting Disease. Making use of the site-specific count trip data, we estimate three KT models with the same specification for each year's data respectively and construct associated welfare measures of site closures. We use non-parametric tests to examine the temporal reliability of coefficient and welfare estimates. We also conduct the same sets of analysis with joint RP and CB data as robustness checks. We find that individuals are not driven away by the wildlife disease and they respond consistently to incentive programs over time. Extra hunting tags in targeted areas with high disease prevalence are mostly favored by hunters across years, seconded by gift cards that apply to the same areas. Season expansion programs, by applying to a larger area, have smaller and consistent impacts on trip decisions. Welfare losses of site closures are larger and more temporally reliable for individuals who take trips to closed sites than the whole sample. Given that the economic value of hunting in the targeted area is consistently high, incentive programs targeted at areas with high CWD prevalence could be effective in engaging the target hunter populations in CWD control. With results from model and reliability tests, the key finding of largely temporally reliable coefficient and welfare estimates in this study gives us confidence in using CB data in recreation demand models and policy evaluation and applying them to KT models.

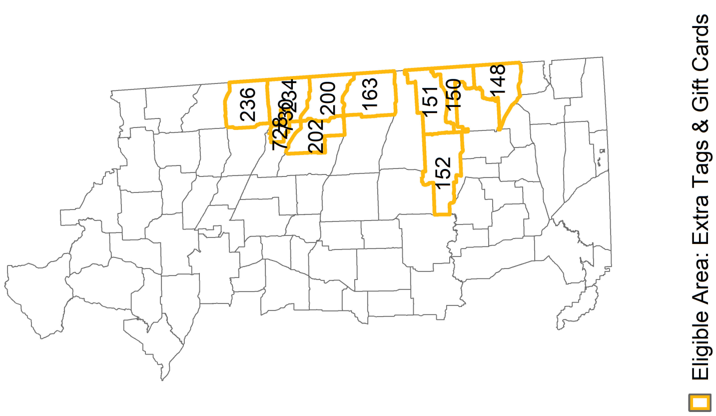
This study provides insights for studies within and beyond recreation demand and policy implications. We show that estimates with CB data are temporally reliable and therefore can be used to examine the convergent validity of RP and CB data that are collected in different time periods. Reliable estimates from KT models with CB data suggest that CB data could be combined with RP data to add variation in complicated recreation demand models. Moving beyond the recreation demand literature, our reliability estimates with CB data add confidence to studies in consumer behavior (e.g. Yang et al., 2020), transportation/energy use (e.g. Shin et al., 2012; Ahn et al., 2008) that collect CB data with discrete-continuous characteristics. Moreover, reliable welfare estimates indicate that researchers and policy makers could rely on CB data to understand costs and benefits of proposed policy programs beforehand. For wildlife managers in Alberta, although with distinct samples of recreational hunters, we show that random samples of hunters' opinions and attitudes towards CWD management programs are likely stable over time without external shocks. Therefore, they could use the findings with information collected from hunters at one time point for future policy design.

This study also has limitations that could be addressed in future work. First, we do not capture the unobserved heterogeneity of the samples in model estimation. The KT model in this study could be extended to incorporate unobserved heterogeneity in a latent class or random parameter KT models (Lloyd-Smith, 2020a) that ideally needs more observations. Another source of unobserved heterogeneity comes from hunters' risk perceptions as those who stopped hunting in sampling areas due to perceived high CWD risks were not captured in our samples. The unobserved heterogeneity could be accounted in both sampling/data collection and analysis steps in future work. Second, our findings are based on three years of data rather than a longer time period. As the time intervals could affect the reliability findings (Yi and Herriges, 2017; Ji et al., 2020), one should be cautious when generalizing our findings to a longer time period. Researchers could further examine how time intervals affect temporal reliability of estimates from recreation demand models in a meta-analysis once more studies have examined this question.

Appendix 4.A Supplementary Maps

Figure 4.A.1: Eligible Areas of Contingent Behavior Scenarios





Appendix 4.B Kuhn-Tucker Model Site-Specific Parameter Estimates

Table 4.B.1: Baseline Marginal Utility Parameters (β_j)

	2018		2019		2020	
Site	**Estimate**	**Std.err**	**Estimate**	**Std.err**	**Estimate**	**Std.err**
102	−5.041***	(0.385)	−4.736***	(0.474)	−4.276***	(0.246)
104	−5.779***	(0.412)	−5.236***	(0.469)	−5.041***	(0.302)
106	−6.299***	(0.416)	−6.204***	(0.462)	−5.475***	(0.317)
108	−5.158***	(0.368)	−5.167***	(0.441)	−4.268***	(0.266)
110	−5.954***	(0.408)	−5.562***	(0.434)	−5.209***	(0.311)
112	−6.065***	(0.364)	−6.084***	(0.462)	−5.797***	(0.353)
116	−5.648***	(0.388)	−5.435***	(0.477)	−4.328***	(0.355)
118	−4.936***	(0.449)	−4.399***	(0.531)	−3.649***	(0.380)
119	−5.686***	(0.366)	−5.232***	(0.496)	−4.014***	(0.528)
124	−6.208***	(0.394)	−5.312***	(0.493)	−5.022***	(0.384)
128	−6.768***	(0.455)	−6.458***	(0.443)	−4.008***	(1.233)
130	−6.466***	(0.369)	−7.035***	(0.472)	−5.839***	(0.320)
132	−6.598***	(0.434)	−6.568***	(0.474)	−5.389***	(0.285)
134	−6.662***	(0.407)	−6.567***	(0.485)	−5.252***	(0.297)
136	−6.664***	(0.423)	−6.557***	(0.467)	−5.589***	(0.286)
138	−7.239***	(0.589)	−5.799***	(0.701)	−5.814***	(0.336)
140	−7.314***	(0.428)	-	-	−6.840***	(0.697)
142	−6.239***	(0.936)	−5.725***	(1.148)	−6.160***	(0.346)
144	−6.981***	(0.553)	−6.073***	(0.491)	−2.643	(1.918)
148	−4.990***	(0.754)	−3.542***	(1.357)	−2.477*	(1.248)
150	−4.803***	(0.865)	−3.266**	(1.626)	−0.386	(2.482)
151	−4.307***	(0.981)	−3.668***	(1.336)	−1.875	(1.418)
152	−4.958***	(1.007)	−4.286***	(1.152)	−2.902**	(1.196)
156	−6.125***	(0.389)	−6.015***	(0.509)	−5.153***	(0.263)
158	−5.664***	(0.396)	−5.865***	(0.521)	−4.254***	(0.569)
160	−5.471***	(0.375)	−5.039***	(0.771)	−3.663***	(0.562)
162	−5.285***	(0.611)	−4.740***	(0.835)	−3.530***	(0.885)
163	−4.503***	(1.040)	−3.444**	(1.527)	−1.515	(1.759)
164	−5.394***	(0.479)	−4.747***	(1.031)	−3.348***	(0.744)
166	−5.782***	(0.387)	−5.014***	(0.496)	−3.952***	(0.409)
200	−4.176***	(1.317)	−3.682***	(1.010)	−2.073*	(1.196)
202	−4.713***	(0.866)	−3.914***	(1.264)	−2.064	(1.423)
203	−5.369***	(0.772)	−4.247***	(1.181)	−2.654**	(1.266)
204	−5.701***	(0.376)	−5.206***	(0.594)	−3.832***	(0.619)
206	−6.167***	(0.384)	−6.784***	(0.501)	−5.487***	(0.283)
208	−5.688***	(0.371)	−5.666***	(0.439)	−4.803***	(0.255)
210	−7.118***	(0.498)	−6.540***	(0.475)	−5.397***	(0.284)
212	−8.119***	(0.435)	−7.834***	(0.455)	−7.632***	(0.386)
214	−6.399***	(0.366)	−6.658***	(0.450)	−5.521***	(0.274)
216	−6.640***	(0.412)	−6.908***	(0.517)	−5.730***	(0.280)

	2018		2019		2020	
Site	**Estimate**	**Std.err**	**Estimate**	**Std.err**	**Estimate**	**Std.err**
220	−6.096***	(0.381)	−6.398***	(0.469)	−5.036***	(0.266)
221	−7.244***	(0.447)	−6.724***	(0.417)	−6.038***	(0.286)
222	−6.761***	(0.410)	−7.603***	(0.546)	−6.014***	(0.342)
224	−6.380***	(0.410)	−6.304***	(0.433)	−5.541***	(0.257)
226	−6.916***	(0.427)	−7.894***	(0.727)	−5.789***	(0.253)
228	−5.998***	(0.375)	−6.185***	(0.470)	−4.884***	(0.263)
230	−5.762***	(0.365)	−6.101***	(0.452)	−4.115***	(0.483)
232	−5.326***	(1.028)	−4.655***	(1.315)	−2.425	(1.508)
234	−4.359***	(0.938)	−3.507***	(1.328)	−1.101	(1.821)
236	−4.338***	(1.306)	−4.400***	(1.146)	−1.902	(1.634)
238	−6.850***	(0.390)	−5.704***	(0.983)	−4.787***	(0.525)
240	−6.734***	(0.437)	−6.118***	(0.481)	−5.630***	(0.286)
242	−5.878***	(0.339)	−5.333***	(1.063)	−3.962***	(0.799)
244	−7.372***	(0.484)	-	-	−6.393***	(0.308)
246	−6.914***	(0.401)	-	-	−6.096***	(0.297)
248	−7.548***	(0.389)	−7.669***	(0.401)	−7.046***	(0.293)
250	−6.226***	(0.401)	−6.588***	(0.483)	−5.461***	(0.296)
252	−6.371***	(0.396)	−6.455***	(0.468)	−5.298***	(0.403)
254	−5.905***	(0.399)	−5.882***	(0.496)	−4.536***	(0.305)
256	−5.836***	(0.405)	−5.805***	(0.460)	−3.060***	(1.054)
258	−6.040***	(0.413)	−5.809***	(0.474)	−4.719***	(0.279)
260	−6.375***	(0.384)	−6.268***	(0.487)	−5.518***	(0.302)
300	−4.141***	(0.363)	−4.277***	(0.414)	−3.616***	(0.247)
400	−5.654***	(0.356)	−5.749***	(0.465)	−5.251***	(0.278)
500	−5.632***	(0.431)	−5.538***	(0.447)	−1.568	(2.151)
501	−5.850***	(0.420)	−6.718***	(0.637)	−5.850***	(0.347)
502	−6.272***	(0.447)	−6.406***	(0.518)	−5.657***	(0.326)
503	−7.060***	(0.725)	-	-	−5.669***	(0.301)
504	−6.321***	(0.457)	-	-	−5.441***	(0.313)
505	−6.062***	(0.433)	-	-	−6.237***	(0.357)
506	−7.300***	(0.682)	−6.387***	(0.472)	−5.909***	(0.341)
507	−5.658***	(0.395)	−6.398***	(0.515)	−5.181***	(0.311)
508	−6.709***	(0.494)	-	-	−5.572***	(0.307)
509	−6.302***	(0.447)	−6.375***	(0.503)	−5.766***	(0.382)
510	−5.658***	(0.393)	−6.125***	(0.516)	−4.884***	(0.290)
511	−4.757***	(0.396)	−4.541***	(0.433)	−3.909***	(0.258)
728	−5.727***	(0.697)	−5.519***	(1.255)	−4.371***	(0.885)
730	−5.880***	(0.491)	−4.923***	(1.418)	−4.454***	(1.173)
732	−6.241***	(0.440)	−6.693***	(0.580)	−6.300***	(0.474)

Note: Site numbers denote Wildlife Management Unit (WMU) numbers in Alberta. 79 sites would have been visited in 2018 and 2020 surveys while 72 sites would have been visited in 2019 survey. Standard errors computed using 50 multivariate normal draws are in parenthesis. ***, ** and * denote statistical significance at the 1%, 5% and 10% level respectively.

Table 4.B.2: Translation Parameters (γ_j)

	2018		2019		2020	
Site	**Estimate**	**Std.err**	**Estimate**	**Std.err**	**Estimate**	**Std.err**
102	3.479***	(0.766)	2.896***	(0.738)	2.787***	(0.687)
104	4.720***	(1.469)	3.147***	(0.865)	2.757***	(0.881)
106	6.231*	(3.501)	6.285**	(2.700)	7.502***	(2.959)
108	4.661***	(0.935)	4.305***	(0.999)	4.403***	(0.707)
110	4.120***	(1.449)	4.586***	(1.174)	3.109***	(1.100)
112	4.719***	(1.553)	7.016***	(3.225)	5.635**	(2.955)
116	4.217***	(1.154)	5.648***	(1.849)	4.405***	(1.233)
118	3.034***	(0.741)	3.761***	(0.744)	4.257***	(0.848)
119	5.663***	(1.631)	3.989***	(1.155)	4.653***	(0.913)
124	6.789***	(2.441)	4.216***	(1.405)	6.027***	(2.038)
128	5.379*	(3.008)	9.532*	(5.660)	5.152**	(2.468)
130	4.637***	(1.268)	6.602	(6.141)	4.649***	(1.636)
132	4.221***	(1.822)	2.280***	(0.961)	2.224***	(0.601)
134	2.891*	(1.594)	4.208	(2.570)	3.173***	(1.007)
136	3.822***	(1.449)	7.933	(5.115)	3.614***	(1.425)
138	4.442	(4.623)	2.799	(1.862)	2.641	(1.884)
140	7.161	(6.048)	-	-	7.535	(9.037)
142	6.463	(4.595)	3.375	(3.083)	6.618**	(2.671)
144	9.329**	(4.754)	2.679**	(1.182)	4.919	(1.746)
148	4.207***	(0.809)	3.798***	(0.717)	3.355***	(0.571)
150	3.305***	(0.911)	4.183***	(1.048)	2.498***	(0.466)
151	3.603***	(0.668)	3.016***	(0.707)	2.350***	(0.301)
152	3.905***	(0.628)	3.084***	(0.551)	3.794***	(0.610)
156	5.228***	(1.317)	6.135***	(2.192)	3.771***	(0.728)
158	3.289***	(0.827)	4.066**	(1.594)	3.617***	(0.739)
160	4.354***	(1.046)	5.715***	(2.198)	4.087***	(0.696)
162	3.117***	(0.794)	3.941***	(0.866)	2.640***	(0.792)
163	3.468***	(0.756)	3.518***	(0.678)	3.316***	(0.497)
164	3.300***	(1.019)	2.469***	(0.752)	3.121***	(0.564)
166	5.174***	(1.247)	3.626***	(0.815)	5.359***	(0.859)
200	3.267***	(0.776)	3.765***	(0.721)	3.554***	(0.444)
202	3.119***	(0.600)	2.767***	(0.760)	5.085***	(0.739)
203	4.307***	(1.324)	5.166***	(1.752)	3.921***	(0.766)
204	3.681***	(0.938)	7.313***	(2.079)	4.308***	(0.911)
206	4.184***	(1.188)	6.431*	(3.539)	4.221***	(0.958)
208	5.242***	(0.860)	4.242***	(1.167)	3.903***	(0.776)
210	9.568	(5.915)	8.124**	(3.728)	5.704***	(1.721)
212	7.887**	(3.589)	7.130*	(4.072)	4.980**	(2.289)
214	8.055***	(2.316)	7.139*	(3.454)	6.860***	(1.672)
216	10.677***	(3.219)	4.076*	(2.239)	7.186***	(2.522)

	2018		2019		2020	
Site	**Estimate**	**Std.err**	**Estimate**	**Std.err**	**Estimate**	**Std.err**
220	8.909***	(1.881)	6.509***	(2.440)	6.914***	(1.389)
221	7.438***	(3.602)	11.650***	(3.611)	4.667**	(1.947)
222	10.622***	(4.050)	11.132***	(6.323)	12.935***	(4.732)
224	9.041***	(3.000)	5.435**	(2.442)	5.086***	(1.858)
226	7.445***	(2.645)	10.405***	(6.778)	12.069***	(3.506)
228	6.833***	(1.476)	3.212***	(1.311)	5.182***	(0.899)
230	5.038***	(1.315)	5.144***	(1.804)	7.472***	(1.385)
232	3.803***	(0.920)	4.510***	(1.212)	4.782***	(0.743)
234	3.748***	(0.601)	5.323***	(1.133)	4.616***	(0.617)
236	4.563***	(1.117)	4.736***	(1.695)	5.737***	(1.055)
238	3.794***	(1.191)	4.158	(2.823)	6.456***	(1.247)
240	8.167*	(4.413)	10.920***	(3.469)	6.452***	(2.290)
242	6.175***	(1.208)	7.666**	(3.490)	9.848***	(2.061)
244	4.963*	(2.762)	-	-	9.163**	(4.342)
246	2.485*	(1.290)	-	-	6.712***	(2.538)
248	4.447***	(1.684)	9.471**	(4.411)	9.815***	(3.304)
250	6.872***	(2.007)	6.620*	(3.580)	5.614***	(1.308)
252	5.234**	(2.035)	8.612**	(3.920)	8.155**	(3.944)
254	8.711***	(2.757)	9.167*	(5.040)	6.850***	(1.399)
256	4.117***	(1.459)	4.154**	(1.803)	3.985***	(0.937)
258	4.894**	(2.307)	7.347***	(2.743)	6.891***	(1.407)
260	5.595*	(3.144)	7.133*	(3.672)	10.25 ***	(3.730)
300	3.628***	(0.494)	5.127***	(0.782)	3.271***	(0.379)
400	5.986***	(1.490)	4.363***	(1.263)	4.667***	(1.297)
500	5.037***	(1.915)	6.367***	(2.716)	8.437***	(2.627)
501	8.301***	(3.170)	8.990	(8.037)	11.034**	(5.486)
502	2.174**	(1.126)	7.053	(6.607)	12.619***	(4.169)
503	2.768	(4.202)	-	-	2.698*	(1.400)
504	2.264**	(1.115)	-	-	6.598**	(2.893)
505	3.792*	(2.143)	-	-	3.651	(4.470)
506	5.711	(6.790)	11.471*	(6.836)	4.114	(4.140)
507	9.329***	(3.055)	6.361	(5.969)	6.828**	(3.050)
508	5.574	(3.500)	-	-	4.890**	(2.353)
509	3.225	(3.082)	3.238	(3.153)	3.582	(3.338)
510	6.207***	(2.307)	8.023	(6.101)	2.363***	(0.689)
511	2.248***	(0.619)	3.936***	(1.398)	2.973***	(0.683)
728	1.661***	(0.442)	2.748*	(1.547)	2.237***	(0.687)
730	1.537***	(0.459)	2.219	(1.792)	4.188	(2.819)
732	3.644*	(1.956)	1.650	(1.335)	2.252	(2.759)

Note: Site numbers denote Wildlife Management Unit (WMU) numbers in Alberta. 79 sites would have been visited in 2018 and 2020 surveys while 72 sites would have been visited in 2019 survey. Standard errors computed using 50 multivariate normal draws are in parenthesis. ***, ** and * denote statistical significance at the 1%, 5% and 10% level respectively.

Appendix 4.C Welfare Estimates of Site Closures

Table 4.C.1: Welfare Estimates (CAD$) Per Trip Per Person of Site Closures

	2018			2019			2020		
Site	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**
102	-3.00	-3.89	-2.18	-5.92	-7.79	-4.33	-2.10	-2.57	-1.57
104	-0.50	-0.71	-0.33	-1.69	-2.54	-1.09	-0.44	-0.67	-0.25
106	-0.29	-0.47	-0.12	-0.27	-0.43	-0.10	-0.14	-0.25	-0.08
108	-2.10	-2.90	-1.59	-1.73	-2.39	-1.32	-1.32	-1.51	-1.17
110	-0.50	-0.68	-0.33	-1.37	-1.99	-0.93	-0.59	-0.76	-0.43
112	-0.38	-0.57	-0.23	-0.27	-0.43	-0.17	-0.08	-0.15	-0.03
116	-1.10	-1.44	-0.69	-1.02	-1.49	-0.64	-0.86	-1.07	-0.69
118	-2.57	-3.45	-1.86	-6.04	-7.56	-4.65	-2.63	-3.14	-2.26
119	-0.62	-0.87	-0.44	-1.72	-2.34	-0.95	-1.19	-1.55	-0.89
124	-0.37	-0.50	-0.28	-1.03	-1.33	-0.70	-0.23	-0.37	-0.12
128	-0.06	-0.11	-0.03	-0.14	-0.21	-0.07	-0.12	-0.21	-0.06
130	-0.32	-0.46	-0.21	-0.12	-0.23	-0.06	-0.13	-0.21	-0.06
132	-0.28	-0.41	-0.15	-0.41	-0.67	-0.21	-0.42	-0.65	-0.26
134	-0.38	-0.72	-0.14	-0.20	-0.35	-0.07	-0.45	-0.61	-0.30
136	-0.27	-0.39	-0.16	-0.28	-0.48	-0.17	-0.44	-0.58	-0.25
138	-0.13	-0.31	-0.04	-0.54	-0.85	-0.24	-0.06	-0.12	-0.02
140	-0.14	-0.36	-0.03	-	-	-	-0.03	-0.09	-0.01
142	-0.07	-0.15	-0.03	-0.43	-0.94	-0.09	-0.16	-0.31	-0.06
144	-0.06	-0.13	-0.03	-0.80	-1.13	-0.39	-0.15	-0.29	-0.06
156	-0.76	-1.08	-0.52	-0.55	-0.75	-0.35	-0.62	-0.79	-0.43
158	-1.74	-2.33	-1.33	-0.87	-1.36	-0.52	-1.06	-1.36	-0.73
160	-1.91	-2.53	-1.38	-1.30	-1.92	-0.93	-2.15	-2.59	-1.80
162	-1.70	-2.39	-1.19	-2.07	-3.01	-1.23	-0.76	-0.99	-0.55
164	-1.70	-2.54	-1.17	-1.41	-2.34	-0.81	-1.74	-2.15	-1.24
166	-1.20	-1.53	-0.81	-2.80	-3.96	-2.16	-2.02	-2.52	-1.57
203	-1.10	-1.69	-0.72	-1.44	-1.97	-1.05	-1.57	-1.97	-1.33
204	-1.47	-2.11	-1.13	-0.93	-1.36	-0.66	-1.05	-1.39	-0.77
206	-0.73	-1.03	-0.49	-0.19	-0.46	-0.06	-0.55	-0.74	-0.44
208	-1.90	-2.24	-1.52	-1.80	-2.39	-1.32	-1.37	-1.75	-1.06
210	-0.13	-0.22	-0.06	-0.33	-0.46	-0.21	-0.48	-0.63	-0.34
212	-0.07	-0.12	-0.04	-0.11	-0.19	-0.05	-0.03	-0.05	-0.01
214	-0.54	-0.75	-0.33	-0.26	-0.37	-0.14	-0.41	-0.53	-0.29

	2018			2019			2020		
Site	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**
216	-0.22	-0.32	-0.15	-0.12	-0.21	-0.06	-0.22	-0.34	-0.14
220	-0.73	-0.94	-0.55	-0.53	-0.82	-0.31	-0.77	-0.96	-0.58
221	-0.09	-0.13	-0.04	-0.27	-0.38	-0.16	-0.15	-0.25	-0.09
222	-0.11	-0.19	-0.07	-0.05	-0.09	-0.03	-0.25	-0.35	-0.17
224	-0.33	-0.49	-0.21	-0.28	-0.47	-0.17	-0.28	-0.38	-0.19
226	-0.09	-0.14	-0.06	-0.12	-0.24	-0.05	-0.23	-0.30	-0.17
228	-0.95	-1.25	-0.72	-0.48	-0.74	-0.24	-0.73	-0.94	-0.52
230	-0.96	-1.39	-0.61	-0.52	-0.90	-0.32	-0.90	-1.12	-0.72
232	-0.73	-0.98	-0.51	-0.71	-1.08	-0.49	-1.49	-1.74	-1.27
238	-0.18	-0.24	-0.13	-0.52	-0.96	-0.20	-0.97	-1.16	-0.78
240	-0.23	-0.42	-0.11	-0.57	-0.86	-0.40	-0.27	-0.38	-0.15
242	-1.09	-1.39	-0.85	-0.33	-0.60	-0.16	-0.63	-0.76	-0.52
244	-0.11	-0.20	-0.05	-	-	-	-0.08	-0.13	-0.04
246	-0.27	-0.46	-0.11	-	-	-	-0.15	-0.22	-0.08
248	-0.22	-0.30	-0.15	-0.12	-0.19	-0.07	-0.08	-0.11	-0.05
250	-0.63	-1.03	-0.43	-0.27	-0.54	-0.11	-0.53	-0.69	-0.39
252	-0.31	-0.45	-0.19	-0.29	-0.47	-0.11	-0.15	-0.23	-0.08
254	-0.88	-1.24	-0.63	-1.39	-2.07	-0.80	-0.99	-1.24	-0.79
256	-0.57	-0.91	-0.33	-0.51	-0.76	-0.24	-1.23	-1.51	-0.95
258	-0.58	-1.10	-0.24	-1.03	-1.47	-0.65	-1.08	-1.37	-0.82
260	-0.31	-0.53	-0.16	-0.42	-0.69	-0.18	-0.29	-0.38	-0.17
300	-18.31	-21.01	-14.70	-18.00	-21.03	-14.68	-9.99	-11.26	-8.63
400	-1.72	-2.36	-1.05	-2.45	-3.27	-1.88	-1.06	-1.38	-0.78
500	-0.58	-0.86	-0.32	-0.82	-1.20	-0.54	-0.55	-0.78	-0.36
501	-0.14	-0.23	-0.09	-0.03	-0.06	-0.01	-0.03	-0.05	-0.02
502	-0.40	-0.65	-0.19	-0.24	-0.47	-0.08	-0.08	-0.12	-0.05
503	-0.23	-0.73	-0.02	-	-	-	-0.27	-0.43	-0.13
504	-0.21	-0.46	-0.10	-	-	-	-0.19	-0.35	-0.08
505	-0.52	-0.82	-0.20	-	-	-	-0.11	-0.22	-0.04
506	-0.05	-0.14	-0.01	-0.36	-0.62	-0.17	-0.19	-0.33	-0.09
507	-0.90	-1.33	-0.60	-0.24	-0.41	-0.10	-0.30	-0.42	-0.17
508	-0.22	-0.35	-0.09	-	-	-	-0.16	-0.25	-0.09
509	-0.18	-0.45	-0.05	-0.56	-1.59	-0.19	-0.10	-0.18	-0.05
510	-0.91	-1.36	-0.52	-0.42	-0.82	-0.17	-0.65	-1.06	-0.40
511	-2.51	-3.46	-1.63	-4.99	-7.03	-3.08	-3.89	-5.04	-2.91
732	-0.74	-1.24	-0.40	-0.23	-0.45	-0.06	-0.07	-0.16	-0.02

Note: Site numbers denote Wildlife Management Unit (WMU) numbers in Alberta. Welfare estimates per person are calculated by averaging welfare estimates over the whole sample for each survey. Low and high are 95% confidence intervals of the mean estimates calculated from 30 simulations with 50 individual conditional error draws.

