Property Rights for Managing Chronic Wasting Disease

by

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ABSTRACT

Chronic Wasting Disease (CWD) is a fatal prion disease that spreads among members of the deer family (Cervidae). As new cases of CWD are being reported in several Canadian provinces, states within the USA and countries in Europe this thesis had two main goals. The first was to attempt to understand how different stakeholders might be affected by both the disease and the available management options. The second goal is to investigate stakeholder preferences towards such management options.

The thesis begins with an exploration of the literature surrounding property rights and wildlife management in order to better understand how changes to property rights have been used to fix problems in wildlife management in the past. In Chapter 3 property rights frameworks are developed for the general public and hunters in Alberta. These frameworks are defined at a level specific enough that it allows for the characterization and comparison of alternative CWD management approaches based upon how they impact the characteristics of property rights. In Chapter 4 a paired comparison survey method is used to present the aforementioned CWD management approaches to stakeholders across Canada. The paired comparison method allows for the collection of stakeholder-specific preference information for each management action.

The analysis of property rights with the frameworks described in Chapter 3 suggest that regardless of the action taken against CWD there will be effects on the property rights of stakeholders such as the general public, hunters and landowners and these effects can be pinpointed to specific characteristics of property rights. The results of the analysis of stakeholder preferences in Chapter 4 suggests that stakeholders may not like many of the available options for CWD, but they may prefer that the government take some type of action rather than let the

disease run its course. The results also suggest that there may be some level of heterogeneity in preferences for CWD management between groups of stakeholders.

In summary, this thesis presents both a qualitative analysis of how cervid stakeholders may be affected by CWD and its management as well as a quantitative analysis of preferences towards CWD management actions. Although they are adapted from other property rights literature, the property rights frameworks created here are distinct from the rest of the property rights literature in their focus on wildlife and public good properties. The results of the preference analysis can tell policymakers which management actions may be favoured by the general public and thus may increase the success of such management.

PREFACE

This thesis is an original work by Geoffrey Durocher under the supervision of his graduate supervisor Dr. Marty Luckert. The research protocol for this study was approved by the University of Alberta Research Ethics Board (Pro00081014).

The research conducted for this thesis forms part of a social science research collaboration led by Drs. Vic Adamowicz, Ellen Goddard, Marty Luckert, Brenda Parlee and John Pattison-Williams, as well as several grad students and post-doctoral researchers in the Department of Resource Economics and Environmental Sociology at the University of Alberta.

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1 INTRODUCTION

1.1 Background

Chronic Wasting Disease (CWD) is a Transmissible Spongiform Encephalopathy (TSE), which are commonly known as prion diseases. The disease has been found in white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*) and moose (*Alces alces*) in North America; European elk (*Alces alces*) and reindeer (*Rangifer tarandus*) in Finland and Norway, respectively; and in elk (*Cervus canadensis*) as well as other farmed deer species in South Korea (CWD Alliance 2017; VKM 2017, Yle 2018). Prion diseases develop due to the accumulation of misfolded proteins, which cause lesions in the brain of the affected individual and are inevitably fatal (Williams and Young 1980). Prions diseases are found in several species, but the most widely known forms are Bovine Spongiform Encephalopathy (BSE or Mad Cow Disease) in cattle and related species and Creutzfeldt-Jakob Disease in humans, but due to its contagious nature, the disease is most similar to scrapie, which is a TSE that appears in sheep (Miller and Williams 2004). The general public is becoming increasingly aware of CWD and its implications, and wildlife managers are facing tough choices with regards to managing the disease.

CWD is persistent and contagious, perhaps more-so than other prion diseases (Gilch et al 2011). In general, prions have been known to withstand all forms of disinfectants, incineration techniques and wastewater treatments (Brown et al 2000; Hinckley et al 2008). CWD is also more contagious than other prion diseases because the infected hosts can shed prions in many ways. CWD prions reside in saliva, antler velvet, skin, milk, urine and feces; as well as in the fat and muscle tissue of the cervid host as well as in central nervous system tissue, where the prions are at their highest concentration (Angers et al 2006; Mathiason et al 2006; Haley et al 2009;

Race et al 2009; Spickler 2016). All of these prion sources can then transfer the prions onto plants or to the soil, where they can then be picked up through plants and transferred back to cervids (Belay et al 2004; Johnson et al 2015; Pritzkow et al 2015).

In Alberta, the first cases of CWD were detected in 2002 on elk and deer farms (AEP 2016). In 2005 the first cases of CWD in wild cervids were detected (AEP 2016). Since then, the number of infected cervids detected by the Alberta government has increased every year, with the first CWD case in moose discovered in 2012 (AEP 2016). As of 2017, 5.2% of cervids that were tested through hunter submission of heads, tested positive for CWD, including 8.2% of mule deer (AEP 2018).

1.2 Management Implications and Property Rights

As CWD has spread across North America, wildlife managers have been faced with difficult questions regarding what should be done about the disease. Management is difficult due to the complexity of the disease, and because of the great number of stakeholders who interact with cervids on the landscape. The only management options we currently have for CWD are to cull affected populations, control the movement of infected animals and animal parts and monitor for the presence of CWD in cervid populations. Whenever a management option is undertaken, there are many stakeholders affected by the decision. Hunters are affected because CWD affects their ability to go out and enjoy a hunt, and potentially acquire food. Landowners are affected, whether or not they are hunters, because wildlife can spread CWD on their property. Indigenous people are and will be affected by CWD because cervid species are an important food source for

many groups and the insecurity of that food source could put their existence at risk.[1] The general public is also affected by CWD management because they appreciate the existence of these animals on the landscape, and there is the possibility that management options or declining populations could decrease and/or increase that value.

Since CWD management involves many competing voices, policymakers are tasked with creating policies that account for these voices. The concept of property rights is one means of understanding the CWD management problem through the eyes of the stakeholders and is useful in suggesting management options that may be appropriate based upon the different viewpoints. In economics, property rights are used to describe how individuals and governments control the benefits that come from resources. These benefits are subject to sets of rules that define what individuals can and cannot do with regards to a resource (Bromley 1991). For example, the property rights to deer that are allocated to hunters are subject to rules such as hunting seasons. When we are making management decisions that create new rules, it may be helpful to do so with a good understanding of current property right regimes so that we are aware of whether and how rule changes contradict or alter current property rights. In doing so, property rights can allow us to better understand CWD management and make management suggestions that consider stakeholder viewpoints.

1.3 Research Objectives

The goal of this research is to attempt to understand the issue of CWD in the context of property rights in a way that allows us to provide management approaches that are appealing to

[1] The impacts of CWD, and potential CWD management approaches, on groups such as cervid farmers and indigenous people is an important topic. To maintain a realistic scope for this project, these stakeholders will be addressed as a separate part of the Genome Canada project titled "Systems Biology and Molecular Ecology of Chronic Wasting Disease".

stakeholders. In pursuit of this goal there are several objectives I will attempt to accomplish. Firstly, I will describe how property rights to cervids, associated with different stakeholders such as hunters, landowners, and the general public, can be used to characterize and analyze implications of alternative CWD management approaches. Secondly, I will attempt to understand how current property rights to cervids in Alberta will change with desired CWD management approaches. And finally, I will try to understand what people think about potential new management options for CWD in terms of trade-offs associated with changes to current property rights. These management approaches will include currently-existing options as well as options being created through new technologies that are currently being created through genomics research[2].

In pursuit of these objectives, I will first develop an analytical framework, to be populated with current property right conditions for cervids in Alberta for the general public, hunters and landowners.[3] Next, I will use the frameworks to identify changes to property rights that will occur as a result of alternative CWD management approaches. Finally, I will use a paired comparison survey method to investigate the social acceptability of the different management approaches and new technologies, and the trade-offs they imply. The comparisons will measure stakeholder preferences regarding trade-offs and the different management options. In pursuing these three objectives it is my hope that this research will make us better able to create CWD management options by understanding whether and how they fit with existing property right regimes and align with public values.

[2] The genomics research referred to here is part of the Genome Canada project titled "Systems Biology and Molecular Ecology of Chronic Wasting Disease".
[3] The property rights of landowners and hunters are sufficiently similar enough that I combine the two into one property rights framework.

In the sections that follow I will firstly document the literature surrounding property rights, and then analyze the research focused on property rights in wildlife management that can be useful for CWD management. Next, I will document the CWD management approaches that are currently being used elsewhere and I will explain and demonstrate the use of the property right frameworks to show how CWD management options change these property rights. Following the review of management approaches, I will document the process of conducting paired comparison experiments and survey stakeholders to reveal their preferences regarding the management options and the associated trade-offs. I will conclude by presenting the findings and discussing the potential implications for CWD management within the context of concurrent CWD research.

2 LITERATURE REVIEW

2.1 Introduction

In this review I will first describe the literature that form the basis for the analytical use of property rights in resource management. I will then explain the rationale behind using property rights to correct market failures. And finally, I will provide examples of market failures in wildlife management and proceed to give examples of how property rights have been used to try and fix these failures. This literature review will create the basis for the property rights frameworks for cervids that I use to analyze different CWD management approaches. A description of these frameworks, and the process used to create them, will be provided in Chapter 3.

2.2 Property rights

Property rights are a fundamental aspect of modern society (Demsetz 1967). They define what individuals expect to happen in their interactions with others, and the property controlled by either party. Demsetz (1967) explains that property rights define how individuals may be able to have positive or negative effects on themselves and others. He describes how these concepts can be applied in the context of resource use, and how property rights are closely related to the economic principles of externalities. His main argument, following Coase (1960), is that property rights develop to internalize externalities if the benefits of the internalization outweigh the costs. In a broader sense, Cohen (1978), focuses on property rights as interactions between individuals who control the resource and those who do not. Cohen argues that the most common aspect of property rights is the exclusiveness of resources.

In his publication *Environment and Economy* (1991), Bromley argues that property rights consist of both an asset and a set of social conditions. In the resource economics literature that follows Bromley's description, the asset is typically the resource that is being managed, while the social conditions are formal, or informal, ways of regulating the behaviour of property rights holders. Taken together, there is a benefit stream, with associated incentives that arise from use of the property right, and these incentives influence the way in which the rights are used.

The range of different benefits that these assets or resources provide makes utility a useful concept because it can transcend the many ways in which an individual may benefit from a property right. Utility can manifest in different ways; for example, there can be utility derived from both consumptive and non-consumptive uses of a resource. Arnot et al (2011), among others, have used utility directly in their analysis, defining benefit streams from property rights as utility. The wide array of benefit streams that may flow from a resource allows us to include a wide range of stakeholder interests when evaluating resource management options. These different stakeholder interests result from different property right structures for individual resources. Bromley's (1991) definition of property rights is useful for this analysis because it provides a direct link between property rights and utility theory.

Authors have used many different frameworks to describe and analyze property rights in resource management scenarios. What differentiates these frameworks is often the level of resolution at which the property rights are analyzed. In the more general sense, many authors define property rights frameworks on a continuum from private to community to state ownership of resources (Bromley 1991; Arnot et al 2011; Jagger et al 2014). Schlager and Ostrom (1992) further define property rights on a continuum from authorized users, to claimants, to proprietors and finally to owners. They assign stakeholders to these groups based upon the rights associated

with the resource that they control (1992). For example, in their framework "authorized users" only have access and withdrawal rights, whereas on the other side of the continuum the "owners" of the resource have access and withdrawal rights in addition to management, exclusion and alienation rights. In the middle, "proprietors" do not have alienation rights and "claimants" do not have alienation or exclusion rights.

Fundamental to these different characterizations of property rights are differences between *de jure* and *de facto* rights (Schlager and Ostrom 1992). The former describes formal control of the property right, as created by laws and regulations, and the latter describes control of the property right as is usually established by informal norms. Jagger et al (2014) describe property rights frameworks with two levels, one for the *de jure* rights held privately, by the community or by the state; and one for the *de facto* rights that can be held by the individual groups or any combination of the three.

The above analytical approaches may be desirable because they separate stakeholders into categories that align with common definitions in regulations. For example, following Bromley's (1991) approach, the Alberta *Wildlife Act* clearly states that wildlife is managed through state ownership of the resource for the benefit of the citizens (Government of Alberta 2014a). One could also argue that, under the *Wildlife Act,* rights are differentiated as either public or private property rights. These definitions of rights seem to align with the approach of Schlager and Ostrom (1992) because, depending on the specific rights, individuals or groups can have access and withdrawal rights, management rights and exclusion rights, which allows us to classify them as "proprietors" of property rights (Government of Alberta 2014a). However, descriptions of property rights like these may fail to provide us with frameworks that are useful

for analytical comparisons in some applications, because they do not provide enough resolution to investigate very specific structures.

Luckert et al (2011) sought to understand property rights with a set of property right characteristics that could be used for forest policy analysis. Their framework is built upon an understanding of what economists have shown to be important aspects of property rights. The list of property right characteristics they developed was based upon the work of Scott and Johnson (1983) and Haley and Luckert (1990) and includes, among others, such characteristics as the transferability of rights, the duration and renewability, the comprehensiveness, exclusiveness and the security of property rights. Property right frameworks such as these will be useful for my analysis because they enable us to distinguish between alternative property right regimes and explore the economic implications of differences in these regimes. Further discussion of these frameworks will occur in Chapter 3.

2.3 Market failures and property rights

Lueck (1989) argues that resource managers can correct market failures through the use of property rights in their policy decisions. These market failures can develop when property arrangements do not account for the interests of society. When failure occurs, policymakers use specific actions to correct the market failure, hopefully without creating other regulatory failures. Policymakers can use the social conditions associated with property rights to make private behaviours more compatible with social interests. Changing these social conditions is often achieved through changes to laws and regulations that govern the use of the resource. Demsetz (1967) argues that to modify an individuals' behaviour, one must first understand the property rights that the individual possesses, as well as the externalities that may be associated with those

rights. Moreover, when policymakers are aiming to correct market failures by adjusting property rights, they must have a good understanding of current property rights as to ensure that they do not create other problems, namely regulatory failures, by their actions. Feldman and Jonas (2000) explain that an example of one of these regulatory failures is uncompensated "takings" of property when governments choose to move away from private property regimes in order to manage resources for the public. Takings can be a problem in many different property rights regimes as noted in depth by Epstein (1985). It is important for decision-makers to have a good understanding of property rights so that market failures be effectively addressed without unintended consequences.

2.4 Market failures and property rights to wildlife

A feature that distinguishes wildlife from many other resources is the large number of benefit streams that come from its use (or non-use). There are several consumptive benefit streams for cervids that come from hunting activities. In general, these benefit streams include hunting for food and/or trophies. Wild cervids also have non-consumptive benefit streams in the form of use values, enjoyed through viewing the animals on the landscape, and passive-use values attributed to the knowledge that these animals remain on the landscape. The different benefit streams may each have their own associated market failures. Property rights to wildlife are said to have developed over time to limit the externalities in wildlife resource management (Lueck 1991; Lueck 1995).

Market failures in wildlife management often stem from the fact that the passive-use values associated with wildlife are a public good and, by definition, non-rival and non-exclusive. There are no markets for passive-use values of wildlife and therefore, the benefits enjoyed by

anyone who places value on the existence of wildlife cannot be bought and sold. For these reasons, private actions may fail to account for passive-use values (Franks 2011; Nelson 2009; Tisdell 2004). If private individuals do, in fact, decide to manage the resource for the public, for example if farmers managed their land for wildlife habitat, the benefits that would result would not flow only to them, but to all members of the public. This free-rider problem creates an under-allocation of the passive-use values of wildlife (Tisdell 2004). In an attempt to fix this problem individuals may be required to pay to access the land on which they can enjoy these non-consumptive benefits, as is the case with National Park fees, however these fees likely do not internalize the entire passive-use value of these landscapes and therefore the passive-use value of wildlife on the landscape will likely still be under-allocated.

Public wildlife is also often fugitive, migrating along long pathways between seasons (Tisdell 2004). This fugitive quality makes wildlife management difficult because it requires the management to be conducted over large areas and because habitat boundaries do not coincide with property boundaries. Because the benefits of wildlife are external to individuals and the boundaries do not align, externalities are created.

There are also market failures associated with the consumptive benefit streams of wildlife. Hunting is an activity that makes the wildlife resource a private good, in that once the consumptive products that come from cervid species are harvested, the hunter has exclusive rights. In some places, such as Europe and Africa, hunting may be disproportionately available to those who are very wealthy, which is a market failure associated with the inequality of access to the resource. A further potential market failure associated with hunting are negative externalities that some hunters may create when they go on hunting trips. While many hunters act to limit the impacts they have on others, especially in order to continue receiving permission to hunt on

private land in the future, some hunters leave messes, or in some way make a disturbance while hunting.

These market failures can be addressed through alterations to property right arrangements. In textbook definitions, property rights to wildlife are often characterized by either public or private control. However, describing property rights in this way does not provide enough resolution to allow us to analyze property rights in the context of CWD management. Lueck (1995) argues that an optimal structure for property rights to wildlife is likely a mix of both private and public control. The relationship between private and public control is necessary, as Lueck argues, because allowing pure private interests to dominate wildlife resource management would allow market failures to develop due to what he calls "incomplete ownership" of the wildlife resource (1995). Incomplete ownership would occur due to the lack of incentive private landowners have for managing wildlife for passive-uses that are generally enjoyed by members of the public. Lueck argues that this incomplete ownership problem is why private landowners often control hunting through access to land, while the government controls hunting through regulations (1995). Moreover, he argues that the value of wildlife resources (inclusive of both consumptive and non-consumptive value) can be internalized through shifts in property right arrangements (1995).

2.5 How property rights can correct market failures in wildlife management

2.5.1 The evolution of property rights

To understand the property rights regimes that will influence cervid and CWD management policy, it is important first to understand how property rights have developed and been used to

correct market failures in wildlife management in a broader context.[4] In his publication *Who Owns the Wildlife*, Tober (1981) documents the development of wildlife laws, and the property rights that result from these laws, in the early history of the United States. He argues that as European settlers crossed the ocean, they found that the "New World" was full of resources that had become scarce to nonexistent in Europe. Therefore, unlike the situation in Britain, property rights to wildlife in the colonies developed under open access resource regimes. Due to the resource richness of the New World, the creation of private property arrangements was not seen as necessary. The system that existed in the New World may seem like a more egalitarian regime than that of Europe at the time (Tober 1981; Lund 1980), however the open access condition led to overexploitation of resources. As the overexploitation continued to occur, property rights shifted to fix the market failures. Common property regimes began to develop as governments began to claim jurisdiction over resources for the sake of managing them for the public (Tober 1981).

Lueck (2002) documents how an open access property regime led to the near-extinction of the bison in North America. He argues that as the value of the bison increased with increased demand, we would expect private property rights to develop (2002). However, the costs required to establish private property rights were too high, which allowed open-access to continue as the resource stock declined (Lueck 2002). The extreme scarcity of the bison resource then spurred the creation of exclusive property rights (Lueck 2002).

Property rights continue to evolve over time to deal with market failures. The common property arrangements that existed in Britain, and early in the colonization of North America,

[4]While there is a large amount of literature on property rights issues in fisheries, my main focus will be on terrestrial wildlife due to its application to cervid species and CWD.

were characterized by a lack of distinction between what was private and what was common property (Lueck 1989). The result was land management that was characterized by both underused and overused areas of land. The lack of defined property rights itself is a market failure because it often results in socially inefficient resource use. The development of private property rights in this system was an attempt to correct the market failure, and more efficiently manage the landscape.