Table 4.C.2: Welfare Estimates (CAD$) Per Trip Per Participant of Site Closures

	2018			2019			2020		
Site	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**
102	-94	-122	-68	-194	-255	-142	-102	-125	-76
104	-43	-61	-28	-68	-102	-44	-66	-101	-37
106	-46	-76	-19	-39	-63	-15	-32	-55	-18
108	-52	-72	-39	-43	-59	-32	-42	-48	-37
110	-36	-49	-24	-48	-70	-33	-73	-94	-54
112	-29	-43	-18	-22	-34	-14	-23	-43	-10
116	-52	-68	-33	-56	-83	-36	-47	-58	-38
118	-85	-114	-61	-118	-148	-91	-98	-117	-84
119	-30	-41	-21	-80	-109	-44	-74	-96	-55
124	-34	-46	-26	-46	-59	-31	-43	-69	-22
128	-16	-29	-6	-25	-38	-13	-45	-79	-21
130	-21	-29	-13	-26	-51	-13	-24	-38	-12
132	-30	-44	-16	-51	-84	-26	-37	-58	-23
134	-69	-132	-26	-35	-62	-12	-50	-68	-33
136	-38	-56	-22	-42	-71	-25	-62	-81	-35
138	-84	-200	-25	-79	-125	-36	-32	-65	-10
140	-89	-230	-20	-	-	-	-69	-192	-20
142	-14	-32	-7	-125	-276	-27	-50	-98	-20
144	-20	-43	-9	-71	-100	-34	-33	-65	-14
156	-29	-42	-20	-30	-41	-19	-34	-43	-24
158	-61	-81	-46	-64	-100	-38	-72	-92	-49
160	-57	-75	-41	-61	-89	-43	-65	-78	-54
162	-87	-123	-61	-87	-126	-52	-63	-82	-45
164	-78	-117	-54	-104	-173	-59	-71	-87	-50
166	-57	-73	-38	-63	-90	-49	-60	-75	-47
203	-74	-114	-49	-61	-83	-44	-63	-79	-53
204	-54	-78	-41	-36	-52	-25	-41	-53	-30
206	-45	-63	-30	-34	-80	-11	-49	-67	-39
208	-57	-67	-45	-57	-75	-41	-50	-64	-39
210	-34	-56	-15	-33	-45	-21	-38	-50	-27
212	-10	-17	-5	-9	-17	-5	-14	-24	-5
214	-28	-39	-17	-21	-30	-11	-27	-35	-19

	2018			2019			2020		
Site	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**
216	-20	-29	-14	-21	-38	-10	-29	-45	-18
220	-25	-33	-19	-36	-56	-21	-26	-32	-19
221	-16	-24	-7	-20	-28	-12	-19	-33	-12
222	-16	-27	-10	-23	-41	-11	-46	-65	-33
224	-26	-39	-17	-21	-34	-12	-30	-41	-20
226	-17	-26	-11	-105	-216	-44	-31	-39	-22
228	-39	-52	-30	-43	-65	-21	-28	-36	-20
230	-42	-62	-27	-46	-79	-28	-32	-40	-25
232	-36	-49	-25	-45	-68	-31	-40	-47	-34
238	-15	-20	-11	-57	-106	-22	-42	-50	-33
240	-37	-67	-17	-42	-64	-29	-32	-45	-18
242	-35	-45	-27	-29	-53	-14	-31	-38	-26
244	-35	-65	-17	-	-	-	-25	-42	-14
246	-38	-65	-16	-	-	-	-26	-38	-14
248	-22	-30	-15	-13	-21	-8	-12	-17	-7
250	-48	-78	-32	-40	-79	-16	-47	-62	-35
252	-33	-48	-20	-42	-69	-16	-29	-43	-15
254	-51	-73	-37	-102	-153	-59	-42	-53	-33
256	-40	-65	-24	-45	-67	-21	-62	-76	-48
258	-58	-109	-24	-83	-118	-53	-47	-59	-35
260	-56	-97	-29	-62	-101	-26	-53	-70	-32
300	-167	-191	-134	-153	-179	-125	-135	-153	-117
400	-69	-95	-42	-94	-125	-72	-108	-140	-79
500	-44	-65	-24	-60	-88	-40	-62	-88	-41
501	-18	-29	-12	-13	-27	-3	-15	-24	-7
502	-74	-119	-34	-71	-138	-24	-19	-29	-12
503	-296	-942	-22	-	-	-	-86	-139	-42
504	-54	-119	-25	-	-	-	-43	-77	-19
505	-66	-106	-26	-	-	-	-81	-166	-29
506	-65	-179	-18	-79	-136	-37	-84	-147	-42
507	-78	-114	-51	-69	-121	-30	-48	-68	-27
508	-71	-114	-28	-	-	-	-25	-41	-15
509	-57	-143	-17	-165	-468	-55	-54	-103	-26
510	-106	-159	-61	-94	-180	-38	-80	-131	-50
511	-154	-212	-100	-220	-310	-136	-223	-289	-167
732	-136	-227	-73	-100	-198	-26	-76	-175	-19

Note: Site numbers denote Wildlife Management Unit (WMU) numbers in Alberta. Welfare estimates per participant are calculated by averaging welfare estimates over respondents who would have taken at least 1 trip in each survey. Low and high are 95% confidence intervals of the mean estimates calculated from 30 simulations with 50 individual conditional error draws.

Appendix 4.D Robustness Checks with Joint RP-CB Data in KT Models

Table 4.D.1: Average Number of Trips Per Participant under RP and CB Scenarios

Scenario	**RP**	**October**	**December**	**Extra tags**	**Gift cards**
Season length	*30 days*	*37 days*	*47 days*	*30 days*	*30 days*
2018 survey	**8.51**	**9.40**	**11.13**	**7.24**	**6.44**
	(636)	(214)	(238)	(208)	(202)
2019 survey	**9.35**	**9.10**	**11.19**	**7.79**	**8.08**
	(328)	(148)	(163)	(131)	(130)
2020 survey	**9.97**	**9.71**	**11.93**	**7.40**	**8.00**
	(872)	(387)	(413)	(304)	(330)

Note: Average numbers of trips per person are in bold. Numbers of respondents are in brackets. Unrealistically large trip numbers are adjusted to be consistent with the allowable hunting days (with 30 days maximum) in all scenarios.

Table 4.D.2: Selected Kuhn-Tucker Model Parameter Estimates (Joint RP and CB)

	2018	**2019**	**2020**
Baseline marginal utility parameters (β_j)			
CWD	−6.075	−11.834	−10.295
	(8.477)	(9.546)	(7.576)
October scenario	0.272***	0.205***	0.220***
	(0.044)	(0.070)	(0.039)
December scenario	0.380***	0.274***	0.280***
	(0.048)	(0.060)	(0.041)
Extra tags scenario	0.632***	0.654***	0.688***
	(0.065)	(0.093)	(0.050)
Gift cards scenario	0.331***	0.272**	0.445***
	(0.086)	(0.106)	(0.056)
Extended season	−0.123***	−0.194***	−0.148***
	(0.047)	(0.063)	(0.033)
RP	0.334***	0.258***	0.347***
	(0.042)	(0.063)	(0.037)
College	−0.027	−0.011	−0.043
	(0.040)	(0.044)	(0.027)
Urban	0.058	0.056	0.033
	(0.045)	(0.044)	(0.024)
Children	−0.120**	−0.113*	−0.069*
	(0.050)	(0.061)	(0.039)
Years of hunt	−0.012	0.023	−0.014*
	(0.015)	(0.015)	(0.008)
Satiation parameter (α)	0.158***	0.182***	0.246***
	(0.022)	(0.037)	(0.017)
Scale parameter (σ)	0.567***	0.552***	0.546***
	(0.010)	(0.012)	(0.008)
Number of observations	1921	1211	3108
Number of respondents	636	330	873
Log-likelihood	-20519.14	-12403.07	-31528.47

Note: This table reports selected estimates for KT model parameters with RP and CB data. The specification is the same as the model in Table 4.4 except that RP coefficient is for a dummy variable that captures the difference between RP and CB data.
Standard errors computed using 50 multivariate normal draws are in parenthesis. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level respectively.

Table 4.D.3: Welfare Estimates (CAD$) Per Trip of Closing Selected Sites (Joint RP and CB)

Per person

(i.e. averaging over all respondents in each survey)

	2018			2019			2020		
Site	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**
148	-2.40	-2.80	-1.89	-3.71	-4.79	-3.06	-2.40	-2.87	-2.13
150	-3.03	-3.98	-2.51	-4.01	-5.12	-2.75	-2.50	-3.00	-2.04
151	-4.92	-6.16	-3.95	-3.40	-4.09	-2.54	-4.40	-4.93	-3.84
152	-2.55	-3.10	-2.15	-3.32	-3.95	-2.35	-1.98	-2.26	-1.72
163	-3.65	-4.54	-2.93	-3.79	-4.71	-2.88	-3.14	-3.64	-2.69
200	-3.52	-4.25	-2.83	-7.25	-8.84	-5.67	-6.28	-7.07	-5.65
202	-3.16	-3.94	-2.58	-3.50	-4.49	-2.70	-3.55	-4.06	-3.12
234	-3.79	-4.36	-3.08	-4.38	-5.25	-3.45	-5.35	-6.09	-4.62
236	-1.40	-1.70	-1.12	-1.53	-2.03	-0.98	-2.08	-2.33	-1.70
728	-2.96	-3.76	-2.27	-0.32	-0.50	-0.12	-0.86	-1.14	-0.62
730	-1.76	-2.34	-1.25	-0.56	-0.98	-0.30	-0.12	-0.22	-0.05

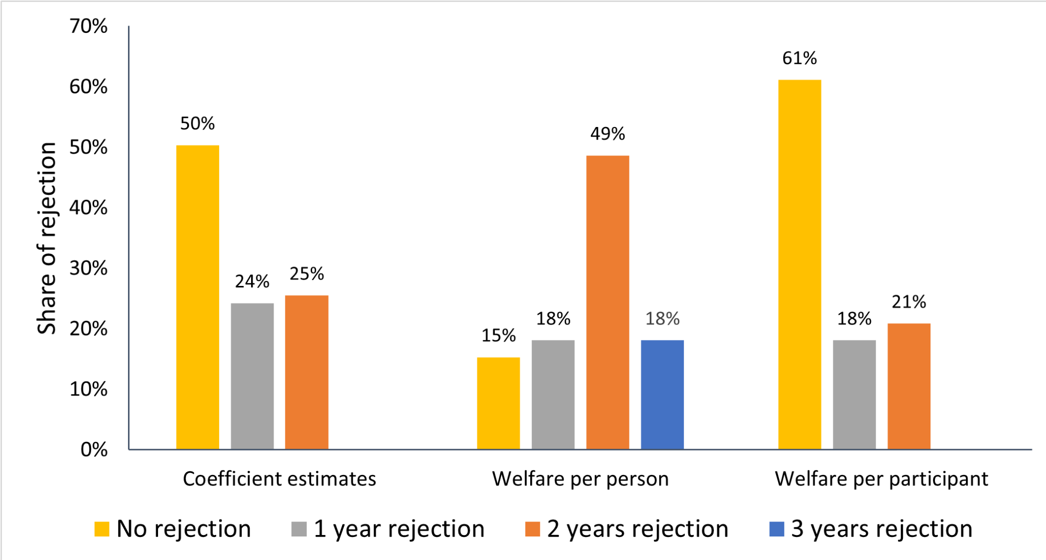
Per participant

(*i.e. averaging over respondents who would have taken at least 1 trip to the site in each survey)*

	2018			2019			2020		
Site	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**	**Mean**	**Low**	**High**
148	-59	-69	-47	-64	-83	-53	-56	-67	-50
150	-99	-130	-82	-88	-113	-61	-76	-91	-62
151	-99	-123	-79	-94	-113	-70	-96	-107	-83
152	-57	-69	-48	-57	-67	-40	-53	-60	-46
163	-106	-132	-85	-96	-119	-73	-92	-107	-79
200	-93	-112	-75	-99	-120	-77	-95	-107	-86
202	-72	-90	-59	-88	-113	-68	-70	-80	-62
234	-68	-78	-55	-74	-88	-58	-73	-83	-63
236	-39	-47	-31	-74	-98	-47	-56	-63	-46
728	-90	-115	-69	-48	-75	-18	-96	-126	-68
730	-130	-173	-92	-113	-199	-60	-75	-139	-32

Note: This table reports the average welfare estimates per trip of closing sites (one at a time) with high CWD prevalence and all CB scenarios applied. Welfare estimates per person are calculated by averaging welfare estimates over the whole sample for each survey. Welfare estimates per participant are calculated by averaging welfare estimates over respondents who would have taken at least 1 trip to corresponding sites in each survey. Low and high are 95% confidence intervals of the mean estimates calculated from 30 simulations with 50 individual conditional error draws.

Figure 4.D.1: Percentage of Temporally Reliable Coefficient and Welfare Estimates (Joint RP and CB)



Appendix 4.E Contingent Behavior Scenario Screenshots

Figure 4.E.1: October Season Expansion Scenario Example in Surveys

Potential Hunting Policy Scenario

Expanding the hunting seasons for one week into October:

- Prairie WMUs 100 Series (except 162, 163, 164, 166), marked in dark green on the map:

  Wednesday to Saturday in **the last week of October** and November (**Oct.25** – Nov.30)

- Parkland WMUs 200 Series; WMU 162, 163, 164, 166; WMU 500, marked in light green on the map:

  Oct.23 – Nov.30

If the hunting policies were described as above, you may have changed the number of trips that you took in 2017 in November and in the extended season in October. How many BIG GAME hunting trips do you think you would have taken if the hunting policies included an extended season? Please fill in the table below for **October** AND **November**.

1. During the extended hunting season in **October** of 2017, how many hunting trips **would you have taken** and how many deer would you have harvested in each WMU?
2. During the regular hunting season in **November** of 2017, how many hunting trips **would you have taken** and how many deer would you have harvested in each WMU?

In considering your responses, please assume that any features about the hunting trips that are not mentioned such as associated expenditures and CWD prevalence in WMUs are the same as your 2017 experience.

Figure 4.E.2: December Season Expansion Scenario Example in Surveys

Potential Hunting Policy Scenario

Expanding the hunting seasons into December in:

- Prairie WMUs 100 Series (except 162, 163, 164, 166), marked in dark green on the map:

  Wednesday to Saturday in November and **December** (Nov.1 – **Dec.17**)

- Parkland WMUs 200 Series; WMU 162, 163, 164, 166; WMU 500, market in light green on the map:

  Nov.1 – **Dec.17**

You can purchase *an extra tag* if you decide to hunt in extended seasons.

If the hunting policies were described as above, you may have changed the number of trips that you took in 2017 in November and in the extended season in December. How many BIG GAME hunting trips do you think you would have taken if the hunting policies included an extended season? Please fill in the table below for **November** AND **December**.

1. During the regular hunting season in **November** of 2017, how many hunting trips **would you have taken** and how many deer would you have harvested in each WMU?
2. During the extended hunting season in **December** of 2017, how many hunting trips **would you have taken** and how many deer would you have harvested in each WMU?

In considering your responses, please assume that any features about the hunting trips that are not mentioned such as associated expenditures and CWD prevalence in WMUs are the same as your 2017 experience.

Figure 4.E.3: Extra Hunting Tags Scenario Example in Surveys

Potential Hunting Policy Scenario

When you win a special licence draw for WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you can purchase two tags for mule deer instead of one for the current hunting season.

Figure 4.E.4: Gift Cards Scenario Example in Surveys

Potential CWD Management Scenario

For each <u>CWD-positive</u> head you submit from WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you will get a gift card valued at $50 at a popular hunting store.

For each <u>CWD-negative</u> head you submit from WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you will get a gift card valued at $30 at a popular hunting store.

The number of heads you submit cannot exceed the number of tags you have.

Figure 4.E.5: October/December Season Expansion Response Table Example in Surveys

EXTENDED HUNTING SEASON TRIPS (OCTOBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during *the extended hunting season (i.e. October) in 2017* under the scenario above.

	Number of trips you would have taken in *October* of 2017 under the scenario above	Average number of days you would have spent in *October* of 2017 under the scenario above	Number of deer you would have harvested in *October* of 2017 under the scenario above
WMU			
WMU			
WMU			
WMU			
WMU			

REGULAR HUNTING SEASON TRIPS (NOVEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *regular hunting season (i.e. November) in 2017* under the scenario above.

	Number of trips you would have taken in 2017 under the scenario above	Average number of days per trip you would have spent in 2017 under the scenario above	Number of deer you would have harvested in 2017 under the scenario above
WMU			
WMU			
WMU			
WMU			
WMU			

Figure 4.E.6: Extra Tags/Gift Cards Response Table Example in Surveys

If the hunting policies were described as above, how many BIG GAME hunting trips would you have taken and how many deer would you have harvested in 2017 in each WMU? In considering your responses, please assume that any features about the hunting trips not mentioned (such as associated expenditures and CWD prevalence) are the same as your 2017 experience.

Please complete the table indicating all the BIG GAME hunting trips by WMU you would have taken in 2017 under the scenario above.

	Number of trips you would have taken in 2017 under the scenario above	**Average number of days per trip you would have spent in 2017 under the scenario above**	**Number of deer you would have harvested in 2017 under the scenario above**
WMU			
WMU			
WMU			
WMU			
WMU			

Chapter 5

Conclusion

This thesis is comprised of three studies that examine non-market behavior involving environmental resources and various incentives to generate socially desirable outcomes. The empirical application of the thesis is to study the behavioral and welfare impacts of the presence of a potentially zoonotic wildlife disease and incentive programs to engage recreational hunters in disease control.

Using different empirical approaches, this thesis presents the following three key findings that provide insights into designing effective policy tools for the management of a wildlife disease (Chronic Wasting Disease, CWD), and broader implications for the use of incentives in other contexts, such as infectious disease control and pandemics.

Key Finding 1: Incentives associated with time choices are effective in encouraging desirable behavioral outcomes, when people's activities involve location and time.

Individuals often choose locations and time periods for their activities such as restaurant visits and recreation trips. When they are offered opportunities to choose the time periods of the activities more flexibly, like the extended recreation seasons for controlling the wildlife disease in the first paper, individuals are found to change behavior and obtain welfare benefits. To achieve this finding in the first paper, I extend a discrete-continuous recreation demand model by incorporating spatial and temporal decisions and estimate the model with RP and SP data from an online survey to recreational hunters. For the control of CWD, this finding provides evidence that extended recreation seasons can be used to encourage hunting trips to reduce the prevalence and the spread of the disease. In general, this finding suggests that allowing for more flexibility in deciding the timing of activities can be used as an incentive.

Key Finding 2: In a specific context, incentives and behavioral nudges have different behavioral responses from groups with various levels of experience and knowledge about the context.

Since individuals have different experience with various contexts, the motivations that result in behavioral responses to incentives are likely divergent – this affects the effectiveness of incentives and behavioral nudges on generating desirable outcomes. In the second paper, in the context of recreational hunting, while pro-social information is found to have the same impacts on students and recreational hunters, monetary incentives and removal of incentives result in different behavioral outcomes in students and recreational hunters. I arrive at this finding by developing a theoretical framework of motivational crowding and testing the theorized predictions in a multiple threshold public goods game implemented to students and recreational hunters. For CWD management, this finding shows that pro-social information and fixed monetary rewards are effective to increase contributions of recreational hunting trips to the public benefit of healthy wildlife populations. Broadly regarding the use of incentives to encourage private provision of public goods, this finding draws attention to the differences in behavioral responses to incentives from different groups of individuals.

Key Finding 3: Contingent behavior (CB) data and Kuhn-Tucker (KT) recreation demand models provide temporally reliable insights into behavioral and welfare impacts of incentives.

Although contingent behavior data, by collecting information about intended behavior under hypothetical scenarios, is a popular data source for recreation demand models, its temporal reliability – a measurement of accuracy of the non-market valuation methods – has not been examined in KT recreation demand models. In the third paper, I find that KT models with CB data generate results that are reliable or consistent over time. This finding is obtained by estimating separate KT models with CB datasets from three surveys to understand recreational hunters' behavioral responses to incentives, constructing welfare measures of site closures, and testing the consistency of coefficient and welfare estimates across models. For curbing CWD, this finding adds confidence for wildlife managers on assessing behavioral and welfare impacts of incentives on recreational hunters. Generally, this finding suggests that researchers and policy makers could rely on CB data and apply KT models to datasets from multiple years.

With the key findings, the research in this thesis contribute to the literature from various perspectives. From the methodological perspective, this thesis contributes to recreation demand studies by extending a KT model and showing the temporal reliability of estimates from KT model. The thesis also adds confidence in using CB methods as a non-market valuation approach. This research adds values to experimental economics literature through designing a multiple threshold impure public goods game and showing differences between students and non-students in the same experimental setting. Regarding the use of incentives, this thesis provides conceptual insights and empirical evidence by drawing attention to temporal flexibility incentives and heterogeneous responses from different groups of individuals.

This thesis provides many insights into topics for further investigation on empirical approaches and policy implementation. With similar Kuhn-Tucker recreation demand models and online surveys, the first and third papers could be extended in several areas in modeling and sampling techniques as outlined in Lupi et al. (2020). For modeling techniques, it would be useful to incorporate preference heterogeneity. As individuals with the same characteristics can behave differently even in the same situation (e.g. choice sets, attributes), accounting for heterogeneity can address bias in model estimation and better evaluate the distribution of behavioral and welfare impacts. If heterogeneity is correlated with observed factors (e.g. demographics) or unobserved factors (error terms from researchers' perspective), assuming homogeneous preferences might result in biased coefficient and welfare estimates. A better understanding of the distribution of welfare impacts will help with policy and regulatory decisions. Preference heterogeneity can be incorporated in the following two aspects. First, capturing heterogeneous preferences with utility parameters through model specifications, such as interaction terms with site attributes and demographic variables for observed heterogeneity and latent class or random parameter KT models for unobserved heterogeneity (Lloyd-Smith, 2020a). However, larger datasets are necessary for such analyses because latent class or random parameter models add complications to model estimation. Second, accounting for heterogeneous values of travel time. As two recreation seasons (regular and extended) are discussed in the two papers, it is possible that individuals value the time differently during the two seasons. In these studies, this heterogeneity might be confounded with preferences towards the two seasons and potentially bias the welfare estimates. Individual values of travel time could be constructed through stated preference tasks of time valuation and random parameter logit models (Lloyd-Smith et al., 2020).

While the flexibility of the KT models and consideration of preference heterogeneity might improve model fit, model prediction (in-sample and/or out-of-sample predictions) also deserves further investigation, as an option to statistically validate the KT models. As KT models are not widely used in environmental economics, a comparison between KT models and repeated discrete choice models would add confidence for practitioners to apply KT models, even though the two types of models might not be directly comparable.

As the two papers collected data with online surveys, several limitations should be noted and further addressed. First, although all surveys used in the studies were based on random samples from a database of licensed hunters, the samples did not include individuals who stopped hunting the specific animals and therefore “left” the database. Inability to account for these individuals might result in a bias of the welfare measures. Second, even with the random samples, survey respondents participated voluntarily – a potential source of selection bias. These two limitations likely affect the representativeness of the samples. Given the existing survey approach, post-stratification raking could be used to address the issue of representativeness (Lupi et al., 2020) conditional on available information of populations. A third limitation is related to the validity of RP and SP methods. The RP data used in the first paper (and appendix to the third paper) could be subject to recall bias and RP practitioners could explore new data sources such as mobile phone records to capture or adjust for recall bias. On the other hand, SP/CB data used in the two papers could be subject to hypothetical bias. Although all angles of validity – criterion, construct, and content validity (Bishop and Boyle, 2017) – are not easily examined at once for any single CB dataset collected and hypothetical bias is challenging to detect with the surveys, it is worth considering in future studies. Loosely speaking, temporal reliability examined in the third study is a measure of convergent validity, although CB data from a repeated sample rather than distinct samples would be ideal. Another extension is to examine temporal convergent validity of estimates from *different* models with the same datasets used in the paper. Although there is no universal approach to address SP validity, SP practitioners could adapt findings from the active ongoing research for SP survey designs.

The second paper uses a different empirical approach yet concerns on its validity are worth noting. A controlled experimental setting in this study guarantees its interval validity but imposes threats to its external validity. First, this study is likely subject to selection bias, given a small sample of recreational hunters. Compared to the selection bias associated with surveys, selection bias in this paper is more challenging to address with ad-hoc econometrics or statistics tools. Second, the paper has a specific and applicable background and intends to examine field behavior with stylized treatments while findings were from a controlled environment in an experimental lab. It is unclear whether one would behave the same in the field as in the lab. To mitigate these threats, more framed field experiments and eventually field experiments should be conducted in the future. However, given the challenges associated with recruiting specific groups, either recreational hunters in this study or participants specific to other applications, attention should be paid to recruitment efforts and techniques for obtaining larger and more representative samples (Weigel et al., 2020). Another benefit of larger and more representative samples is to better examine preference heterogeneity as discussed above. In the second paper, heterogeneity may arise from differences in motivational crowding effects on individuals.

Altogether, for the empirical application of CWD management in these studies, several steps are necessary to provide stronger evidence for policy decisions. Within the field of environmental valuation, the research in this thesis examines the benefits of incentive programs. It is equally important to estimate associated costs for a benefit-cost analysis so that wildlife managers will have more information on trade-offs related to each incentive program. Moving beyond environmental valuation, economic models and insights from this thesis should be combined with epidemiological models using approaches such as bioeconomic models (Horan et al., 2011) because the interactions between humans and wildlife populations require interdisciplinary research for CWD management. The next step in examining the incentive programs considered in this thesis is to evaluate them in the field. As such, one of the steps before formally implementing these programs is a set of randomized controlled trials (RCT). With the data from RCT, economists could assess the economic impacts of incentive programs on recreational hunters and epidemiologists could assess the impacts of hunter harvest on the spread and prevalence of the wildlife disease.

Although this thesis focuses on recreational hunting and CWD management in Alberta, Canada, there are some broader considerations regarding the policy options for CWD management because CWD affects other Canadian provinces and various countries. As CWD prevalence levels remain relatively low in Alberta, recreational hunters are not found to be driven away by the disease and are motivated to hunt more by incentive programs examined in the research. However, if CWD prevalence reaches the point where it causes wildlife populations to decline (e.g. in Wyoming as in DeVivo et al. 2017), recreational hunters might reduce or stop hunting and will not be motivated by incentive programs. To evaluate the long-term impacts of CWD on hunters, interdisciplinary approaches with multi-year models and datasets are required to predict and evaluate the changes in CWD progression and hunting activities. In addition, this thesis focuses on the non-market impacts of incentive programs, yet the regional economic impacts on recreational hunting are worth noting. Beyond recreational hunters, in the long term, it is also important to examine how CWD influences other stakeholders such as outfitters who provide services of guided hunting for non-residents, and Indigenous People who heavily rely on wild game animals as a food source.

Apart from the impacts of the COVID-19 pandemic mentioned in the introduction of this thesis, the COVID-19 pandemic raises concerns about other zoonotic diseases (Naguib et al., 2020) that may or may not include CWD. These concerns might adversely affect hunters' motivations of contributing to CWD management. At the same time, these concerns highlight the potential of adapting insights in this thesis for combating the COVID-19 pandemic and other infectious or zoonotic diseases. Challenges and opportunities to examine human behavior and incentives continue to motivate research within and beyond environmental and resource economics.

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Supplementary Materials A
2018 Hunter Survey

Information Sheet

Deer Hunting in Alberta:
A Survey of Hunter Opinions

Study title: Deer Hunting in Alberta: A Survey of Hunter Opinions

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Background: We intend to collect information on recreational hunting activities from Albertan hunters to advise on wildlife management. Recreational hunting activities have been affected by the presence of Chronic Wasting Disease (CWD) and its management strategies. Therefore, it is necessary and important to know how you respond to the presence of CWD and how you will adjust behaviors when relevant management strategies change. The information you will provide in the survey can also help evaluate the potential to engage hunters in CWD management by harvesting additional deer.

Purpose: The purpose of this project is to determine Albertan hunters' opinions about the current deer hunting situation with a focus on issues associated with Chronic Wasting Disease in Alberta.

Study Procedures: We are conducting a survey done on computer in order to identify these opinions. The entire survey will take approximately about 30 minutes to complete. You will have a chance of winning one of two gift cards valued at $150 each for Cabela's.

The odds of winning will depend on the number of people who actually participate in the survey, but the approximate odds are 1/600.

Benefits: This information, once processed, will be shared with people in various levels of the government. They can use this to make better informed decisions about policies and management issues related to Chronic Wasting Disease in Alberta. We will also be able to do an economic analysis on the data to advise on better management of CWD to increase hunting satisfaction.

Risks: We do not anticipate any direct risks associated with participation. The one potential risk, albeit a very small one, is that the secure servers on which Qualtrics (our survey research software supplier) stores its data could face a breach. But this is very unlikely, and we will take every possible precaution to ensure that any information you provide is secure.

Confidentiality: All your responses will be kept completely confidential. By doing the survey on computer your answers are going to be recorded in a database on a server at the University of Alberta. Only the research team will have access to this database. Your answers will not be shared with anyone outside this group. Any reports or papers written will include only survey averages or similar measures; individual responses will not be reported nor will individuals be distinguishable.

Withdrawal from the Study: You are free to stop doing the survey at any time. Once you have completed the survey and submitted it however, we cannot remove the data from the database as it will be anonymous.

Use of your Information: This information will be used for a graduate student thesis, academic papers, and reports. This study is being funded by Genome Canada (a federal research agency). The project is not funded by any NGOs or hunting organizations. The results will be placed in reports which will be available to any organization or individual wishing to read it. The Government may use this information in their decision making process.

The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding

participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

I understand the purpose, risks, and benefits of this survey. By clicking below I agree to participate in the survey.

- ○ Agree
- ○ Disagree

Please note that once you advance by clicking "NEXT" you cannot go back and revise your answers.

Did you go hunting last year (2017)?

- ○ Yes
- ○ No

Section 1: Background Information

The following questions are meant to collect information regarding your deer hunting trips taken in Alberta and your opinions about wildlife resources in Alberta. Your answers will help us to understand preferences for hunting and create better wildlife management decisions.

How many years have you been deer hunting?

____

Which weapon(s) do you use to hunt deer? Please select all that apply.

- ☐ Rifle
- ☐ Cross bow

- ☐ Bow and arrow
- ☐ Shotgun
- ☐ Muzzleloader
- ☐ Other

What type of land do you typically hunt deer on in Alberta?

- ○ Private
- ○ Public / Crown
- ○ Both

What WMU would you list as your favorite WMU for mule deer hunting?

____

What kind of transportation do you usually use to access to hunting sites? Please select all that apply.

- ☐ Cars
- ☐ Off-highway Vehicles
- ☐ Trucks / pickup trucks
- ☐ RVs
- ☐ __________ Other (Please specify)

Please rate the following statements about quality deer hunting attributes on the scale of "Not at all important" to "Extremely important".

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
Having the thrill of hunting / adventure	○	○	○	○	○
Good access to the hunting area (e.g. paved roads and/or 2WD access)	○	○	○	○	○

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
Opportunity to harvest a mature animal	○	○	○	○	○
Harvesting a deer	○	○	○	○	○
Close proximity to overnight accommodation / camp thereby allowing multiple-day hunting trips	○	○	○	○	○
Seeing few other hunters and not being disturbed	○	○	○	○	○
Being far away from a city/town	○	○	○	○	○

Section 2: Hunting trips

In this next section we ask you to recall BIG GAME hunting trips that you personally took during 2017. Please recall as much information as possible and be as specific as possible. A map of WMUs and calendars are available.