The movement towards private property spurred the "enclosure movement" in which private landowners could contain wildlife and therefore own wildlife as private property. This gave landowners an incentive to manage the land for the benefit of wildlife, thus creating more complete property rights and correcting the market failure (Lueck 1989). In addition, the migratory nature of wildlife creates large transaction costs for wildlife management. Governments in Canada have since attempted to fix these problems by managing wildlife at regional or provincial resolution levels, as can be seen through the various provincial and federal wildlife laws and regulations across the country (Lueck 1989)

2.5.2 Modern applications of property rights: Conservation easements and game ranches

In present times, one way in which managers have attempted to address the migratory and fugitive nature of wildlife is through the development of conservation easements. Some argue that conservation easements have developed primarily because allocating private property rights to wildlife is difficult due to the mobility and elusiveness of the animals, combined with the difficulty of matching land ownership to wildlife habitat ranges (Lueck 1995). Cheever (2001) explains that these easements often develop through the purchase of rights from private landowners by government entities or non-governmental organisations. However, regardless of

the method in which they are created, the easements potentially allow policymakers or individual landowners to manage the land for both consumptive and non-consumptive benefit streams. Cheever argues that in order for wildlife management goals to be achieved there must be accompanying regulations to support the easement, such as endangered species legislation (2001).

There are multiple functional examples of these conservation easements being used to solve market failures. Hurley et al (2002) explain that the Vermont Agency of Natural Resources utilizes conservation easement policies in order to limit the externalities on the environment that persist due to industrial activity. The conservation easement strategy allows the Agency of Natural Resources to balance economic interests with specific ecological goals; if not eliminating, then significantly reducing externalities (Hurley et al 2002). Similarly, in a study of two different Californian conservation easements, Rissman (2013) argues that easements are critical to managing the landscapes for biodiversity because private interests would not accomplish the same goal. Rissman argues that attempting to protect biodiversity on a property-by-property approach is not sufficient because it does not guarantee habitat connectivity (2013).

In response to negative externalities that land uses often have on wildlife, wild cervid farms or reserves have been established in Africa, through programs like the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in Zimbabwe. These farms turn wildlife from being an externality into being a commodity (Child 1993). Through communal ownership or aggregating private properties, farmers have been able to increase the value of their land by managing for game rather than crops or domestic livestock. Prior to raising game, these farms operate under private property arrangements, which do not appropriately manage the land for wildlife or biodiversity because crops or livestock were the main consumptive goods they

produced (Child 1993; Schmidtz and Willott 2012). Often these private farm operations will occur on marginal agricultural land which provide little revenue to the farmer and they generally create negative externalities that effect wildlife and biodiversity (Child 1993). The communal ownership, or aggregation of private ownership, establishes property rights for wildlife in an attempt to both achieve higher profits and simultaneously manage for biodiversity, internalizing the previously-existing negative externalities (Reilly et al 2003; Schmidtz and Willott 2012). Whether these farms are for non-consumptive uses such as ecotourism or consumptive uses such as hunting, managers often can achieve higher levels of profit with them than are available from the agricultural opportunities.

The use of such farms has not been without controversy because the farms require large expanses of land controlled by a small group of individuals, which has placed a lot of power in the hands of a few select individuals. Critics say that these farms create luxurious spaces, which are unavailable to locals and located near poor communities (Pasmans and Hebinck 2017). In some cases, game farms can become the primary employers in remote African regions, providing a large social benefit which may alleviate the market failure associated with the distribution of benefits from the resource (Schmidtz and Willott 2012). However, in some cases there are unintended consequences that may occur such as increased poaching (Pasmans and Hebinck 2017).

2.6 Conclusion

There are many market failures that wildlife resource management attempts to fix. The literature has shown different ways in which property rights have been used to attempt to correct market

failures in wildlife management. Careful analysis is required to decide how property rights can be used to correct these market failures and do so without creating other regulatory failures.

The literature has not however, used property rights to implicitly analyze management options for wildlife, and in particular cervid species in the context of CWD. The literature has also not documented the use of property rights within the context of multiple benefit streams for individual stakeholders, or in a way that allows us to examine cervids or CWD analytically. The next section will document the process of developing property rights frameworks for hunters, landowners, and the general (non-hunting) public with regards to cervid resources. These frameworks will allow me to compare different CWD management options, their effect on property rights and the trade-offs they imply.

3 PROPERTY RIGHTS TO CERVIDS IN ALBERTA AND THE IMPACT OF CHRONIC WASTING DISEASE MANAGEMENT

3.1 Introduction

Chronic Wasting Disease (CWD) is a fatal neurological disease that occurs in cervid species (i.e. deer, elk, moose and caribou) and is a Transmissible Spongiform Encephalopathy (TSE). TSEs develop due to an accumulation of prions, which cause lesions on the brain of the affected animal, and they are eventually fatal (Williams and Young 1980). Although rare, prion diseases have been known to appear in several species; well-known examples are bovine spongiform encephalopathy (Mad Cow Disease) and Creutzfeldt-Jakob Disease in humans. One reason why prion diseases are so difficult to manage is because prions are known to survive most attempts at inactivation (Brown et al 2000; Hinckley et al 2008).

CWD is considered to be more contagious than other prion diseases because of its ability to transfer between individuals and because of the infectivity of the saliva, antler velvet, skin, milk, urine and feces, meat and fat, but especially the nervous tissue of infected animals (Angers et al 2006; Mathiason et al 2006; Haley et al 2009; Race et al 2009; Spickler 2016). The prions that are shed from these different parts of the animal's body can be transferred to the soil where they then can either reside on, or be taken up by, plants and transferred back to other animals when they are grazing (Belay et al 2004; Johnson et al 2015; Pritzkow et al 2015).

To date, CWD has been detected in the United States, Canada, Norway, Finland and South Korea (CWD Alliance 2017; VKM 2017; Yle 2018). In Alberta[5], CWD was first detected on cervid farms in 2002, and it was not until 2005 that a case in wild cervids was documented (AEP 2016). As of the 2016 hunting season, the prevalence level of CWD among cervids that

[5] I use Alberta as a case study for this paper because CWD is currently present and spreading within the province.

were hunted in high risk areas, and had their heads submitted for testing, had risen to 5.2% (AEP 2018).

CWD has a number of stakeholders concerned, including hunters, cervid farmers, indigenous people and the general public. Because CWD affects many groups, it can be important to consider the preferences of stakeholders when deciding how best to conduct disease management.

Concepts of property rights can be useful for considering how stakeholders may be affected by disease management. Property rights describe how individuals and governments receive and control streams of benefits that come from resources (Bromley 1991). In this case, property rights to cervids describe how people receive benefits that come from their use, or non-use. These benefits are conditioned by rules or social conditions, such as hunting regulations, that the property right "owner" must abide by in order to receive the benefit of the property rights (Bromley 1991). These social conditions are used by governments to attempt to align the actions of individuals or groups with public objectives or societal goals. The threat of CWD in cervids is an example of this need to use social conditions so that stakeholders may help meet public objectives of CWD management.

The goals of this paper are, using Alberta as a case study, firstly to describe how property rights to cervids, associated with different stakeholders (i.e. hunters, landowners and the general public), can be used to characterize and analyze implications of alternative CWD management approaches.[6] These management approaches, commonly used in North America, include the culling of cervids and monitoring the spread of the disease. Secondly, I will attempt to

[6] Other stakeholders who are affected by cervid management include groups such as cervid farmers and indigenous people. The analysis of their property rights is important for the management of CWD but is beyond the scope of this paper.

understand how property rights to cervids in Alberta change as a result of different CWD management approaches. In pursuit of these goals I will develop and specify analytical property right frameworks for the different stakeholders, which reflect the specific ways that they benefit from cervid resources. These frameworks will then be used to categorize potential CWD management options, and thus be used to explore how the management options would change current property right arrangements.

In the following sections I will firstly describe the cervid property right frameworks. Secondly, I will populate the frameworks with information for stakeholders in Alberta. Finally, I will describe the opportunity these property right frameworks present for CWD management in the province of Alberta.

3.2 Methods

3.2.1 A Property Rights Approach for Cervids and CWD management

Wildlife is a resource that can provide benefits to people without them actually having to interact with animals. These benefits are called "passive-use values" as the value exists without any direct human behaviour (Adamowicz et al 1998). The passive-use values associated with wildlife are typically non-rival and non-exclusive. Since the passive-use value of wildlife is not bought and sold in a market, the expectation is that private individuals would under-allocate resources towards providing for these passive-use values (Krutilla 1967). CWD is part of this public good problem of passive-use values, in that private individuals will likely not have sufficient incentives to manage the disease in order to maintain the passive-use value of the wildlife. Government management of wildlife resources may be used in an attempt to correct these types of problems associated with wildlife (Lueck 1989).

Government management of wildlife, including CWD management, can be pursued by changing the property right arrangements held by different stakeholders. In order to document how the property rights of stakeholders are affected by management plans for CWD, it can be useful to systematically categorize and compare the property rights of the different stakeholders through the use of property right frameworks.

Numerous property right frameworks have been developed for analyzing resource management regimes. Schlager and Ostrom (1992) define property rights on a continuum from "authorized users", to "claimants", to "proprietors" and finally to "owners". They assign stakeholders to these groups based upon the rights associated with the resource that they control. For example, in their framework "authorized users" only have access and withdrawal rights, whereas on the other side of the continuum the "owners" also have management, exclusion and alienation rights. In the middle, "proprietors" do not have alienation rights and "claimants" do not have alienation or exclusion rights. In this framework one could classify the general public as authorized users of wildlife, because they do not have management, exclusion or alienation rights. Landowners have access and withdrawal, management and exclusion rights, but do not have alienation rights and therefore one could consider them to be proprietors of wildlife.

Bromley (1991) provides a working definition of property rights using four regimes: state property; private property; common property and non-property (open access). Using Bromley's approach, wildlife in Alberta is state property and managed for the benefit of the citizens of Alberta. Jagger et al (2014) build on Bromley's (1991) approach by adding a consideration of *de jure* and *de facto* rights. The difference between *de jure* and *de facto* rights is fundamental to classifying property rights (Schlager and Ostrom 1992). The former describes formal control of the property right, as created by laws and regulations, and the latter describes control of the

property right as may be established by informal norms. Formal control of property rights to cervids exist in Alberta in government regulations. An example of an informal norm would be an established relationship between a hunter and landowner where access rights are assumed to be granted without a conversation. Another informal norm that may exist would be how hunters may avoid hunting in an area if they see that another hunter is already present there.

While property rights to cervids in Alberta could fit into any of the three aforementioned approaches, these frameworks all have a common problem in that they do not specify property rights at a level which will show how property rights could change as a result of CWD management actions being undertaken. For example, using any of the three approaches, it is likely that the decision to cull cervids in affected areas would not appear as a change in the property rights, yet such a change could have implications for the benefit streams of the general public, hunters and landowners.

Due to the relatively low resolution in the frameworks provided by Schlager and Ostrom (1992), Bromley (1991) and Jagger et al (2014) for identifying the impacts of CWD management options, one must look elsewhere for suitable frameworks. Luckert et al (2011) sought to analyze forest policy with a framework which contains a set of property right characteristics which provide more resolution than the frameworks described above. Their framework is built upon an understanding of what economists have shown to be important aspects of property rights. The list of property right characteristics they developed was based upon the work of Scott and Johnson (1983) and Haley and Luckert (1990) and includes, among others, such characteristics as the transferability, duration, renewability, comprehensiveness, exclusiveness and security of property rights. These types of property right frameworks will be useful for my analysis because

they enable us to distinguish between alternative property right regimes and explore the implications of differences between CWD management options in these regimes.

3.2.2 Property right characteristics for cervid stakeholders

In creating the property rights frameworks for cervids that I employed in my analysis, I started with the characteristics used by Luckert et al (2011) and then I assessed how well they fit the wildlife, and specifically cervid, context. This process allowed me to decide which characteristics I needed to drop, change, or add for the purpose of the analysis. Ultimately, the property right characteristics which make up the contents of the frameworks were chosen because they are of particular importance to property rights for cervid resources and CWD management.

Table 3.1 describes the characteristics that apply for the stakeholders in each of my frameworks. Table 3.1 also provides a simple definition of each characteristic, with more description to follow in the next section. The general public framework contains fewer characteristics because it only addresses non-use values associated with cervids. The characteristics included are: comprehensiveness; exclusiveness; operational requirements and controls; levies and fees, security and the social conditions surrounding passive-use values. The hunter framework is developed for more benefit streams, so more characteristics are used.

For the purposes of creating the framework, I consider the general public stakeholder group to be everyone who may benefit from the existence of cervids on the landscape; meaning that it includes the hunter and landowner stakeholder groups as well. I combine hunters and landowners into one framework because in Alberta there are only a few differences between their property rights. Further descriptions of the property right characteristics in these frameworks follow below.

The content of the property rights framework for members of the general public in Alberta is presented in Appendix 1. These property rights are tied to non-consumptive benefit streams attributed to cervids. The content of the property rights framework for hunters in Alberta is presented in Appendix 2. The hunter framework is designed to include many types of hunters including urban/non-landowning hunters, rural/landowner hunters and outfitters. These hunters are combined in the framework because their benefit streams are similar and tend to be managed together. While indigenous people are also hunters of cervid resources, they are not included with this framework because there are different sets of regulations that apply to them, and they may have benefit streams that are not accessible to other hunters.

The specific content within each of the frameworks follows the definitions for each of the characteristics. The content is often derived from government documents such as laws and regulations and operational guidelines, but also includes informal norms that inform stakeholder interactions with the resource. In some cases, it would not be realistic to provide the entire list of empirics in the framework because doing so would include more detail than is needed for the analysis. In those cases, I provide one or more examples of how the empirics could be filled in.

Table 3.1 Property right characteristics used in each of the stakeholder frameworks

Characteristic	Definition[a]	General Public Framework	Hunter/Landowner Framework
Comprehensiveness	The number and type of benefit streams conferred to users for holding property rights (Bromley 1991). These benefit streams may be in the form of use or passive-use values.	✓	✓
Exclusiveness	The extent to which property right holders can exclude others from accessing the benefits of a property right (Luckert et al 2011)	✓	✓
Operational Requirements and Controls	The rules that property rights holders must abide by in order to receive, or continue to receive, the benefits of their property rights, as well as how these rules are enforced (Luckert et al 2011)	✓	✓
Levies and Fees	Monetary payments that a rights holder must pay in order to obtain or maintain rights (Luckert et al 2011)	✓	✓
Security	How certain rights holders are that their rights will be assured and protected in the future (Arnot et al 2011)	✓	✓
Social Conditions Surrounding Passive-Use Values	The influence of social conditions, which while directly affecting other stakeholder's use values, indirectly affect the passive-use values of the general public.	✓	
Initial Allocation	The way in which property rights are first allocated to property rights holders (Luckert et al 2011)		✓
Residency/Age Requirements	Necessary age and residency requirements that an individual must meet in order attain and hold property rights		✓
Size Specification	An indication of the size of the property right (Haley and Luckert 1990)		✓
Allotment Type	Whether the property rights are granted on an area or volume basis (Haley and Luckert 1990)		✓
Transferability	Whether or not rights can be reassigned or sold between individuals or groups (Haley and Luckert 1990)		✓
Duration	The period over which rights can be exercised, and whether, and under what conditions, the rights can be renewed or replaced with similar rights agreements (Luckert et al 2011)		✓

[a] The sources provided here do not, necessarily, reflect the original source for each of the property right characteristics. Instead the sources document the definitions that I use here.

3.3 Results

In this section I introduce the content for each of the characteristics within the property right frameworks for cervid stakeholders in Alberta. I start by providing working definitions for the property right characteristics and apply these concepts to cervid resources. Next, I populate the frameworks with property right arrangements for the general public and hunter stakeholder groups in Alberta. I then identify the potential impact that the increasing spread and prevalence CWD will have on the characteristics of property rights. I conclude by identifying the changes to property rights that will result from their implementation of CWD management strategies for the general public, hunters and landowners in Alberta.

3.3.1 Characteristics of the framework

3.3.1.1 Comprehensiveness

The comprehensiveness of property rights refers to the number and type of benefit streams conferred to users who hold property rights (Haley and Luckert 1990). The concept of benefit streams, refers to the different ways in which a property rights holder may receive benefits (Bromley 1991). The more benefit streams that the property rights holder receives, the more comprehensive are the rights. Though benefit streams from property rights are typically consumptive, rights may also be based on non-consumptive values.

The comprehensiveness of property rights to cervid species for the general public is generally made up of non-consumptive benefit streams. The comprehensiveness of property rights to cervids for the general public includes the passive-use value of cervid species and the benefits to individuals that come from viewing cervids on the landscape (Appendix 1). The comprehensiveness of hunter property rights in Alberta specifically refers to a number of

additional benefit streams available to the hunter (Appendix 2). Rights to hunt include: the right to access land; the right to pursue game; the right to harvest an animal; and the rights to the products derived from the animal. The possession of hunting tags, which may be specific to species, sex and size of the animal, grant the rights to pursue, harvest and possess the products of the hunt. Access rights are dependent on whether the land is privately or publicly held, because landowners decide who accesses their land. Access rights are available to licensed hunters on those sections of public land that do not have specific regulations prohibiting hunting practices.

3.3.1.2 Exclusiveness

Exclusiveness refers to the extent to which an individual or group that holds a property right can exclude others from accessing the benefits of that property right (Luckert et al 2011). The benefits from the rights of the general public flow from passive-use values, which are typically public goods and therefore not exclusive to any one individual (Appendix 1). For the property rights of hunters, the benefit streams can either be exclusive or non-exclusive (Appendix 2). Hunters do not have exclusive rights to pursue cervids on public land as other hunters may pursue animals within the same areas. Though the right to access public land is non-exclusive on a legal basis, informal norms may create exclusive access, if other hunters do not enter an area if another hunter is already there. Rights to access private land for hunting are exclusive to the landowner, who may choose to allow access to those of their choosing. Hunters must first ask for permission to access such private land (AEP 2017a; CWD & Property Rights Workshop 2017). Additionally, hunters who would like to access land that is held under a public land grazing lease must ask permission from the leaseholder before accessing such land. Rights to harvest an animal are exclusive to the hunter, except in the case of partner licenses in which case the rights

are shared (AEP 2017a). The rights to the products from the harvested animal are exclusive to the hunter, or the hunter and their partner hunter (AEP 2017a).

3.3.1.3 Operational Requirements and Controls

Operational requirements indicate the rules that property rights holders must abide by in order to receive, or continue to receive, the benefits of their property rights. Operational controls refer to how the rules are enforced (Luckert et al 2011). There are operational requirements and controls in place for the general public who access wildlife resources (Appendix 1). These requirements are often in the form of rules that regulate interactions with wildlife. These requirements exist for the safety of both the wildlife and members of the general public. An example of such an operational requirement for the general public is the restriction in National Parks on approaching wildlife (Government of Canada 2009). Operational requirements for hunters include the requirements that a hunter must meet before they can be allocated their rights to hunt such as taking hunter education courses or obtaining weapons permits. Operational requirements also include requirements that hunters must meet while exercising their right to the wildlife resource, which includes regulations on where hunting can occur (distance from roads or buildings) and when it can occur (relative to sunrise and sunset); as well as regulations on what must be done after the hunting activity, such as mandatory head submission in specific WMUs (Appendix 2; AEP 2017a; Government of Alberta 2014a). Requirements may be delineated by wildlife management units (WMUs), which encompass both public and private land. In addition, hunter outfitters are subject to the requirement that they cannot hunt recreationally on the same day that they guide (Alberta Professional Outfitters Society 2017). The operational controls in place to ensure compliance with the requirements for both hunters and the general public come in the

form of Fish and Wildlife Officers, Conservation Officers and the Royal Canadian Mounted Police (Government of Alberta 2014a; CWD & Property Rights Workshop 2017).

3.3.1.4 Levies and Fees

Levies and fees is the property right characteristic referring to monetary payments that a potential rights holder must provide in order to have rights allocated to them (Luckert et al 2011). In some cases, members of the general public have to pay fees to benefit from their property rights (Appendix 1). In order for wildlife to be managed for the general public, the government requires tax revenue. Moreover, the general public must sometimes pay a fee to gain access to view cervids, such as in National Parks (Government of Canada 2017). For hunters, levies and fees include a number of payments needed to obtain their property rights. In order to hunt in Alberta, hunters must pay for their WIN (Wildlife Identification Number) card ($8), wildlife certificate ($28.22) as well as tags which vary in price (Appendix 2). Hunter-hosts need to buy a license ($27) in order to host non-resident Canadians or individuals from other countries on hunting trips (AEP 2017a). Outfitters have to purchase a Big Game Outfitter permit, which costs $250, with a $25 renewal fee each year (Alberta Professional Outfitters Society 2017).

3.3.1.5 Security

Security of property rights is defined as the certainty that rights holders have that their rights will be assured and protected in the future (Arnot et al 2011). The more secure a property right is, the more the holder of those rights expects that the rules that condition their benefit streams will result in maintained or increased value over time (Arnot et al 2011). Security often depends upon the trust the rights holder has in the decision-maker who allocates their rights. It may also

include details about if and how compensation would be awarded if the decision-maker decided to revoke rights. In the context of wildlife management, and in particular the management of cervids, wildlife agencies tend to influence the security of property rights by establishing and changing rules. Arnot et al (2011) refer to tenure security as the uncertainty of the rules regulating the resource but recognizes that the stock of the resource itself could be uncertain due to other factors, such as ecological variability. Because property rights are defined as a combination of both benefit streams and the rules that regulate their use (Bromley 1991), I include concepts of benefit stream security (security of the wildlife resource) with the concept of property right security.

Property rights to public wildlife could be perceived as relatively secure because public wildlife is managed by the government in perpetuity for the citizens of the province (Appendix 1; Government of Alberta 2014a). In Alberta, wildlife is managed by the provincial government, with the exception of within National Parks where the federal government is responsible for management (Government of Canada 2017). Hunting is protected under provincial law (Government of Alberta 2008). However, property rights can change between seasons and create some insecurities. An example of this is the variability of supplemental tags that are available for specific WMUs over multiple years. Some years these supplemental tags may be available and some years they may not. Another example is if the government changes the boundaries of WMUs and changes the regulations for specific areas. But hunters seem to have expectations that they will be able to hunt for the foreseeable future (Appendix 2). They exhibit this expectation in their accumulation of priority points, which can be applied to draw applications in the future (AEP 2017b).

3.3.1.6 Social Conditions Surrounding Passive-Use Values

Social conditions, such as those defined as operational requirements and controls, can influence the behaviour of property right holders, depending on whether the affected benefit streams are associated with passive-use or use values. While use values can be increased or decreased through the impacts of regulations on allowed behaviour, passive-use values increase or decrease based on whether the individual likes or dislikes the social conditions that influence their passive-use value. Accordingly, whereas regulations directly affect the use-values for stakeholders, such as hunters, in addition, these regulations indirectly affect the passive-use values of the general public. This characteristic allows us to consider the general public's likes and dislikes of policies or management actions that can affect the levels of the passive-use values held by the general public.

3.3.1.7 Initial Allocation of Rights

The initial allocation specifies how property rights are first allocated to rights holders (Luckert et al 2011). This characteristic explains who allocates the rights to the property right holders, as well as the ways in which rights may be attained. In the hunting context, rights are allocated through application processes which are jurisdiction-specific. In Alberta, hunting rights are initially allocated by the province with the purchase of a WIN card and a wildlife certificate as well as licenses and tags (Appendix 2). These tags can be received through either direct purchases or draw systems. Landowners may apply for Landowner Special Licenses, which allocate additional hunting rights that can be used on their own property. In order to become a hunter-outfitter in Alberta and be allocated such rights, individuals must be recommended by an outfitter-guide in their first year and then it is mandatory to apply to be a big game outfitter-

guide and a member of the Alberta Professional Outfitters Society (Alberta Professional Outfitters Society 2017).

3.3.1.8 Residency and Age Requirements

Residency and age requirements refer to the conditions that must be met for an individual to qualify to hold property rights. In Alberta, wildlife belongs to the general public and the government can price discriminate against, those who are not residents of Alberta. In order to be allocated rights, the potential rights holder must attain a minimum age, or hold a specific residency status, which could include owning land. In the context of hunting, there are often age requirements and potentially special privileges for landowners or residents. Age requirements for hunting can be important for safety. In order to purchase hunting rights in Alberta you must be twelve years of age or older (Appendix 2). In order to hunt without the supervision of an adult, you must be eighteen or older. There is a standard list of licenses which are available to resident Albertans. However, Canadians from other provinces and visitors from other countries may purchase licenses from a more restricted list and hunt with resident hunter hosts or outfitters (AEP 2017a; Alberta Professional Outfitters Society 2017).

3.3.1.9 Size Specification

Size specification is an indication of how large the property right is in terms of what the rights holder has control over (Haley and Luckert 1990). For hunting, this characteristic identifies how many animals may be pursued and harvested. The size specification characteristic for hunting rights specifies the number of licenses or tags that an individual may hold (Appendix 2). In Alberta, one example of such a specification allows a single adult resident hunter to hold up to

four tags, which each allow the hunting of one or more cervids. The number of tags available to hunters often depends upon population numbers and meeting specific conservation goals (AEP 2017a). By specifying the number of animals that may be harvested by each group in each WMU, the government can manage the public resource on both public and private land.

3.3.1.10 Allotment Type

Allotment type describes whether the property rights are granted on an area or volume basis. (Haley and Luckert 1990). Allotment types based on area are subject to geographical boundaries, whereas volume allotments refer to specific quantities that may be harvested. Property rights for hunting are limited by the number of licenses and tags issued (Appendix 2). These licenses and tags specify the WMUs in which they must be used. In this way, the allotment for hunting rights is both area-based and volume-based.

3.3.1.11 Transferability

Transferability as a property right characteristic that describes whether or not rights can be reassigned or sold between individuals or groups (Haley and Luckert 1990). In the context of hunting, transferability refers to whether or not hunters may sell or give away their rights to pursue game, access land, harvest animals or keep the products of a hunt. No products from hunted animals can be sold (Government of Alberta 2014a). Property rights for hunting, granted through licenses and tags, are non-transferable for individual hunters (Appendix 2; AEP 2017b). Hunter-outfitters can however transfer their tag allotment to other outfitters with the approval of the Government of Alberta (CWD & Property Rights Workshop 2017). Landowners have the ability to transfer access rights to hunters, but they cannot accept payment for such a transfer

(AEP 2017a). A Bill of Lading is required for the transfer of harvested animals between individuals if the animal has not been processed into the final product; upon processing the animals and producing the final product, a Bill of Lading is not necessary for transferring ownership of the products (AEP 2017a).

3.3.1.12 Duration

The duration characteristic of property rights describes the period over which the rights can be exercised and whether, and under what conditions, the rights can be renewed or replaced with similar rights agreements (Luckert et al 2011). Hunters have duration limits placed on their property rights in a number of ways (Appendix 2). WIN cards are valid for a period of 5 years from the date of purchase (AEP 2017a). Hunting licenses, tags and draws are allocated on an annual basis and are subject to specific hunting seasons that are based on the weapon used and the WMU in which the hunting rights are being granted (AEP 2017a). Hunters can accumulate priority points over multiple years, which can eventually be applied to specific hunting draws (AEP 2017b). Hunter outfitters must renew their allocations on an annual basis and may be subject to review every 5 years (CWD & Property Rights Workshop 2017).

3.3.2 Effects of CWD and its management on property rights to cervids

Using the property right frameworks I have described above, I will now document how the increasing spread and prevalence of CWD may impact the property rights of the selected stakeholders who interact with the cervid resource; namely the general public, hunters and landowners. I will then further document the ways in which property rights of these stakeholders

may change as a result of different CWD management strategies that could be chosen to manage the disease.

3.3.2.1 Impacts of the increasing spread and prevalence of CWD on property rights to cervids

The characteristics of property rights I have discussed can be used to indicate how the progression of CWD could affect property rights. Given what has been observed in other CWD-endemic areas (DeVivo et al 2017), one would expect that the main impact of the increasing spread and prevalence of CWD is fewer healthy cervids and then a reduction in cervid populations. Common among all of the stakeholders is that CWD potentially makes their property rights less secure. The full effect of CWD on cervid populations is currently unknown and therefore the future availability of rights is also unknown.

The general public has two main benefit streams that are at risk due to the increasing spread and prevalence of CWD. Firstly, the passive-use value associated with the cervid wildlife resource could be diminished by both a decrease in the health of the resource and a reduction in the stock of the resource. It is likely that the general public will care if a public wildlife resource is unhealthy and populations are declining. Secondly, the non-consumptive use values commonly-associated with activities such as viewing wildlife on the landscape could also be at risk due to diseased and decreasing populations as the public would likely prefer to see healthy animals in sustained populations.

Hunters may also experience reductions to their benefit streams. The increasing spread and prevalence of CWD may not directly impact the rights of hunters to access land for hunting or to pursue game. However, a declining resource stock would lower the probability of a successful hunt, reducing the ability of hunters to harvest animals. Additionally, as more cases of

CWD are found, the possibility of using the products from the harvested animals is also at risk because these products will be of less or no value if they are contaminated. There is also a risk that hunters may experience increases to their costs as a result of waiting for the results of CWD-testing and dealing with potentially-infected deer. The reduction in the cervid resource through decreasing population sizes and decreasing health has the potential to diminish or eliminate some of these benefit streams.

3.3.2.2 The impacts of CWD management actions on property rights to cervids

Property rights are likely not only affected by the increasing spread and prevalence of CWD, they may also be affected by new regulations, or changes to current regulations, which come about in an attempt to manage the disease. Currently there are three main options for managing Chronic Wasting Disease; monitoring the spread of the disease, controlling the movement of infected animals and animal parts and/or culling infected populations. However, there are many ways in which these actions could be pursued. Management actions will affect the property rights of the different stakeholders, and it is therefore useful to analyze how these options correspond with existing property rights.

Table 3.2 provides a list of potential management options that I believe may be feasible in Alberta. These options mainly reflect approaches that have been proposed in Canada, or used elsewhere, for CWD management. But the list also includes some approaches, which to my knowledge, have not been used. The list of management options was also augmented with input from policymakers and stakeholders through consultations that took place in workshops and focus groups held in late 2017 and early 2018. The table indicates which property right characteristics are likely to be affected by each management action for hunters and landowners.

Although I present hunters and landowners together in the property right frameworks, they are presented separately here because there are potential policy changes that are specific to each stakeholder.

Table 3.2 A list of potential CWD management options and the corresponding affected property right characteristics for hunters and landowners

Management Action	Hunter Property Right Characteristics	Landowner Property Right Characteristics
Allowing landowners to charge hunters for access to private land	Levies and Fees; Transferability	Comprehensiveness; Transferability
Using hunters to increase harvest on public land	Size Specification	
Extending the hunting season by 2 weeks	Duration	
Doubling the number of available tags	Size Specification	
Providing free tags in CWD-endemic areas	Levies and Fees; Size Specification	
Distributing $50 and a tag to hunters who submit heads that test positive for CWD	Operational Requirements and Controls; Size Specification	
Restricted movement of carcasses and hunted products	Operational Requirements and Controls	
Requiring unwanted animal parts be disposed of at a county dump site	Operational Requirements and Controls	
Government compensation to landowners for providing access to hunters		Comprehensiveness; Transferability
Requiring landowners to allow government sharpshooters on private land		Operational Requirements and Controls
Increasing the number of available landowner special licenses		Size Specification
Providing extra tags to landowners who work cooperatively with their neighbours to manage their lands for CWD		Operational Requirements and Controls; Size Specification
Mandatory environmental sampling[a] on private land to identify areas in need of CWD management		Operational Requirements and Controls
Providing extension services to landowners who work cooperatively with their neighbours to manage their lands for CWD		Comprehensiveness; Operational Requirements and Controls

[a] The environmental sampling referred to here is dependent on new technology which would allow quick on-site testing of environmental samples such as soil and plants in order to check for the presence of CWD prions. Such technology is currently under development as part of the Genome Canada project that is funding this work.

I start with two aspects of property rights that are not included in Table 3.2 because they are common across all management actions. First, the property rights characteristic of security is not included because all management options that are used to attempt to manage CWD could change rules, and the condition of the cervid populations, which affect the future benefit streams for all of the cervid stakeholders. The CWD management options could create insecurity in that

stakeholders do not know what management options will be adopted. Moreover, insecurity could also arise because of uncertain effects of changes in rules on cervid populations.

Secondly, the impacts of CWD management on the property right characteristics of the general public are not listed in Table 3.2 because all of the management options could potentially impact the social conditions that govern the passive-use values associated with wildlife, and therefore change the utility that the general public can receive from their property rights. Additionally, any policy that reduces population sizes, or affects cervid health, could reduce the general public's value of viewing wildlife.

For property rights held by hunters, management options may change a number of specific property right characteristics. In Table 3.2 the options of allowing landowners to charge hunters for access and providing free tags would change the payments hunters must make in order to obtain their rights, so the levies and fees associated with their property rights would change. Management options that allow hunters to harvest more cervids in order to manage the disease would increase the size specification of their property rights. These options include: using additional hunter harvest to manage CWD on public land, doubling the number of available tags, providing free tags in CWD-endemic areas and a reward system for the submission of CWD-positive heads (Table 3.2). Extending the hunting season changes the duration of hunter property rights as it provides hunters with a longer time frame in which they can fill their tags and benefit from their property rights. The operational requirements and controls for hunter property rights will be affected by any policy which changes the rules that hunters must abide by. In Table 3.2, examples of such policies include requirements to submit CWD-positive heads for testing, the restricted movement of carcasses and hunted products, and requiring the disposal of unwanted animal parts at specified locations.

Though landowners share a property rights framework with hunters, landowners have a set of policies that may affect them specifically, and I therefore indicate how CWD management may impact their property rights in a separate column (Table 3.2). Firstly, a number of management options add to the comprehensiveness of landowner property rights because they will increase the number or type of benefit streams available to the landowner. Examples of these options include compensating landowners to provide hunter access, allowing landowners to charge hunters for access and providing extension services to landowners who cooperatively manage CWD with their neighbours (Table 3.2). The transferability of landowner property rights will be affected by management options such as allowing landowners to charge hunters for access to their private land or providing government compensation for landowners to increase hunter access (Table 3.2). A number of the options presented in Table 3.2 would place additional rules or restrictions on landowners and therefore increase the operational requirements and controls of landowner property rights. Examples of such options include requiring landowners to allow government sharpshooters or environmental sampling on their land, as well as cooperatively managing CWD with their neighbours in exchange for additional hunting tags or extension services (Table 3.2). Size specification could be increased by a number of options that allow more animals to be harvested by landowners on their land, such as increasing the number of available landowner special licenses and providing extra tags to landowners who cooperatively manage CWD with their neighbours.

3.4 Conclusion

In this paper I began by providing an indication of the widespread concern about the increasing spread and prevalence of CWD by many different stakeholders in Alberta. One can see how

these stakeholders can be directly and indirectly affected by CWD and CWD management. I investigated several property right regimes which could be used to indicate how property rights can be used to characterize policy analysis questions, and specifically, how they can be utilized in the context of CWD. I created a set of frameworks based upon the framework of Luckert et al (2011) that I use for the characterization of property rights for stakeholders affected by CWD. These frameworks categorize the property rights of the different stakeholders and are specific enough that one can see how individual stakeholders will be affected by both the disease and the disease management actions.

It is useful to understand the nature of property rights regimes in cervid resource management to effectively manage cervids for the disruptions caused by CWD, given that both the disease and the management options will impact the stakeholders. The frameworks I describe in this paper can be used to better understand how stakeholders may react to potential management options for the disease and how their individual property rights will be affected by the management options chosen.

Additionally, these frameworks could allow us to investigate the impacts of CWD and CWD management and compare them not only by the affected stakeholders, but also between jurisdictions. Here I have compared the impacts of CWD and its management on the general public, hunters and landowners in an Alberta case study. The frameworks are flexible enough that they can be used to identify similarities and differences between stakeholders in other provinces or countries.

Randall (1987), using the term “conservative reinforcement”, suggests that uncertainty surrounding future property right arrangements and their corresponding economic implications sometimes inhibits our ability to propose new policies and biases policy development or analysis

towards the status quo. In CWD management it may be difficult to propose new management actions, which would change property right arrangements, because it may be difficult to imagine what impact alternative property right structures may entail. The frameworks described here allow us to specifically identify alternative structures of property rights, thereby drawing our attention beyond current property right arrangements, and allowing us to potentially reduce the effect that conservative reinforcement may have on the list of available management options.

Through a consideration of the property rights of the general public, these frameworks allow fir the consideration of passive-use values associated with the resource. Passive-use values are typically not analyzed in detail in the property rights literature, however they are potentially important to the general public's rights to wildlife, and these frameworks suggest that it may be important, in contexts like this, to explore the impacts that changes to property rights have on passive-use values.

In order to develop this paper, I had to limit the scope of the analysis. My main focus was the property rights of the general public, hunters and landowners. But I know that there are other important stakeholders or groups who are affected by the increasing spread and prevalence of CWD. Additionally, as stated above, these frameworks have been created using Alberta as a case study and therefore are also limited in their scope in this way. Future work on CWD management could use these frameworks to repeat this process for the property rights of other stakeholders, such as indigenous people, cervid farmers and hunter-outfitters, as well as in other jurisdictions. Doing so would provide policymakers with a more comprehensive understanding of how CWD management affects each of the affected stakeholders in Alberta, and elsewhere, as well as potentially improve the implementation of management plans for the disease.

In this thesis, these frameworks lay the groundwork for the analysis of stakeholder preferences for CWD management. The next step in this process is to investigate the preferences of the affected stakeholders for each of the identified management actions for CWD. The list of potential policy actions has been created to fit within the property right frameworks I have created in order for us to understand how the property rights of individual stakeholders will be affected by CWD management. In the following chapter, the management options are brought directly to the stakeholders to investigate their preferences.

4 PUBLIC ACCEPTABILITY OF CHRONIC WASTING DISEASE MANAGEMENT APPROACHES IN CANADA: A PAIRED COMPARISON APPROACH

4.1 Introduction

Chronic Wasting Disease (CWD) is a fatal prion disease that has been found among cervid species such as white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*) and moose (*Alces alces*) in North America; European elk (*Alces alces*) and reindeer (*Rangifer tarandus*) in Finland and Norway, respectively; and in elk (*Cervus canadensis*) as well as other farmed deer species in South Korea (CWD Alliance 2017; VKM 2017, Yle 2018). It is a Transmissible Spongiform Encephalopathy (TSE) similar to diseases such as Bovine Spongiform Encephalopathy (Mad Cow Disease) in bovine species and Creutzfeldt-Jakob Disease in humans. TSEs develop when misfolded proteins, called prions, accumulate in the body of the affected animal. The accumulations of prions eventually cause lesions to form on the brain of the affected animal, which grow until the host succumbs to the brain damage (Williams and Young 1980). TSEs are particularly hard to manage because prions are persistent in animal habitats (Brown et al 2000; Gilch et al 2011; Hinckley et al 2008).