Please complete the following tables for your 2017 BIG GAME hunting trips. You are asked to indicate the following:

1. Please write down each WMU and closest town/city or landmark where you hunted (Note: there are a WMU map and calendars below). For example, after listing WMUs, you could write down, Battle River near the Saskatchewan border or Paradise Valley. If you hunted in various places in the WMU, please choose a town or landmark most central to all the areas hunted in, or the most commonly visited area where you hunted.

2. Please write down the overall number of trips made to that WMU during the 2017 hunting season. Please note that if there were multiple destinations or overnight trips, the number of trips to that WMU may not equal the number of days spent there. A trip is defined as travel to and from a hunting site and may involve one or more days at a site.

3. Please indicate how many years you have previously hunted in that WMU. If this is your first season hunting there, please write 0.

4. Please write down the total number of each deer species and any other cervids (moose, elk) you harvested in that WMU. If you didn't harvest any, please write 0.

THIS IS AN EXAMPLE:
Please complete the following table for each WMU you went BIG GAME hunting in during the 2017 hunting season.

WMU you hunted in	Number of trips to the WMU	Average number of days per trip to the WMU	Nearest landmark or town to where you hunted	How many years have you previously hunted in this WMU?
151	5	1	Empress	1 year
256	3	2	Marwayne	10 years
164	1	10	Coronation	5 years

Please complete the following table for each WMU you went BIG GAME hunting in during the 2017 hunting season. A WMU map and calenders are below for reference.

		Number of trips to the WMU	Average number of days per trip to the WMU	Nearest landmark or town to where you hunted	How many years have you previously hunted in this WMU?	Harvest: Mule deer	Harvest: White-tailed deer	Harvest: Other cervids species (e.g. elk, moose)
WMU								
WMU								
WMU								

	Number of trips to the WMU	Average number of days per trip to the WMU	Nearest landmark or town to where you hunted	How many years have you previously hunted in this WMU?	Harvest: Mule deer	Harvest: White-tailed deer	Harvest: Other cervids species (e.g. elk, moose)
WMU							
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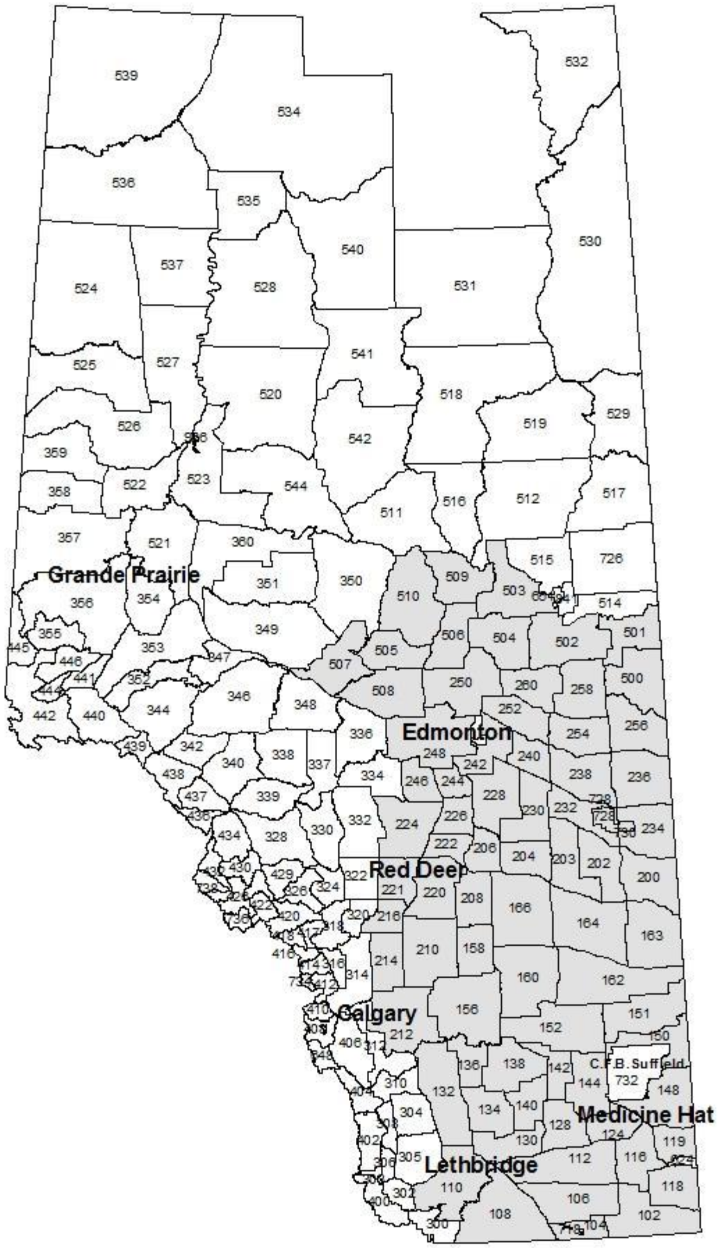
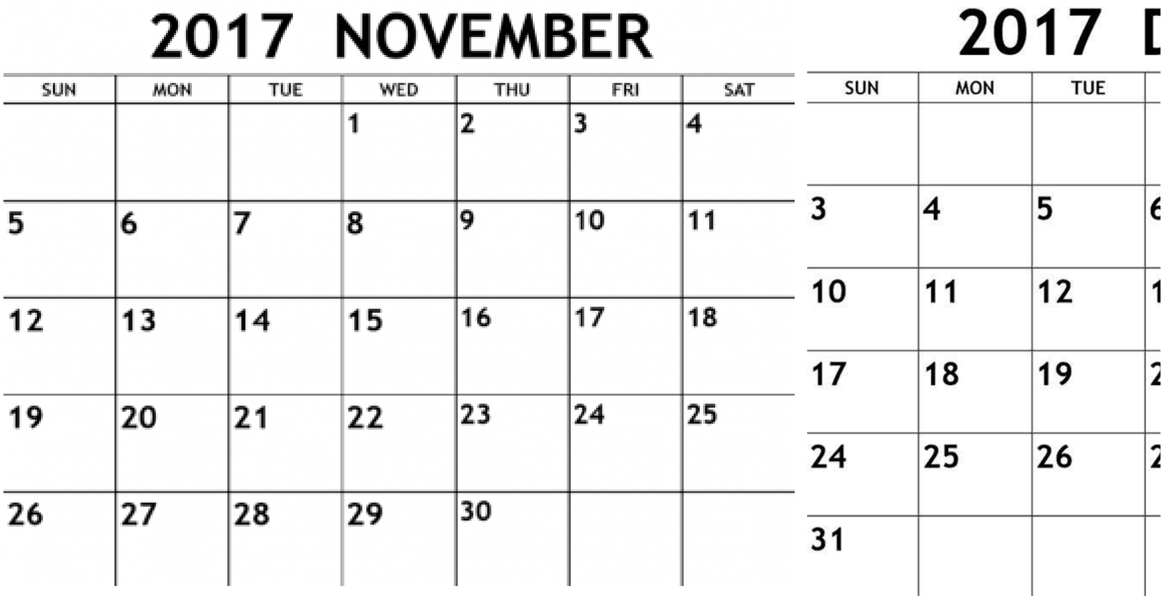

Grande Prairie
Edmonton
Red Deer
Calgary
C.F.B. Suffield
Medicine Hat
Lethbridge



Section 3: Chronic Wasting Disease (CWD)

In this section we are trying to determine what is important to you during hunting trips and how the presence of wildlife disease may affect your hunting decisions. Please read all the information presented first and then answer the questions accordingly.

Please read the following information about Chronic Wasting Disease.

Chronic wasting disease (CWD) is a serious disease that kills members of the deer family such as mule deer, white-tailed deer, elk, and moose in Alberta. It is caused by infectious proteins (prions) that are associated with lethal changes in the brain. The disease process is similar to mad cow disease in cattle and scrapie in sheep. Infected animals may exhibit significant weight loss, lowered heads, excessive drooling, grinding teeth, and decreased relationships with other animals.

CWD transmits through direct contact with infected animals and indirect contact with contaminated environments. CWD prions are resilient and can exist in a contaminated area for more than a year. According to the latest CWD update in April 2017 from the Government of Alberta, 592 CWD cases in wild cervids were documented in Alberta[1]. The number of cases identified annually increased from 4 in 2005 to 179 in 2016. CWD is found most often in male mule deer. The Government of Alberta has conducted several CWD management programs such as education, mandatory testing, disease control programs and import restrictions to prevent or reduce the spread of CWD. However, it is likely that CWD will continue to increase and spread in deer populations across Alberta. In some U.S states local deer populations are declining because of CWD[2].

CWD only infects cervids such as deer, elk, and moose. No cases have been reported of CWD transferring to livestock. While the possibility of transmission to humans is a concern, human health authorities state that there are no verified cases of humans contracting CWD. However, as a precaution they recommend that hunters do not eat the meat of an infected animal and should take precautions when handling any carcass.

[1] http://aep.alberta.ca/fish-wildlife/wildlife-diseases/chronic-wasting-disease/cwd-updates/default.aspx

[2] DeVivo MT, Edmunds DR, Kauffman MJ, Schumaker BA, Binfet J, Kreeger TJ, et al. (2017) Endemic chronic wasting disease causes mule deer population decline in Wyoming. PLoS ONE 12 (10): e0186512.

Edmunds DR, Kauffman MJ, Schumaker BA, Lindzey FG, Cook WE, Kreeger TJ, et al. (2016) Chronic Wasting Disease Drives Population Decline of White-Tailed Deer. PLoS ONE 11(8): e0161127.

Have you heard of CWD before you received this survey?

- ○ Yes, I have heard a little of CWD.
- ○ Yes, I have read or heard detailed information on CWD such as its scientific basis and its recent spread / prevalence.
- ○ No

How did you receive CWD-relevant information? (Please select all that apply)

- ☐ Outdoor magazines
- ☐ Social media (e.g. twitter, Facebook)
- ☐ Government website
- ☐ Newspapers
- ☐ Television news coverage
- ☐ Word-of-mouth from friends and relatives
- ☐ Podcasts
- ☐ Other

Do you consider CWD when choosing hunting sites or applying for draws at specific WMU?

- ○ Yes
- ○ No

Did you check CWD maps and / or statistics on government website before making hunting location decisions?

- ○ Yes, I checked CWD maps.
- ○ Yes, I checked CWD statistics (i.e. number of identified positive cases).
- ○ Yes, I checked both CWD maps and statistics.
- ○ No

Were there WMUs, where you had previously hunted, that you excluded for hunting in 2017, because of CWD? Please list the WMU(s) if any.

Before you received this survey, had you considered the role of hunters in CWD management / surveillance?

- ○ Yes
- ○ No

The following are some statements regarding CWD management programs. Indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement by selecting one of the boxes:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Hunters can play a role in CWD management through hunting	O	O	O	O	O
Current government programs can be more effective in controlling CWD by engaging hunters.	O	O	O	O	O

Alberta Fish and Wildlife is currently, or has in the past, conducted a variety of programs to address CWD in the province of Alberta. Please indicate your agreement with the use of these programs on the scale of "Strongly disagree" to "Strongly agree" .

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Provisions of freezer locations for deer head submission.	O	O	O	O	O
Providing additional hunting opportunities (e.g. extra tags) in CWD high-risk areas	O	O	O	O	O
Mandatory submission of heads for CWD testing in certain WMUs.	O	O	O	O	O
Voluntary submission of heads for the province.	O	O	O	O	O
Reducing local deer herds in the areas where CWD is most concentrated.	O	O	O	O	O

Do you own land in any of these WMUs where CWD occurs?

Prairie WMU Series (100 Series & 732):
116, 118, 119, 142, 144, 148, 150, 151, 152, 158, 160, 162, 163, 164, 166, 732

Parkland WMU Series (200 Series & 728, 730) & 500:
200, 202, 203, 230, 232, 234, 236, 238, 242, 250, 254, 256, 500, 728, 730

- ○ Yes
- ○ No

Are you concerned about CWD-infected wildlife being on your land?

- ○ Yes
- ○ No

Why are you concerned? (Please select all that apply)

- ☐ CWD is a threat to farm animals / livestock
- ☐ CWD is a threat to humans
- ☐ CWD is a threat to wildlife populations
- ☐ Other (please specify) ________

Do you allow hunting on your lands?

- ○ Yes
- ○ No

Who are you most likely to grant permission to hunt on your land ?

Family	Friends / Neighbours	Strangers	Anyone who asks

Are you likely to allow hunting on your land if it would help reduce CWD?

- Yes
- No

Would you consider participating in programs that compensate you for allowing hunting on your lands if it would reduce CWD?

- Yes
- No

Would you consider joining with adjacent landowners to increase hunting on your combined lands if it would reduce CWD?

- Yes
- No

The following are some statements regarding risks associated with CWD. Please indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Stro ag
On average Alberta hunters think CWD is a threat to wildlife herd health in Alberta.					
On average Alberta hunters think CWD is a threat to human health.					
CWD is a threat to human health.					
CWD will result in the eventual extinction of cervids in Alberta.					

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Stro ag
CWD will be eradicated in Alberta.	○	○	○	○	○
CWD will eventually disappear as a result of natural evolution.	○	○	○	○	○
CWD is a threat to wildlife herd health in Alberta.	○	○	○	○	○
CWD will not be eradicated in Alberta, but it will remain at a low level.	○	○	○	○	○

We would like to know how extensive and how serious you think CWD currently is in the wild mule deer population in Alberta.

Please complete the chart below for each WMU provided (Note: there is a WMU map below). Please select what you feel the correct prevalence (infection rate) is for each WMU. A map of CWD affected WMUs is available. We would like to know what you think the infection rates are and how you think CWD will affect the wild mule deer population. **There is no right or wrong answer – we are interested in your perception of CWD infection rates in a WMU.** We provide 4 categories of severity based upon the number of infected mule deer per 100 in each WMU. The infection rates are explained in the table below.

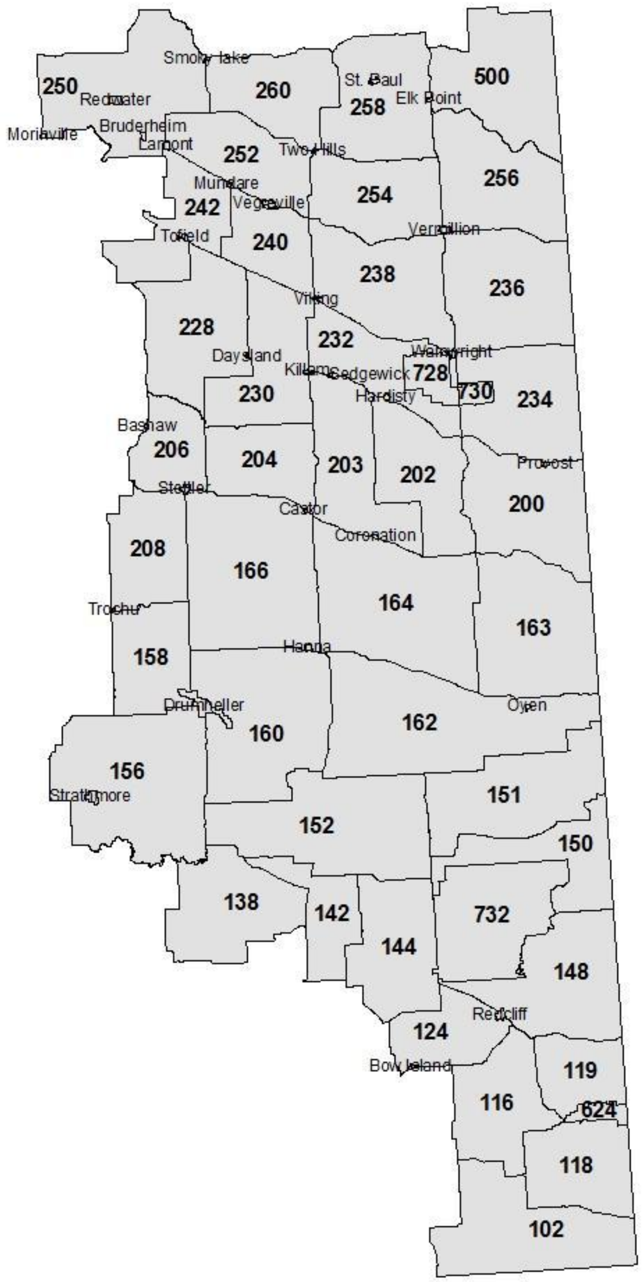
Infection Rate	# Infected Mule Deer per 100 (%)
None	0
Low	1 to 5
Medium	6 to 10
High	11 or more
I Don't Know	I am not familiar enough with the WMU to answer

Please select what you feel is the rate of CWD in each WMU during 2017.

NOTE: Please select "I Don't Know" if you have no perception about the conditions in the WMU.

	None	Low	Medium	High	I Don't Know
WMU 118	○	○	○	○	○
WMU 148	○	○	○	○	○
WMU 150	○	○	○	○	○
WMU 151	○	○	○	○	○
WMU 152	○	○	○	○	○
WMU 162	○	○	○	○	○
WMU 163	○	○	○	○	○
WMU 200	○	○	○	○	○
WMU 202	○	○	○	○	○
WMU 203	○	○	○	○	○
WMU 232	○	○	○	○	○
WMU 234	○	○	○	○	○
WMU 236	○	○	○	○	○
WMU 728	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/1}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/2}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/3}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/4}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/5}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/6}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/7}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/8}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/9}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/10}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/11}	○	○	○	○	○

	None	Low	Medium	High	I Don't Know
WMU ${q://QID3/ChoiceTextEntryValue/12}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/13}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/14}	○	○	○	○	○


250
Redwater
Smoky lake
260
St. Paul
258
Elk Point
500
Morinville
Bruderheim
Lamont
252
Two Hills
256
Mundare
254
242
Vegreville
Vermillion
Tofield
240
238
236
Viking
228
232
Daysland
Wainwright
Killam
Sedgewick
728
730
Hardisty
230
234
Bashaw
206
204
203
202
Provost
Stettler
Castor
200
208
Coronation
166
164
Trochu
163
158
Hanna
Drumheller
Oyen
160
162
156
Strathmore
151
152
150
138
142
732
144
148
Redcliff
124
Bow Island
119
116
624
118
102

You indicated the following WMUs have high CWD prevalence:

WMU 118
WMU 148
WMU 150
WMU 151
WMU 152
WMU 162
WMU 163
WMU 200
WMU 202
WMU 203
WMU 232
WMU 234
WMU 236
WMU 728

Within these WMUs, what do you think is the chance that CWD will result in a decline in wild mule deer populations in next ten years? Please indicate the chance on a scale of 0 (no chance) to 100 (definitely will decline) in following categories.

- ○ 0% (no chance)
- ○ 1 - 25%
- ○ 26 - 50%
- ○ 51 - 75%
- ○ 76 - 100%

You indicated the following WMUs have low or medium CWD prevalence:

WMU 118
WMU 148
WMU 150

WMU 151
WMU 152
WMU 162
WMU 163
WMU 200
WMU 202
WMU 203
WMU 232
WMU 234
WMU 236
WMU 728

Within these WMUs, what do you think is the average chance that the prevalence level will increase in next ten years? Please indicate the chance on a scale of 0 (no chance) to 100 (definitely will increase) in following categories.

- ○ 0% (no chance)
- ○ 1 - 25%
- ○ 26 - 50%
- ○ 51 - 75%
- ○ 76 - 100%

You indicated the following WMUs have <u>no</u> CWD prevalence:

WMU 118
WMU 148
WMU 150
WMU 151
WMU 152
WMU 162
WMU 163
WMU 200

WMU 202
WMU 203
WMU 232
WMU 234
WMU 236
WMU 728

What do you think is the chance that CWD will spread to these WMUs in next ten years? Please indicate the chance on a scale of 0 (no chance) to 100 (definitely will spread) in following categories.

- 0% (no chance)
- 1 - 25%
- 26 - 50%
- 51 - 75%
- 76 - 100%

Section 4: Contingent Behavior

In this section we are trying to understand what you would do if management policies changed in the areas where you normally hunt. Please read the following instructions carefully then answer the following questions.

Wildlife managers are considering changes to recreational hunting policy in CWD affected areas to help manage the rate at which spread and prevalence is increasing in Alberta.

Limited attempts to manage CWD in the past focused on reducing local deer populations through a combination of hunter harvest and directed herd reduction (Blanchong et al 2006, Conner et al 2007, Pybus 2012, Mateus-Pinilla et al 2013, Manjerovac et al 2014[3]). While there is evidence that some of these were effective, the programs were unsustainable over time. A key factor in future CWD management will be long-term hunter support. Programs that manage hunter harvest to maximize hunter satisfaction and remove infected deer are seen as a possible approach to limiting the rate at which the disease increases and spreads in deer populations.

To help inform future decisions regarding CWD management in Alberta, we are going to present you with two different potential management scenarios and would like you to indicate how these scenarios would affect the number of hunting trips you would have taken and the number of deer you think you would have harvested in 2017. In thinking of the trips you would have taken, please treat each scenario by itself, completely independently from the other.

We know that how people respond in surveys is often not a reliable indication of how they will actually make choices. Therefore, we'd like you to respond in this survey as if your decisions are real. Imagine that you actually will have to take additional time and pay the additional trip expenses if you choose such activities. If you choose to take more hunting trips, remember that you will have less time, and possibly less money, to spend on other activities.

[3] Blanchong JA, Joly DO, Samuel MD, Langenberg JA, Rolley RE, Sausen JF. (2006) White-tailed Deer Harvest from the Chronic Wasting Disease Eradication Zone in South-central Wisconsin. Wildlife Society Bulletin 34(3): 725-731.

Conner MM, Miller MW, Ebinger MR, Burnham KP. (2007) A Meta-BACI Approach for Evaluating Management Intervention on Chronic Wasting Disease in Mule Deer. Ecological Applications 17(1): 140-153

Pybus M. (2012) CWD Program Review 2012. Alberta Sustainable Resource Development, Fish and Wildlife Division. http://aep.alberta.ca/fish-wildlife/wildlife-diseases/chronic-wasting-disease/documents/CWD-ProgramReview-May-2012.pdf

Mateus-Pinilla N, Weng HY, Ruiz MO, Shelton P, Novaskofski J. (2013) Evaluation of a Wild White-tailed Deer Population Management Program for Controlling Chronic Wasting Disease in Illinois, 2003-2008. Preventive Veterinary Medicine 110 (3): 541-548

Manjerovic MB, Green ML, Mateus-Pinilla N, Novakofski J. (2014) The Importance of Localized Culling in Stabilizing Chronic Wasting Disease Prevalence in White-tailed Deer Populations. Preventive Veterinary Medicine 113(1): 139-1458

Policy A

Potential Hunting Policy Scenario

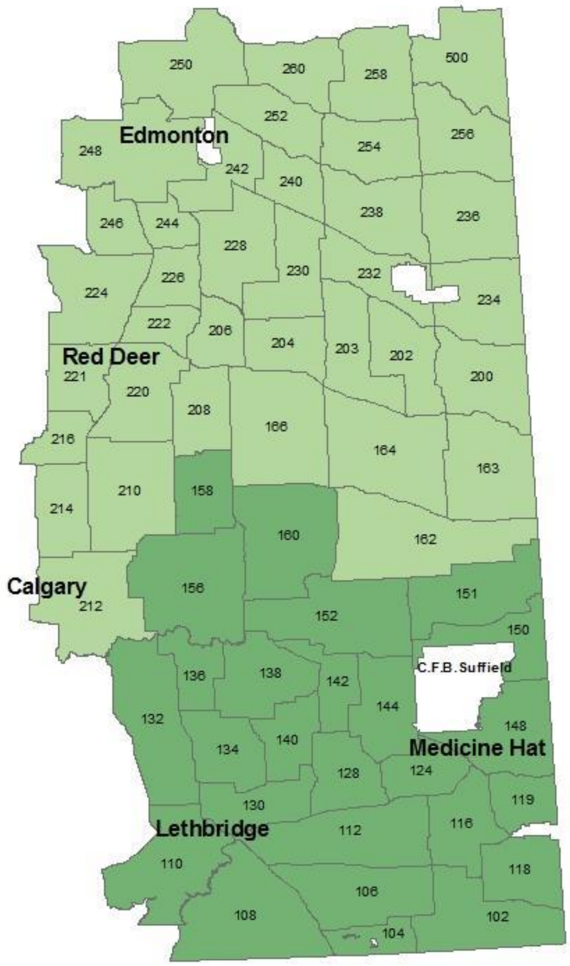
Expanding the hunting seasons for one week into October:

- Prairie WMUs 100 Series (except 162, 163, 164, 166), marked in dark green on the map:

  Wednesday to Saturday in **the last week of October** and November (**Oct.25** – Nov.30)

- Parkland WMUs 200 Series; WMU 162, 163, 164, 166; WMU 500, marked in light green on the map:

  Oct.23 – Nov.30


Edmonton
Red Deer
Calgary
C.F.B. Suffield
Medicine Hat
Lethbridge
250
260
258
500
252
254
256
248
242
240
238
236
246
244
228
230
232
234
224
226
222
206
204
203
202
200
221
220
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166
164
163
216
210
158
160
162
214
156
151
212
152
150
136
138
142
144
148
132
134
140
128
124
130
119
116
112
110
118
106
108
104
102

If the hunting policies were described as above, you may have changed the number of trips that you took in 2017 in November and in the extended season in October. How many BIG GAME hunting trips do you think you would have taken if the hunting policies included an extended season? Please fill in the table below for **October** AND **November**.

1. During the extended hunting season in **October** of 2017, how many hunting trips **would you have taken** and how many deer would you have harvested in each WMU?
2. During the regular hunting season in **November** of 2017, how many hunting trips **would you have taken** and how many deer would you have harvested in each WMU?

In considering your responses, please assume that any features about the hunting trips that are not mentioned such as associated expenditures and CWD prevalence in WMUs are the same as your 2017 experience.

Here is a reminder of what you actually did during the *regular season (i.e. November)* in 2017.

	Number of trips in 2017 actually taken	Average number of days per trip in 2017 actually spent	Number of deer actually harvested in 2017
WMU ${q://QID3/ChoiceTextEntryValue/1}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/4}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/5}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/6}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/7}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/9}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/10}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/11}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0

	Number of trips in 2017 <u>actually taken</u>	Average number of days per trip in 2017 <u>actually spent</u>	Number of deer <u>actually harvested</u> in 2017
WMU ${q://QID3/ChoiceTextEntryValue/12}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/13}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/14}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0

EXTENDED HUNTING SEASON TRIPS (OCTOBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during *the extended hunting season (i.e. October) in 2017* under the scenario above.

	Number of trips you would have taken in *October* of 2017 under the scenario above	Average number of days you would have spent in *October* of 2017 under the scenario above	Number of deer you would have harvested in *October* of 2017 under the scenario above
WMU			
WMU			
WMU			
WMU			
WMU			

REGULAR HUNTING SEASON TRIPS (NOVEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *regular hunting season (i.e. November) in 2017* under the scenario above.

	Number of trips you would have taken in 2017 under the scenario above	Average number of days per trip you would have spent in 2017 under the scenario above	Number of deer you would have harvested in 2017 under the scenario above
WMU			
WMU			
WMU			

	Number of trips you <u>would have taken</u> in 2017 under the scenario above	Average number of days per trip you <u>would have spent</u> in 2017 under the scenario above	Number of deer you <u>would have harvested</u> in 2017 under the scenario above
WMU [ ]	[ ]	[ ]	[ ]
WMU [ ]	[ ]	[ ]	[ ]

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very certain	Somewhat certain	Somewhat uncertain	Very uncertain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very likely	Somewhat likely	Unlikely	Very unlikely
○	○	○	○

If you said you would not take any trips in October, please tell us why not. (Please select all that apply)

- ☐ There is an overlap with other hunting seasons (e.g. archery).
- ☐ I am usually too busy to go hunting in October.
- ☐ I am not interested in deer hunting in October.
- ☐ [ ] Other (please specify)

Policy B

Potential Hunting Policy Scenario

Expanding the hunting seasons into December in:

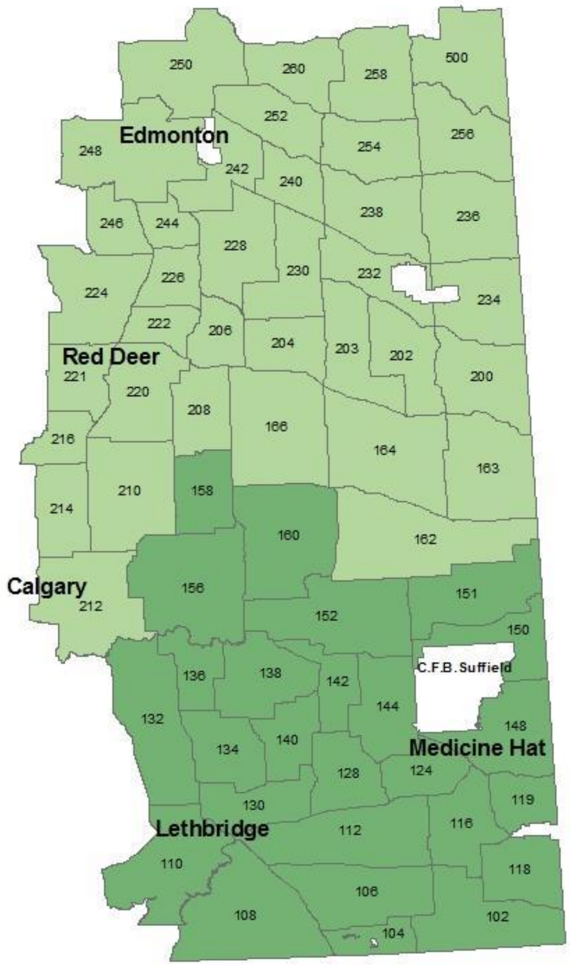
- Prairie WMUs 100 Series (except 162, 163, 164, 166), marked in dark green on the map:

  Wednesday to Saturday in November and **December** (Nov.1 – **Dec.17**)

- Parkland WMUs 200 Series; WMU 162, 163, 164, 166; WMU 500, market in light green on the map:

  Nov.1 – **Dec.17**

You can purchase *an extra tag* if you decide to hunt in extended seasons.