In Canada, CWD has been found in both farmed and wild populations of cervids in Alberta and Saskatchewan dating back to 1996, and more recently found on a cervid farm in Quebec in September of 2018 (Government of Québec 2018). Management strategies, including surveillance plans, were put in place soon after detection and remain in effect to this day (CWD Alliance 2018a). However, due to the difficulty in managing CWD, managers currently have three main options for disease management; culling effected populations, controlling the movement of infected animal parts and monitoring the spread of the disease. However, these options may be carried out in numerous ways. The specific practices can cause public outcry if

the management option does not align with social values. An example of this misalignment was the public outcry that arose when Albertans became aware of the culling practices being used by the government in Eastern Alberta (Weber 2008). Therefore, it may be important to consider the views of stakeholders prior to choosing a plan of action.

There are three main objectives to this research. The first is to understand how willing the different stakeholders affected by CWD are to accept different management strategies for the disease. The second goal is to gain a sense of whether segments of the Canadian population have different opinions about the management options. Finally, the third goal of this research is to investigate whether having the option to take no action has an impact on the acceptability of other management options.

4.2 Methods

4.2.1 Data Collection

To investigate the acceptability of these different management options for CWD, I developed a large nationwide survey that was designed to collect data on the preferences of Canadians towards CWD risk and management (Appendix 3). Because I knew that many of the respondents would have a limited knowledge of CWD, and therefore not be able to make complex decisions about CWD management, I chose to use a paired comparison approach to investigate the respondent preferences for the CWD management options. The paired comparison method allowed me to provide the respondents with some background information about the disease and the implications of each of the management options and then ask them simply which option they prefer in a pair (Brown and Peterson 2003).

The pairs of management options were created based on the ways in which wildlife, and specifically cervids, are managed in Canada. I consulted with groups of stakeholders and policymakers in various ways, including a workshop held in November of 2017, and focus groups in February and May of 2018. Finally, I pre-tested the survey in April and June of 2018. The focus groups and pretesting allowed me to create a list of management options that are provided by stakeholder group in Table 4.1.

Table 4.1 The CWD management options presented in pairs to the survey respondents[7]

General Public	Hunters	Landowners
Using *hunters* to increase harvest on *public land*	*Extending* the *hunting season* by *2 weeks*	Mandatory *environmental sampling* on *private land* to identify areas in need of CWD management
Allowing *landowners* to *charge hunters for access* to private land	*Doubling* the *number of* available *tags*	Providing *extension services* to *landowners* who *work cooperatively with their neighbours* to *manage* their *lands for CWD*
Government *compensation* to *landowners* for providing *access to hunters*	Providing *free tags in CWD-endemic areas*	Providing *extra tags* to *landowners* who *work cooperatively with their neighbours* to *manage* their *lands for CWD*
Government *sharpshooters* on *public land*	Requiring *unwanted* animal *parts* be *disposed of* at a *county dump site*	Allowing *landowners* to *charge hunters for access* to private land
Restricted movement of *carcasses* and *hunted products*	Distributing *$50 and a tag to hunters* who *submit heads that test positive for CWD*	
Requiring landowners to allow government *sharpshooters* on *private land*		
Increasing the number of available *landowner special licenses*		

The survey was distributed to Canadians through an online open panel format in June of 2018 by the marketing research firm *Asking Canadians*. Responses from 5236 individuals were collected. In addition to the responses to the paired comparison questions, demographic and respondent activity data were also collected.

The survey was designed so that all respondents would firstly respond to a set of paired management options that could impact the Canadian public in general. In addition to being a

[7] These are only abbreviated descriptions of the management options. The options are listed in their entirety in the survey provided as Appendix 3. The wording of each option was fine-tuned through the stakeholder engagement processes described in the previous chapter.

member of the general public, the respondent may have also been a hunter and/or a rural landowner and in these cases they received additional sets of ordered pairs tailored to their situation (see Table 4.1). Figure 4.1 presents an example of what one of these paired comparisons looked like to the respondents.

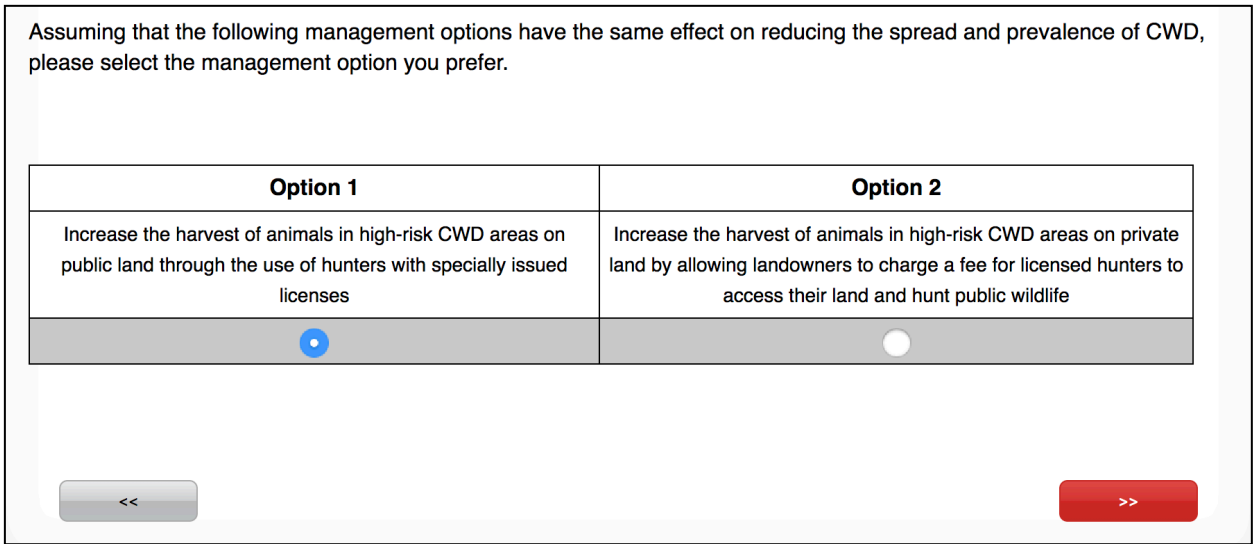

Figure 4.1 Example of a paired comparison question where the respondent chooses their preferred management option between the two presented

Because in most cases the true impact of the CWD management options could not be adequately-presented to the respondents, I created the assumption that each of the management options would have the same impact on the spread and prevalence of the disease. This assumption is reflected in the question that preceded each pair (Figure 4.1).

The number of pairs presented to respondents in a paired comparison survey is based upon the number of available options. If there are *n* options available, then there will be *n(n-1)/2* pairs to compare (Brown and Peterson 2003). The list of management options presented to all respondents as members of the general public included 7 management options, giving us 21 possible pairs of management options. The number of management options presented to hunters

and landowners were 5 and 4, respectively, creating 10 pairs of management options for the hunters and 6 for the landowners.

While I was not concerned about presenting 10 or 6 pairs to the hunters and landowners, I decided that 21 pairs would be too burdensome for the general public and would likely cause respondent fatigue. Thus, I followed the example provided by Davison et al (2012) and adopted a matrix sampling design for the general public stakeholder group. In this design, I used three forms, or versions, of the survey each containing 7 pairs to be judged by the survey respondents. Each of the three forms were given to different portions of the general public, allowing me to analyze the responses to all of the possible pairs, with a lower likelihood of causing respondent fatigue. I ensured that each of the forms had the same number of pairs and that each management option appeared the same number of times on each version of the survey. For each set of paired comparisons, the management options appeared equally on the left and right of the comparison, and the order of pairs was also randomized between participants.

4.2.2 Data Analysis

With the responses to each of the pairs in the complete survey designs for the hunter and landowner sections, I can aggregate the data into preference scores[8] (Brown and Peterson 2003). Individual preference scores can be calculated by creating a preference matrix such as the one provided in Table 4.2. In the preference matrix, an X is placed in each cell where the respondent preferred the option represented by the column over the option represented by the row. The sum of the X's in each column gives the preference score for that management option, and the

[8] The matrix sampling method I used for the general public does not allow for the calculation of preference scores.

preference ordering for all of the management options. In Table 4.2, the respondent had a preference score of 3 for option A and a score of 2 for option B. These scores mean that option A is preferred to option B. Following that logic, option B is preferred to option C, and option C to option D. The individual preference scores can be combined into an aggregate preference score for the entire sample (Brown and Peterson 2003). In a general sense, these preference scores tell us which option is preferred most and least often across the sampled population.

Table 4.2 Example of a preference matrix with associated preference scores

	Option A	Option B	Option C	Option D
Option A				
Option B	x			
Option C	x	x		
Option D	x	x	x	
Score	3	2	1	0

One potential problem that one may encounter in the calculation of preference scores is the presence of circular triads. Table 4.3 provides another example of a preference matrix, but this time with two circular triads. In the table, this respondent preferred option A to option B, and option B to option D, but preferred option D to option A, resulting in the following circular triad: *a>b>d>a.* This inconsistency can weaken the strength of the preference analysis.

Table 4.3 Example of a preference matrix with circular triads indicated by repeated preference scores

	Option A	Option B	Option C	Option D
Option A				x
Option B	x		x	
Option C	x			
Option D		x	x	
Score	2	1	2	1

To investigate such inconsistencies, one can use measures of preference reliability and consistency, such as the coefficient of consistency (Equation 1), to indicate the strength of the preferences (Brown and Peterson 2003). The coefficient of consistency is an indication of the number of circular triads in a preference matrix relative to the maximum number of circular triads possible given the number of alternatives (Brown and Peterson 2003). The number of circular triads *c* is dependent upon the number of options available, *t*, the preference score for each option a_i and the average preference score *b*, where $b = (t-1)/2$ (Brown and Peterson 2003).

$$c = \frac{t}{24}(t^2 - 1) - \frac{1}{2}\sum(a_i - b)^2 \quad (1)$$

The coefficient of consistency *C* (Equation 2) therefore relates this number of circular triads *c* to the maximum number of circular triads possible.

$$C = 1 - {}^{c}/_{m} \quad (2)$$

The maximum number of circular triads, *m,* is equal to $\frac{t}{24}(t^2 - 1)$ when *t* is an odd number and $\frac{t}{24}(t^2 - 4)$ when *t* is an even number (Brown and Peterson 2003; David 1988; Kendall and Babington Smith 1940). The coefficient ranges from 0, indicating that an individual has the maximum number of triads in their preferences, to 1, which indicates that the preferences are free from circular triads.

In addition to the preference scores, the responses were analyzed using random utility models. Random utility models are used in order to give me specific utility measures for each management option in comparison to each other, which is information I do not get from the preference scores alone. In these models, I assume that when individuals make decisions, they

choose options that provide them with the largest amount of utility. Following Holmes et al (2017), I specify a utility function as:

$$U_{x_1k} = V_{x_1k} + \varepsilon_{x_1k} \quad (3)$$

Equation 3 shows that the utility that an individual receives from choosing option 1, U_{x_1k}, is a combination of both the systematic utility, V_{x_1k}, derived from the chosen option, x_1, and a random component, ε_{x_1k}, which depends on the individual, *k,* making the decision between a pair of options, option x_1 and x_2, in a set of options C_S, which are specific to the stakeholder group S.

Since I assume that individuals make decisions based upon the utility that may result from an outcome, the probability, *P*, of an individual in a paired comparison scenario choosing one option over another is directly related to the probability that the utility derived from the chosen option is higher than the alternative. This relationship is represented by Equations 4-6:

$$P_{x_1k} = P\left(U_{x_1k} \geq U_{x_2k}\,, \forall\, x_1 \neq x_2;\; x_1, x_2 \in C_S\right) \quad (4)$$

$$P_{x_1k} = P\left(V_{x_1k} + \varepsilon_{x_1k} \geq V_{x_2k} + \varepsilon_{x_2k}\,, \forall\, x_1 \neq x_2;\; x_1, x_2 \in C_S\right) \quad (5)$$

$$P_{x_1k} = P\left(V_{x_1k} - V_{x_2k} \geq \varepsilon_{x_2k} - \varepsilon_{x_1k}\,, \forall\; x_1 \neq x_2;\; x_1, x_2 \in C_S\right) \quad (6)$$

where the probability of choosing option x_1, P_{x_1k}, depends on the probability of the utility derived from option x_1, V_{x_1k}, being greater than the utility derived from option x_2, V_{x_2k}, when both x_1 and x_2 are within the set of available stakeholder-specific options, C_S (Holmes et al 2017). If one assumes that the error terms are independently and identically distributed with Type 1 extreme value distributions, the result is a conditional logit model where the probability of individual *k* selecting option x_1, from a pair of options, $x_1$and x_2, that are part of set C_S is:

$$P_{x_1 k} = \frac{\exp\left(\mu V_{x_1 k}\right)}{\sum_{j \epsilon C} \exp\left(\mu V_{x_2 k}\right)} \tag{7}$$

In this conditional logit model the probability of individual *k* selecting option x_1 is a relation between the systematic utility associated with the two options being considered. The scale term, μ, is used to capture unobserved aspects of utility which affect the variability in the utility measures (Holmes et al 2017). In this study I set the scale term to equal one, as is usually the case when there is unidentified variability. If the scale parameter was zero all choices that the respondent makes would be random. Alternatively, a scale parameter set at infinity would indicate that there is no variance and there would be no error term in the utility function for that individual. In that case, utility would strictly be a function of the systematic utility and utility would not differ by respondent.

Random utility models were estimated for each stakeholder group with conditional logistic regressions represented by the following function:

$$logit\left(Y \middle| \left(x_i, x_j\right); x_i, x_j \in C_S\right) = \sum_{i=1}^{n} \beta_i x_{iS} \tag{8}$$

The conditional nature of this analysis relies on the design of the paired comparisons because the respondent's decision, Y between two management options depends upon which two options $\left(x_i, x_j\right)$ from the set of available stakeholder-specific options, C_S, were presented in the pair. Therefore, each choice a respondent makes in a paired comparison survey is conditional on a different pair of options selected from C_S, C_S: $\{x_{1S}, x_{2S}, \ldots, x_{nS}\}$. The number of available options, n, depends on the stakeholder being analyzed. In this study there were 7 options given to the general public, (C_G: $\{x_{1G}, \ldots, x_{7G}\}$), 5 options presented to hunters (C_H: $\{x_{1H}, \ldots, x_{5H}\}$) and 4 options presented to landowners (C_L: $\{x_{1L}, \ldots, x_{4L}\}$) (see Table 4.1). The independent variables, x_{iS}, are binary variables indicating whether a given management option was represented in the

presented pair. The coefficients for each management option, β_i, in these random utility models can be interpreted as the utility that the average respondent would receive from that option being chosen.

The coefficients are estimated relative to a baseline represented by omitting one of the management options. Therefore, I require only x_{n-1} independent variables. In order to decide which management option to omit from the model, I conducted initial, non-conditional logistic regressions and identified the option that provided closest to zero utility or disutility to the respondents. The chosen options were either statistically insignificant or closest to zero if they were significant. Additionally, the errors in each regression are clustered by respondent because not all of the observations are independent, as multiple responses come from the same individual.

In addition to measuring preferences for policy choices, I also investigated whether there were demographic characteristics, or types of activities with which respondents were involved, which made a stakeholder more or less likely to choose a particular management option. Looking into variables such as demographics or activity types is important because some types of stakeholders may prefer some management options to others. For example, one might hypothesize that hunters would be more likely to choose a management option that utilizes hunters, or landowners may be more likely to choose a management option that provides landowners with financial benefits. I investigated such relationships through conditional logistic regressions with interaction terms. These interaction terms I_z represent variables that identify individual segments, *z,* of the Canadian population based upon demographic characteristics and respondent activities. Based on data collected in the survey, $z = 16$ for the general public paired comparisons, $z = 15$ for the hunter paired comparisons and $z = 14$ for the landowner paired comparisons. These options are presented in Table 4.4. Equation 9 specifies the interaction

models. In order to keep models to a reasonable size, I investigate the impacts of demographic characteristics and respondent activities one at a time for each stakeholder group; that is, I_z is held constant in a given stakeholder model. Thus, I have 16 interaction models for the general public, 15 interaction models for hunters and 14 interaction models for landowners. β_{iz} can be interpreted as the utility a respondent (from a specific segment of the population) would receive from the management option they selected.

Table 4.4 Options presented in each of the paired comparison sections

Option	General Public $z = 16$	Hunters $z = 15$	Landowners $z = 14$
Respondents who identified themselves as hunters	x		x
Respondents who identified themselves as landowners	x	x	
Respondents who identified as rural residents	x	x	
Respondents who identified themselves as male	x	x	x
Respondents from households that consume venison	x	x	x
Respondents with prior knowledge of CWD	x	x	x
Respondents from provinces without reported cases of CWD in the wild	x	x	x
Respondents between the age of 30 and 45	x	x	x
Respondents over the age of 46	x	x	x
Respondents who feed wildlife	x	x	x
Respondents who photograph wildlife	x	x	x
Respondents who are members of wildlife organizations	x	x	x
Respondents who contribute to organizations that protect endangered wildlife	x	x	x
Respondents who contribute to organizations that promote wildlife conservation	x	x	x
Respondents who participate in general outdoor recreational activities	x	x	x
Respondents who participate in motorized recreational activities	x	x	x

$$logit\left(Y\middle|\left(x_i, x_j\right); x_i, x_j \in C_S\right) = \sum_{i=1}^{n} \beta_i x_{iS} + \sum_{i=1}^{n} \beta_{iz} I_z x_{iS} \quad (9)$$

Additionally, I assume that there may be stakeholders who believe that doing nothing is an appropriate action (Verburg 2016). Therefore, I designed a question to follow each paired comparison which asked the respondent to choose between their previously selected option and

no action. This question allowed the respondent to back out of their previously chosen option by saying that they prefer the government take "no action" to manage CWD. To analyze these responses, I collapsed the two questions into a 3-alternative choice task represented by the following variation on Equation 8:

$$logit\big(Y\big|\big(x_i, x_j\big); x_i, x_j \in C_S\ \big) = \sum_{i=1}^{n} \beta_i x_{iS} + \beta_{NA} x_{NA} \tag{10}$$

where the individual makes a decision between two management options, (x_i, x_j) and the option of doing nothing (x_{NA}). The dependent variable, Y, is still the respondent's choice between options, and still conditional on two options selected from the set C_S. However, the "no action" option is added to the list of independent variables, x_{iS}. I also adjusted the model represented by Equation 9 to identify differences in preferences among the same segments, z, of the Canadian public with the interaction terms, I_z:

$$logit\big(Y\big|\big(x_i, x_j\big); x_i, x_j \in C_S\ \big) = \sum_{i=1}^{n} \beta_i x_{iS} + + \beta_{NA} x_{NA} + \sum_{i=1}^{n} \beta_{iz} I_z x_{iS} + + \beta_{NAz} I_z x_{NA} \tag{11}$$

The results from the models with and without the "no action" option are presented separately in the results below.

4.3 Results

4.3.1 Summary Statistics

Table 4.5 provides a list of the summary statistics that informed the variables I used as interaction terms in the different models. Given that the survey was sent out by a marketing research company in an online open panel format, I compare the sample to statistics from the population of Canada in order to investigate how representative the sample is. In the sample, 6.2% identified themselves as hunters, a similar number to the 5.9% of Canadians who hunt or

trap (Statistics Canada 2016a). The proportion of the sample who said they lived in provinces or territories with no reported cases of CWD in the wild (thus excluding residents of Alberta and Saskatchewan) was 87.1%, which is similar to the 85.2% estimate made by Statistics Canada for the second quarter of 2018 (Statistics Canada 2018). 56.2% of the sample said that they participated in some type of outdoor motorized recreation, an amount higher than the 37% estimated by Statistics Canada (2016b). And finally, while 24.8% of the sample said that they photograph wildlife, an estimated 32% of Canadians say they do so (Statistics Canada 2016b). From these comparisons I assume that the survey sample is generally-reflective of the Canadian population.

Table 4.5 Summary statistics which identify segments of the Canadian population

Variable	Frequency	Proportion of Sample
Respondents who identified themselves as hunters	325	0.062
Respondents who identified themselves as landowners	286	0.055
Respondents who identified as rural residents	1671	0.319
Respondents who identified themselves as male	2550	0.487
Respondents from households that consume venison	4181	0.799
Respondents with prior knowledge of CWD	1521	0.290
Respondents from provinces without reported cases of CWD in the wild	4561	0.871
Respondents between the age of 30 and 45	2438	0.466
Respondents over the age of 46	1959	0.374
Respondents who feed wildlife	1415	0.270
Respondents who photograph wildlife	1299	0.248
Respondents who are members of wildlife organizations	1210	0.231
Respondents who contribute to organizations that protect endangered wildlife	334	0.064
Respondents who contribute to organizations that promote wildlife conservation	595	0.114
Respondents who participate in general outdoor recreational activities	664	0.127
Respondents who participate in motorized recreational activities	2944	0.562

4.3.2 Preference Scores and Consistency

Preference scores can give us an idea of which management options are preferred to others. Preference scores identify how many times each option was chosen in the paired comparison questions for a single respondent, and also indicate whether the preferences are consistent as measured by the coefficient of consistency (Brown and Peterson 2003). As was previously mentioned, I cannot calculate preference scores for the general public due to the matrix sampling method I used to analyze their preferences, however I can complete this process for the hunter and landowner stakeholder groups.

Of the 5 management options presented to hunters, the median score for four of the policy options was 2, while the option to give $50 and a new tag for the next season to hunters who submit a head that tests positive for CWD had a preference score of 3 (Table 4.6). These scores suggest that among hunters there is a preference for the "$50 and a tag for next season" option. Landowners only had four options to choose between in their paired comparisons. The option of using environmental sampling (of soil, feces, etc.) on private land was preferred, with a preference score of 2, was greater than other options that had preference scores of 1 (Table 4.7). The median coefficient of consistency was 1 for both the hunter and landowner paired comparisons. Recall that coefficient of consistency can vary between a 1 (with no circular triads) and 0 (with the maximum number of circular triads given a choice set). A median coefficient of 1 indicates that at least 50% of the respondents had no circular triads in their preferences for a given set of management options. This result adds strength to the interpretation of the utility measures I obtained through logistic regressions because it means that the utility measures were measured based on a sample with generally consistent preferences.

Table 4.6 Median preference scores of hunters

Management Option	Extend hunting season by 2 weeks	Double the number of available tags	Provide free tags in CWD areas	Dispose of unwanted animal parts at county dump site	Provide $50 and a tag for next season to hunters who submit heads that test positive for CWD
Median Score	2	2	2	2	3

Table 4.7 Median preference scores of landowners

Management Option	Mandatory environmental sampling on private land	Extension services to landowners who cooperatively manage their land for CWD with their neighbours	Extra tags to landowners who cooperatively manage their land for CWD with their neighbours	Allow landowners to charge hunters for access to their land
Median Score	2	1	1	1

4.3.3 Logistic Regression of Paired Comparisons Without the Opt-Out Option

Table 4.8 provides a description of the results of the paired comparisons model without interactions for the general public and without the opt-out option. Results indicate that, in comparison to the option of compensating landowners to provide hunter access, the general public prefers the implementation of policy actions that use hunters to increase cervid harvest and those that restrict the movement of carcasses and hunted products. Results also indicate that the other management actions: allowing landowners to charge hunters for access; using sharpshooters on public or private land; and increasing the number of landowner special licenses may provide less utility than the option of compensating landowners to provide hunter access.

Table 4.8 Results of the paired comparisons model without interactions for the general public

Management Option	Coefficient (Robust Std Error)	p-value	95% Confidence Interval	
Hunters increase harvest public land	0.235 (0.026)	0.000	0.185	0.285
Landowners charge hunters for access	-0.297 (0.024)	0.000	-0.344	-0.250
Sharpshooters on public land	-0.322 (0.030)	0.000	-0.380	-0.264
Restricted movement of carcasses and hunted products	0.232 (0.029)	0.000	0.175	0.289
Sharpshooters on private land	-0.323 (0.029)	0.000	-0.380	-0.267
More landowner special licenses	-0.194 (0.025)	0.000	-0.242	-0.146
Government compensation for hunter access on private land	omitted			

Using the interaction models (Equation 11), I can then compare these utility measures to other segments of the general public. Figure 4.2 shows the results for the general public with comparisons across stakeholders (panel a), across demographic group (panel b) and across respondent activities (panel c). The first bar for each option on all three panels represents the preferences of the general public as indicated in Table 4.8. The magnitude of the preferences is indicated by both the height of the bars and the error bars representing the 95% confidence interval. Insignificant coefficients are not included in the graphs.

Heterogeneity in preferences for a given option is evident by comparing results across segments of the population as presented in Figures 4.2a-c. For the option of using hunters to increase harvest on public land there are few significant results, but one can see that respondents over the age of 46 might like the option, but landowners might receive less utility for this option than the option to compensate landowners to provide hunting access. For the option of allowing landowners to charge hunters for access to their land there are generally similarities in preferences across groups, and those that believe they would receive less utility than they would from a policy where government compensation is provided to landowners include rural residents, respondents from households where venison is consumed, respondents over the age of 46, those

who feed wildlife, and those who participate in outdoor recreation. For the option of using sharpshooters on public land one can see that groups generally believe that the option would provide less utility than compensating landowners to provide hunting access, however there are groups that would like the option, including: respondents from provinces without cases of CWD in the wild; those over the age of 46; respondents who are members of wildlife organizations; and those who contribute to wildlife conservation. The option to restrict the movement of carcasses and hunted products would be liked by groups such as the general public as a whole, respondents from provinces without cases of CWD in the wild, those over the age of 46, as well as those who photograph wildlife, or participate in outdoor recreation or motorized recreation. However, hunters and landowners indicated that they would receive less utility from this option than the option of providing government compensation to landowners for providing hunting access. For the option of using government sharpshooters on private land one can see that hunters, landowners, rural residents, respondents from households where venison is consumed, those with prior knowledge of CWD, 30-45 year olds, those who feed wildlife and those who participate in motorized recreation all believe the option will provide less utility than providing government compensation to landowners for hunter access. However, similar to the option of using sharpshooters on public land, this option would be liked by respondents from provinces without cases of CWD in the wild, those over the age of 46, respondents who are members of wildlife organizations and those who contribute to wildlife conservation. Lastly, for the option of increasing the availability of landowner special licenses, there are few significant results, but one can see that respondents who photograph wildlife would like the option while the general public indicated that they would rather government compensation be provided to landowners to increase hunter access.

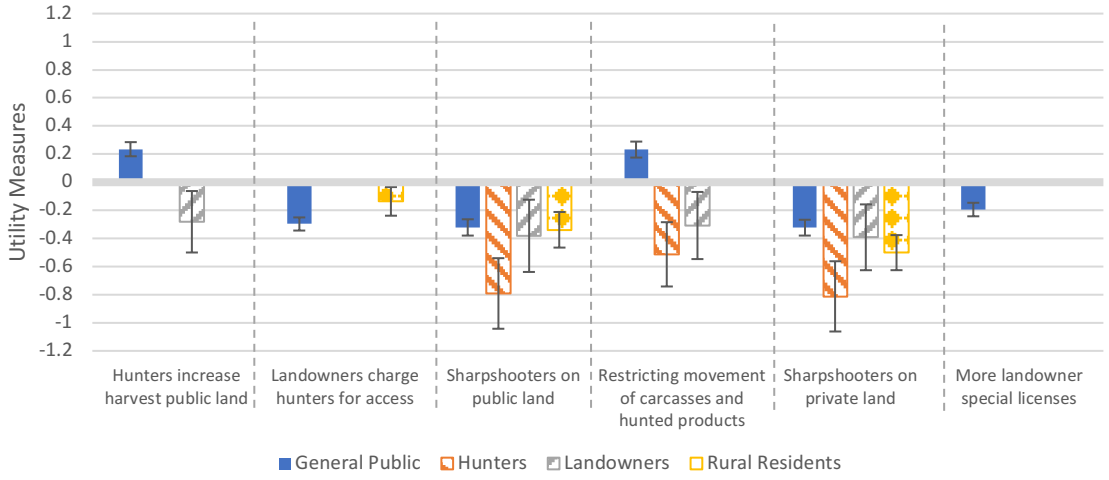

Figure 4.2a. Comparing the general public utility measures by stakeholder

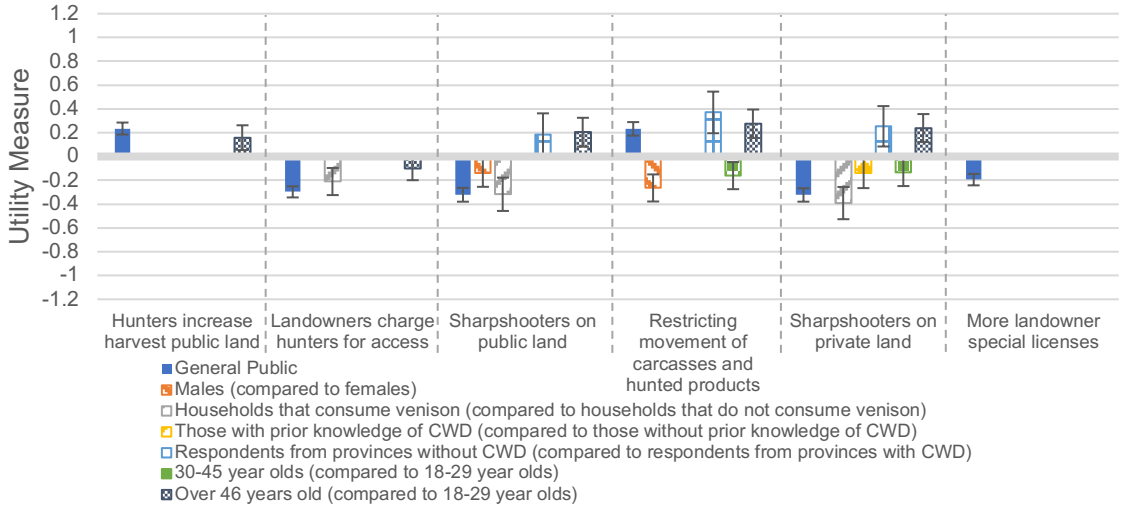

Figure 4.2b. Comparing the general public utility measures by demographic

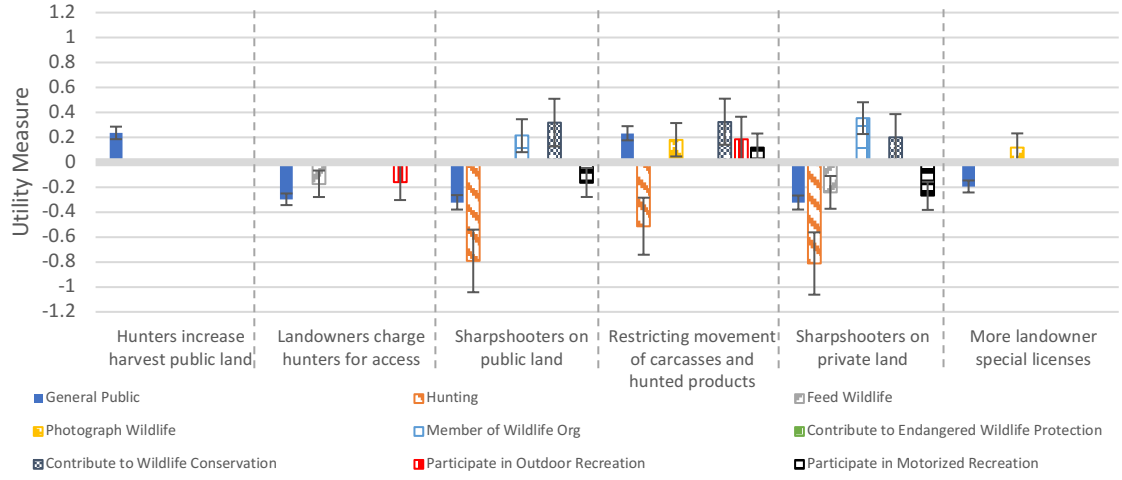

Figure 4.2c. Comparing the general public utility measures by respondent activity

Figure 4.2 Utility measures for segments of the Canadian public

Table 4.9 presents the results of the model without interactions for the paired comparisons presented to hunters. The results suggest that in comparison to the option of increasing the hunting season by 2 weeks, hunters prefer CWD management options such as doubling the number of available tags and a reward system for submitting heads that test positive for CWD. Hunters receive less utility from policies that provide tags for free in areas where there have been reported cases of CWD in the wild than they would from the decision to extend the hunting season. The preferences of hunters for establishing centralized dump sites for carcasses and unwanted animal parts are not significantly different than the preferences for extending the hunting season.

Table 4.9 Results of the paired comparison model without interactions for hunters

Management Option	Coefficient (Robust Std Error)	p-value	95% Confidence Interval	
Doubling the available tags	0.259 (0.069)	0.000	0.124	0.394
Providing free tags in CWD areas	-0.160 (0.076)	0.036	-0.310	-0.010
Disposing of unwanted animal parts at county dump site	-0.035 (0.087)	0.690	-0.206	0.137
$50 and tag for the next season to hunters who submit heads that test positive for CWD	0.372 (0.086)	0.000	0.204	0.541
Extending hunting season by 2 weeks	omitted			

As I did with the paired comparisons for the general public, I can also compare these results by segments of the Canadian hunting population. Again, I can look for heterogeneity by comparing the results to other segments of Canadian hunters as shown by Figure 4.3a-c. The first bar for each option on all three panels represents the preferences of hunters as indicated in Table 4.9. Such comparisons indicate that there are relatively few significant results. For the option of doubling the number of available tags one can see that the general hunting population and, specifically, hunters who participate in motorized recreation may like the option. For the option of providing free tags in CWD-endemic areas, respondents who are male, and those with prior

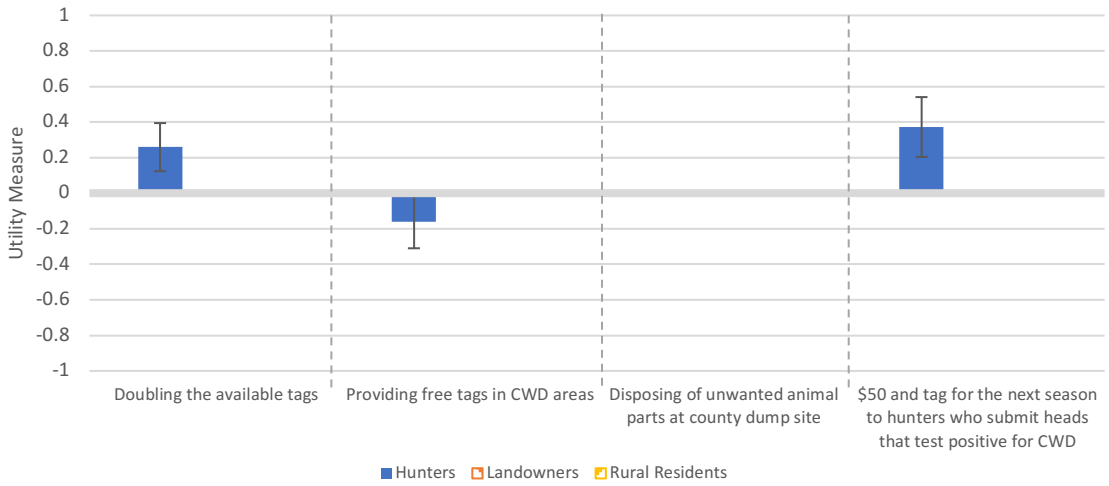

Figure 4.3a. Comparing the utility measures for the hunter paired comparisons by stakeholder

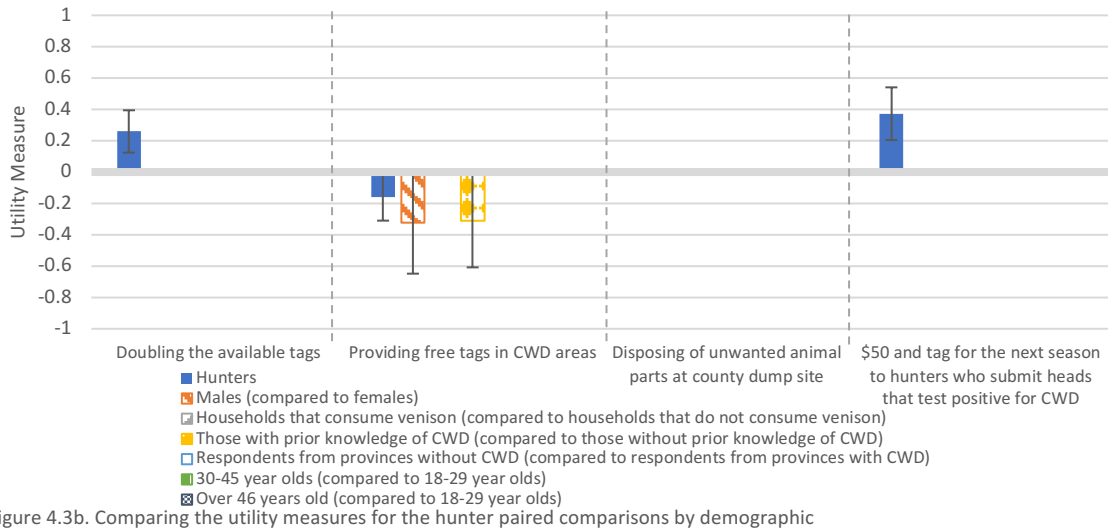

Figure 4.3b. Comparing the utility measures for the hunter paired comparisons by demographic

Figure 4.3c. Comparing the utility measures for the hunter paired comparisons by respondent activity

Figure 4.3 Utility measures for segments of the hunting population in Canada

knowledge of CWD agreed with the general hunting population and may not like the option in comparison to the option of extending the hunting season. There results for the option of making it mandatory to dispose of unwanted animal parts at a county dump site were not significantly different from extending the hunting season. Finally, respondents who participate in outdoor recreation agreed with the general hunting population and indicated that they might like a reward system for submitting heads that test positive for CWD.

Table 4.10 provides the results from the paired comparison model without interactions for landowners. From these results one could suggest that when compared to the option of providing landowner cooperatives with extra hunting tags, landowners may be in favour of allowing environmental sampling to occur on their land, should such testing become available. Additionally, in comparison to the option of receiving extra tags for cooperatively managing their land for CWD, landowners may not be in favour of charging hunters for access. The preferences of landowners for receiving extension services for cooperatively managing their land are not significantly different from the preferences for receiving extra tags for the same cooperative arrangement.

Table 4.10 Results of the paired comparisons model without interactions for landowners

Management Option	Coefficient (Robust Std Error)	p-value	95% Confidence Interval	
Use environmental sampling (soil, fecal matter, etc.) on private land to identify CWD management areas	0.578 (0.104)	0.000	0.375	0.781
Extension services to landowners who cooperatively manage CWD on combined private lands	-0.130 (0.080)	0.103	-0.286	0.026
Landowners charge hunters for access	-0.353 (0.092)	0.000	-0.532	-0.173
Extra tags to landowners who cooperatively manage CWD on combined private lands	omitted			

As I did for the general public and hunter paired comparisons, I can use these initial measures to identify differences in the preferences of segments of Canadian landowners. In the landowner utility measures, there is little heterogeneity among segments of the population (Figures 4.4a-c). The first bar for each option on all three panels represents the preferences of landowners as indicated in Table 4.10. For the option of instituting mandatory environmental sampling on private land, hunter-landowners disagree with the rest of the landowning population and indicated that they may receive less utility from this option compared to the option of receiving extra tags for cooperatively managing their land for CWD. Alternatively, respondents who participate in motorized recreation may like the option. For the option to provide extension services to landowners who cooperatively manage their lands for CWD, hunter-landowners indicated that they might receive less utility than they would receive from the option of receiving extra tags for cooperatively managing their land for CWD. Lastly, for the option to allow landowners to charge hunters for access, respondents from provinces without cases of CWD in the wild might like the option, while respondents who are over the age of 46 and those who photograph wildlife indicated that they might receive less utility from this option than the option of receiving extra tags for cooperatively managing their land for CWD.