250
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500
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Edmonton
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232
234
222
206
204
203
202
Red Deer
221
220
200
208
166
164
216
163
210
158
214
160
162
Calgary
212
156
151
152
150
C.F.B. Suffield
136
138
142
132
144
148
134
140
Medicine Hat
128
124
130
119
Lethbridge
112
116
110
118
106
108
102
104

If the hunting policies were described as above, you may have changed the number of trips that you took in 2017 in November and in the extended season in December. How many BIG GAME hunting trips do you think you would have taken if the hunting policies included an extended season? Please fill in the table below for **November** AND **December**.

1. During the regular hunting season in **November** of 2017, how many hunting trips **would you have taken** and how many deer would you have harvested in each WMU?
2. During the extended hunting season in **December** of 2017, how many hunting trips **would you have taken** and how many deer would you have harvested in each WMU?

In considering your responses, please assume that any features about the hunting trips that are not mentioned such as associated expenditures and CWD prevalence in WMUs are the same as your 2017 experience.

Here is a reminder of what you actually did during *the regular season (i.e. November)* in 2017.

	Number of trips in 2017 actually taken	**Average number of days per trip in 2017 actually spent**	**Number of deer actually harvested in 2017**
WMU ${q://QID3/ChoiceTextEntryValue/1}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/4}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/5}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/6}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/7}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/9}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/10}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/11}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0

	Number of trips in 2017 actually taken	Average number of days per trip in 2017 actually spent	Number of deer actually harvested in 2017
WMU ${q://QID3/ChoiceTextEntryValue/12}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/13}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/14}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0

REGULAR HUNTING SEASON TRIPS (NOVEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *regular hunting season (i.e. November) in 2017* under the scenario above.

	Number of trips you would have taken in 2017 under the scenario above	Average number of days per trip you would have spent in 2017 under the scenario above	Number of deer you would have harvested in 2017 under the scenario above
WMU			
WMU			
WMU			
WMU			
WMU			

EXTENDED HUNTING SEASON TRIPS (DECEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during *the extended hunting season (i.e. December) in 2017* under the scenario above..

	Number of trips you would have taken in *December* of 2017 under the scenario above	Average number of days you would have spent in *December* of 2017 under the scenario above	Number of deer you would have harvested in *December* of 2017 under the scenario above
WMU			
WMU			

	Number of trips you would have taken in *December* of <u>2017</u> under the scenario above	Average number of days you would have spent in *December* of <u>2017</u> under the scenario above	Number of deer you would have harvested in *December* of <u>2017</u> under the scenario above
WMU			
WMU			
WMU			

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very certain	Somewhat certain	Somewhat uncertain	Very uncertain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very likely	Somewhat likely	Unlikely	Very unlikely
○	○	○	○

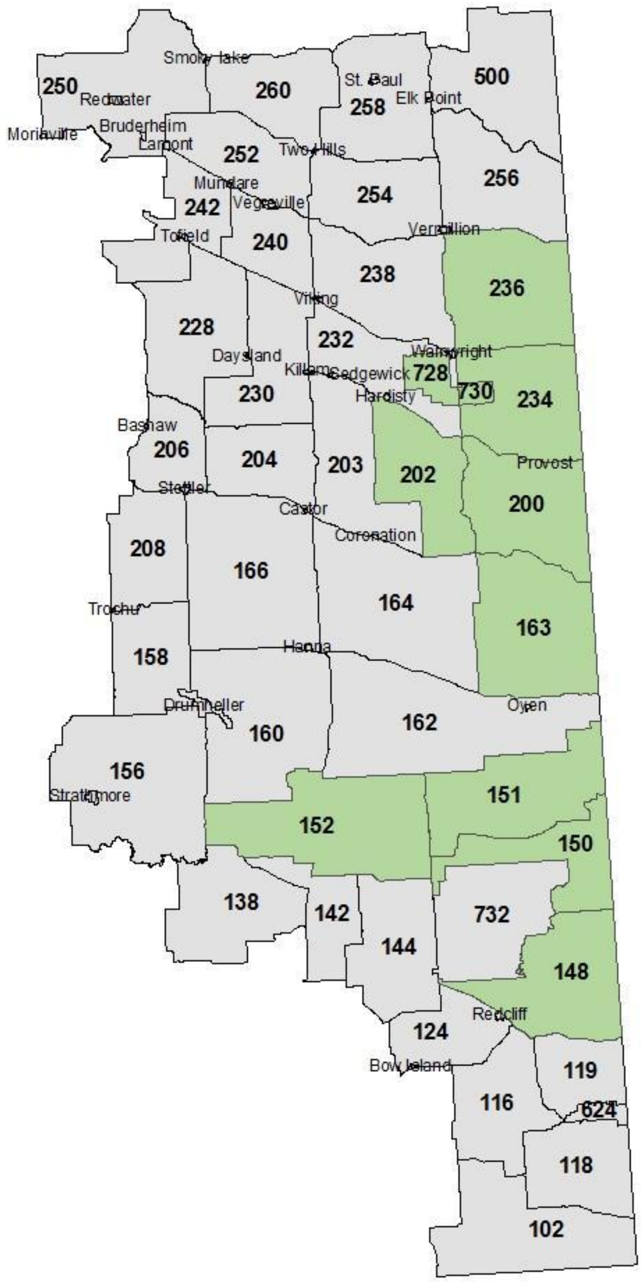
If you said you would not take any trips in December, please tell us why not. (Please select all that apply)

- ☐ The weather in December is not as good as the weather in November.
- ☐ I'm usually too busy to go hunting in December.
- ☐ I'm not interested in deer hunting in December.
- ☐ ________ Other (please specify)

Policy C

Potential Hunting Policy Scenario

When you win a special licence draw for WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you can purchase two tags for mule deer instead of one for the current hunting season.


250
Redwater
Smoky lake
260
St. Paul
258
Elk Point
500
Morinville
Bruderheim
Lamont
252
Two Hills
256
Mundare
242
Vegreville
254
Vermilion
Tofield
240
238
236
Viking
228
232
Daysland
Wainwright
Killam
Sedgewick
728
730
234
Hardisty
230
Bashaw
206
204
203
202
Provost
200
Stettler
Castor
Coronation
208
166
164
163
Trochu
158
Hanna
Drumheller
Oyen
160
162
156
Strathmore
151
152
150
138
142
732
144
148
Redcliff
124
Bow Island
119
116
624
118
102

If the hunting policies were described as above, how many BIG GAME hunting trips would you have taken and how many deer would you have harvested in 2017 in each WMU? In considering your responses, please assume that any features about the hunting trips not mentioned (such as associated expenditures and CWD prevalence) are the same as your 2017 experience.

Here is a reminder of what you actually did in 2017.

	Number of trips in 2017 actually taken	Average number of days per trip in 2017 actually spent	Number of deer actually harvested in 2017
WMU ${q://QID3/ChoiceTextEntryValue/1}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/4}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/5}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/6}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/7}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/9}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/10}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/11}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/12}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/13}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/14}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0

Please complete the table indicating all the BIG GAME hunting trips by WMU you would have taken in 2017 under the scenario above.

		Number of trips you <u>would have taken</u> in 2017 under the scenario above	Average number of days per trip you <u>would have spent</u> in 2017 under the scenario above	Number of deer you <u>would have harvested</u> in 2017 under the scenario above
WMU				
WMU				
WMU				
WMU				
WMU				

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very certain	Somewhat certain	Somewhat uncertain	Very uncertain
○	○	○	○

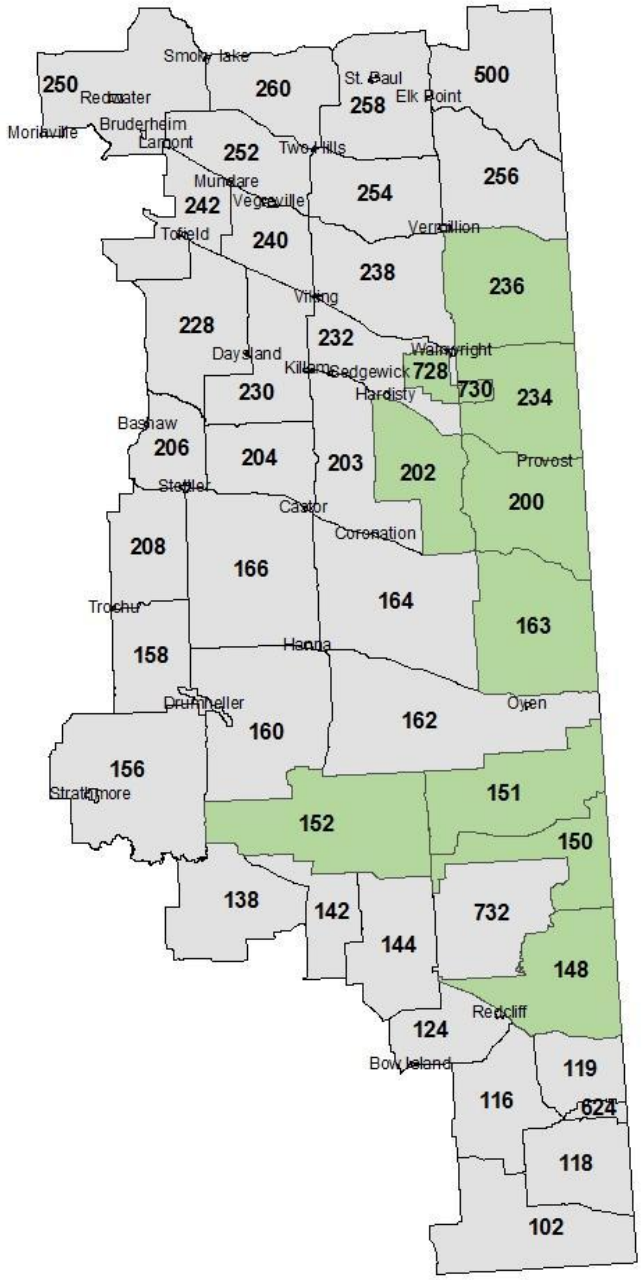
How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very likely	Somewhat likely	Unlikely	Very unlikely
○	○	○	○

Policy D

Potential Hunting Policy Scenario

There is no mandatory requirement of head submission for the CWD test. However, when you voluntarily submit one mule deer head, you will get an extra priority point in the draw system for mule deer special licences for WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map) in the next year.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624
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St. Paul
Elk Point
Bruderheim
Lamont
Two Hills
Vegreville
Vermilion
Tofield
Viking
Daysland
Killam
Sedgewick
Wainwright
Hardisty
Bashaw
Provost
Castor
Coronation
Trochu
Hanna
Drumheller
Oyen
Strathmore
Redcliff
Bow Island

If the hunting policies were described as above, how many BIG GAME hunting trips would you have taken and how many deer would you have harvested in 2017 in each WMU? In considering your responses, please assume that any features about the hunting trips not mentioned (such as associated expenditures and CWD prevalence) are the same as your 2017 experience.

Here is a reminder of what you actually did in 2017.

	Number of trips in 2017 actually taken	Average number of days per trip in 2017 actually spent	Number of deer actually harvested in 2017
WMU ${q://QID3/ChoiceTextEntryValue/1}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/4}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/5}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/6}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/7}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
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WMU ${q://QID3/ChoiceTextEntryValue/11}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/12}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/13}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/14}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0

Please complete the table indicating all the BIG GAME hunting trips by WMU you would have taken in 2017 under the scenario above.

	Number of trips you <u>would have taken</u> in 2017 under the scenario above	Average number of days per trip you <u>would have spent</u> in 2017 under the scenario above	Number of deer you <u>would have harvested</u> in 2017 under the scenario above
WMU [ ]	[ ]	[ ]	[ ]
WMU [ ]	[ ]	[ ]	[ ]
WMU [ ]	[ ]	[ ]	[ ]
WMU [ ]	[ ]	[ ]	[ ]
WMU [ ]	[ ]	[ ]	[ ]

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very certain	Somewhat certain	Somewhat uncertain	Very uncertain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very likely	Somewhat likely	Unlikely	Very unlikely
○	○	○	○

Policy E

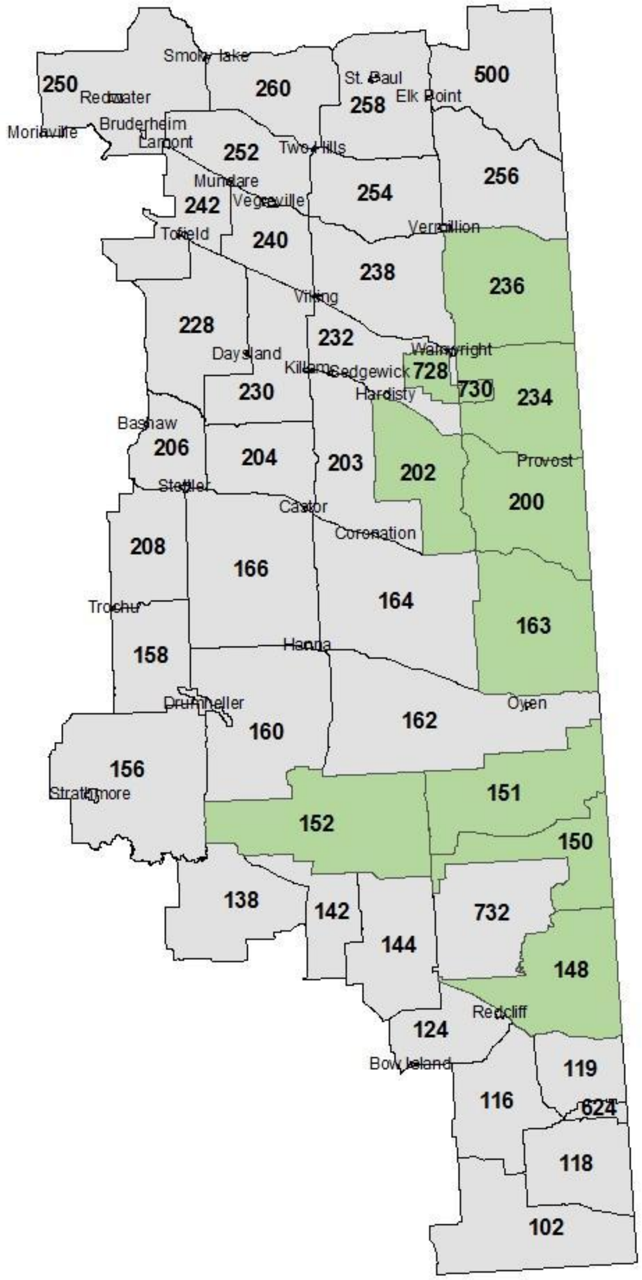
Potential Hunting Policy Scenario

For each <u>CWD-positive</u> head you submit from WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you will get a gift card valued at $50 at a popular hunting store.

For each <u>CWD-negative</u> head you submit from WMUs 148, 150, 151, 152, 163,

200, 202, 234, 236, 728/730 (the green area on the map), you will get a gift card valued at $30 at a popular hunting store.

The number of heads you submit cannot exceed the number of tags you have.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Redwater
Smoky lake
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St. Paul
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Elk Point
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Morinville
Bruderheim
Lamont
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Two Hills
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Mundare
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Vegreville
254
Vermillion
Tofield
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Viking
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Daysland
Wainwright
Killam
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Hardisty
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Bashaw
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Provost
Stettler
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Castor
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Hanna
Drumheller
Oyen
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Strathmore
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Redcliff
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Bow Island
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If the hunting policies were described as above, how many BIG GAME hunting trips would you have taken and how many deer would you have harvested in 2017 in each WMU? In considering your responses, please assume that any features about the hunting trips not mentioned (such as associated expenditures and CWD prevalence) are the same as your 2017 experience.

Here is a reminder of what you actually did in 2017.

	Number of trips in 2017 actually taken	Average number of days per trip in 2017 actually spent	Number of deer actually harvested in 2017
WMU ${q://QID3/ChoiceTextEntryValue/1}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/4}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/5}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/6}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
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WMU ${q://QID3/ChoiceTextEntryValue/13}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/14}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0

Please complete the table indicating all the BIG GAME hunting trips by WMU you would have taken in 2017 under the scenario above.

		Number of trips you would have taken in 2017 under the scenario above	Average number of days per trip you would have spent in 2017 under the scenario above	Number of deer you would have harvested in 2017 under the scenario above
WMU				
WMU				
WMU				
WMU				
WMU				

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very certain ○ Somewhat certain ○ Somewhat uncertain ○ Very uncertain ○

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very likely ○ Somewhat likely ○ Unlikely ○ Very unlikely ○

Policy F

Potential Hunting Policy Scenario

For each CWD-positive head you submit from WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you can choose between the following options (please select the one you will choose):

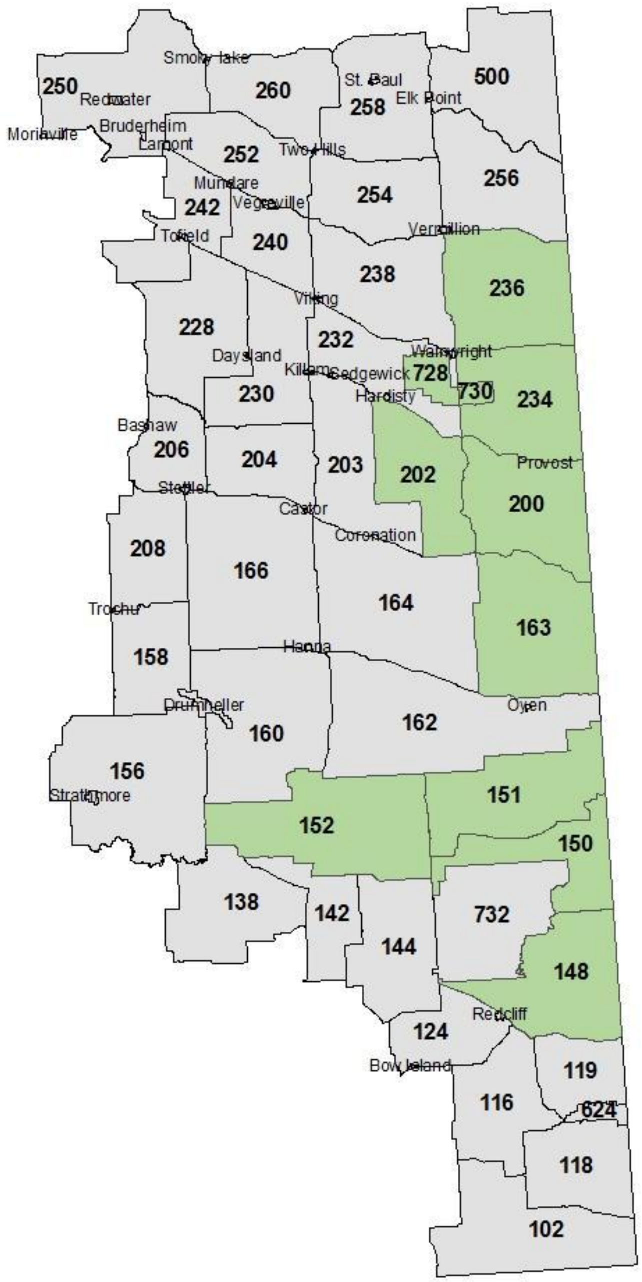
○ **Get a gift card valued at $50 at a popular hunting store**

- ○ Donate $50 to a major conservation organization of your choice

For each CWD-negative head you submit from WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you can choose between the following options (please select the one you will choose):

- ○ Get a gift card valued at $30 at a popular hunting store
- ○ Donate $30 to a major conservation organization of your choice

The number of heads you submit cannot exceed the number of tags you have.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Redwater
Morinville
Bruderheim
Lamont
Smoky lake
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St. Paul
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Elk Point
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Two Hills
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Mundare
242
Vegreville
254
Tofield
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Oyen
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Redcliff
Bow Island
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If the hunting policies were described as above, how many BIG GAME hunting trips would you have taken and how many deer would you have harvested in 2017 in each WMU? In considering your responses, please assume that any features about the hunting trips not mentioned (such as associated expenditures and CWD prevalence) are the same as your 2017 experience.

Here is a reminder of what you actually did in 2017.

	Number of trips in 2017 actually taken	Average number of days per trip in 2017 actually spent	Number of deer actually harvested in 2017
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WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/4}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/5}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
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WMU ${q://QID3/ChoiceTextEntryValue/13}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0
WMU ${q://QID3/ChoiceTextEntryValue/14}	${q://QID3/ChoiceT	${q://QID3/ChoiceT	0

Please complete the table indicating all the BIG GAME hunting trips by WMU you would have taken in 2017 under the scenario above.

	Number of trips you <u>would have taken</u> in 2017 under the scenario above	Average number of days per trip you <u>would have spent</u> in 2017 under the scenario above	Number of deer you <u>would have harvested</u> in 2017 under the scenario above
WMU			
WMU			
WMU			
WMU			
WMU			

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

- Very certain
- Somewhat certain
- Somewhat uncertain
- Very uncertain

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

- Very likely
- Somewhat likely
- Unlikely
- Very unlikely

Debriefing

In addition to the two scenarios presented to you above, there are two other potential policy options. Please read a short description of four potential CWD management policy options below.

Expansion of hunting season	Extending current hunting seasons in high-risk CWD areas for two weeks i December (or one week in October).

Extra tags / licences	You can purchase one extra tags for mule deer if you win a special license draw high-risk CWD areas. You can get an extra priority point in the draw system for mule deer special licen for high-risk CWD areas if you submit one mule deer head.
Gift cards	You can get a gift card reward if you submit heads from high-risk CWD areas.
Donation	You can donate the monetary reward to a conservation organization if you sub heads from high-risk CWD areas.

Taking into account your responses to the previous questions, overall which type of policy option would you prefer? Please indicate using the scale of "Not desirable" to "Very desirable"

	Not desirable	Somewhat undesirable	Indifferent	Somewhat desirable	Very desirable
Expansion of hunting season	○	○	○	○	○
Extra tags/licences	○	○	○	○	○
Donation	○	○	○	○	○
Gift cards	○	○	○	○	○

Which policy option would you most prefer ?

- ○ Donation
- ○ Extra tags / licences
- ○ Expansion of hunting season
- ○ Gift cards
- ○ I prefer that none of these policies are used.

How likely do you think the information from your responses will be used in designing CWD management programs?

Very unlikely	Unlikely	Somewhat likely	Very likely	I don't know
○	○	○	○	○

Would you support policies that use hunters in CWD management?

- ○ Yes
- ○ No

How supportive do you think other Alberta hunters would be towards the idea of engaging hunters in CWD management?

Very unsupportive	Unsupportive	Somewhat supportive	Very supportive
○	○	○	○

How supportive do you think the general public would be towards the idea of engaging hunters in CWD management?

Very unsupportive	Unsupportive	Somewhat supportive	Very supportive
○	○	○	○

How likely do you think it is that engaging hunters to manage CWD can result in healthy deer population in the long run?

Very unlikely	Unlikely	Somewhat likely	Very likely
○	○	○	○

Would you participate in programs associated with engaging hunters for CWD management in the future? Please select all that apply.

- ☐ Yes, because it would help control CWD effectively.
- ☐ Yes, because I would have more hunting opportunities.
- ☐ Maybe, it depends on the costs and my availability.
- ☐ No, because I don’t think hunters can help CWD control.

☐ No, please write down the reason if the above reasons don't apply

What is the most important reason for you to participate in programs?

- ○ These programs would help control CWD effectively
- ○ I would have more hunting opportunities.

What is the most important reason that discourages you from participating in programs?

- ○ I don't think these programs would help control CWD. There should be more effective alternative approaches.
- ○ These programs are too costly and time consuming for me.
- ○ ${q://QID120/ChoiceTextEntryValue/5}
- ○ Other (please specify)

Do you think that the majority of hunters in your region/community would participate in programs associated with engaging hunters for CWD management in the future? Please choose one only.

- ○ Yes, because they think these programs would help control CWD effectively.
- ○ Yes, because they would have more hunting opportunities.
- ○ No, because these programs may be too costly and time consuming for them.
- ○ No, because they may think hunters are not effective in helping CWD management.

For the policy options that offered gift cards in exchange for submission of heads, would you take additional hunting trips if there was no gift card?

- Yes
- No

Please indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement by selecting one of the lines:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The value of the gift card isn't enough to interest the majority of hunters who hunt in my region in taking additional trips.	○	○	○	○	○

The following are some statements regarding hunter behaviour and CWD. Please indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I regularly submit my deer heads for CWD testing.	○	○	○	○	○
I have changed where I normally hunt because of CWD.	○	○	○	○	○
I think hunters should report back to landowners if there was a positive animal found on their land.	○	○	○	○	○
I have not hunted in a CWD affected area.	○	○	○	○	○
I eat or give away the deer meat before I get the test results.	○	○	○	○	○
If the prevalence of CWD decreased, I would increase my hunting in Alberta.	○	○	○	○	○
Hunters should not be paid for participating in additional hunts for CWD management.	○	○	○	○	○
I think current hunting seasons are too short.	○	○	○	○	○
I no longer consume deer meat because of CWD.	○	○	○	○	○

What other things do you think could be done to engage hunters in CWD management / surveillance (e.g. promote submitting heads)? Please list any types of program (reward, information, recognition) that you feel may improve CWD management and surveillance.

Section 5: Demographic Information

Now we would like to ask some questions about you. The next set of questions are to help us find similarities between different groups of people and to identify trends in the hunting population. Please be ensured that your responses will be kept strictly confidential.

Are you

Male	Female	Other	Prefer not to say
○	○	○	○

Are you a member of any of the following organizations?

- ○ Alberta Fish and Game Association
- ○ Canadian Parks and Wilderness Society
- ○ Nature Conservancy of Canada
- ○ Sierra Club
- ○ An affiliation with government (i.e. Alberta Environment and Parks, Alberta Justice and Solicitor General)
- ○ Alberta Professional Outfitter Society

- Alberta Federation of Naturalists

In what year were you born? (enter 4-digit birth year; for example, 1970)

What are the first three digits of your postal code?

What is the highest level of schooling you have completed?

- Some high school or less
- High school diploma
- Some university, college, or technical school
- Technical school graduate
- University/College graduate
- Some graduate school
- Graduate degree

Please indicate your household income before taxes in 2017.

- Less than 10,000
- 10,000 to 19,999
- 20,000 to 29,999
- 30,000 to 39,999
- 40,000 to 49,999
- 50,000 to 59,999
- 60,000 to 79,999
- 80,000 to 99,999
- 100,000 to 149,999
- Greater than 150,000

Please indicate, by circling the most appropriate category, where you currently live.

- Large urban setting (100 000 people or more)

- Small urban setting (20 000 to 99 999 people)
- Town or village (1 000 to 19 999 people)
- Rural setting (999 people or less)

Are there any children under 12 in your household?

- Yes
- No

In order to continue our research in this area, we would like to contact you again, in approximately one year, to request information and your opinions on the 2018 hunting season. We would also like to be able to link your answers from this survey to the next one. In order to do this, your contact information would be recorded along with your answers (your email address would not be used for any other reason). This would reduce the anonymity of your answers although they would still be kept strictly confidential. Your information will not be given out or shared in any way. The only person with access to your information will be the researcher contacting you next year to ask for your participation in the survey.

Would you be willing to participate in a similar survey next hunting season?

- Yes
- No

Please provide your email address:

If you wish to leave comments about the survey or hunting-related issues in it, please use the box below. Your feedback is highly appreciated.

For more information about CWD, please check following websites:

http://aep.alberta.ca/fish-wildlife/wildlife-diseases/chronic-wasting-disease/default.aspx
http://cwd-info.org/

As a thank you for participating in this survey, we would like to offer you a chance to enter a prize draw to win one of two gift cards valued at $150 each for Cabela's. If you wish to enter the draw, you will have to answer a skill-testing question as a legal requirement. We will also need to collect your email address to inform you of the draw result. Your email address will not be used for any other reason.

Would you like to enter the prize draw?

- Yes
- No

Under federal law, it is necessary that you answer a skill-testing question successfully in order to qualify for a chance to win the prize. Please answer the following question (write your answer in the blank space provided):

(5+5) / 2 =

Please provide your email address

Powered by Qualtrics

Supplementary Materials B
2019 Hunter Survey

Information Sheet

Deer Hunting in Alberta:
A Survey of Hunter Opinions

Study title: Deer Hunting in Alberta: A Survey of Hunter Opinions

Investigators:

UNIVERSITY OF ALBERTA

Department of Resource Economics and Environmental Sociology

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Edmonton, AB T6G 2H1

Vic Adamowicz

Professor

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(780) 492-4603

John K. Pattison-Williams

Postdoctoral Fellow

johnp@ualberta.ca

(780) 878-5175

Lusi Xie

PhD Student

lxie@ualberta.ca

Background and Purpose: You are being asked to participate in a research project. Recreational hunting activities have been affected by the presence of Chronic Wasting Disease (CWD) and its management strategies. Therefore, it is necessary and important to know how Alberta Hunters respond to the presence of CWD and how they may adjust behaviors when relevant management strategies change. We are doing this study to collect information on recreational hunting activities from Alberta hunters and to get their opinions about the current cervid hunting situation with a focus on issues associated with Chronic Wasting Disease in Alberta. The information we get from the survey may also help evaluate the potential to engage hunters in CWD management by harvesting additional cervids.