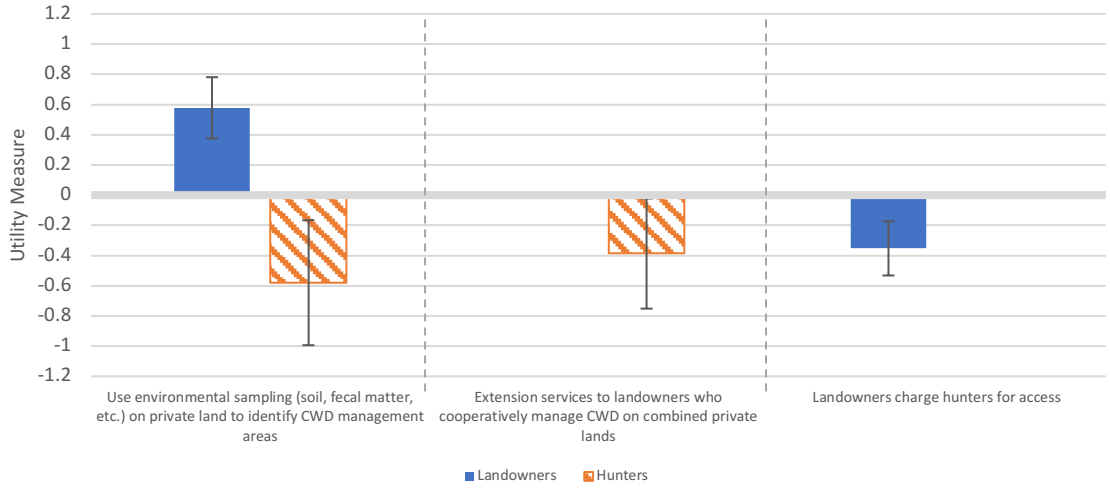

Figure 4.4a. Comparing the utility measures for the landowner paired comparisons by stakeholder

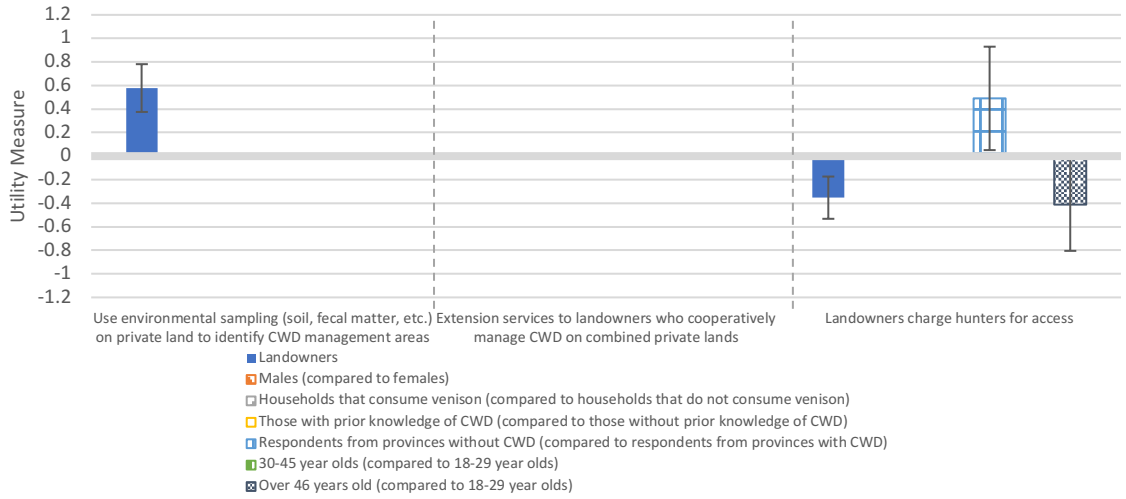

Figure 4.4b. Comparing the utility measures for the landowner paired comparisons by demographic

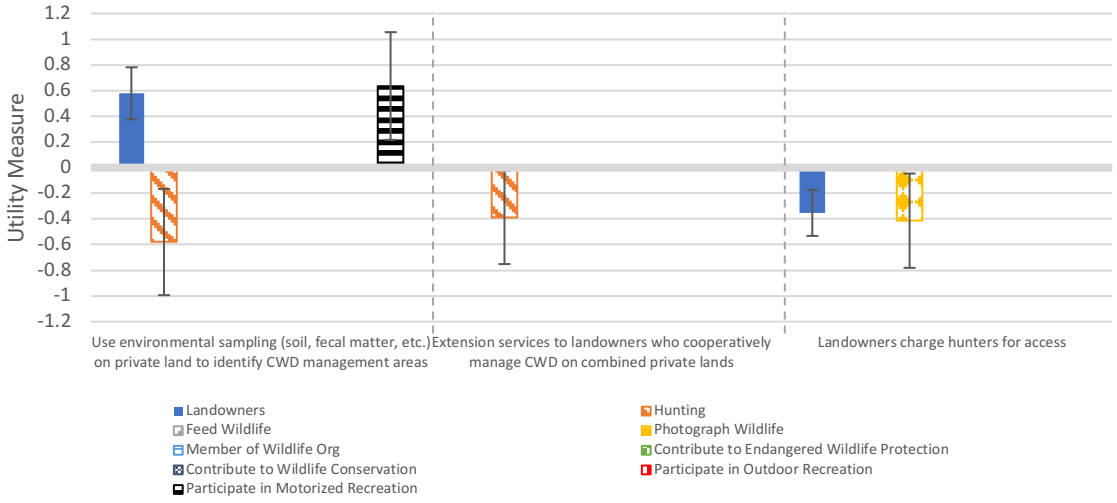

Figure 4.4c. Comparing the utility measures for the landowner paired comparisons by respondent activity

Figure 4.4 Utility measures for segments of the landowner population in Canada

4.3.4 Logistic Regressions of Paired Comparisons with the Opt-out Option

In addition to the analysis above, I also investigated the data that allowed the respondents to opt-out of their choice in the paired comparison. I analyzed the data as a 3-alternative choice task where the opt-out choice was a control variable (Equation 10). The models were analyzed in the same manner as the previous paired comparisons with conditional logistic regressions. As was the case in the paired comparisons, one of the options in each set of questions had to be omitted from the analyses. To maintain consistency with the previous results, the same options were omitted in this 3-alternative choice analysis. Tables 4.11a-c compare the results of the conditional logit models for the paired comparison questions which included the option to opt-out of CWD management, to the results I previously presented, which did not include the "no action" option. These results show that the addition of the "no action" option does not change the signs of the coefficients, and that the significance and size of the coefficients are not appreciably different.[9] The majority of the coefficients on the interaction term of the "no action" variable suggest that, in comparison to the baseline option in each analysis, respondents dislike the option of doing nothing to manage CWD. These results, by in large, carry across segments of the sampled population (Figure 4.5). But in some cases, there are segments of the population that prefer no action be taken to manage CWD as indicated as positive utility measures (Figure 4.5). For the general public paired comparisons, members of wildlife organizations and those between the ages of 30 and 45 (compared to those between 18 and 29 years old) seem to like taking no action to manage CWD in comparison to the baseline option of providing government compensation to landowners to provide hunter access (Figure 4.5a). There were no significant

[9] As I did before, I can compare these results across segments of the population, however they are not appreciably different from the comparisons I conducted above. The graphs that depict these comparisons are provided as Appendix 4 through 12.

results in the hunter paired comparison analysis to indicate that segments of the hunter population would like the option of taking no action to manage CWD in comparison to the baseline option of extending the hunting season by two weeks (Figure 4.5b). For the landowner analysis the results indicate that landowners from provinces without confirmed cases of CWD seem to like the no action option in comparison to the baseline option of providing extra tags to members of landowner cooperatives (Figure 4.5c).

Table 4.11 Comparisons of the models for each stakeholder with and without the opt-out option

Table 4.11a. Results of the model for the general public with and without the opt-out option

Management Option	Coefficient With Opt-Out (Rob. Std. Err.)	p-value	Coefficient Without Opt-Out (Rob. Std. Err.)	p-value
Hunters increase harvest public land	0.205 (0.025)	0.000	0.235 (0.026)	0.000
Landowners charge hunters for access	-0.311 (0.024)	0.000	-0.297 (0.024)	0.000
Sharpshooters on public land	-0.312 (0.031)	0.000	-0.322 (0.030)	0.000
Restricted movement of carcasses and hunted products	0.287 (0.030)	0.000	0.232 (0.029)	0.000
Sharpshooters on private land	-0.282 (0.030)	0.000	-0.323 (0.029)	0.000
More landowner special licenses	-0.206 (0.026)	0.000	-0.194 (0.025)	0.000
No action	-0.907 (0.033)	0.000		
Government compensation for hunter access on private land	omitted		omitted	

Table 4.11b. Results of the model for hunters with and without the opt-out option

Management Option	Coefficient With Opt-Out (Rob. Std. Err.)	p-value	Coefficient Without Opt-Out (Rob. Std. Err.)	p-value
Doubling the available tags	0.282 (0.072)	0.000	0.259 (0.069)	0.000
Providing free tags in CWD areas	-0.174 (0.082)	0.034	-0.160 (0.076)	0.036
Disposing of unwanted animal parts at county dump site	-0.024 (0.094)	0.795	-0.035 (0.087)	0.690
$50 and tag for the next season to hunters who submit heads that test positive for CWD	0.354 (0.091)	0.000	0.372 (0.086)	0.000
No action	-1.067 (0.131)	0.000		
Extending hunting season by 2 weeks	omitted		omitted	

Table 4.11c. Results of the model for landowners with and without the opt-out option

Management Option	Coefficient With Opt-Out (Rob. Std. Err.)	p-value	Coefficient Without Opt-Out (Rob. Std. Err.)	p-value
Use environmental sampling (soil, fecal matter, etc.) on private land to identify CWD management areas	0.665 (0.107)	0.000	0.578 (0.104)	0.000
Extension services to landowners who cooperatively manage CWD on combined private lands	-0.162 (0.084)	0.055	-0.130 (0.080)	0.103
Landowners charge hunters for access	-0.472 (0.101)	0.000	-0.353 (0.092)	0.000
No action	-0.951 (0.135)	0.000		
Extra tags to landowners who cooperatively manage CWD on combined private lands	omitted		omitted	

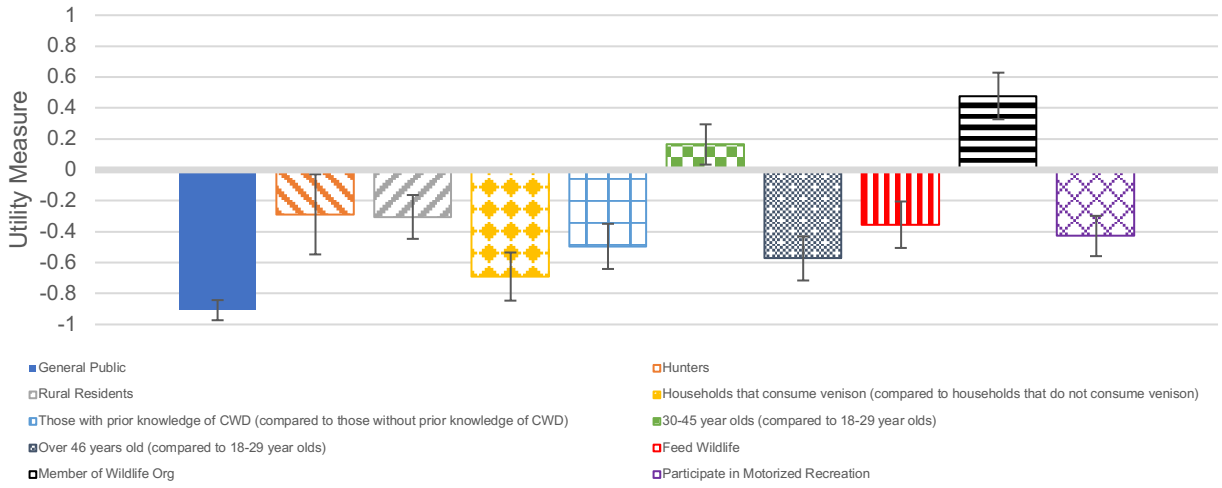

Figure 4.5a. Utility measures for segments of the Canadian public towards taking no action to manage CWD

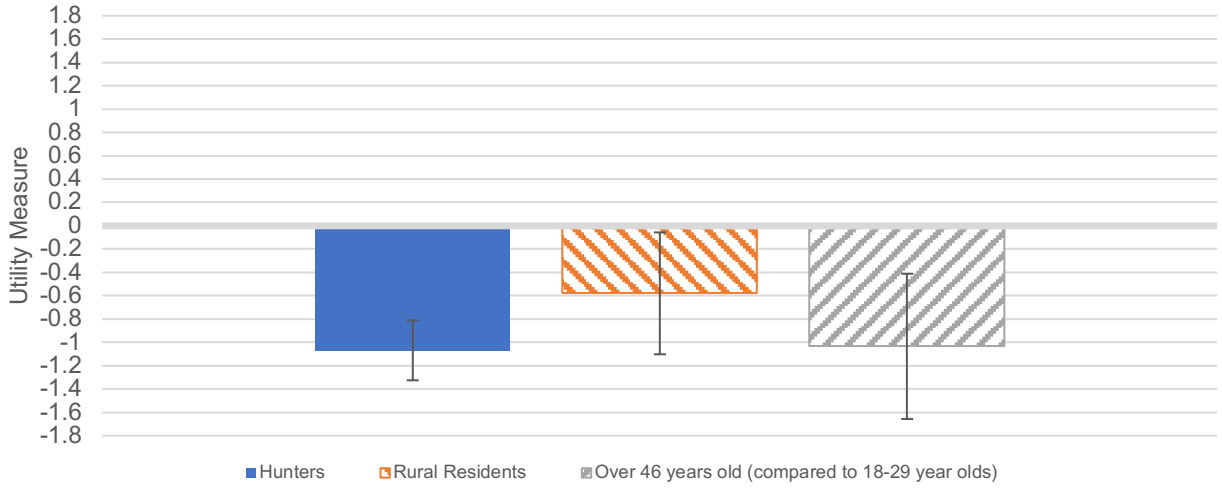

Figure 4.5b. Utility measures for segments of the hunter population in Canada towards taking no action to manage CWD

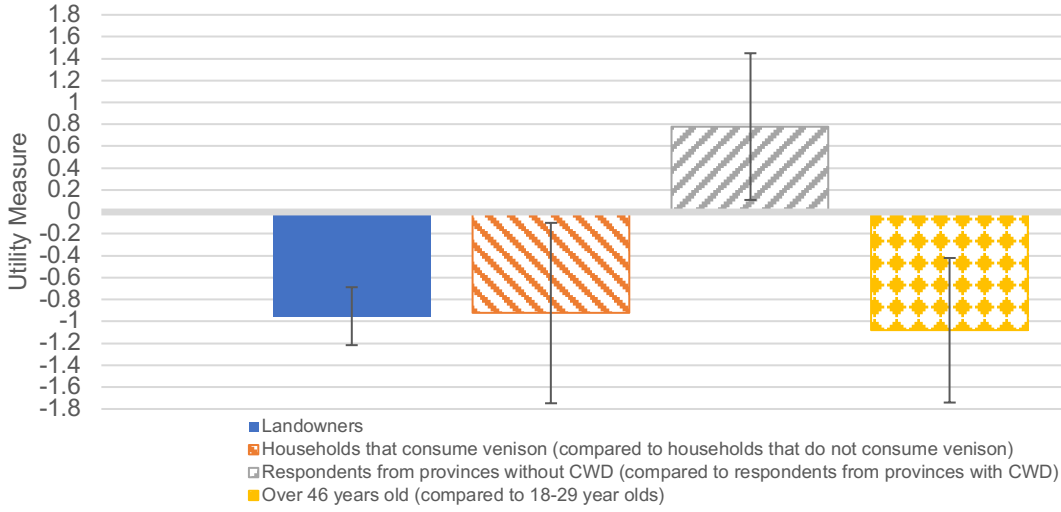

Figure 4.5c. Utility measures for segments of Canadian landowners towards taking no action to manage CWD

Figure 4.5 Utility measures for taking no action to manage CWD compared across stakeholders

4.4 Summary and Conclusion

In this chapter I started by examining how willing different stakeholders are to accept CWD management strategies. Through conditional logit models of paired comparison survey responses, I was able to better understand the preferences of these stakeholders regarding specific management options. Next, I wanted to investigate whether in some cases there may be segments of the population who have differing preferences, and through additional analyses of paired comparison survey responses, I found that in some cases there may be heterogeneity in preferences within stakeholder groups. Lastly, I wanted to explore whether the addition of the option to take no action to manage CWD changes stakeholder preferences towards CWD management. Through this analysis I found that the option to take no action against CWD does not have an appreciable effect on the preferences towards other management options and that in most, but not all, cases the stakeholders do not like the option of taking no action.

Due to the many different ways in which people interact with cervid resources, CWD management may require policymakers to use different policies to influence the actions of the different stakeholders. Every policy action will have some sort of effect on the utility of affected stakeholders. For example, if policymakers decide they want to increase the harvest of animals in an attempt to reduce the prevalence and spread of the disease one could assume that hunters, landowners and other members of the general public will all be affected by this decision. Understanding the preferences of these groups towards policy options that may impact their rights and well-being is important for the policymaking process.

From the results some suggestions can be made for policymakers which consider stakeholder perspectives. First of all, the Canadian public prefers action against CWD as opposed to no action in most cases. If policymakers decide to act, it may firstly be helpful to

know that many of the available options are viewed as less preferable than the baseline option for the majority of the stakeholders. However, there are some management options where stakeholders seem to have definitive preferences. For example, it might be preferable to use hunters to reduce populations for disease management as opposed to using government sharpshooters. Moreover, if policymakers want to target the actions of hunters for CWD management, the most preferable method would be through increasing the number of available tags or creating a reward system for positive head submissions. The most preferable way to target landowner actions would be using environmental sampling on private land when such tests become available. With these suggestions in mind, policymakers may find it easier to introduce policy that relevant stakeholders actively want to participate in. Stakeholder participation may in turn make it possible to manage the spread and prevalence of CWD in Alberta.

There are a number of limitations to this analysis. But above all, the biggest limitations come from the assumptions that were enforced in the paired comparisons. Firstly, in the paired comparisons I asked the respondents to assume that each of the management strategies would be equally effective in the management of CWD, which may not be the case. Secondly, there was no cost information provided for the different options and this may have allowed the respondents to create their own assumptions about the likelihood of the policies being adopted. Thirdly, since CWD has only been found in the wild cervid populations of Alberta and Saskatchewan and the large majority of the respondents do not live in an area where CWD has been found[10], the responses may be biased by a lack of knowledge or an insufficient understanding of wildlife management in this context. Additionally, although I present the utility measures in a graph

[10] At the time of writing new cases of CWD in captive populations of cervids in Quebec were discovered. However, the survey was conducted before these results were announced so I consider respondents from Quebec to be from a province without cases of CWD.

format to compare them between segments of the Canadian population, the different utility measures come from separate regressions and therefore I need to be careful not to overstate the claims I make about the similarities and differences. Lastly, when I included the "no action" option in the analysis I assumed that the sequential nature of the two questions (option A vs. option B first, A/B vs. no action second) would not affect the results, which may not be the case.