Study Procedures: The study involves completing a survey on the computer to identify your opinions. The entire survey will take approximately about 30 minutes to complete. To thank you for your time, if you complete the survey you will be entered into a draw where you will have a chance of winning one of two gift cards valued at $150 each for Cabela's. The actual odds of winning will depend on the number of people who actually participate in the survey, but the approximate odds are 1/500.

Benefits: You will not receive any benefit from participating in this study. The data we get from this survey will be shared with people in various levels of the government. They can use this to make better-informed decisions about policies and management issues related to Chronic Wasting Disease in Alberta. We will also be able to do an economic analysis on the data to advise on better management of CWD to increase hunting satisfaction.

Risks: We do not anticipate any risks associated with participation.

Confidentiality: All of the data we collect from you and your responses will be kept completely confidential. Personal identifying information such as first three digits of your postal code, year of birth and gender will be collected in order to determine differences in hunting behaviour and travel costs. We will not possess your contact information, unless at the end of the survey you provide your email to enter the prize draw. This information will be maintained in a separate password-protected spreadsheet, which will be removed once the prize draw is finished. Your data and survey responses will be collected using a survey program called Qualtrics and will be recorded in a database on a server at the University of Alberta. Only the research team will have access to this database. Your answers will not be shared with anyone outside this group. Any reports or papers written will include only survey averages or similar measures; individual responses will not be reports nor will individuals be distinguishable.

Withdrawal from the Study: Being in this study is completely voluntary. Also, even if you agree, you are free to stop doing the survey at any time. However because we are not collecting any information that can be linked to you personally, once you have completed the survey and submitted it, we cannot remove your survey responses from the database.

Use of your Information: The information we get from doing this study will be used for a graduate student thesis, academic papers, and reports. This study is being funded by Alberta Prion Research Institute (a provincial research agency). The project is not funded by any NGOs or hunting organizations. The results will be placed in reports which will be available to any organization or individual wishing to read it. The Government may use this information in their decision making process.

The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

I understand the purpose, risks, and benefits of this survey. By clicking below I agree to participate in the survey.

Agree	Disagree
○	○

Have you recently received a survey called **"Phase 2 Alberta Deer Hunting Survey"** from the University of Alberta in January 2019? If so, please click YES below as you DO NOT need to complete this survey. Thank you very much for participating in the previous survey — we appreciate your support of our research and of wildlife management in Alberta. If you have any questions, please contact us at UofACWDsurvey@ualberta.ca. If you have not completed the Phase 2 Survey in January 2019, please click NO to continue.

YES - I have already completed the Phase 2 Survey	**NO** - I have not completed the Phase 2 Survey
○	○

Please note that once you advance by clicking "NEXT" you cannot go back and revise your answers.

Did you go hunting last year (2018)?

Yes ○ No ○

Section 1: Background Information

The following questions are meant to collect information regarding your deer hunting trips taken in Alberta and your opinions about wildlife resources in Alberta. Your answers will help us to understand preferences for hunting and create better wildlife management decisions.

How many years have you been deer hunting?

[ ]

What WMU would you list as your favourite WMU for mule deer hunting?

[ ]

Did you go hunting in your favourite WMU listed above last year?

Yes ○ No ○

Did you go BOW hunting last year?

Yes ○ No ○

Which weapon(s) do you use to hunt deer? Please select all that apply.

- ☐ Rifle
- ☐ Cross bow
- ☐ Bow and arrow
- ☐ Shotgun

☐ Muzzleloader
☐ Other

What type of land do you typically hunt deer on in Alberta?

○ Private
○ Public / Crown
○ Both

What kind of transportation do you usually use to access to hunting sites? Please select all that apply.

☐ Cars
☐ Off-highway Vehicles
☐ Trucks / pickup trucks
☐ RVs
☐ ________ Other (Please specify)

Section 2: Hunting trips

In this next section we ask you to recall BIG GAME hunting trips that you personally took during 2018. Please recall as much information as possible and be as specific as possible. A map of WMUs and calendars are available.

Please complete the following table for each hunting season. A map of WMUs and calendars are available below. You are asked to indicate the following:

1. Please write down each WMU where you hunted.

2. Please write down the overall number of trips made to that WMU during the 2018 hunting season. Please note that if there were multiple destinations or overnight trips, the number of trips to that

WMU may not equal the number of days spent there. A trip is defined as travel to and from a hunting site and may involve one or more days at a site.

3. Please write down the total number of each deer species and any other cervids (moose, elk) you harvested in that WMU. If you didn't harvest any, please write 0.

THIS IS AN EXAMPLE:
Please complete the following table for each WMU you went BIG GAME hunting in during the 2018 hunting season.

WMU you hunted in	Do you live in this WMU?	Number of trips to the WMU	Average number of days per trip to the WMU	Harvest				
				Mule deer		White-tailed deer		Other cervids species (e.g. elk, moose)
				Male	Female	Male	Female	
151	Y	5	1	0	0	0	1	1
256	N	3	2	0	1	1	0	0
164	Y	1	10	1	0	0	0	0

Please complete the following table for each WMU you went BIG GAME hunting in during the 2018 hunting season. *(A trip is defined as travel to and from a hunting site and may involve one or more days at a site.)*

		Do you live in this WMU?	Number of trips to the WMU	Average number of days per trip to the WMU	Harvest: Male Mule Deer	Harvest: Female Mule Deer	Harvest: Male Whitetail Deer	Harvest: Female Whitetail Deer	Harvest: Other Cervid Species (ie. moose, elk)
WMU									
WMU									
WMU									

	Do you live in this WMU?	Number of trips to the WMU	Average number of days per trip to the WMU	Harvest: Male Mule Deer	Harvest: Female Mule Deer	Harvest: Male Whitetail Deer	Harvest: Female Whitetail Deer	Harvest: Other Cervid Species (ie. moose, elk)
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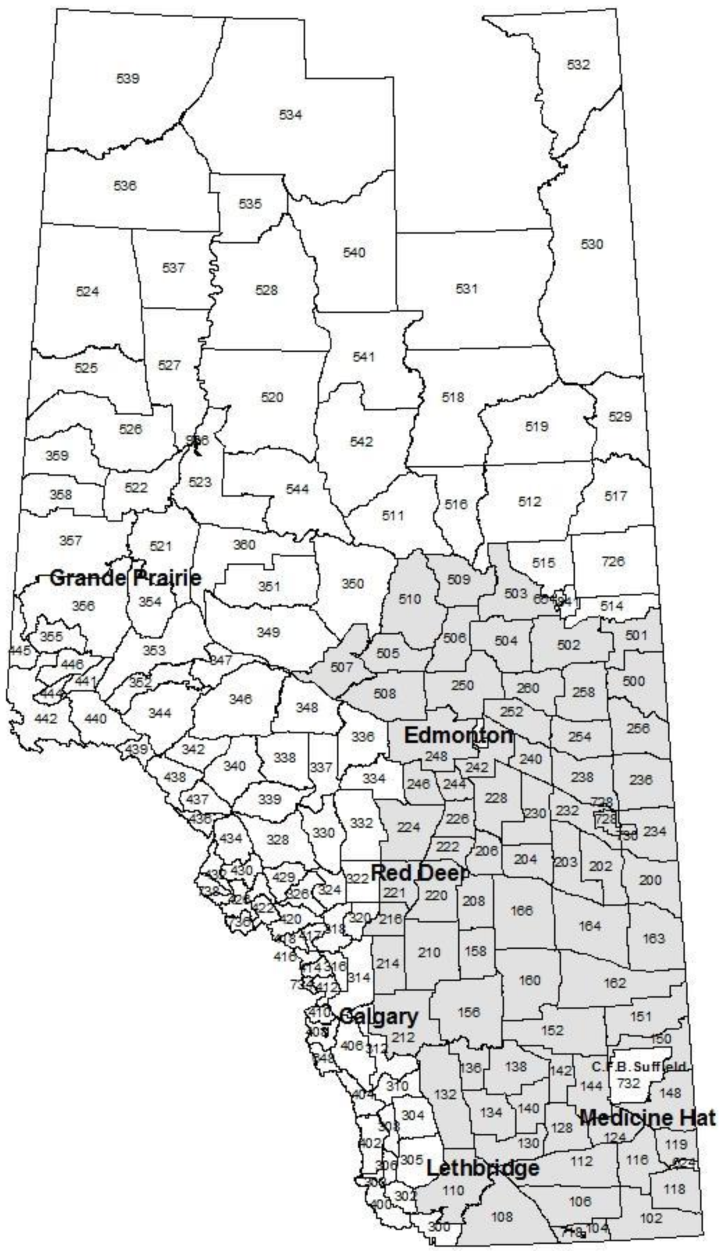
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206
204
203
202
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Red Deer
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220
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158
214
160
162
314
Calgary
156
151
212
152
406
C.F.B. Suffield
138
142
144
732
148
310
132
134
140
304
Medicine Hat
124
128
130
119
305
Lethbridge
112
116
110
118
106
108
102
104
300

November 2018						
SUN	MON	TUE	WED	THU	FRI	SAT
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

December 2018						
SUN	MON	TUE	WED	THU	FRI	SAT
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Section 3: Chronic Wasting Disease (CWD)

In this section we are trying to determine what is important to you during hunting trips and how the presence of wildlife disease may affect your hunting

decisions. Please read all the information presented first and then answer the questions accordingly.

Please read the following information about Chronic Wasting Disease.

Chronic wasting disease (CWD) is a serious disease that kills members of the deer (cervid) family such as mule deer, white-tailed deer, elk, and moose in Alberta. It is caused by infectious proteins (prions) that are associated with lethal changes in the brain. The disease process is similar to mad cow disease in cattle and scrapie in sheep.

CWD transmits through direct contact with infected animals and indirect contact with contaminated environments. In some U.S states local cervid populations are declining because of CWD.[1] According to the latest CWD update in April 2018 from the Government of Alberta, a total of 919 CWD cases in wild cervids have been documented in Alberta.[2] The number of cases identified annually increased from 4 in 2005 to 327 in 2017. CWD is found most often in male mule deer. CWD will likely continue to increase and spread in cervid populations across Alberta.

CWD only infects cervids such as deer, elk, and moose. No cases have been reported of CWD transferring to livestock. While the possibility of transmission to humans is a concern, human health authorities state that there are no verified cases of humans contracting CWD. However, as a precaution they recommend that hunters do not eat the meat of an infected animal and should take precautions when handling any carcass.

[1] DeVivo MT, Edmunds DR, Kauffman MJ, Schumaker BA, Binfet J, Kreeger TJ, et al. (2017) Endemic chronic wasting disease causes mule deer population decline in Wyoming. PLoS ONE 12 (10): e0186512. Edmunds DR, Kauffman MJ, Schumaker BA, Lindzey FG, Cook WE, Kreeger TJ, et al. (2016) Chronic Wasting Disease Drives Population Decline of White-Tailed Deer. PLoS ONE 11(8): e0161127.

[2] http://aep.alberta.ca/fish-wildlife/wildlife-diseases/chronic-wasting-disease/cwd-updates/default.aspx

Have you heard of CWD before you received this survey?

- Yes, I have heard a little of CWD.
- Yes, I have read or heard detailed information on CWD such as its scientific basis and its recent spread / prevalence.
- No

Before you had received this survey, were you aware that CWD was present and increasing in prevalence and geographic distribution in Alberta?

Yes	No
○	○

How did you receive CWD-relevant information? (Please select all that apply)

- Outdoor magazines
- Social media (e.g. twitter, Facebook)
- Podcasts
- Television news coverage
- Word-of-mouth from friends and relatives
- Government website
- Newspapers
- Other

Did you already know or check for the presence of CWD in the WMU(s) you hunted in before applying for special license draws?

Yes	No
○	○

Did you avoid hunting in CWD-infected areas in 2018?

Yes	No
○	○

Did you harvest any cervids (ie. deer, elk or moose) in 2018?

Yes	No
○	○

Did you submit heads you harvested for CWD testing to help CWD surveillance?

Yes	No
○	○

Why did you submit heads you harvested for CWD testing? Please select all that apply.

- ☐ Because I am concerned about the effect of CWD on wildlife populations.
- ☐ Because the deer were harvested in mandatory CWD testing WMUs.
- ☐ Because I was worried about CWD risks to me and my family from eating the deer meat.

How many days did it take to receive the results from your submitted head?

- ○ Less than one month
- ○ Between one month to two months
- ○ More than two months
- ○ Have not received the results back

How satisfied were you with the amount of time taken to receive the results from the CWD testing?

Extremely unsatisfied	Somewhat unsatisfied	Neither satisfied nor unsatisfied	Somewhat satisfied	Extremely satisfied
○	○	○	○	○

How satisfied were you with the instructions from AEP regarding how to submit the heads?

Extremely unsatisfied	Somewhat unsatisfied	Neither satisfied nor unsatisfied	Somewhat satisfied	Extremely satisfied
○	○	○	○	○

How satisfied were you with the freezer locations?

Extremely unsatisfied	Somewhat unsatisfied	Neither satisfied nor unsatisfied	Somewhat satisfied	Extremely satisfied
○	○	○	○	○

Why didn't you submit heads for CWD testing? Please select all that apply.

- ☐ Because the instructions on head submission were not clear to me.
- ☐ Because the deer were not harvested in mandatory CWD testing areas.
- ☐ Because I was not worried about CWD risks to me and my family from eating deer meat.
- ☐ I prefer not to say
- ☐ ________ Other (please specify)

Before you received this survey, had you considered the role of hunters in CWD management / surveillance?

Yes	No
○	○

The following are some statements regarding CWD management programs. Indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement by selecting one of the boxes:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Current government programs can be more effective in controlling CWD by engaging hunters.	O	O	O	O	O
Hunters can play a role in CWD management through hunting	O	O	O	O	O

Alberta Fish and Wildlife is currently, or has in the past, conducted a variety of programs to address CWD in the province of Alberta. Please indicate your agreement with the use of these programs on the scale of "Strongly disagree" to "Strongly agree" .

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Reducing local deer herds in the areas where CWD is most concentrated.	O	O	O	O	O
Mandatory submission of heads for CWD testing in certain WMUs.	O	O	O	O	O
Providing additional hunting opportunities (e.g. extra tags) in CWD high-risk areas	O	O	O	O	O
Voluntary submission of heads for the province.	O	O	O	O	O
Provisions of freezer locations for deer head submission.	O	O	O	O	O

Do you own land in any of these WMUs where CWD occurs?

Prairie WMU Series (100 Series & 732):
102,116, 118, 119, 142, 144, 148, 150, 151, 152, 158, 160, 162, 163, 164, 166, 732

Parkland WMU Series (200 Series & 728, 730) & 500:
200, 202, 203, 204, 206, 208, 228, 230, 232, 234, 236, 238, 242, 250, 252, 254, 256, 258, 260, 500, 728, 730

Yes ○ No ○

Are you concerned about CWD-infected wildlife being on your land?

Yes ○ No ○

Why are you concerned? (Please select all that apply)

- ☐ CWD is a threat to farm animals / livestock
- ☐ CWD is a threat to humans
- ☐ CWD is a threat to wildlife populations
- ☐ Other (please specify) ______

Do you allow hunting on your lands?

Yes ○ No ○

Who are you most likely to grant permission to hunt on your land ?

Strangers	Friends / Neighbours	Anyone who asks	Family
○	○	○	○

Are you likely to allow hunting on your land if it would help reduce CWD?

Yes ○ No ○

Would you consider participating in programs that compensate you for allowing hunting on your lands if it would reduce CWD?

Yes	No
◯	◯

Would you consider joining with adjacent landowners to increase hunting on your combined lands if it would reduce CWD?

Yes	No
◯	◯

The following are some statements regarding risks associated with CWD. Please indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Stro ag
CWD will be eradicated in Alberta.	◯	◯	◯	◯	◯
CWD will not be eradicated in Alberta, but it will remain at a low level.	◯	◯	◯	◯	◯
On average Alberta hunters think CWD is a threat to human health.	◯	◯	◯	◯	◯
CWD is a threat to wildlife herd health in Alberta.	◯	◯	◯	◯	◯
CWD is a threat to human health.	◯	◯	◯	◯	◯
On average Alberta hunters think CWD is a threat to wildlife herd health in Alberta.	◯	◯	◯	◯	◯
CWD will result in the eventual extinction of cervids in Alberta.	◯	◯	◯	◯	◯
CWD will eventually disappear as a result of natural evolution.	◯	◯	◯	◯	◯

We would like to know how extensive and how serious you think CWD currently is in the wild mule deer population in Alberta.

Please complete the chart below for each WMU provided (Note: there is a WMU map below). Please select what you feel the correct prevalence (infection rate) is for each WMU. A map of CWD affected WMUs is available. We would like to know what you think the infection rates are and how you think CWD will affect the wild mule deer population. **There are no right or wrong answers – we are interested in your perception of CWD infection rates in a WMU.** We provide 4 categories of severity based upon the number of infected mule deer per 100 in each WMU. The infection rates are explained in the table below. Please only select "I Don't Know" if you really feel you have no knowledge of CWD and its potential impact in these WMUs.

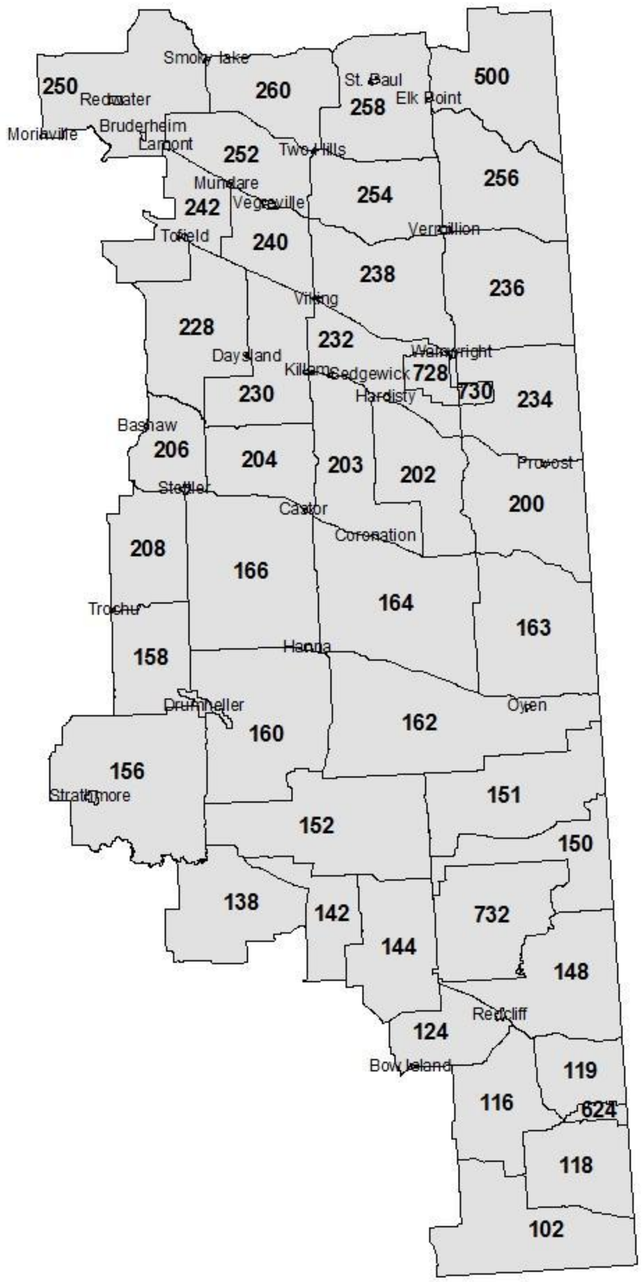
Infection Rate	**# Infected Mule Deer per 100 (%)**
None	0
Low	1 to 5
Medium	6 to 10
High	11 or more
I Don't Know	I am not familiar enough with the WMU to answer

Please select what you feel is the rate of CWD in each WMU during 2018.

NOTE: Please select "I Don't Know" if you have no perception about the conditions in the WMU.

	None	Low	Medium	High	I Don't Know
WMU 118	○	○	○	○	○
WMU 148	○	○	○	○	○
WMU 150	○	○	○	○	○
WMU 151	○	○	○	○	○
WMU 152	○	○	○	○	○
WMU 162	○	○	○	○	○
WMU 163	○	○	○	○	○

	None	Low	Medium	High	I Don't Know
WMU 200	○	○	○	○	○
WMU 202	○	○	○	○	○
WMU 203	○	○	○	○	○
WMU 232	○	○	○	○	○
WMU 234	○	○	○	○	○
WMU 236	○	○	○	○	○
WMU 728	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/1}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/2}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/3}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/4}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/5}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/6}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/7}	○	○	○	○	○
WMU ${q://QID3/ChoiceTextEntryValue/8}	○	○	○	○	○


250
Redwater
Morinville
Bruderheim
Lamont
Smoky lake
260
St. Paul
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Elk Point
500
252
Two Hills
Mundare
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Vegreville
254
256
Tofield
240
Vermillion
238
236
228
Viking
232
Daysland
Wainwright
Killam
Sedgewick
728
730
Hardisty
230
234
Bashaw
206
204
203
202
Provost
Stettler
Castor
200
208
166
Coronation
164
163
Trochu
158
Hanna
Drumheller
160
162
Oyen
156
Strathmore
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152
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138
142
144
732
148
Redcliff
124
Bow Island
119
116
624
118
102

CWD surveillance results in Fall 2017 from the Government of Alberta shows that the CWD prevalence (infection rate) is 8.2% for mule deer in the province.

Please write in the box below any WMUs that you think the CWD prevalence is *higher* than 8.2%. (Please refer to the map above)

Section 4: Contingent Behavior

In this section we are trying to understand what you would do if management policies changed in the areas where you normally hunt. Please read the following instructions carefully then answer the following questions.

Wildlife managers are considering changes to recreational hunting policy in CWD affected areas to help manage the rate at which spread and prevalence is increasing in Alberta.

Across North America there have been some jurisdictions in the past that have attempted to manage CWD by reducing local cervid populations through a combination of hunter harvest and direct herd reduction (Blanchong et al 2006, Conner et al 2007, Pybus 2012, Mateus-Pinilla et al 2013, Manjerovac et al 2014[3]). While there is evidence that some of these were effective, the programs were unsustainable over time. A key factor in future CWD management will be long-term hunter support. Programs that manage hunter harvest to maximize hunter satisfaction and remove infected cervids are seen as a possible approach to limiting the rate at which the disease increases and spreads in cervid populations.

[3] Blanchong JA, Joly DO, Samuel MD, Langenberg JA, Rolley RE, Sausen JF. (2006) White-tailed Deer Harvest from the Chronic Wasting Disease Eradication Zone in South-central Wisconsin. Wildlife Society Bulletin 34(3): 725-731.

Conner MM, Miller MW, Ebinger MR, Burnham KP. (2007) A Meta-BACI Approach for Evaluating Management Intervention on Chronic Wasting Disease in Mule Deer. Ecological Applications 17(1): 140-153

Pybus M. (2012) CWD Program Review 2012. Alberta Sustainable Resource Development, Fish and Wildlife Division. http://aep.alberta.ca/fish-wildlife/wildlife-diseases/chronic-wasting-disease/documents/CWD-ProgramReview-May-2012.pdf

Mateus-Pinilla N, Weng HY, Ruiz MO, Shelton P, Novaskofski J. (2013) Evaluation of a Wild White-tailed Deer Population

Management Program for Controlling Chronic Wasting Disease in Illinois, 2003-2008. Preventive Veterinary Medicine 110 (3): 541-548

Manjerovic MB, Green ML, Mateus-Pinilla N, Novakofski J. (2014) The Importance of Localized Culling in Stabilizing Chronic Wasting Disease Prevalence in White-tailed Deer Populations. Preventive Veterinary Medicine 113(1): 139-1458

Where you aware of past CWD management programs?

Yes	No
○	○

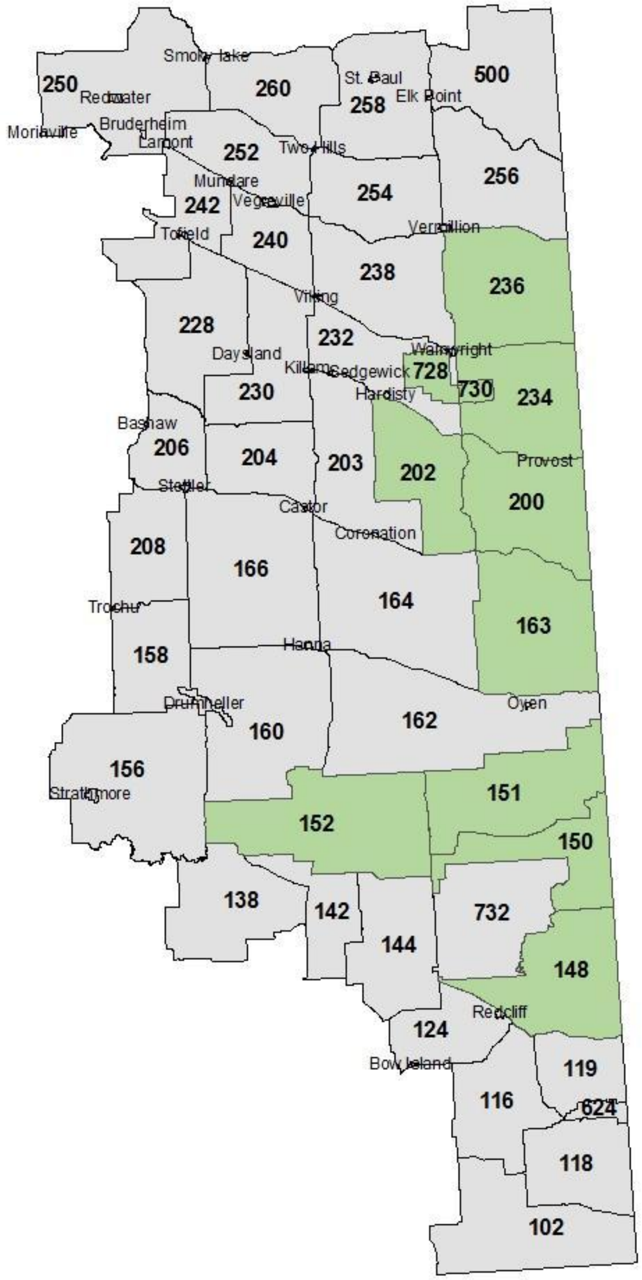
To help inform future decisions regarding CWD management in Alberta, we are going to present you with two different potential management scenarios and would like you to indicate how these scenarios would affect the number of hunting trips you would have taken and the number of deer you think you would have harvested in 2018. In thinking of the trips you would have taken, please treat each scenario by itself, completely independently from the other.

We know that how people respond in surveys is often not a reliable indication of how they will actually make choices. Therefore, we'd like you to respond in this survey as if your decisions are real. Imagine that you actually will have to take additional time and pay the additional trip expenses if you choose such activities. If you choose to take more hunting trips, remember that you will have less time, and possibly less money, to spend on other activities.

Policy A: Extra Tags

Potential CWD Management Scenario

When you win a special license draw for WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you can purchase two tags for mule deer instead of one for the current hunting season.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Redwater
Morinville
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Lamont
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Elk Point
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Mundare
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Vegreville
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Tofield
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Vermillion
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Viking
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Daysland
Killam
Sedgewick
Wainwright
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Hardisty
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Bashaw
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Provost
Stettler
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Castor
Coronation
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Trochu
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Hanna
Drumheller
160
162
Oyen
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Strathmore
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732
148
124
Redcliff
Bow Island
119
116
624
118
102

If the hunting policies were described as above, how many hunting trips would you have taken and how many cervids would you have harvested in 2018 in each WMU? In considering your responses, please assume that any features about the hunting trips not mentioned (such as associated expenditures and CWD prevalence) are the same as your 2018 experience.

This is a reminder of what you actually did in 2018.

	Number of trips in 2018 actually taken	Average number of days per trip in 2018 actually spent	Number of male mule deer actually harvested in 2018	Number of female mule deer actually harvested in 2018	Number of male white-tailed deer actually harvested in 2018	Num of fen whit taile dee actua harve in 20
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Please complete the following table for BIG GAME hunting trips to each WMU under the scenario above.