My work also fails to collect preference data for CWD management from three impacted stakeholder groups, namely game farmers, indigenous people and hunter-outfitters. Presenting these groups with possible management options in order to investigate their perspectives will allow policymakers to better understand the preferences of the Canadian public as a whole.

5 CONCLUSION

5.1 Summary

This thesis has attempted to show how Chronic Wasting Disease could present a real and present threat to those who benefit from cervid resources through their property rights, but also to show how property rights can be considered and utilized when disease management decisions are being made.

In Chapter 2 my goals were to explore the literature to better understand how concepts of property rights have been used to understand wildlife problems historically. I sought to develop an understanding of the concept of property rights and their importance to modern society, especially as they are used to correct market failures that persist without government intervention. I then explored how these property rights can be used to address market failures in a wildlife, and specifically cervid, context that would be applicable to CWD management.

In Chapter 3 my first objective was to describe how the property rights held by different cervid stakeholders could be used to characterize CWD management approaches. Secondly, I wanted to investigate how property rights to cervids might change as a result of the different CWD management approaches. To accomplish these goals, I first reviewed the literature in order to develop property rights frameworks for cervid resources. Next, I applied these frameworks in order to characterize different CWD management approaches in terms of how they may impact the property rights of affected stakeholders, which allowed me to compare the effects between stakeholders.

The characterization of CWD management approaches with property right frameworks in Chapter 3 allowed me to analyze stakeholder preferences for these management options in Chapter 4. There were three specific goals of this preference analysis: firstly, to investigate

stakeholder preferences towards the CWD management actions that will change their property rights; to study whether different segments of the Canadian public differ in their opinions on CWD management; and to investigate whether the availability of a non-action policy decision would impact stakeholder preferences for the other available options. All three of these goals were achieved through investigations of stakeholder preferences, which were analyzed with a paired comparison approach.

When these chapters are considered as a single unit, as they are presented in this thesis, they can inform the exploration of CWD management in the future.

5.2 Research Contributions

The literature on property rights has not fully extended into the realm of wildlife resources, especially not through the use of frameworks of characteristics. The frameworks characterize property rights to wildlife differently than most of the literature and describe them in a manner that is specific enough to show the individual impacts of alternative CWD management options. This information is important for policy decisions as one could argue that such decisions should account for the specific implications of the management actions, and these frameworks allow policymakers to better understand the impacts of their decisions on the affected stakeholders. The frameworks also allowed us to consider specific aspects of property rights to develop new management options for CWD aside from what seems available as the status quo.

As property rights are a fundamental aspect of democracy, understanding how the property right characteristics I have used and defined are affected by different policy or management decisions can be helpful in many different situations and contexts. The property right frameworks I developed could allow for the comparison of the effects of CWD

management across not only additional stakeholder groups, but also additional jurisdictions. Although this research applies the concepts of property right characteristics to wildlife resources, it also opens up opportunities for policy analysis in new disciplines.

Additionally, there are passive use values associated with cervids and passive use values are often not accounted for in the property rights literature. These frameworks allow for the characterization of property rights for passive use values, which may be important in this context because of the rights that the general public may claim over the wildlife resource. My analysis indicates that in cases where the resource has public good properties, it may be important to investigate passive use values in addition to use values when considering management strategies.

Long survey designs are a common problem in research settings and often cause respondent fatigue. The paired comparison survey allowed me to investigate stakeholder preferences in a simple manner which does not place too much of a burden on the individual respondents. Accounting for stakeholder perspectives can be a crucial part of the decision-making process for the implementation of new policies. My analysis of these paired comparisons provides relevant information to policymakers, not only in Alberta, but elsewhere as well, about what individual stakeholders would like to see in CWD management. The analysis is also specific enough, regarding individual segments of the population, that it can allow policymakers to target their management and improve their messaging to increase the effectiveness of management.

5.3 Limitations and Future Research

There are several limitations of this research. Firstly, in the characterization of property rights frameworks in Chapter 3 I limited the scope to the general public, hunters and landowner

stakeholder groups. This analysis of property rights is also limited to the Alberta context because I used it as a case study for the creation of the frameworks. There are other stakeholders and jurisdictions to consider if one is to fully investigate the potential for regional or nationwide CWD management.

Secondly, there are also limitations on the results of the paired comparison analysis in Chapter 4 for the preferences of Canadians towards CWD management actions. In the paired comparison questions, I asked the respondents to assume that each of the management options would be equally effective at managing the spread and prevalence of CWD because the effects of the CWD management actions on the spread and prevalence of the disease are not fully known. This assumption was also adopted to ensure the simplicity of the survey method; however, it almost certainly will not hold in reality as some of the management options will be more effective than others. Also, in the analysis of the preferences I analyzed each interaction independently due to the simplicity of the approach, however I recognize that the effects that we are seeing in the differences between individual utility measures could be related. Additionally, in order to have a survey sample that was representative of the population structure of Canada, the majority of the responses came from respondents in provinces and territories that do not currently have reported cases of CWD in wild cervid populations. Roughly 13% of the respondents came from Alberta and Saskatchewan and these are the only provinces with such reported cases of CWD in the wild.

Future work on property rights and CWD management may consider additional stakeholders such as cervid farmers, indigenous people, and hunter-outfitters, among others. A better understanding of the property rights of these individuals in addition to their preferences could provide insights into new management strategies and the preferences towards such

strategies. Additionally, in the time in which I have been writing this thesis, CWD was found in 3 new states (Montana, Mississippi and Tennessee), one new Canadian province (Québec) and one new European Country (Finland) (CWD Alliance 2018b). The issues presented by CWD are still evolving as the disease becomes more prevalent and spreads into new jurisdictions. As such, management strategies should continue to evolve with the disease in order to be able to incorporate more perspectives as more stakeholders are affected. As the science evolves, and public perceptions shift, the analysis could be repeated, and information about the cost and effectiveness of the management options could be included, in order to reveal new insights into the preferences of stakeholders for CWD management.

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APPENDICES

Appendix 1: Cervid Property Rights Framework for the General Public in Alberta

Property Right Characteristic	**Content of the Property Rights Framework**
Comprehensiveness	Property rights held by the general public include non-consumptive benefit streams such as passive-use values, which are associated with an appreciation for wildlife and having it exist on the landscape. The passive-use values have public good properties in that one individual's use of their property rights typically does not exclude or prevent others from benefitting from the resource. There is also value associated with viewing animals on the landscape and this can be considered a non-consumptive use value.
Exclusiveness	The passive-use values of cervids held by the general public are generally non-exclusive. The value of viewing animals on the landscape is also generally non-exclusive but can be exclusive in some cases. An example of this exclusivity in viewing wildlife would be if the fees associated with entering National Parks prevented some individuals from viewing wildlife in the Parks.[a]
Levies and Fees	Management of public land requires tax revenue from the general public in addition to funding derived from hunting and fishing licenses. There may also be fees that users must pay in order to access the property right; for example, members of the public must pay National Park entrance fees in order to enter the parks.[a]
Operational Requirements and Controls	Laws and regulations apply for public interactions with wildlife. One of these regulations is the restriction on the disturbance of habitat.[b]
Security	Wildlife in Alberta is maintained in perpetuity for the citizens of the province by the federal government in National Parks and by the provincial government elsewhere.[a,b] Security is influenced by both the management of wildlife, the success of which is uncertain, and the variability in the wildlife resources as a result of ecological pressures.
Social Conditions Surrounding Passive-Use Values	The passive-use values associated with wildlife and its management may increase or decrease depending on the social conditions established by new regulations or changes to current regulations.

[a] Government of Canada 2017
[b] Government of Alberta 2014a

Appendix 2: Cervid Property Rights Framework for Hunters in Alberta

Property Right Characteristic	**Content of the Property Rights Framework**
Comprehensiveness	Rights to hunt involve many benefit streams, including: the right to access land, the right to pursue game, the right to harvest an animal, and the rights to the products derived from the animal. Rights to pursue, harvest and use the products derived from animals are granted through hunting tags. Hunting tags, which accompany hunting licenses, are specific to species, and frequently specify sex and size/age of harvested animals.[a] Access rights depend upon whether the land is privately or publicly held because, while public land typically has open access rights, landowners get to choose who can access their private land.[a] Specific permits are required to discharge firearms in: Provincial Parks; Provincial Recreation Areas; Natural Areas (may be subject to access conditions) and Heritage Rangelands (subject to grazing lease access conditions).[b,c] Firearms cannot be discharged in Wilderness Areas, Ecological Reserves or National Parks.[c,d]
Exclusiveness	Hunters have non-exclusive rights to pursue cervids (along with other hunters) on public lands within wildlife management units (WMUs). Rights to access land for hunting are non-exclusive on public land, except in the case of informal norms where one hunter may avoid entering an area if another hunter is already present.[a] Rights to access land for hunting are exclusive to the landowner on private land. However, the landowner may choose to allow access to individuals of their choosing, and hunters must ask for permission to access the land even when following a blood trail.[a,e] In the case of a grazing lease, hunters must obtain permission from the leaseholder prior to hunting.[a] Harvest rights are exclusive to a tag holder who harvests and tags an animal.[a] Harvest rights may sometimes be shared through a partner license where both hunters must be present.[a] Rights to the products derived from a harvested animal are exclusive to the hunter/partner.[a]
Operational Requirements and Controls	There are a large number of operational requirements and controls for hunting activities. Examples of operational requirements include: new hunters must pass a hunter education course; bow hunters require a bow hunting permit; no firing of weapons within 183m of an occupied building, across roads, or within a distance of 20 feet from roads; no hunting one half hour before sunrise or one half hour after sunset; no hunting from a moving vehicle, boat, etc.; no shooting an animal while it is swimming; the submission of heads from harvested deer for CWD testing is mandatory in some WMUs; must abide by weapon and caliber requirements; cannot hunt within 6 hours of disembarking from an aircraft.[a,g] Outfitters cannot hunt recreationally on the same day that they guide.[f] The primary means of controlling operational requirements in the field is through the deployment of fish and wildlife officers, conservation officers and RCMP officers who have the authority to impose penalties for infractions.[g]

Levies and Fees	Costs for purchasing hunting rights include: $8 for a WIN (Wildlife Identification Number) card; $28.22 for a wildlife certificate; the purchase of tags (eg. for Alberta residents $39.95 for a general white-tailed deer (white-tailed deer) licence, $39.95 for an antlered white-tailed deer special licence; $39.95 for a general mule deer (mule deer) licence, $39.95 for an antlered mule deer special licence; $44.95 for an archery moose licence, $44.95 for an antlerless moose special licence, $44.95 for an antlered moose special licence, $44.95 for a calf moose special licence, $12.00 for a special antlered moose partner licence or $12.00 for a special antlerless moose partner licence; $39.95 for a general elk licence, $39.95 for an antlerless elk special licence, $39.95 for an antlered elk special licence, $39.95 for a Cypress Hills elk archery licence, $39.95 for an either sex elk special licence or $39.95 for a WMU 300 elk special licence.[a] $27 for a hunter-host license, $250 (one-time fee) for a big game outfitter permit with a $25 renewal fee per year).[a,f] Fees are higher for non-residents and vary with choice of weapon.[a]
Security	There is a long history of the Alberta government allocating rights to hunt, implying that the allocation of hunting rights will continue into the future.[g] Hunting and other practices of wildlife utilization are protected under law.[h] However, the conditions under which rights are granted are continuously changing. For example, whether supplemental white-tailed deer permits are allowed in a given WMU may vary between years.[a] The accumulation of priority points and the investments hunters make into their hunting locations show their level of confidence in the continued availability of hunting rights.
Initial Allocation of Rights	Hunting rights are allocated by the province of Alberta with the purchase of a WIN card, wildlife certificate and licenses/tags (some of which are generally available and some of which are draws).[a] Hunter-outfitters are allocated their rights by firstly being recommended by an outfitter-guide in their first year and secondly by applying to be a big game outfitter-guide and becoming a member of the Alberta Professional Outfitters Society.[f] Landowners can be allocated additional hunting rights through applications for Landowner Special Licenses.[a]
Residency and Age Requirements	An applicant for a hunting license must be a resident of Alberta and be 12 years of age. In order to hunt without supervision an applicant must be 18 years of age.[e] Non-resident Canadians and non-resident aliens can only hunt with resident hunter-hosts or outfitters.[a,f]
Size Specification	A single adult resident hunter may firstly hold up to four of the following (allowing the hunting of a single cervid): either a general white-tailed deer licence or an antlered white-tailed deer special licence; either a general mule deer licence or an antlered mule deer special licence; an archery moose licence, an antlerless moose special licence, an antlered moose special licence, a calf moose special licence, a special antlered moose partner licence or a special antlerless moose partner licence; a general elk licence, an antlerless elk special licence, an antlered elk special licence, a Cypress Hills elk archery licence, an either-sex elk special licence or a WMU 300 elk special licence.[a] An adult resident hunter may also apply for other licenses

	including supplemental white-tailed deer licenses.[a] The number of draws available often depends upon population numbers and meeting specific conservation goals.[a] Landowner Special Licenses allocate rights for the harvest of additional animals.[a]
Allotment Type	Quantities of animals harvested are controlled by the number of licenses/tags issued.[i] Allocated licenses/tags specify the WMU(s) within which they may be used.[i]
Transferability	Licenses and draw applications are non-transferable.[i] Outfitters can transfer their tag allotment to another outfitter with approval from the Government of Alberta.[j] There are no regulations that prohibit cash payments for the transfer.[j] Landowners cannot sell access to their land.[a] Some products derived from hunted animals can be transferred between users with a Bill of Lading and processed products may be transferred without a Bill of Lading.[a] However, none of these products may be sold; they may however be gifted if there is no expectation of reciprocity.[e,f]
Duration	Licenses or draws are allocated annually and subject to set seasons based upon the weapon of choice and the WMU in which rights are granted.[a] Hunting may also be limited to Mon-Sat or Wed-Sat hunting depending on the WMU.[a] Although licenses are granted annually, hunters have expectations of repeated availability. Priority points (which may be accumulated to increase probabilities of being drawn) are allocated on an annual basis and can be accumulated over multiple years.[i] Outfitters must renew their allocation each year and may be reviewed every 5 years.[e,f] WIN cards are valid for a period of 5 years.[a]

[a] AEP 2017a
[b] Government of Alberta 2017
[c] Government of Alberta 2014b
[d] Government of Canada 2017
[e] CWD and property rights workshop, November 16, 2017
[f] Alberta Professional Outfitters Society 2017
[g] Government of Alberta 2014a
[h] Government of Alberta 2008
[i] AEP 2017b
[j] Email communication with Anne Hubbs, Government of Alberta (October 13, 2017)

Appendix 3: National Chronic Wasting Disease Survey

1. In which of the following age groups do you fall?

1. ❒ 18 -20
2. ❒ 21-24
3. ❒ 25 -29
4. ❒ 30 -36
5. ❒ 37 -45
6. ❒ 46 -55
7. ❒ 56 -65
8. ❒ 65+

2. Please indicate your gender.

1. ❒ Male
2. ❒ Female
3. ❒ Other – please identify_____

3. How many people live in your household?

1. ❒ 1
2. ❒ 2
3. ❒ 3
4 ❒ 4 or more

4. How many children younger than 18 live in your house?

1. ❒ No home living children < 18 years
2. ❒ 1
3. ❒ 2
4. ❒ 3
5. ❒ 4
6. ❒ More than 4

5. What is the highest level of education you've achieved? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Elementary school
2. ❒ Secondary (high) school
3. ❒ Technical/ business school/Community college
4. ❒ University
5. ❒ Post graduate studies (Masters or PhD)

6. What is the approximate range of your total household income? **ONLY ONE ANSWER POSSIBLE**

1. ❒ $ 24,999 or under
2. ❒ Between $ 25,000 and $ 34,999
3 ❒ Between $ 35,000 and $44,999
4. ❒ Between $ 45,000 and $ 64,999
5. ❒ Between $ 65,000 and $ 79,999
6. ❒ Between $ 80,000 and $ 99,999
7. ❒ Between $ 100,000 and $ 119,999
8. ❒ $ 120,000 or more

7. Which region do you live in? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Newfoundland
2. ❒ Prince Edward Island
3. ❒ Nova Scotia
4. ❒ New Brunswick
5. ❒ Quebec
6. ❒ Ontario
7. ❒ Manitoba
8. ❒ Saskatchewan
9. ❒ Alberta
10. ❒ British Columbia
11. ❒ Yukon
12. ❒ Northwest Territories
13. ❒ Nunavut

8. Do you live in a city, in a town or in the countryside? **ONLY ONE ANSWER POSSIBLE**

1. ❒ In a city (>100,000 inhabitants)
2. ❒ In a town (> 10,000 inhabitants)
3. ❒ In the countryside/rural district

9. Do you own any rural land? (cottage, farm etc.)

1 ❒ Yes
2 ❒ No

10. Which of the following best describes your food preferences?

1	❒	I eat meat and fish
2	❒	I eat fish but don't eat meat
3	❒	I do eat meat but I don't eat fish
4	❒	I am a vegetarian (I don't eat either meat or fish)
5	❒	I am a vegan (I eat no animal products including dairy products, eggs, seafood, fish, white meat and red meat)

11. Please select disagree for this question.

1.	❒	Agree
2	❒	Disagree

12. Have you, or has any member of your household, ever eaten venison (meat from deer, elk or moose)?

1.	❒	Yes
2	❒	No

13. Generally speaking, would you say that most people can be trusted?

People can be trusted	**Can't be too careful in dealing with people**	**Don't know**
1	**2**	**3**
❒	❒	❒

14.

In the last twelve months did you take any overnight trips within Canada for any of the following reasons?			
		Yes	No
		1	2
Sightseeing in natural areas	1.	❒	❒
Watch, feed, photograph or study wildlife	2	❒	❒
Hunt wildlife	3	❒	❒

15.

In the last twelve months did you take any day trips within Canada for any of the following reasons?			
		Yes	No
		1	2
Sightseeing in natural areas	1.	❒	❒
Watch, feed, photograph or study wildlife	2.	❒	❒
Hunt wildlife	3.	❒	❒

16. Which of the following activities do you participate in?			
		Yes	**No**
		1	**2**
Feeding wildlife at my house with table scraps or special food (including bird seed) for wildlife	**1.**	❒	❒
Photographing, studying or recording wildlife	**2**	❒	❒
Observing, collecting or creating wildlife related art or literature	**3**	❒	❒
Being a member of any wildlife related organization	**4**	❒	❒
Contributing to an organization that protects endangered wildlife	**5**	❒	❒
Contributing to an organization that promotes wildlife conservation	**6**	❒	❒
Other general outdoor recreation (e.g. camping, hiking, backpacking, biking, cross country skiing, canoeing, rafting)	**7**	❒	❒
Motorized outdoor recreation (e.g. all terrain vehicle driving (ATVing), snowmobiling, boating	**8**	❒	❒

17. Indicate how strongly you agree or disagree with all of these sentences.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
	1	2	3	4	5
1. Wildlife is an important part of the natural environment	❒	❒	❒	❒	❒
2. Wildlife is an important part of the Alberta and/or Canadian economy	❒	❒	❒	❒	❒
3. Wildlife is more of a nuisance than a benefit to my life	❒	❒	❒	❒	❒
4. Diseases seriously endanger wildlife	❒	❒	❒	❒	❒
5. Wildlife diseases can seriously affect people's health	❒	❒	❒	❒	❒

18. Please identify whether you agree or disagree with the following statements:

Statement	Strongly Disagree	Mildly Disagree	Neutral	Mildly Agree	Strongly Agree
	1	2	3	4	5
1. I worry about changes to the countryside, such as the loss of native plants and animals	❒	❒	❒	❒	❒
2. There is nothing I can personally do to help stop the losses in the world's biodiversity	❒	❒	❒	❒	❒
3. We can afford to lose some of the world's biodiversity	❒	❒	❒	❒	❒
4. Biodiversity losses in animals domesticated for food production are less serious than similar losses in wildlife	❒	❒	❒	❒	❒

(UK survey with some attitudes towards biodiversity)

19. To what extent do you feel knowledgeable about environmental problems? 1 means that "you have little knowledge", and 10 means that "you know a lot."