	Number of trips you would have taken in 2018 under the scenario above	Average number of days per trip you would have spent in 2018 under the scenario above	Number of male mule deer you would have harvested in 2018 under the scenario above	Number of female mule deer you would have harvested in 2018 under the scenario above	Number of male white-tailed deer you would have harvested in 2018 under the scenario above	Number of female white-tailed deer you would have harvested in 2018 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
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WMU							
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How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
○	○	○	○

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain

O O O O

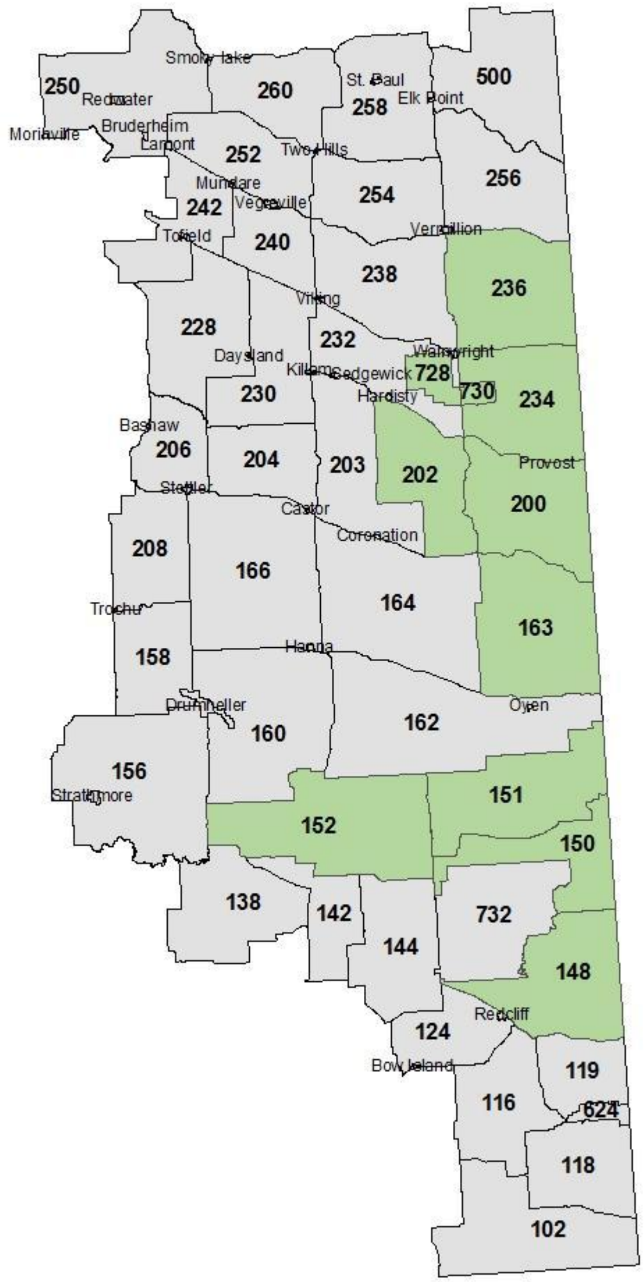
Policy B: Gift Cards

Potential CWD Management Scenario

For each <u>CWD-positive</u> head you submit from WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you will get a gift card valued at $50 at a popular hunting store.

For each <u>CWD-negative</u> head you submit from WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you will get a gift card valued at $30 at a popular hunting store.

The number of heads you submit cannot exceed the number of tags you have.



250
Redwater
Smoky lake
260
St. Paul
258
Elk Point
500
Morinville
Bruderheim
Lamont
252
Two Hills
256
Mundare
242
Vegreville
254
Tofield
240
Vermilion
238
236
Viking
228
232
Daysland
Wainwright
Killam
Sedgewick
728
730
Hardisty
230
234
Bashaw
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Provost
Stettler
200
Castor
Coronation
208
166
164
Trochu
163
158
Hanna
Drumheller
Oyen
160
162
156
Strathmore
151
152
150
138
142
732
144
148
124
Redcliff
Bow Island
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116
624
118
102

If the hunting policies were described as above, how many hunting trips would you have taken and how many cervids would you have harvested in 2018 in each WMU? In considering your responses, please assume that any features about the hunting trips not mentioned (such as associated expenditures and CWD prevalence) are the same as your 2018 experience.

Here is a reminder of what you actually did in 2018.

	Number of trips in 2018 actually taken	Average number of days per trip in 2018 actually spent	Number of male mule deer actually harvested in 2018	Number of female mule deer actually harvested in 2018	Number of male white-tailed deer actually harvested in 2018	Num of fen whit taile dee actua harves in 20
WMU ${q://QID3/ChoiceTextEntryValue/1}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
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WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
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WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:

Please complete the following table for BIG GAME hunting trips to each WMU under the scenario above.

	Number of trips you would have taken in 2018 under the scenario above	Average number of days per trip you would have spent in 2018 under the scenario above	Number of male mule deer you would have harvested in 2018 under the scenario above	Number of female mule deer you would have harvested in 2018 under the scenario above	Number of male white-tailed deer you would have harvested in 2018 under the scenario above	Number of female white-tailed deer you would have harvested in 2018 under the scenario above	Num ot cervi elk, n you h harv in 2 und sce ab
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How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very uncertain ○ Somewhat uncertain ○ Somewhat certain ○ Very certain ○

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very unlikely Somewhat unlikely Somewhat likely Very likely

O O O O

Policy C: October Season

Potential CWD Management Scenario

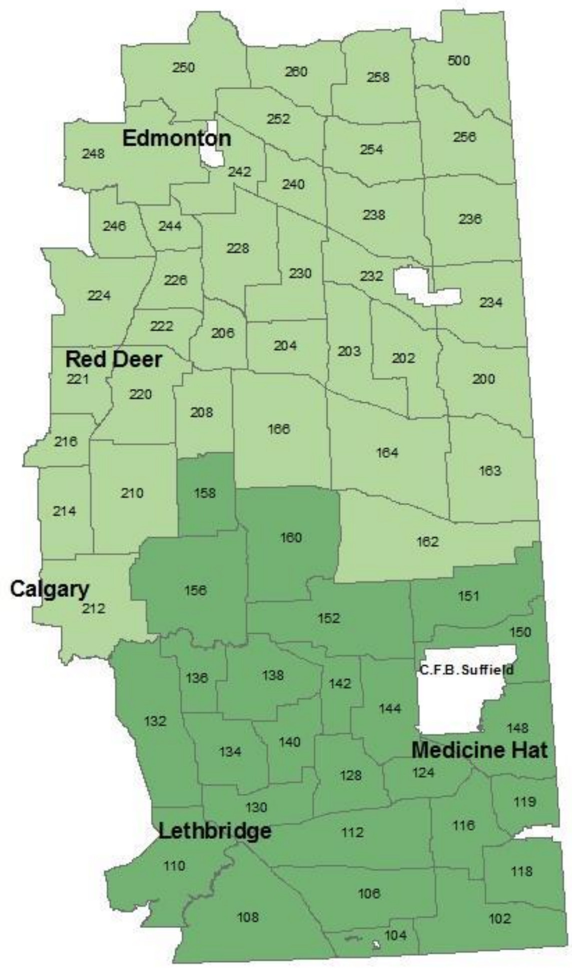
Expanding the hunting seasons for one week into October:

- Prairie WMUs 100 Series (except 162, 163, 164, 166), marked in dark green on the map:

  Wednesday to Saturday in **the last week of October** and November (**Oct.24 - Nov.30**)

- Parkland WMUs 200 Series; WMU 162, 163, 164, 166; WMU 500, marked in light green on the map:

  Oct.22 - Nov.30


Edmonton
Red Deer
Calgary
Lethbridge
Medicine Hat
C.F.B. Suffield
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If the hunting policies were described as above, you may have changed the number of trips that you took in 2018 in November and in the extended season in October. How many trips do you think you would have taken if the hunting policies included an extended season and you had special licenses to the WMUs?

1) During the extended hunting season in **October** of 2018, how many hunting trips **would you have taken** and how many cervids would you have harvested in each WMU?

2) During the regular hunting season in **November** of 2018, how many hunting trips **would you have taken** and how many cervids would you have harvested in each WMU?

In considering your responses, please assume that any features about the hunting trips that are not mentioned such as associated expenditures and CWD prevalence in WMUs are the same as your 2018 experience.

This is a reminder of what you actually did during the *regular season* (*i.e. November*) in 2018.

	Number of trips in 2018 actually taken	Average number of days per trip in 2018 actually spent	Number of male mule deer actually harvested in 2018	Number of female mule deer actually harvested in 2018	Number of male white-tailed deer actually harvested in 2018	Num of fen whit taile dee actu harve in 20
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	Number of trips in 2018 actually taken	Average number of days per trip in 2018 actually spent	Number of male mule deer actually harvested in 2018	Number of female mule deer actually harvested in 2018	Number of male white-tailed deer actually harvested in 2018	Num of fen whit taile dee actu harve in 20
WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:

EXTENDED HUNTING SEASON TRIPS (OCTOBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *extended hunting season (i.e. October) in 2018* under the scenario above.

	Number of trips you would have taken in *October* of 2018 under the scenario above	Average number of days you would have spent in *October* of 2018 under the scenario above	Number of male mule deer you would have harvested in *October* of 2018 under the scenario above	Number of female mule deer you would have harvested in *October* of 2018 under the scenario above	Number of male white-tailed deer you would have harvested in *October* of 2018 under the scenario above	Number of female white-tailed deer you would have harvested in *October* of 2018 under the scenario above	Num of cervi elk, n you ha harv in Oc of 2 und sce ab
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REGULAR HUNTING SEASON TRIPS (NOVEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting

in during the *regular hunting season (i.e. November) in 2018* under the scenario above.

	Number of trips you would have taken in 2018 under the scenario above	Average number of days per trip you would have spent in 2018 under the scenario above	Number of male mule deer you would have harvested in 2018 under the scenario above	Number of female mule deer you would have harvested in 2018 under the scenario above	Number of male white-tailed deer you would have harvested in 2018 under the scenario above	Number of female white-tailed deer you would have harvested in 2018 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
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How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

If you said you would not take any trips in October, please tell us why not. (Please select all that apply)

- ☐ There is an overlap with other hunting seasons (e.g. archery).
- ☐ I am usually too busy to go hunting in October.
- ☐ I am not interested in deer hunting in October.
- ☐ [ ] Other (please specify)

Policy D: December Season

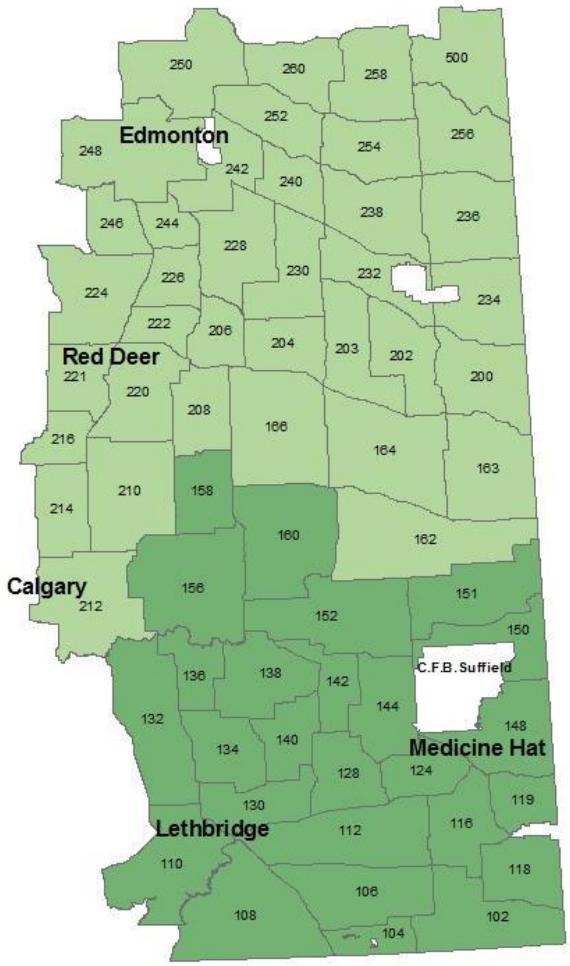
Potential CWD Management Scenario

Expanding the hunting seasons into December in:

- Prairie WMUs 100 Series (except 162, 163, 164, 166), marked in dark green on the map: Wednesday to Saturday in November and **December (Dec. 1 - Dec.15**)

- Parkland WMUs 200 Series; WMU 162, 163, 164, 166; WMU 500, marked in light green on the map: **Dec. 1 - Dec.16**

You can purchase *an extra tag* if you decide to hunt in extended seasons.


Edmonton
Red Deer
Calgary
Medicine Hat
Lethbridge
C.F.B. Suffield
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If the hunting policies were described as above, you may have changed the number of trips that you took in 2018 in November and in the extended season in December. How many trips do you think you would have taken if the hunting policies included an extended season and you had special licenses to the WMUs?

1) During the regular hunting season in **November** of 2018, how many hunting trips **would you have taken** and how many cervids would you have harvested in the each WMU?

2) During the extended hunting season in **December** of 2018, how many hunting trips **would you have taken** and how many cervids would you have harvested in the each WMU?

In considering your responses, please assume that any features about the hunting trips that are not mentioned such as associated expenditures and CWD prevalence in WMUs are the same as your 2018 experience.

This is a reminder of what you actually did during the regular season (i.e. November) in 2018.

	Number of trips in 2018 actually taken	Average number of days per trip in 2018 actually spent	Number of male mule deer actually harvested in 2018	Number of female mule deer actually harvested in 2018	Number of male white-tailed deer actually harvested in 2018	Num of fen whi taile dee actua harve in 20
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	Number of trips in 2018 actually taken	Average number of days per trip in 2018 actually spent	Number of male mule deer actually harvested in 2018	Number of female mule deer actually harvested in 2018	Number of male white-tailed deer actually harvested in 2018	Num of fen whit taile dee actu harve in 20
WMU ${q://QID3/ChoiceTextEntryValue/7}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:

REGULAR HUNTING SEASON TRIPS (NOVEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *regular hunting season (i.e. November) in 2018* under the scenario above.

	Number of trips you would have taken in 2018 under the scenario above	Average number of days per trip you would have spent in 2018 under the scenario above	Number of male mule deer you would have harvested in 2018 under the scenario above	Number of female mule deer you would have harvested in 2018 under the scenario above	Number of male white-tailed deer you would have harvested in 2018 under the scenario above	Number of female white-tailed deer you would have harvested in 2018 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
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WMU							

	Number of trips you would have taken in 2018 under the scenario above	Average number of days per trip you would have spent in 2018 under the scenario above	Number of male mule deer you would have harvested in 2018 under the scenario above	Number of female mule deer you would have harvested in 2018 under the scenario above	Number of male white-tailed deer you would have harvested in 2018 under the scenario above	Number of female white-tailed deer you would have harvested in 2018 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
WMU							

EXTENDED HUNTING SEASON TRIPS (DECEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *extended hunting season (i.e. December) in 2018* under the scenario above.

	Number of trips you would have taken in *December* of 2018 under the scenario above	Average number of days you would have spent in *December* of 2018 under the scenario above	Number of male mule deer you would have harvested in 2018 under the scenario above	Number of female mule deer you would have harvested in 2018 under the scenario above	Number of male white-tailed deer you would have harvested in 2018 under the scenario above	Number of female white-tailed deer you would have harvested in 2018 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
WMU							
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WMU							
WMU							

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

If you said you would not take any trips in December, please tell us why not. (Please select all that apply)

- ☐ The weather in December is not as good as the weather in November.
- ☐ I'm usually too busy to go hunting in December.
- ☐ I'm not interested in deer hunting in December.
- ☐ [ ] Other (please specify)

Debriefing

A list of several alternative policy options for CWD management are described below.

Expansion of hunting season	Extending current hunting seasons in high-risk CWD areas for two weeks i December (or one week in October).
Extra tags / licenses	You can purchase one extra tags for mule deer if you win a special license draw high-risk CWD areas. You can get an extra priority point in the draw system for mule deer special licen for high-risk CWD areas if you submit one mule deer head.

Gift cards	You can get a gift card reward if you submit heads from high-risk CWD areas.
Donation	You can donate the monetary reward to a conservation organization if you sub heads from high-risk CWD areas.
Special quota hunts	To reduce deer populations in the most CWD prevalent areas have special qu hunts from December through February
Extra female tags	To reduce infected herd sizes, increase the number of female tags in high-risk CV areas.
Three-point buck restriction	Reduce number of mature, infected males with a minimum 3-point restriction in hi risk CWD areas.

Overall, which type of policy option would you prefer? Please indicate using the scale of "Not desirable" to "Very desirable"

	Not desirable	Somewhat undesirable	Indifferent	Somewhat desirable	Very desirable
Extra tags/licenses	○	○	○	○	○
Expansion of hunting season	○	○	○	○	○
Three-point buck restriction	○	○	○	○	○
Extra female tags	○	○	○	○	○
Donation	○	○	○	○	○
Gift cards	○	○	○	○	○
Special quota hunts	○	○	○	○	○

Which policy options do you most prefer? Please numerically (1, 2, 3, etc.) rank at least three choices in the question below.

☐ Donation

☐ Expansion of hunting season

☐ Extra tags / licenses

☐ Gift cards

- [ ] Special quota hunts
- [ ] Extra female tags
- [ ] Three-point buck restriction

How likely do you think the information from your responses will be used in designing CWD management programs?

Very unlikely	Unlikely	Somewhat likely	Very likely	I don't know
○	○	○	○	○

Would you support policies that use hunters in CWD management?

Yes	No
○	○

How supportive do you think other Alberta hunters would be towards the idea of engaging hunters in CWD management?

Very unsupportive	Unsupportive	Somewhat supportive	Very supportive
○	○	○	○

How supportive do you think the general public would be towards the idea of engaging hunters in CWD management?

Very unsupportive	Unsupportive	Somewhat supportive	Very supportive
○	○	○	○

How likely do you think it is that engaging hunters to manage CWD can result in healthy deer population in the long run?

Very unlikely	Unlikely	Somewhat likely	Very likely
○	○	○	○

Would you participate in programs associated with engaging hunters for CWD management in the future? Please select all that apply.

- ☐ Yes, because it would help control CWD effectively.
- ☐ Yes, because I would have more hunting opportunities.
- ☐ Maybe, it depends on the costs and my availability.
- ☐ No, because I don't think hunters can help CWD control.
- ☐ No, please write down the reason if the above reasons don't apply

What is the most important reason for you to participate in CWD management programs?

- ○ I would have more hunting opportunities.
- ○ These programs would help control CWD effectively

What is the most important reason that discourages you from participating in CWD management programs?

- ○ I don't think these programs would help control CWD. There should be more effective alternative approaches.
- ○ These programs are too costly and time consuming for me.
- ○ ${q://QID120/ChoiceTextEntryValue/5}
- ○ ____ Other (please specify)

Do you think that the majority of hunters in your region/community would participate in programs associated with engaging hunters for CWD management in the future? Please choose one only.

- ○ No, because they may think hunters are not effective in helping CWD management.
- ○ Yes, because they would have more hunting opportunities.
- ○ Yes, because they think these programs would help control CWD effectively.
- ○ No, because these programs may be too costly and time consuming for them.

For the policy options that offered gift cards in exchange for submission of heads, would you take additional hunting trips if there was no gift card?

- ○ Yes
- ○ No

Please indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the following statement by selecting one of the lines:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The value of the gift card isn't enough to interest the majority of hunters who hunt in my region in taking additional trips.	○	○	○	○	○

The following are some statements regarding hunter behaviour and CWD. Please indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I no longer consume deer meat because of CWD.	○	○	○	○	○
If the prevalence of CWD decreased, I would increase my hunting in Alberta.	○	○	○	○	○
I regularly submit my deer heads for CWD testing.	○	○	○	○	○

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strong agree
I eat or give away the deer meat before I get the test results.	○	○	○	○	○
I think current hunting seasons are too short.	○	○	○	○	○
I have changed where I normally hunt because of CWD.	○	○	○	○	○
I think hunters should report back to landowners if there was a positive animal found on their land.	○	○	○	○	○
Hunters should not be paid for participating in additional hunts for CWD management.	○	○	○	○	○
I have not hunted in a CWD affected area.	○	○	○	○	○

What other things do you think could be done to engage hunters in CWD management / surveillance (e.g. promote submitting heads)? Please list any types of program (reward, information, recognition) that you feel may improve CWD management and surveillance.

Section 5: Demographic Information

Now we would like to ask some questions about you. The next set of questions are to help us find similarities between different groups of people and to identify trends in the hunting population. Please be assured that your responses will be kept strictly confidential.

Are you

Male	Female	Other	Prefer not to say
○	○	○	○

Are you a member of any of the following organizations?

- ☐ Nature Conservancy of Canada
- ☐ Alberta Fish and Game Association
- ☐ Alberta Federation of Naturalists
- ☐ Alberta Professional Outfitter Society
- ☐ Sierra Club
- ☐ An affiliation with government (i.e. Alberta Environment and Parks, Alberta Justice and Solicitor General)
- ☐ Canadian Parks and Wilderness Society

In what year were you born? (enter 4-digit birth year; for example, 1970)

What are the first three digits of your postal code?

What is the highest level of schooling you have completed?

- ○ Some high school or less
- ○ High school diploma
- ○ Some university, college, or technical school
- ○ Technical school graduate
- ○ University/College graduate
- ○ Some graduate school
- ○ Graduate degree

Please indicate your household income before taxes in 2018.

- ○ Less than 10,000
- ○ 10,000 to 19,999
- ○ 20,000 to 29,999
- ○ 30,000 to 39,999
- ○ 40,000 to 49,999
- ○ 50,000 to 59,999
- ○ 60,000 to 79,999
- ○ 80,000 to 99,999
- ○ 100,000 to 149,999
- ○ Greater than 150,000

Please indicate, by circling the most appropriate category, where you currently live.

- ○ Large urban setting (100 000 people or more)
- ○ Small urban setting (20 000 to 99 999 people)
- ○ Town or village (1 000 to 19 999 people)
- ○ Rural setting (999 people or less)

Are there any children under 12 in your household?

Yes	No
○	○

In order to continue our research in this area, we would like to contact you again, in approximately one year, to request information and your opinions on the 2019 hunting season. We would also like to be able to link your answers from this survey to the next one. In order to do this, your contact information would be recorded along with your answers (your email address would not be used for any other reason). This would reduce the anonymity of your answers although they would still be kept strictly confidential. Your information will not be given out or shared in any way. The only person with access to your information will be the researcher contacting you next year to ask for your participation in the survey.

Would you be willing to participate in a similar survey next hunting season?

Yes	No

○ ○

Please provide your email address

If you wish to leave comments about the survey or hunting-related issues in it, please use the box below. Your feedback is highly appreciated.

For more information about CWD, please check following websites:

http://aep.alberta.ca/fish-wildlife/wildlife-diseases/chronic-wasting-disease/default.aspx
http://cwd-info.org/

As a thank you for participating in this survey, we would like to offer you a chance to enter a prize draw to win one of two gift cards valued at $150 each for Cabela's. If you wish to enter the draw, you will have to answer a skill-testing question as a legal requirement. We will also need to collect your email address to inform you of the draw result. Your email address will not be used for any other reason.

Would you like to enter the prize draw?

Yes	No
○	○

Under federal law, it is necessary that you answer a skill-testing question successfully in order to qualify for a chance to win the prize. Please answer the following question (write your answer in the blank space provided):

(5+5) / 2 =

Please provide your email address

Powered by Qualtrics

Supplementary Materials C
2020 Hunter Survey

Information Sheet

Deer Hunting in Alberta:
A Survey of Hunter Opinions

Study title: Deer Hunting in Alberta: A Survey of Hunter Opinions

Investigators:

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Department of Resource Economics and Environmental Sociology

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Professor

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John K. Pattison-Williams

Postdoctoral Fellow

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(780) 878-5175

Lusi Xie

PhD Student

lxie@ualberta.ca

Background and Purpose: You are being asked to participate in a research project. Recreational hunting activities have been affected by the presence of Chronic Wasting Disease (CWD) and its management strategies. Therefore, it is necessary and important to know how Alberta Hunters respond to the presence of CWD and how they may adjust behaviors when relevant management strategies change. We are doing this study to collect information on recreational hunting activities from Alberta hunters and to get their opinions about the current cervid hunting situation with a focus on issues associated with Chronic Wasting Disease in Alberta. The information we get from the survey may also help evaluate the potential to engage hunters in CWD management by harvesting additional cervids.

Study Procedures: The study involves completing a survey on the computer to identify your opinions. The entire survey will take approximately about 30 minutes to complete. To thank you for your time, if you complete the survey you will be entered into a draw where you will have a chance of winning one of two gift cards valued at $150 each for Cabela's. The actual odds of winning will depend on the number of people who actually participate in the survey, but the approximate odds are 1/500.

Benefits: You will not receive any benefit from participating in this study. The data we get from this survey will be shared with people in various levels of the government. They can use this to make better-informed decisions about policies and management issues related to Chronic Wasting Disease in Alberta. We will also be able to do an economic analysis on the data to advise on better management of CWD to increase hunting satisfaction.

Risks: We do not anticipate any risks associated with participation.

Confidentiality: All of the data we collect from you and your responses will be kept completely confidential. Personal identifying information such as first three digits of your postal code, year of birth and gender will be collected in order to determine differences in hunting behaviour and travel costs. We will not possess your contact information, unless at the end of the survey you provide your email to enter the prize draw. This information will be maintained in a separate password-protected spreadsheet, which will be removed once the prize draw is finished. Your data and survey responses will be collected using a survey program called Qualtrics and will be recorded in a database on a server at the University of Alberta. Only the research team will have access to this database. Your answers will not be shared with anyone outside this group. Any reports or papers written will include only survey averages or similar measures; individual responses will not be reports nor will individuals be distinguishable.

Withdrawal from the Study: Being in this study is completely voluntary. Also, even if you agree, you are free to stop doing the survey at any time. However because we are not collecting any information that can be linked to you personally, once you have completed the survey and submitted it, we cannot remove your survey responses from the database.

Use of your Information: The information we get from doing this study will be used for a graduate student thesis, academic papers, and reports. This study is being funded by Alberta Prion Research Institute (a provincial research agency). The project is not funded by any NGOs or hunting organizations. The results will be placed in reports which will be available to any organization or individual wishing to read it. The Government may use this information in their decision making process.

The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

I understand the purpose, risks, and benefits of this survey. By clicking below I agree to participate in the survey.

Agree	Disagree
○	○

Please note that once you advance by clicking "NEXT" you cannot go back and revise your answers.

Did you go hunting last year (2019)?

Yes	No
○	○

Section 1: Background Information

The following questions are meant to collect information regarding your deer hunting trips taken in Alberta and your opinions about wildlife resources in Alberta. Your answers will help us to understand preferences for hunting and create better wildlife management decisions.

How many years have you been deer hunting?

What WMU would you list as your favourite WMU for mule deer hunting?

Did you go hunting in your favourite WMU listed above last year?

Yes ○ No ○

Did you go BOW hunting last year?

Yes ○ No ○

Which weapon(s) do you use to hunt deer? Please select all that apply.

- ☐ Rifle
- ☐ Cross bow
- ☐ Bow and arrow
- ☐ Shotgun
- ☐ Muzzleloader
- ☐ Other

What type of land do you typically hunt deer on in Alberta?

- ○ Private
- ○ Public / Crown
- ○ Both

What kind of transportation do you usually use to access hunting sites? Please select all that apply.

- ☐ Cars
- ☐ Off-highway Vehicles
- ☐ Trucks / pickup trucks
- ☐ RVs
- ☐ ________ Other (Please specify)

Section 2: Hunting trips

In this next section we ask you to recall BIG GAME hunting trips that you personally took during 2019. Please recall as much information as possible and be as specific as possible. A map of WMUs and calendars are available.

Please complete the following table for each hunting season. A map of WMUs and calendars are available below. You are asked to indicate the following:

1. Please write down each WMU where you hunted.

2. Please write down the overall number of trips made to that WMU during the 2019 hunting season. Please note that if there were multiple destinations or overnight trips, the number of trips to that WMU may not equal the number of days spent there. A trip is defined as travel to and from a hunting site and may involve one or more days at a site.

3. Please write down the total number of each deer species and any other cervids (moose, elk) you harvested in that WMU. If you didn't harvest any, please write 0.

THIS IS AN EXAMPLE:

Please complete the following table for each WMU you went BIG GAME hunting in during the 2019 hunting season.

WMU you	Do you live in	Number of trips	Average number	Harvest		
				Mule deer	White-tailed	Other cervids

hunted in	this WMU?	to the WMU	of days per trip to the WMU			deer		species (e.g. elk, moose)
				Male	Female	Male	Female	
151	N	5	1	0	0	0	1	1
256	N	3	2	0	1	1	0	0
164	Y	1	10	1	0	0	0	0

Please complete the following table for each WMU you went BIG GAME hunting in during the 2019 hunting season. *(A trip is defined as travel to and from a hunting site and may involve one or more days at a site.)*

	Do you live in this WMU?	Number of trips to the WMU	Average number of days per trip to the WMU	Harvest: Male Mule Deer	Harvest: Female Mule Deer	Harvest: Male Whitetail Deer	Harvest: Female Whitetail Deer	Harvest: Other Cervid Species (ie. moose, elk)
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WMU								
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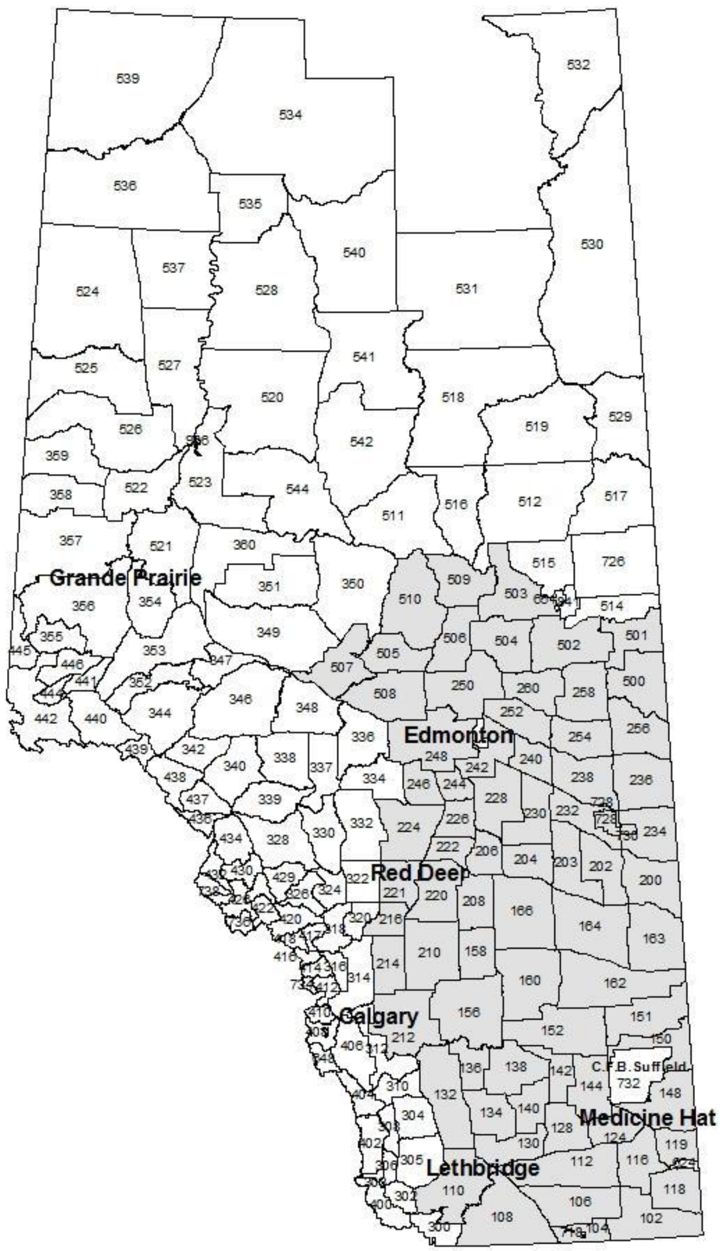
	Do you live in this WMU?	Number of trips to the WMU	Average number of days per trip to the WMU	Harvest: Male Mule Deer	Harvest: Female Mule Deer	Harvest: Male Whitetail Deer	Harvest: Female Whitetail Deer	Harvest: Other Cervid Species (ie. moose, elk)
WMU								
WMU								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360
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726
Grande Prairie
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510
503
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258
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348
252
256
442
440
336
Edmonton
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234
434
328
330
222
206
204
203
202
200
Red Deer
322
221
220
208
166
164
163
324
320
216
210
158
416
214
160
162
314
Calgary
156
151
212
152
406
150
138
142
C.F.B. Suffield
136
144
732
148
310
132
304
134
140
Medicine Hat
128
124
119
130
305
Lethbridge
112
116
302
110
118
108
106
300
104
102

November 2019						
SUN	MON	TUE	WED	THU	FRI	SAT
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	39	30

December 2019						
SUN	MON	TUE	WED	THU	FRI	SAT
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Section 3: Chronic Wasting Disease (CWD)

In this section we are trying to determine what is important to you during hunting trips and how the presence of wildlife disease may affect your hunting decisions. Please read all the information presented first and then answer the questions accordingly.

Please read the following information about Chronic Wasting Disease.

Chronic wasting disease (CWD) is a serious disease that is fatal to members of the deer (cervid) family such as mule deer, white-tailed deer, elk, and moose in Alberta. It is caused by infectious proteins (prions) that are associated with lethal changes in the brain. The disease process is similar to mad cow disease in cattle and scrapie in sheep.

CWD transmits through direct contact with infected animals and indirect contact with contaminated environments. In some U.S states local cervid populations are declining because of CWD.[1] According to the latest CWD update in October 2019 from the Government of Alberta, a total of 1,498 CWD cases in wild cervids have been documented in Alberta.[2] The number of cases identified annually increased from 4 in 2005 to 579 in 2018. CWD is found most often in male mule deer. CWD will likely continue to increase and spread in cervid populations across Alberta.

CWD only infects cervids such as deer, elk, and moose. No cases have been reported of CWD transferring to livestock. While the possibility of transmission to humans is a concern, human health authorities state that there are no verified cases of humans contracting CWD. However, as a precaution they recommend that hunters do not eat the meat of an infected animal and should take precautions when handling any carcass.

[1] DeVivo MT, Edmunds DR, Kauffman MJ, Schumaker BA, Binfet J, Kreeger TJ, et al. (2017) Endemic chronic wasting disease causes mule deer population decline in Wyoming. PLoS ONE 12 (10): e0186512. Edmunds DR, Kauffman MJ, Schumaker BA, Lindzey FG, Cook WE, Kreeger TJ, et al. (2016) Chronic Wasting Disease Drives Population Decline of White-Tailed Deer. PLoS ONE 11(8): e0161127.
[2] www.alberta.ca/cwd

Have you heard of CWD before you received this survey?

- ○ Yes, I have heard a little of CWD
- ○ Yes, I have read or heard detailed information on CWD such as its scientific basis and its recent spread / prevalence

- No

Before you received this survey, were you aware that CWD was present and increasing in prevalence and geographic distribution in Alberta?

Yes	No
○	○

How have your received CWD-relevant information? (Please select all that apply)

- ☐ Newspapers
- ☐ Outdoor magazines
- ☐ Word-of-mouth from friends and relatives
- ☐ Television news coverage
- ☐ Government website
- ☐ Social media (e.g. twitter, Facebook)
- ☐ Podcasts
- ☐ Other

Have you ever submitted a deer head that tested positive for CWD BEFORE the 2019 hunting season?

Yes	No
○	○

What year did this positive test occur?

In what WMU did you hunt this CWD positive animal?

Since you received your positive CWD head test, have you ever returned to the same WMU to hunt?

Yes	No
☐	☐

Did you already know or check for the presence of CWD in the WMU(s) you hunted in before applying for special license draws in 2019?

Yes	No
○	○

Did you avoid hunting in CWD-infected areas in 2019?

Yes	No
○	○

Did you harvest any cervids (ie. deer, elk or moose) in 2019?

Yes	No
○	○

Did you submit heads you harvested for CWD testing in 2019?

Yes	No
○	○

Why did you submit heads you harvested for CWD testing? Please select all that apply.

☐ Because the deer were harvested in mandatory CWD testing WMUs.
☐ Because I am concerned about the effect of CWD on wildlife populations.
☐ Because I was worried about CWD risks to me and my family from eating the deer meat.

How many days did it take to receive the results from your submitted head?

- ○ Less than one month
- ○ Between one month to two months
- ○ More than two months
- ○ Have not received the results back

How satisfied were you with the amount of time it took to receive the results from the CWD testing?

Extremely unsatisfied	Somewhat unsatisfied	Neither satisfied nor unsatisfied	Somewhat satisfied	Extremely satisfied
○	○	○	○	○

How satisfied were you with the instructions from AEP regarding how to submit the heads?

Extremely unsatisfied	Somewhat unsatisfied	Neither satisfied nor unsatisfied	Somewhat satisfied	Extremely satisfied
○	○	○	○	○

How satisfied were you with the freezer locations?

Extremely unsatisfied	Somewhat unsatisfied	Neither satisfied nor unsatisfied	Somewhat satisfied	Extremely satisfied
○	○	○	○	○

Why didn't you submit heads for CWD testing? Please select all that apply.

- ☐ Because the instructions on head submission were not clear to me.
- ☐ Because I was not worried about CWD risks to me and my family from eating cervid meat.
- ☐ Because the cervids were not harvested in mandatory CWD testing areas.

☐ I prefer not to say

☐ ____________ Other (please specify)

Before you received this survey, had you considered the role of hunters in CWD management / surveillance?

Yes	No
○	○

The following are some statements regarding CWD management programs. Indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement by selecting one of the boxes:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Hunters can play a role in CWD management through hunting	○	○	○	○	○
Current government programs can be more effective in controlling CWD by engaging hunters.	○	○	○	○	○

Alberta Environment and Parks is currently, or has in the past, conducted a variety of programs to address CWD in the province of Alberta. Other programs are currently hypothetical but are possible in the future. Please indicate your agreement with the use of these programs on the scale of "Strongly disagree" to "Strongly agree" .

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Changing to a CWD sampling method where the hunter extracts the tissue to be tested (with the assistance of on-line video demonstrations) and mails in the sample	○	○	○	○	○

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Voluntary submission of heads for the entire province.	O	O	O	O	O
If a vaccine for CWD becomes available in the future, establish a program to vaccinate all cervids in high risk WMUs	O	O	O	O	O
Provisions of freezer locations for cervid head submission.	O	O	O	O	O
Reducing local cervid herds in the areas where CWD is most concentrated.	O	O	O	O	O
Providing additional hunting opportunities (e.g. extra tags) in CWD high-risk areas	O	O	O	O	O
Mandatory submission of heads for CWD testing in certain high risk WMUs.	O	O	O	O	O

Do you own land in any of these WMUs where CWD occurs?

Prairie WMU Series (100 Series & 732):
102,116, 118, 119, 128, 130, 132, 134, 136, 140, 142, 144, 148, 150, 151, 152, 158, 160, 162, 163, 164, 166, 732

Parkland WMU Series (200 Series & 728, 730) & 500 and 501:
200, 202, 203, 204, 206, 208, 226, 228, 230, 232, 234, 236, 238, 242, 244, 250, 252, 254, 256, 258, 260, 500, 501, 728, 730

Yes	No
O	O

Are you concerned about CWD-infected wildlife being on your land?

Yes	No
O	O

Why are you concerned? (Please select all that apply)

- ☐ CWD is a threat to farm animals / livestock
- ☐ CWD is a threat to humans
- ☐ CWD is a threat to wildlife populations
- ☐ Other (please specify) ______

Do you allow people to hunt on your land (including yourself)?

Yes	No
○	○

Who are you most likely to grant permission to hunt on your land ?

Friends / Neighbours	Family	Strangers	Anyone who asks
○	○	○	○

Are you likely to allow hunting on your land if it would help reduce CWD?

Yes	No
○	○

Would you consider participating in programs that compensate you for allowing hunting on your lands if it would reduce CWD?

Yes	No
○	○

Would you consider joining with adjacent landowners to increase hunting on your combined lands if it would reduce CWD?

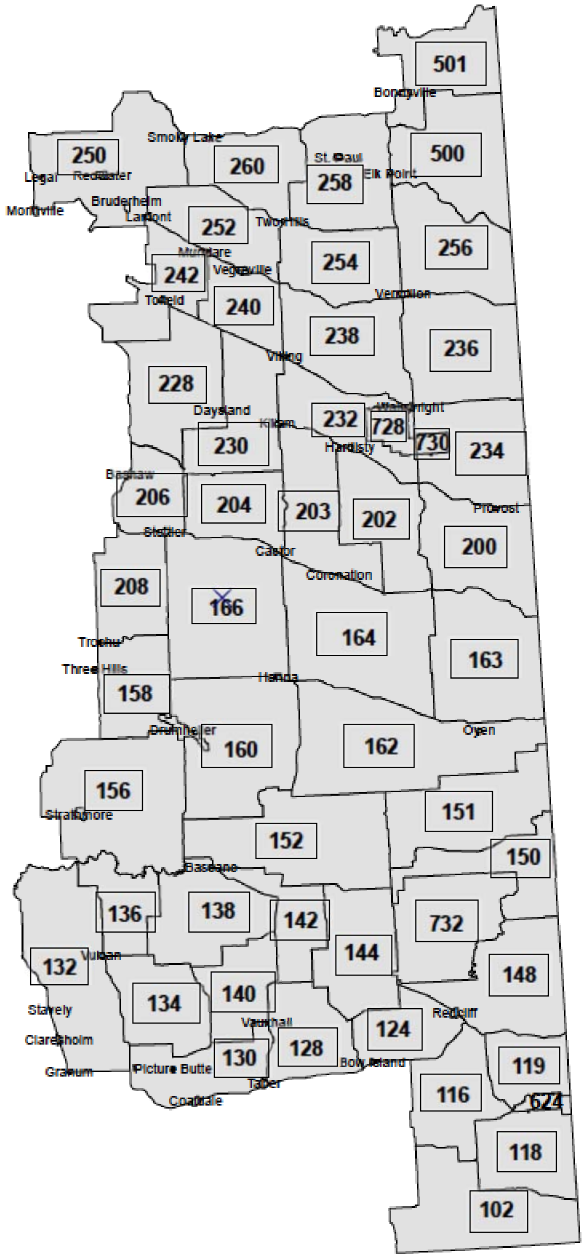
Yes	No
○	○

The following are some statements regarding risks associated with CWD. Please indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Stro ag
CWD is a threat to wild cervid herd health in Alberta.	○	○	○	○	○
On average Alberta hunters think CWD is a threat to wild cervid herd health in Alberta.	○	○	○	○	○
CWD will not be eradicated in Alberta, but it will remain at a low level.	○	○	○	○	○
CWD is a threat to human health.	○	○	○	○	○
CWD will result in the eventual extinction of wild cervids in Alberta.	○	○	○	○	○
CWD will be eradicated in Alberta.	○	○	○	○	○
CWD will eventually disappear as a result of natural evolution.	○	○	○	○	○
On average Alberta hunters think CWD is a threat to human health.	○	○	○	○	○

2018 Fall CWD surveillance results from the Government of Alberta shows that the CWD prevalence (infection rate) is 12% for mule deer in the province.

Please click the rectangle with WMU numbers if you think the CWD prevalence within the WMU is higher than 12% (if you feel it is lower or the same then do not click the rectangle).



Section 4: Contingent Behavior

In this section we are trying to understand what you would do if management policies changed in the areas where you normally hunt. Please read the

following instructions carefully then answer the following questions.

Wildlife managers are considering changes to recreational hunting policy in CWD affected areas to help manage the rate at which spread and prevalence is increasing in Alberta.

Across North America there have been some jurisdictions in the past that have attempted to manage CWD by reducing local cervid populations through a combination of hunter harvest and direct herd reduction (Blanchong et al 2006, Conner et al 2007, Pybus 2012, Mateus-Pinilla et al 2013, Manjerovac et al 2014[3]). While there is evidence that some of these were effective, the programs were unsustainable over time. A key factor in future CWD management will be long-term hunter support. Programs that manage hunter harvest to maximize hunter satisfaction and remove infected cervids are seen as a possible approach to limiting the rate at which the disease increases and spreads in cervid populations.

[3] Blanchong JA, Joly DO, Samuel MD, Langenberg JA, Rolley RE, Sausen JF. (2006) White-tailed Deer Harvest from the Chronic Wasting Disease Eradication Zone in South-central Wisconsin. Wildlife Society Bulletin 34(3): 725-731.

Conner MM, Miller MW, Ebinger MR, Burnham KP. (2007) A Meta-BACI Approach for Evaluating Management Intervention on Chronic Wasting Disease in Mule Deer. Ecological Applications 17(1): 140-153

Pybus M. (2012) CWD Program Review 2012. Alberta Sustainable Resource Development, Fish and Wildlife Division. http://aep.alberta.ca/fish-wildlife/wildlife-diseases/chronic-wasting-disease/documents/CWD-ProgramReview-May-2012.pdf

Mateus-Pinilla N, Weng HY, Ruiz MO, Shelton P, Novaskofski J. (2013) Evaluation of a Wild White-tailed Deer Population Management Program for Controlling Chronic Wasting Disease in Illinois, 2003-2008. Preventive Veterinary Medicine 110 (3): 541-548

Manjerovic MB, Green ML, Mateus-Pinilla N, Novakofski J. (2014) The Importance of Localized Culling in Stabilizing Chronic Wasting Disease Prevalence in White-tailed Deer Populations. Preventive Veterinary Medicine 113(1): 139-1458

Were you aware of past CWD management programs?

Yes	No
○	○

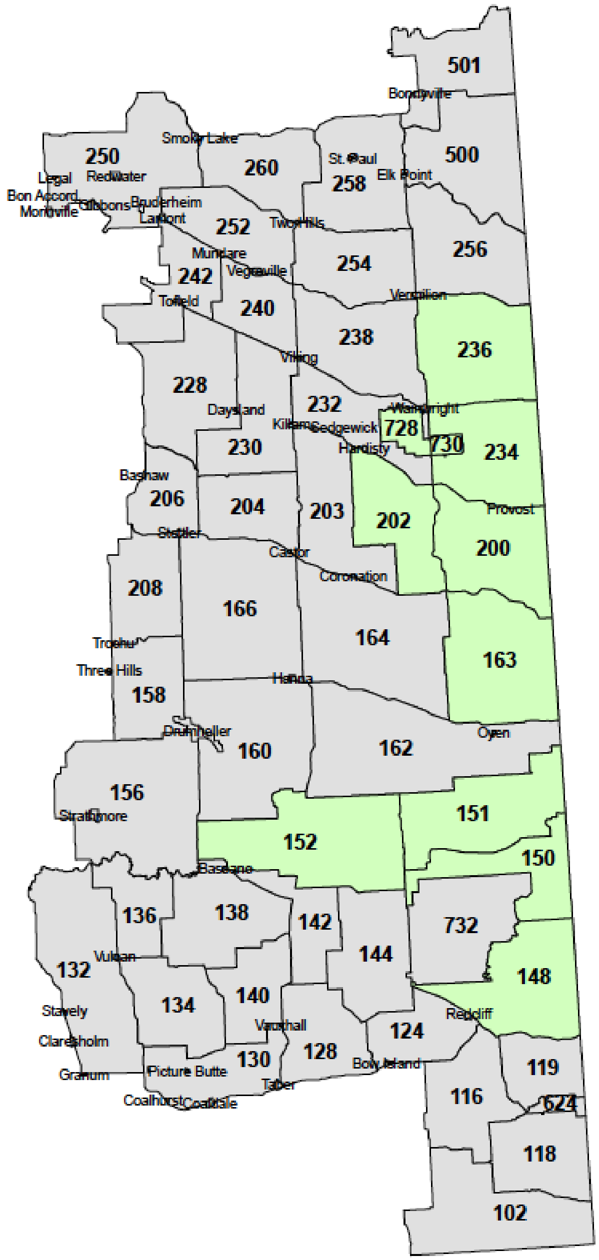
To help inform future decisions regarding CWD management in Alberta, we are going to present you with two different potential management scenarios and would like you to indicate how these scenarios would affect the number of hunting trips you would have taken and the number of deer you think you would have harvested in 2019. In thinking of the trips you would have taken, please treat each scenario by itself, completely independently from the other.

We know that how people respond in surveys is often not a reliable indication of how they will actually make choices. Therefore, we'd like you to respond in this survey as if your decisions are real. Imagine that you actually will have to take additional time and pay the additional trip expenses if you choose such activities. If you choose to take more hunting trips, remember that you will have less time, and possibly less money, to spend on other activities.

Policy A: Extra Tags

Potential CWD Management Scenario

When you win a special license draw for WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you can purchase two tags for mule deer instead of one for the current hunting season.



If the hunting policies were described as above, how many hunting trips would you have taken and how many cervids would you have harvested in 2019 in each WMU? In considering your responses, please assume that any features about the hunting trips not mentioned (such as associated expenditures and CWD prevalence) are the same as your 2019 experience.

This is a reminder of what you actually did in 2019.

	Number of trips actually taken in 2019	Average number of days per trip actually spent in 2019	Number of male mule deer actually harvested in 2019	Number of female mule deer actually harvested in 2019	Number of male white-tailed deer actually harvested in 2019	Num of fen whit taile dee actua harves in 20
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WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
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WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:

Please complete the following table for BIG GAME hunting trips to each WMU under the scenario above.

	Number of trips you would have taken in 2019 under the scenario above	Average number of days per trip you would have spent in 2019 under the scenario above	Number of male mule deer you would have harvested in 2019 under the scenario above	Number of female mule deer you would have harvested in 2019 under the scenario above	Number of male white-tailed deer you would have harvested in 2019 under the scenario above	Number of female white-tailed deer you would have harvested in 2019 under the scenario above	Num ot cervi elk, n you ha harv in 2 und scei ab

	Number of trips you would have taken in 2019 under the scenario above	Average number of days per trip you would have spent in 2019 under the scenario above	Number of male mule deer you would have harvested in 2019 under the scenario above	Number of female mule deer you would have harvested in 2019 under the scenario above	Number of male white-tailed deer you would have harvested in 2019 under the scenario above	Number of female white-tailed deer you would have harvested in 2019 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
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WMU							
WMU							
WMU							

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

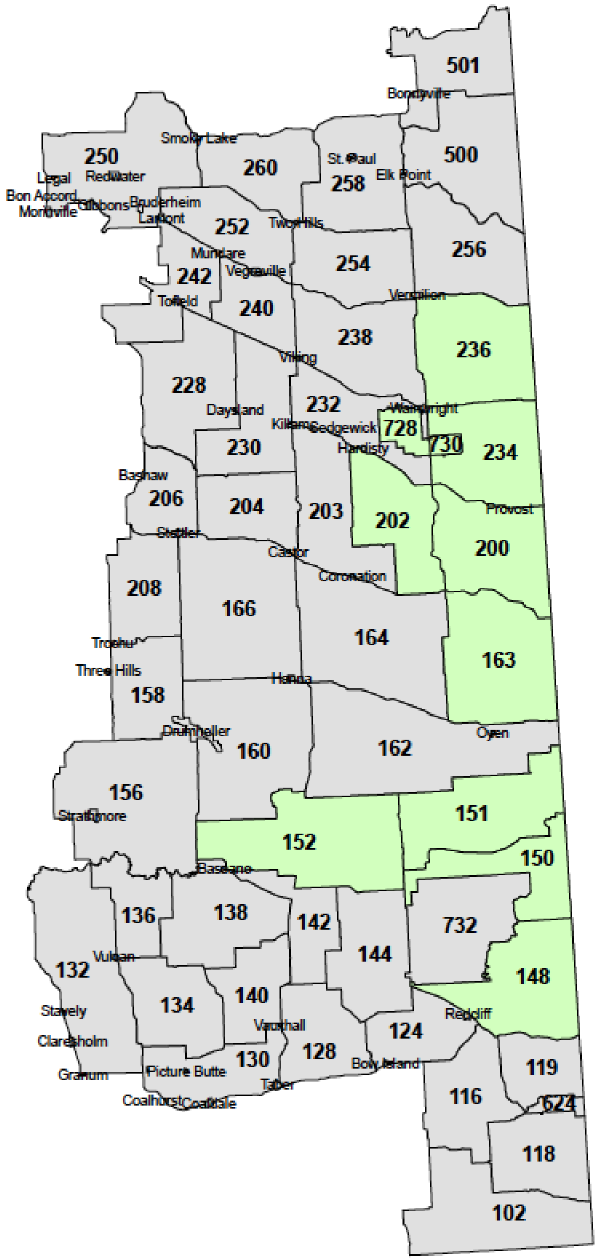
Policy B: Gift Cards

Potential CWD Management Scenario

For each CWD-positive head you submit from WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you will get a gift card valued at $50 at a popular hunting store.

For each CWD-negative head you submit from WMUs 148, 150, 151, 152, 163, 200, 202, 234, 236, 728/730 (the green area on the map), you will get a gift card valued at $30 at a popular hunting store.

The number of heads you submit cannot exceed the number of tags you have.



If the hunting policies were described as above, how many hunting trips would you have taken and how many cervids would you have harvested in 2019 in each WMU? In considering your responses, please assume that any logistical features about the hunting trips not mentioned (such as associated expenditures and CWD prevalence) are the same as your 2019 experience.

Here is a reminder of what you actually did in 2019.

	Number of trips actually taken in 2019	Average number of days per trip actually spent in 2019	Number of male mule deer actually harvested in 2019	Number of female mule deer actually harvested in 2019	Number of male white-tailed deer actually harvested in 2019	Num of fen whit taile dee actua harve: in 20
WMU ${q://QID3/ChoiceTextEntryValue/1}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/4}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
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WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:

Please complete the following table for BIG GAME hunting trips to each WMU under the scenario above.

	Number of trips you would have taken in 2019 under the scenario above	Average number of days per trip you would have spent in 2019 under the scenario above	Number of male mule deer you would have harvested in 2019 under the scenario above	Number of female mule deer you would have harvested in 2019 under the scenario above	Number of male white-tailed deer you would have harvested in 2019 under the scenario above	Number of female white-tailed deer you would have harvested in 2019 under the scenario above	Num ot cervi elk, n you ha harv in 2 und scei ab

	Number of trips you would have taken in 2019 under the scenario above	Average number of days per trip you would have spent in 2019 under the scenario above	Number of male mule deer you would have harvested in 2019 under the scenario above	Number of female mule deer you would have harvested in 2019 under the scenario above	Number of male white-tailed deer you would have harvested in 2019 under the scenario above	Number of female white-tailed deer you would have harvested in 2019 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
WMU							
WMU							
WMU							
WMU							
WMU							
WMU							
WMU							

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

- Very uncertain
- Somewhat uncertain
- Somewhat certain
- Very certain

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

- Very unlikely
- Somewhat unlikely
- Somewhat likely
- Very likely

Policy C: October Season

Potential CWD Management Scenario

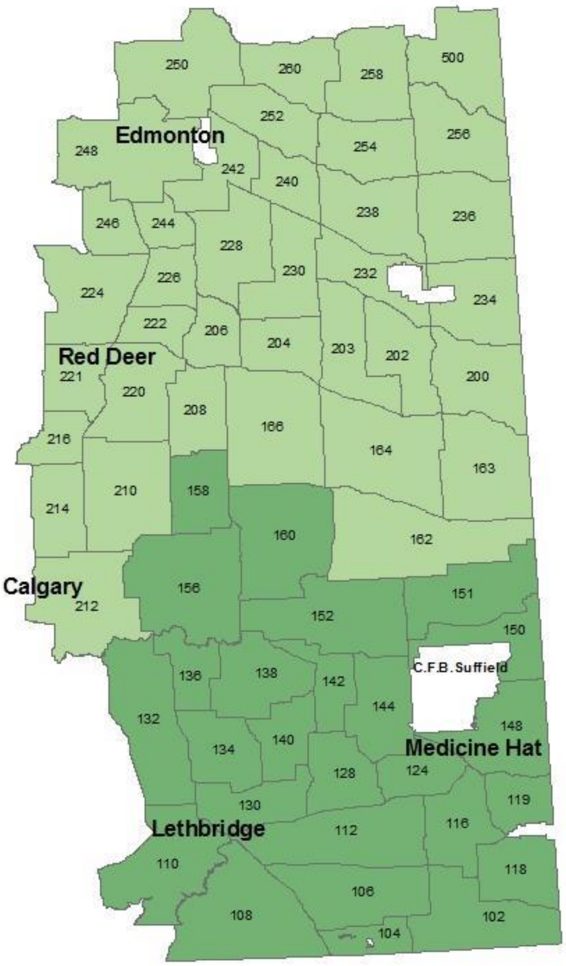
Expanding the hunting seasons for one week into October:

- Prairie WMUs 100 Series (except 162, 163, 164, 166), marked in dark green on the map:

  Wednesday to Saturday in **the last week of October** and November (**Oct.23 - Nov.30**)

- Parkland WMUs 200 Series; WMU 162, 163, 164, 166; WMU 500, marked in light green on the map:

  Oct.21 - Nov.30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204
203
202
Red Deer
221
220
200
208
166
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210
158
214
160
162
Calgary
212
156
151
152
150
C.F.B. Suffield
136
138
142
132
144
148
134
140
Medicine Hat
128
124
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119
Lethbridge
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102
104

If the hunting policies were described as above, you may have changed the number of trips that you took in 2019 in November and in the extended season in October. How many trips do you think you would have taken if the hunting policies included an extended season and you had special licenses to the WMUs?

1) During the extended hunting season in **October** of 2019, how many hunting trips **would you have taken** and how many cervids would you have harvested in each WMU?

2) During the regular hunting season in **November** of 2019, how many hunting trips **would you have taken** and how many cervids would you have harvested in each WMU?

In considering your responses, please assume that any features about the hunting trips that are not mentioned such as associated expenditures and CWD prevalence in WMUs are the same as your 2019 experience.

This is a reminder of what you actually did during the *regular season* (*i.e. November*) in 2019.

	Number of trips actually taken in 2019	**Average number of days per trip actually spent in 2019**	**Number of male mule deer actually harvested in 2019**	**Number of female mule deer actually harvested in 2019**	**Number of male white-tailed deer actually harvested in 2019**	**Num of fen whit taile dee actua harves in 20**
WMU ${q://QID3/ChoiceTextEntryValue/1}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/4}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/5}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/6}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/7}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:

	Number of trips actually taken in 2019	Average number of days per trip actually spent in 2019	Number of male mule deer actually harvested in 2019	Number of female mule deer actually harvested in 2019	Number of male white-tailed deer actually harvested in 2019	Num of fen whit taile dee actua harve in 20
WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:

EXTENDED HUNTING SEASON TRIPS (OCTOBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *extended hunting season (i.e. October) in 2019* under the scenario above.

	Number of trips you would have taken in *October* of 2019 under the scenario above	Average number of days you would have spent in *October* of 2019 under the scenario above	Number of male mule deer you would have harvested in *October* of 2019 under the scenario above	Number of female mule deer you would have harvested in *October* of 2019 under the scenario above	Number of male white-tailed deer you would have harvested in *October* of 2019 under the scenario above	Number of female white-tailed deer you would have harvested in *October* of 2019 under the scenario above	Num ot cervi elk, n you ha harv in Oc of 2 und sce ab
WMU							
WMU							
WMU							
WMU							
WMU							

REGULAR HUNTING SEASON TRIPS (NOVEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting

in during the *regular hunting season (i.e. November) in 2019* under the scenario above.

	Number of trips you would have taken in 2019 under the scenario above	Average number of days per trip you would have spent in 2019 under the scenario above	Number of male mule deer you would have harvested in 2019 under the scenario above	Number of female mule deer you would have harvested in 2019 under the scenario above	Number of male white-tailed deer you would have harvested in 2019 under the scenario above	Number of female white-tailed deer you would have harvested in 2019 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
WMU							
WMU							
WMU							
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WMU							
WMU							

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very uncertain ○ Somewhat uncertain ○ Somewhat certain ○ Very certain ○

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very unlikely Somewhat unlikely Somewhat likely Very likely

O O O O

If you said you would not take any trips in October, please tell us why not. (Please select all that apply)

- ☐ There is an overlap with other hunting seasons (e.g. archery).
- ☐ I am usually too busy to go hunting in October.
- ☐ I am not interested in deer hunting in October.
- ☐ ____________ Other (please specify)

Policy D: December Season

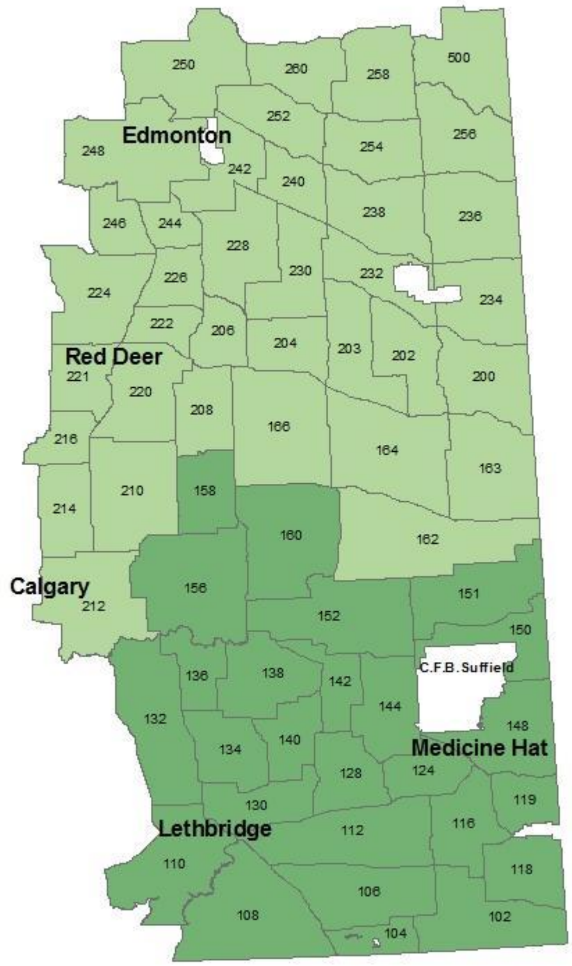
Potential CWD Management Scenario

Expanding the hunting seasons into December in:

- Prairie WMUs 100 Series (except 162, 163, 164, 166), marked in dark green on the map: Wednesday to Saturday in November and **December (Dec. 1 - Dec.14**)

- Parkland WMUs 200 Series; WMU 162, 163, 164, 166; WMU 500, marked in light green on the map: **Dec. 1 - Dec.16**

You can purchase *an extra tag* if you decide to hunt in extended seasons.


Edmonton
Red Deer
Calgary
Medicine Hat
Lethbridge
C.F.B. Suffield
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If the hunting policies were described as above, you may have changed the number of trips that you took in 2019 in November and in the extended season in December. How many trips do you think you would have taken if the hunting policies included an extended season and you had special licenses to the WMUs?

1) During the regular hunting season in **November** of 2019, how many hunting trips **would you have taken** and how many cervids would you have harvested in the each WMU?

2) During the extended hunting season in **December** of 2019, how many hunting trips **would you have taken** and how many cervids would you have harvested in the each WMU?

In considering your responses, please assume that any features about the hunting trips that are not mentioned such as associated expenditures and CWD prevalence in WMUs are the same as your 2019 experience.

This is a reminder of what you actually did during the regular season (i.e. November) in 2019.

	Number of trips actually taken in 2019	**Average number of days per trip actually spent in 2019**	**Number of male mule deer actually harvested in 2019**	**Number of female mule deer actually harvested in 2019**	**Number of male white-tailed deer actually harvested in 2019**	**Num of fen whit taile dee actua harves in 20**
WMU ${q://QID3/ChoiceTextEntryValue/1}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/2}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/3}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/4}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/5}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/6}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:

	Number of trips actually taken in 2019	Average number of days per trip actually spent in 2019	Number of male mule deer actually harvested in 2019	Number of female mule deer actually harvested in 2019	Number of male white-tailed deer actually harvested in 2019	Num of fen whit taile dee actu harve in 20
WMU ${q://QID3/ChoiceTextEntryValue/7}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:
WMU ${q://QID3/ChoiceTextEntryValue/8}	${q://(	${q://(	${q://(	${q://(	${q://(	${q:

REGULAR HUNTING SEASON TRIPS (NOVEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *regular hunting season (i.e. November) in 2019* under the scenario above.

	Number of trips you would have taken in 2019 under the scenario above	Average number of days per trip you would have spent in 2019 under the scenario above	Number of male mule deer you would have harvested in 2019 under the scenario above	Number of female mule deer you would have harvested in 2019 under the scenario above	Number of male white-tailed deer you would have harvested in 2019 under the scenario above	Number of female white-tailed deer you would have harvested in 2019 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
WMU							
WMU							
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	Number of trips you would have taken in 2019 under the scenario above	Average number of days per trip you would have spent in 2019 under the scenario above	Number of male mule deer you would have harvested in 2019 under the scenario above	Number of female mule deer you would have harvested in 2019 under the scenario above	Number of male white-tailed deer you would have harvested in 2019 under the scenario above	Number of female white-tailed deer you would have harvested in 2019 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
WMU							

EXTENDED HUNTING SEASON TRIPS (DECEMBER)

Please complete the following table for each WMU you would have gone BIG GAME hunting in during the *extended hunting season (i.e. December) in 2019* under the scenario above.

	Number of trips you would have taken in *December* of 2019 under the scenario above	Average number of days you would have spent in *December* of 2019 under the scenario above	Number of male mule deer you would have harvested in 2019 under the scenario above	Number of female mule deer you would have harvested in 2019 under the scenario above	Number of male white-tailed deer you would have harvested in 2019 under the scenario above	Number of female white-tailed deer you would have harvested in 2019 under the scenario above	Num ot cervi elk, n you ha harv in 2 und sce ab
WMU							
WMU							
WMU							
WMU							
WMU							

How certain are you that your responses are the choices you would make if the proposed policy program above is the actual CWD management program?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would participate in additional hunting activities if the proposed policy program above is the actual CWD management program?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

If you said you would not take any trips in December, please tell us why not. (Please select all that apply)

- ☐ The weather in December is not as good as the weather in November.
- ☐ I'm usually too busy to go hunting in December.
- ☐ I'm not interested in deer hunting in December.
- ☐ [ ] Other (please specify)

Debriefing

A list of several alternative policy options for CWD management are described below.

Expansion of hunting season	Extending current hunting seasons in high-risk CWD areas for two weeks i December (or one week in October).
Extra tags / licences	You can purchase one extra tags for mule deer if you win a special licence draw high-risk CWD areas. You can get an extra priority point in the draw system for mule deer special licen for high-risk CWD areas if you submit one mule deer head.
Gift cards	You can get a gift card reward if you submit heads from high-risk CWD areas.

Donation	You can donate the monetary reward to a conservation organization if you sub heads from high-risk CWD areas.
Special quota hunts	To reduce deer populations in the most CWD prevalent areas have special qu hunts from December through February
Extra female tags	To reduce infected herd sizes, increase the number of female tags in high-risk CV areas.
Three-point buck restriction	Reduce number of mature, infected males with a minimum 3-point restriction in hi risk CWD areas.

Overall, which type of policy option would you prefer? Please indicate using the scale of "Very undesirable" to "Very desirable"

	Very undesirable	Somewhat undesirable	Indifferent	Somewhat desirable	Very desirable
Three-point buck restriction	○	○	○	○	○
Extra female tags	○	○	○	○	○
Special quota hunts	○	○	○	○	○
Extra tags/licences	○	○	○	○	○
Expansion of hunting season	○	○	○	○	○
Gift cards	○	○	○	○	○
Donation	○	○	○	○	○

Which policy options do you most prefer? Please numerically (1, 2, 3, etc. where 1 is the preferred option) rank at least three choices in the question below.

☐ Expansion of hunting season

☐ Extra tags / licences

☐ Gift cards

☐ Donation

- [ ] Special quota hunts
- [ ] Extra female tags
- [ ] Three-point buck restriction

How likely do you think the information from your responses will be used in designing CWD management programs?

Very unlikely	Unlikely	Somewhat likely	Very likely
○	○	○	○

Would you support policies that use hunters in CWD management?

Yes	No
○	○

How likely do you think it is that hunters can help in CWD control through harvesting animals in CWD-infected areas?

Very unlikely	Unlikely	Somewhat likely	Very likely
○	○	○	○

How likely do you think it is that engaging hunters to manage CWD can result in healthy deer population in the long run?

Very unlikely	Unlikely	Somewhat likely	Very likely
○	○	○	○

How likely do you think it is that hunters can help in CWD control through harvesting animals OUTSIDE of the CWD infected area (but nearby)?

Very unlikely	Unlikely	Somewhat likely	Very likely
○	○	○	○

What is the most important reason for you to participate in CWD management programs?

- I would have more hunting opportunities.
- These programs would help control CWD effectively

What is the most important reason that discourages you from participating in CWD management programs?

- I don't think these programs would help control CWD. There should be more effective alternative approaches.
- These programs are too costly and/or time consuming for me.
- ${q://QID120/ChoiceTextEntryValue/5}
- ____________ Other (please specify)

Do you think that the majority of hunters in your region/community would participate in programs associated with engaging hunters for CWD management in the future? Please choose one only.

- No, because they may think hunters are not effective in helping CWD management.
- No, because these programs may be too costly and time consuming for them.
- Yes, because they think these programs would help control CWD effectively.
- Yes, because they would have more hunting opportunities.

For the policy options that offered gift cards in exchange for submission of heads, would you take additional hunting trips if there was no gift card?

- Yes
- No

Please indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the following statement by selecting one of the lines:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The value of the gift card isn't enough to interest the majority of hunters who hunt in my region in taking additional trips.	○	○	○	○	○

The following are some statements regarding hunter behaviour and CWD. Please indicate using the scale of "Strongly disagree" to "Strongly agree" your agreement with the statement.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I have not hunted in a CWD affected area.	○	○	○	○	○
Hunters should not be paid for participating in additional hunts for CWD management.	○	○	○	○	○
If the prevalence of CWD decreased, I would increase my hunting in Alberta.	○	○	○	○	○
I think hunters should report back to landowners if there was a positive animal found on their land.	○	○	○	○	○
I have changed where I normally hunt because of CWD.	○	○	○	○	○
I have changed where I normally hunt because replacement licences for CWD positive deer are no longer available	○	○	○	○	○
I eat or give away the deer meat before I get the test results.	○	○	○	○	○
I no longer consume deer meat because of CWD.	○	○	○	○	○
I regularly submit my deer heads for CWD testing.	○	○	○	○	○
I think current hunting seasons are too short.	○	○	○	○	○

Section 5: Valuation: Public Processing

Your opinion on a program to change test result response time

Survey responses from the 2018 hunting season in Alberta indicate that 19% of hunters who submitted heads received their results within 1 month, 23% received results within 1-2 months and 59% waited for more than 2 months to receive results. As the testing system is currently a first-come-first-served system, hunters who submit heads early in the hunting season will usually receive their results faster than those who submit later in the season.

Consider a program that would guarantee that CWD results for heads submitted from mandatory zones across the province were provided within 30 days of submission. These more rapid results would be achieved by putting more resources into the collection and testing of heads.

However, a program like this would require additional funding – an additional fee from all special mule deer licence holders. **Would you support a program that involved paying an additional fee but guarantees CWD results will be provided within 30 days of submission?** Such a system will provide faster results for hunters and may also improve monitoring and surveillance outcomes for the province.

This additional fee would only apply to special mule deer licences in mandatory CWD submission WMUs and would be in addition to the cost of your special licence. The funds would not be pooled with licence fees, but held separately in order to fund this testing.

If the majority of hunters supported this program, the fee would be added to the cost of special licenses. Note that this fee would be paid when purchasing the license and not when submitting a head.

Did you know that 59% of people waited for more than two months to receive their CWD test results?

Yes	No
○	○

There are various reasons why hunters may support or not support this program. Hunters who WOULD NOT support the program may feel that the amount of money requested is too much to pay for getting a faster test result while hunters who WOULD support such a program feel that getting a test result faster is worth the money.

We know that how people respond in surveys is often not a reliable indication of how they will actually make choices. Therefore, please respond as if your decisions are real. Respond as if you actually will have to pay the additional fee if the majority of hunters voted yes for the program. If the vote is supported, remember that you will have to pay the fee and less money to spend on other activities.

NOTE: as with all other information collected in this survey, we will share the aggregated results from this set of questions with resource managers in the Government of Alberta.

Public 1

Would you vote yes to pay $5 in addition to your mule deer special licence fee in order to guarantee CWD test results are returned within 30 days?

- ○ YES, I would vote to pay $5 to know my CWD test results within 30 days
- ○ NO, I would not vote to pay $5 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would vote in for this option if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

Public 2

Would you vote yes to pay $25 in addition to your mule deer special licence fee in order to guarantee CWD test results are returned within 30 days?

- O YES, I would vote to pay $25 to know my CWD test results within 30 days
- O NO, I would not vote to pay $25 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would vote in for this option if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

Public 3-1

Would you vote yes to pay $2 in addition to your mule deer special licence fee in order to guarantee CWD test results are returned within 30 days?

- O YES, I would vote to pay $2 to know my CWD test results within 30 days

- NO, I would not vote to pay $2 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would vote in for this option if it were a real option in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

Public 4

Would you vote yes to pay $50 in addition to your mule deer special licence fee in order to guarantee CWD test results are returned within 30 days?

- YES, I would vote to pay $50 to know my CWD test results within 30 days
- NO, I would not vote to pay $50 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would vote in for this option if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
○	○	○	○

Public 3-2

Would you vote yes to pay $2 in addition to your mule deer special licence fee in order to guarantee CWD test results are returned within 30 days?

- YES, I would vote to pay $2 to know my CWD test results within 30 days
- NO, I would not vote to pay $2 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would vote in for this option if it were a real option in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

Public 3-3

Would you vote yes to pay $2 in addition to your mule deer special licence fee in order to guarantee CWD test results are returned within 30 days?

- YES, I would vote to pay $2 to know my CWD test results within 30 days
- NO, I would not vote to pay $2 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would vote in for this option if it were a real option in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

Public Debrief

Why did you respond YES to the proposed fee?

- ○ It's worth the money to get the tests back sooner
- ○ Don't like having to wait so long for the results
- ○ I believe it will support CWD management in Alberta

Why did you respond NO to the proposed fee?

- ○ Too much money
- ○ I don't trust the funds would be used for this purpose
- ○ I don't needs the results back any sooner

Do you believe that your responses will be considered in the development of CWD policies by Alberta Environment and Parks?

Definitely not be considered	Unlikely to be considered	Likely to be considered	Definitely be considered
○	○	○	○

What other things do you think could be done to engage hunters in CWD management? Please list any types of program (reward, information, recognition) that you feel may improve CWD management in Alberta.

Valuation: Private Processing

Your opinion on a program to change test result response time

Survey responses from the 2018 hunting season in Alberta indicate that 19% of hunters who submitted heads received their results within 1 month, 23% received results within 1-2 months and 59% waited for more than 2 months to receive results. As the existing public testing system is currently a first-come-first-served system, hunters who submit heads early in the hunting season will usually receive their results faster than those who submit later in the season.

Suppose in addition to the free public CWD testing program run by AEP, there is a private lab that could provide this same (government approved) service. You have the choice of using the public service at no cost and waiting for your results, or paying a private fee to guarantee that you receive the test results within 30 days. After you submit the head you will be contacted by the testing lab to pay the fee.

Please think about whether you would **actually** pay for this service if you had to spend the money (and had less to spend on other things). In some cases people respond to survey questions like this by saying “yes” because they might use the service if it was available – please consider whether you would really spend the money for this.

Did you know that 59% of people waited for more than two months to receive their CWD test results?

Yes	No
○	○

There are various reasons why hunters may support or not support this program. Hunters who WOULD NOT support the program may feel that the amount of money requested is too much to pay for getting a faster test result while hunters who WOULD support such a program would feel that getting a test result faster is worth the money.

We know that how people respond in surveys is often not a reliable indication of how they will actually make choices. Therefore, please respond as if your decisions are real. Respond as if you actually will have to pay the fee. Remember that you will have to pay the fee and have less money to spend on other activities.

NOTE: as with all other information collected in this survey, we will share the aggregated results from this set of questions with resource managers in the Government of Alberta.

Private 1

Would you be willing to pay a fee of $5 to a private lab in order to guarantee CWD test results are returned within 30 days?

- ○ YES, I would pay $5 to know my CWD test results within 30 days
- ○ NO, I would not pay $5 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if this was a real option in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would pay this fee if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

Private 2

Would you be willing to pay a fee of $25 to a private lab in order to guarantee CWD test results are returned within 30 days?

- O YES, I would pay $25 to know my CWD test results within 30 days
- O NO, I would not pay $25 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if this was a real option in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would pay this fee if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

Private 3-1

Would you be willing to pay a fee of $2 to a private lab in order to guarantee CWD test results are returned within 30 days?

- O YES, I would pay $2 to know my CWD test results within 30 days
- O NO, I would not pay $2 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if this was a real option in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would pay this fee if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
○	○	○	○

Private 4

Would you be willing to pay a fee of $50 to a private lab in order to guarantee CWD test results are returned within 30 days?

- ○ YES, I would pay $50 to know my CWD test results within 30 days
- ○ NO, I would not pay $50 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if this was a real option in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would pay this fee if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
○	○	○	○

Private 3-2

Would you be willing to pay a fee of $2 to a private lab in order to guarantee CWD test results are returned within 30 days?

- YES, I would pay $2 to know my CWD test results within 30 days
- NO, I would not pay $2 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if this was a real option in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would pay this fee if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

Private 3-3

Would you be willing to pay a fee of $2 to a private lab in order to guarantee CWD test results are returned within 30 days?

- YES, I would pay $2 to know my CWD test results within 30 days
- NO, I would not pay $2 to know my CWD test results within 30 days

How certain are you that your response is the choice you would make if this was a real option in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would pay this fee if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

Private Debrief

Why did you respond YES to the proposed fee?

- O It's worth the money to get the tests back sooner
- O Don't like having to wait so long for the results
- O I believe it will support CWD management in Alberta

Why did you respond NO to the proposed fee?

- O Too much money
- O I don't trust the funds would be used for this purpose
- O I don't needs the results back any sooner

Do you believe that your responses will be considered in the development of CWD policies by Alberta Environment and Parks?

Definitely not be considered	Unlikely to be considered	Likely to be considered	Definitely be considered
O	O	O	O

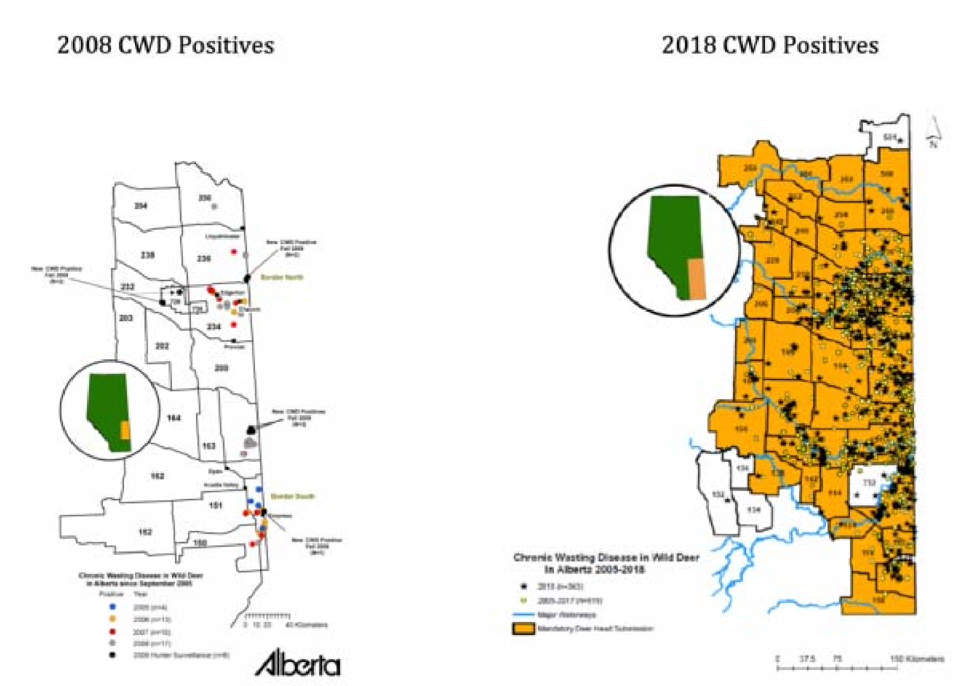
What other things do you think could be done to engage hunters in CWD management? Please list any types of program (reward, information, recognition) that you feel may improve CWD management in Alberta.

Valuation: Surveillance Referendum

Your opinion on a CWD surveillance program

One approach that can be taken to manage the spread of CWD is to increase surveillance or monitoring. Surveillance can help identify how far CWD has spread (how many regions have animals with CWD and how many do not), measure disease prevalence (how many of the animals, of the total population, are infected in areas where the disease is known to occur), and over time identify trends in prevalence or geographic spread. This information could be used to evaluate control programs and to inform needs for research. CWD testing, in wild cervid populations in Alberta, is primarily done with data hunter harvest animals.

The map below shows number of positive CWD cases of CWD found in Alberta in 2008 and 2018.



Without more surveillance, it will be possible for disease to spread into unexpected areas and become more prevalent potentially affecting other animals. The surveillance provides critical information for wildlife managers and government in general as to the significant effects of the disease on populations and whether more interventions are necessary to slow the spread. More surveillance will require funding for diagnostic testing (including more laboratories), for staff time, for the cost of programs to encourage public participation (reporting of sick animals, for example), and for communications.

We would like you to consider a referendum among Alberta cervid hunters that would result in a LEVY ON CERVID HUNTING LICENCE FEES (general and special draw licences) to help fund CWD surveillance. The levy would be dedicated to increased surveillance that would monitor prevalence of CWD. Each hunter would only pay once regardless of the number of licences held.

Were you familiar with the geographic spread of CWD in Alberta as indicated in the maps?

Yes	No
○	○

Please note that this levy would operate similarly to the Canadian Wildlife Habitat Conservation Stamp program. Funds from this levy would be managed in a separate fund for CWD surveillance.

Any decision comes with tradeoffs. There are many reasons to vote for or against a levy on the license fee. For example, you might FOR a program because you believe the benefits of surveillance exceed the costs, or the program would provide useful information. Alternatively, you may vote AGAINST a program because you do not think it would provide sufficient benefit.

SR1

How would you vote in a referendum among cervid licence holders on a proposed CWD surveillance program that resulted in a $5 levy added to the licence fee annually for the next 10 years?

- I vote YES for the proposed $5 CWD surveillance levy annually for 10 years
- I vote NO for the proposed $5 CWD surveillance levy annually for 10 years

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
O	O	O	O

How likely do you think it is that the majority of the hunters who hunt in your region would vote for this option if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

SR2

How would you vote in a referendum among cervid licence holders on a proposed CWD surveillance program that resulted in a $25 levy annually for the next 10 years?

- ○ I vote YES for the proposed $25 CWD surveillance levy annually for 10 years
- ○ I vote NO for the proposed $25 CWD surveillance levy annually for 10 years

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would vote for this option if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
○	○	○	○

SR3-1

How would you vote in a referendum among cervid licence holders on a proposed CWD surveillance program that resulted in a $2 levy annually for the next 10 years?

- ○ I vote YES for the proposed $2 CWD surveillance levy annually for 10 years
- ○ I vote NO for the proposed $2 CWD surveillance levy annually for 10 years

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would vote for this option if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
○	○	○	○

SR4

How would you vote in a referendum among cervid licence holders on a proposed CWD surveillance program that resulted in a $50 levy annually for the next 10 years?

- ○ I vote YES for the proposed $50 CWD surveillance levy annually for 10 years
- ○ I vote NO for the proposed $50 CWD surveillance levy annually for 10 years

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would vote for this option if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
○	○	○	○

SR3-2

How would you vote in a referendum among cervid licence holders on a proposed CWD surveillance program that resulted in a $2 levy annually for the

next 10 years?

- ○ I vote YES for the proposed $2 CWD surveillance levy annually for 10 years
- ○ I vote NO for the proposed $2 CWD surveillance levy annually for 10 years

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would vote for this option if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
○	○	○	○

SR3-3

How would you vote in a referendum among cervid licence holders on a proposed CWD surveillance program that resulted in a $2 levy annually for the next 10 years?

- ○ I vote YES for the proposed $2 CWD surveillance levy annually for 10 years
- ○ I vote NO for the proposed $2 CWD surveillance levy annually for 10 years

How certain are you that your response is the choice you would make if the proposed fee was actually put to a vote in Alberta?

Very uncertain	Somewhat uncertain	Somewhat certain	Very certain
○	○	○	○

How likely do you think it is that the majority of the hunters who hunt in your region would vote for this option if it were a real option in Alberta?

Very unlikely	Somewhat unlikely	Somewhat likely	Very likely
O	O	O	O

SR Debrief

If you responded YES to the proposed fee, please tell us why.

- O It's worth the money to know where CWD exists
- O I believe it will support CWD management in Alberta

If you responded NO to the proposed fee, please tell us why.

- O Too much money
- O I don't trust the funds would be used for this purpose

Do you believe that your responses will be considered in the development of CWD policies by Alberta Environment and Parks?

Definitely not be considered	Unlikely to be considered	Likely to be considered	Definitely be considered
O	O	O	O

What other things do you think could be done to engage hunters in CWD management? Please list any types of program (reward, information, recognition) that you feel may improve CWD management in Alberta.

Section 6: Demographic Information

Now we would like to ask some questions about you. The next set of questions are to help us find similarities between different groups of people and to identify trends in the hunting population. Please be assured that your responses will be kept strictly confidential.

Are you:

Male	Female	Other	Prefer not to say
O	O	O	O

Are you a member of any of the following organizations? (please select all that apply)

- ☐ An affiliation with government (i.e. Alberta Environment and Parks, Alberta Justice and Solicitor General)
- ☐ Alberta Federation of Naturalists
- ☐ Nature Conservancy of Canada
- ☐ Alberta Fish and Game Association
- ☐ Sierra Club
- ☐ Canadian Parks and Wilderness Society
- ☐ Alberta Professional Outfitter Society

In what year were you born? (enter 4-digit birth year; for example, 1970)

What are the first three digits of your postal code?

What is the highest level of schooling you have completed?

- Some high school or less
- High school diploma
- Some university, college, or technical school
- Technical school graduate
- University/College graduate
- Some graduate school
- Graduate degree

Please indicate your household income before taxes in 2019.

- Less than 10,000
- 10,000 to 19,999
- 20,000 to 29,999
- 30,000 to 39,999
- 40,000 to 49,999
- 50,000 to 59,999
- 60,000 to 79,999
- 80,000 to 99,999
- 100,000 to 149,999
- Greater than 150,000

Please indicate the most appropriate category that describes where you currently live.

- Large urban setting (100 000 people or more)
- Small urban setting (20 000 to 99 999 people)
- Town or village (1 000 to 19 999 people)
- Rural setting (999 people or less)

Are there any children under 12 in your household?

Yes ○ No ○

If you live in the Edmonton area, would you be willing to participate in an in-person session on CWD management at the U of A main campus in the future?

Yes ○ No ○

Please provide your email address. *Note that your address will be separated from all the other responses in the survey and will not be connected to them. Your email address will only be used to contact you for the Edmonton area in-person studies.*

Would you be willing to participate in a future online survey on CWD management in Alberta?

Yes ○ No ○

Please provide your email address. Note that your address will be separated from all the other responses in the survey and will not be connected to them.

If you wish to leave comments about the survey or hunting-related issues in it, please use the box below. Your feedback is highly appreciated.

For more information about CWD, please check following websites:

https://www.alberta.ca/chronic-wasting-disease.aspx

As a thank you for participating in this survey, we would like to offer you a chance to enter a prize draw to win one of two gift cards valued at $150 each for Cabela's. If you wish to enter the draw, you will have to answer a skill-testing question as a legal requirement. We will also need to collect your email address to inform you of the draw result. Your email address will not be used for any other reason.

Would you like to enter the prize draw?

Yes ○ No ○

Under federal law, it is necessary that you answer a skill-testing question successfully in order to qualify for a chance to win the prize. Please answer the following question (write your answer in the blank space provided):

(5+5) / 2 =

Please provide your email address