1	2	3	4	5	6	7	8	9	10

20. Please identify whether you agree or disagree with the following statements:

	Strongly Disagree	Mildly Disagree	Neither agree nor disagree	Mildly Agree	Strongly Agree
	1	2	3	4	5
1. Human beings can progress only by conserving nature's resources					
2. Human beings can enjoy nature only if they make wise use of its resources.					
3. Human progress can be achieved only by maintaining ecological balance.					
4. Preserving nature at the present time means ensuring the future of human beings					
5. We must reduce our consumption levels to ensure well-being of the present and future generations					

21. Please indicate which one of the following statements corresponds most with your view on nature: **<u>only one answer is possible</u>**

1. _____ Environmental problems can only be controlled by enforcing radical changes in human behavior in society as a whole.
2. _____ Environmental problems are not entirely out of control, but the government should dictate clear rules about what is and what is not allowed.
3. _____ We do not need to worry about environmental problems because in the end, these problems will always be resolved by technological solutions.
4. _____ We do not know whether environmental problems will magnify or not.

(the above two are from scales in papers by Corral-Verdago et al and by Steg and Sievers)

22. Please answer the following questions. Give your answer on a scale from 1 ("insignificant") to 5 ("a great deal").

	Insignificant	**Very little**	**Minor**	**Some**	**A great deal**
	1	**2**	**3**	**4**	**5**
How much risk do you think there is to **you personally** of experiencing negative consequences from eating unsafe foods?	❒	❒	❒	❒	❒
How much risk do you think there is to **the average Canadian person** of experiencing negative consequences from eating unsafe foods?	❒	❒	❒	❒	❒
How much control do you think **you personally** have over the safety of food?	❒	❒	❒	❒	❒
How much control do you think **the average Canadian person** has over the safety of food?	❒	❒	❒	❒	❒
How much knowledge do you think **you personally** have about the safety of food?	❒	❒	❒	❒	❒
How much knowledge do you think **the average Canadian person** has about the safety of food?	❒	❒	❒	❒	❒

23. **Do you ever eat meat from animals you or someone else has hunted?**

never	tried it once	occasionally	frequently	regularly
1	**2**	**3**	**4**	**5**
❒	❒	❒	❒	❒

24. **Have you ever ordered venison (deer, elk or moose meat) in a restaurant?**

never	tried it once	occasionally	frequently	regularly
1	**2**	**3**	**4**	**5**
❒	❒	❒	❒	❒

25. **Do you ever purchase/obtain venison (deer, elk or moose meat) from a store or other source?**

never	tried it once	occasionally	frequently	regularly
1	2	3	4	5
❒	❒	❒	❒	❒

26. When you obtain/buy deer, elk or moose meat, is it **usually from ……..**
(If yes to question 26 One ONLY)

a supermarket,	❒	**1**
a butcher's shop	❒	**2**
your own hunting experience	❒	**3**
a farmer's market	❒	**4**
or another way (directly from a farm or through acquaintances)	❒	**5**

27. What do you think about eating venison? (answer about your perceptions even if you have never eaten venison)

	1	2	3	4	5	
1. When eating venison, my household is exposed to …						
very little risk	❒	❒	❒	❒	❒	a great deal of risk
2. Members of my household accept the risks of eating venison						
strongly disagree	❒	❒	❒	❒	❒	strongly agree
3. Members of my household think eating venison is risky						
strongly disagree	❒	❒	❒	❒	❒	strongly agree
4. For members of my household, eating venison is …						
not risky	❒	❒	❒	❒	❒	risky
5. For members of my household, eating venison is worth the risk						
strongly disagree	❒	❒	❒	❒	❒	strongly agree
6. My household is … the risk of eating venison						
not willing to accept	❒	❒	❒	❒	❒	willing to accept

Chronic Wasting Disease

Chronic wasting disease (CWD) is a progressive, fatal, degenerative disease belonging to a group of diseases called Transmissible Spongiform Encephalopathies (TSEs).

Other examples of TSEs are Scrapie, BSE (mad cow disease) and Creutzfeldt–Jakob disease (CJD, the most common TSE found in humans). All TSEs are ultimately fatal.
CWD affects some but not all members of the cervid family (elk, moose, mule deer and white-tailed deer to date), has no current treatment or vaccine and is the only TSE to occur in free-ranging species. There is ongoing research to develop treatment or vaccines for CWD as well as live animal tests for the presence of the disease.
Although extensive surveillance has not provided any scientific evidence that CWD has been transmitted to humans, Health Canada suggests the most prudent approach is to consider that CWD has the potential to infect humans. Health Canada continues to recommend avoiding consumption of foods from known CWD infected or any diseased animals, and taking precautions when handling cervid carcasses. In addition, in areas where CWD is known to occur in wild cervids, continued consistent Federal and Provincial/Territorial communications, warning and precautions should be provided to groups who may be expected to have higher exposures to cervids through hunting and diet (e.g., rural and Indigenous populations).There is currently no evidence that CWD can be contracted by livestock such as cattle, sheep, goats, horses or bison although research is ongoing.

28. Before responding to this survey, had you heard of chronic wasting disease (CWD)?

1. Yes	☐	2. No	☐

29. If you had heard of CWD before this survey, did you know that CWD can infect deer, before responding to this survey?

1. Yes	☐	2. No	☐

30. If you had heard of CWD before this survey, did you know that CWD can infect elk, before responding to this survey?

1. Yes	☐	2. No	☐

Please review the following before answering the following questions.

CWD in wild population of deer and elk

Chronic wasting disease is thought to have been introduced into Saskatchewan farmed elk in the late 1980s via affected elk imported from the United States, but it was not recognized in farmed elk until 1996. Wildlife agencies in the prairie provinces began surveillance programs to determine the presence of the disease amongst free-ranging deer and elk in the 1990s.

No cases of chronic wasting disease have been found in Manitoba, Ontario, Quebec, British Columbia or the Maritimes.

Saskatchewan has found 360 mule deer, 94 white tailed deer and 10 elk with chronic wasting disease out of 45,563 wild animals tested to the end of 2016.

The first confirmed case of CWD in a wild Alberta deer occurred in September, 2005, almost 3 years after CWD was found in farmed elk and deer.

In Alberta more than 46,000 wild cervids (deer, elk and moose) have been tested for CWD since 2005.

A total of 590 cases of CWD have been found in wild Alberta deer to the end of 2016, up from 94 cases of CWD to the end of 2010.

To date, 1 case of CWD has been found in a wild elk in Alberta and 1 case has been found in a moose.

Rates of CWD infection in the province of Alberta in 2017, for example, remain low (5.4% of tested mule deer, 1.5% of tested white tailed deer and fewer than 1% of elk).

CWD on prairie elk and deer farms

Alberta (and other prairie provinces) began conducting voluntary testing for CWD in farmed and wild elk and deer in the fall of 1996. In August, 2002 Alberta initiated a mandatory surveillance program for all farmed elk and deer. 89 farmed herds of deer or elk in Saskatchewan and Alberta have been found to have CWD since 1996 – when farms are found to have CWD the farm's herds of animals are depopulated (destroyed). 7 animals (2 white tailed deer and 5 elk) have been found in farmed deer and elk in Alberta since 2002, with the most recent found in 2015 and 2016, out of 72,733 animals tested. Alberta, Saskatchewan, Manitoba and the Yukon test all farmed deer and elk for CWD prior to meat from those animals being sold – other parts of Canada have voluntary testing protocols for farmed deer and elk and no animals have been found.

31. Before responding to this survey, did you know that CWD has recently been found in both farmed and wild deer and elk in Alberta ?

1. Yes	☐	2. No	☐

32. Before responding to this survey did you know that CWD has been found in in both farmed and wild deer and elk in Saskatchewan?

1. Yes	☐	2. No	☐

33. Please answer the following questions. Give your answer on a scale from 1 ("insignificant") to 5 ("a great deal").

	Insignificant	**Very little**	**Minor**	**Some**	**A great deal**
	1	**2**	**3**	**4**	**5**
How much risk do you think there is to **you personally** of experiencing negative consequences from eating unsafe meat from deer, elk or moose?	❒	❒	❒	❒	❒
How much risk do you think there is to **the average Canadian person** of experiencing negative consequences from eating unsafe meat from deer, elk or moose?	❒	❒	❒	❒	❒
How much risk do you think there is to **the average Canadian hunter** of experiencing negative consequences from eating unsafe meat from deer, elk or moose?	❒	❒	❒	❒	❒
How much risk do you think there is to **the average Canadian Indigenous person** of experiencing negative consequences from eating unsafe meat from deer, elk or moose?	❒	❒	❒	❒	❒

34. Please indicate your level of agreement with the following statements on a scale from strongly disagree to strongly agree.

	Strongly Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly Agree	Don't know
	1	2	3	4	5	6
The threat of CWD has been exaggerated.	☐	☐	☐	☐	☐	☐
Efforts should be taken to eliminate CWD from the country.	☐	☐	☐	☐	☐	☐
CWD should be contained to its current geographical area.	☐	☐	☐	☐	☐	☐
I think there is a potential for CWD to be transferred to humans	☐	☐	☐	☐	☐	☐
I, or my family, have concerns about eating elk and deer meat because of CWD.	☐	☐	☐	☐	☐	☐
I believe that eating elk and deer meat will cause CWD related infections in humans.	☐	☐	☐	☐	☐	☐

35. Please answer the following questions to the best of your ability, based on your current knowledge.

Probability of Occurrence	**Very unlikely**	**unlikely**	**Neither likely or unlikely**	**likely**	**Very likely**
	1	**2**	**3**	**4**	**5**
What is the likelihood of CWD transmission to pets?					
What is the likelihood of CWD transmission to domestic livestock, for example cattle or bison?					
What is the likelihood of CWD Transmission to a large enough group of deer, elk and moose that these wild animal populations decline in Canada					
What is the likelihood of CWD transmission to other cervid populations (eg caribou) ?					

What is the likelihood of CWD transmission to other wildlife species (eg. coyotes, snakes, bears)?					
Magnitude of Consequences	**Not very severe**	**Somewh at severe**	**Fairly Severe**	**Severe**	**Very severe**
	1	**2**	**3**	**4**	**5**
If your pet were to contract a version of CWD, how serious do you think the consequences would be?					
If domestic livestock (cattle, bison) were to contract a version of CWD, how serious do you think the consequences would be?					
If enough deer, elk and moose were to contract CWD that the populations of these wild animals were depleted, how serious do you think the consequences would be?					
If other cervids, such as caribou, were to contract CWD, how serious do you think the consequences would be?					
If other wild animals (such as coyotes, snakes, and bears) were to contract CWD, how serious do you think the consequences would be?					

36. Deer, elk and moose are animals strongly associated with Canadian wilderness, tourists and hunters may visit Canada partly or mostly because of the existence of these animals. In addition, deer and elk farms are other economic activities associated with the animals. If CWD were to continue to spread throughout the country please identify how severe you think the following economic impacts might be for Canada

	Not Severe Economic impact	Slightly severe Economic impact	Fairly Severe Economic impact	Severe economic impact	Very severe economic impact	Do Not Know
	1	2	3	4	5	6
Economic trade barriers against the exports of venison or any products from deer and elk farms						
Economic costs for deer and elk farms						

when the disease is spread to the farmed animals from wild animals						
Economic costs for outfitting firms who generate income from hosting and advising hunters from other parts of North America and the world						
Lost tourism revenue from hunters who might not wish to hunt in Canada if the animal disease spreads						
Lost tourism revenue to national parks and towns from declining population of cervids						
Economic costs for cattle or bison farmers if the disease spreads to livestock from wild animals						
Increased costs of food for Indigenous communities who might otherwise have used deer, elk or moose as a source of protein in their diets						

Screening Questions	Yes	No
Have you purchased a license and hunted for deer, elk, or moose within the past 3 years?	☐	☐
Do you own a rural property in Canada of at least one quarter section or 160 acres?	☐	☐
Do you own a farm where cervid species (i.e. deer, elk, or moose) or their products are raised for sale?	☐	☐

General Information:

A number of options are being considered for managing CWD in the different cervid animals (i.e. deer, elk, and moose).

- One approach for regulating the spread of CWD is to include **regulations on the movement of products of the hunt**, such as meat and antlers. CWD prions can exist throughout the animal's body, and such regulations could reduce the spread.
- Another option that has been used in many jurisdictions is **reducing animal populations in high-risk areas**. Reducing the number of animals reduces the spread of infectious prions across the landscape. If we choose to reduce populations, it may either be undertaken by:
    - **Increasing the roles of hunters.** Increased hunting opportunities could come in the form of the increased availability of tags and licenses. However, incentives for hunters to remove animals in high-risk areas may be lacking.
    - **Government-employed sharpshooters**. This approach would allow more control over the number of animals that are harvested.
- Regardless of whether animals are harvested by hunters or government-employed sharpshooters, meat that is tested and free of CWD would be available for consumption, while CWD infected meat would be destroyed.

Throughout Canada, wildlife is owned by the crown for the benefit of the general public, however high-risk CWD areas may exist on public or private lands. On public lands, government agencies have more management options than on private lands. Government-employed sharpshooters on private land would require landowner consent, and hunters are required to obtain permission from landowners to hunt on their land. In an attempt to manage CWD we could improve landowner incentives in these areas in order for CWD management to be effective on private land.

- **Landowners could either be paid by the government to provide access to licensed hunters** or could **allow landowners to charge hunters for access** to their land to hunt public wildlife. Such changes may provide landowners with incentives to reduce animal populations and manage for CWD on their land.
- Regulations could **require private landowners in high-risk CWD areas to allow government-employed sharpshooters to harvest animals on their lands**.
- **Landowners could be allowed to apply for more tags** to increase animal harvests under landowner special licenses, thereby allowing animal populations to be reduced by the landowners themselves.

A summary of current conditions across Canada is as follows:

- Neither licensed hunters nor government-employed sharpshooters are currently being used to reduce populations in high-risk CWD areas.
- The government does not pay landowners to allow licensed hunters to access their private land to hunt public wildlife.
- Landowners are not allowed to charge for access to their land to hunt public wildlife.
- In some provinces, (e.g. Alberta and Ontario) a limited number of special licenses are available for farmers/landowners to hunt on their own land.
- There are minimal restrictions on the movement of animal products within Canada (i.e. meat, hides, antlers, urine, etc.).

SET 1:

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on public land through the use of hunters with specially issued licenses	Increase the harvest of animals in high-risk CWD areas on private land by allowing landowners to charge a fee for licensed hunters to access their land and hunt public wildlife

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by providing government compensation to landowners in return for allowing licensed hunters to access their land and hunt public wildlife	Increase the harvest of animals in high-risk CWD areas on public land through the use of government-employed sharpshooters

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require that deer carcasses or products not be moved out of the county in which the animal is harvested	Require landowners to allow government-employed sharpshooters on private land to reduce populations in high-risk CWD areas

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by increasing the number of available landowner special licenses, which can only be used by landowners	Increase the harvest of animals in high-risk CWD areas on public land through the use of hunters with specially issued licenses

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by allowing landowners to charge a fee for licensed hunters to access their land and hunt public wildlife	Increase the harvest of animals in high-risk CWD areas on private land by providing government compensation to landowners in return for allowing licensed hunters to access their land and hunt public wildlife

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on public land through the use of government-employed sharpshooters	Require that deer carcasses or products not be moved out of the county in which the animal is harvested

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require landowners to allow government-employed sharpshooters on private land to reduce populations in high-risk CWD areas	Increase the harvest of animals in high-risk CWD areas on private land by increasing the number of available landowner special licenses, which can only be used by landowners

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

SET 2:

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on public land through the use of hunters with specially issued licenses	Increase the harvest of animals in high-risk CWD areas on private land by providing government compensation to landowners in return for allowing licensed hunters to access their land and hunt public wildlife

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on public land through the use of government-employed sharpshooters	Require landowners to allow government-employed sharpshooters on private land to reduce populations in high-risk CWD areas

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require that deer carcasses or products not be moved out of the county in which the animal is harvested	Increase the harvest of animals in high-risk CWD areas on private land by increasing the number of available landowner special licenses, which can only be used by landowners

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by allowing landowners to charge a fee for licensed hunters to access their land and hunt public wildlife	Increase the harvest of animals in high-risk CWD areas on public land through the use of government-employed sharpshooters

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by providing government compensation to landowners in return for allowing licensed hunters to access their land and hunt public wildlife	Require that deer carcasses or products not be moved out of the county in which the animal is harvested

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by increasing the number of available landowner special licenses, which can only be used by landowners	Increase the harvest of animals in high-risk CWD areas on private land by allowing landowners to charge a fee for licensed hunters to access their land and hunt public wildlife

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require landowners to allow government-employed sharpshooters on private land to reduce populations in high-risk CWD areas	Increase the harvest of animals in high-risk CWD areas on public land through the use of hunters with specially issued licenses

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

SET 3:

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on public land through the use of hunters with specially issued licenses	Increase the harvest of animals in high-risk CWD areas on public land through the use of government-employed sharpshooters

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require that deer carcasses or products not be moved out of the county in which the animal is harvested	Increase the harvest of animals in high-risk CWD areas on public land through the use of hunters with specially issued licenses

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by allowing landowners to charge a fee for licensed hunters to access their land and hunt public wildlife	Require that deer carcasses or products not be moved out of the county in which the animal is harvested

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require landowners to allow government-employed sharpshooters on private land to reduce populations in high-risk CWD areas	Increase the harvest of animals in high-risk CWD areas on private land by allowing landowners to charge a fee for licensed hunters to access their land and hunt public wildlife

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by providing government compensation to landowners in return for allowing licensed hunters to access their land and hunt public wildlife	Require landowners to allow government-employed sharpshooters on private land to reduce populations in high-risk CWD areas

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by increasing the number of available landowner special licenses, which can only be used by landowners	Increase the harvest of animals in high-risk CWD areas on private land by providing government compensation to landowners in return for allowing licensed hunters to access their land and hunt public wildlife

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on public land through the use of government-employed sharpshooters	Increase the harvest of animals in high-risk CWD areas on private land by increasing the number of available landowner special licenses, which can only be used by landowners

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Hunters

There are a number of CWD management approaches that could influence licensed hunters. These approaches have been used in other jurisdictions and all seem to have varying positive impacts on the spread and prevalence of CWD. In cases where hunters are used to reduce cervid populations in high-risk areas, there are three ways that harvest levels could be increased. First, the hunting seasons could be lengthened. Second, the government could make more tags per hunter available at current fee levels. Third, the current number of tags in these regions could be offered without fees. Regulations could be changed so that hunters are required to bring unwanted animal parts to centralized dump sites, rather than current practices that leave animal parts the field.

To aid in the monitoring of the spread and prevalence of the disease, hunters could be given compensation in return for cervid head submissions. Such monitoring programs would allow for more targeted population reductions.

A summary of current conditions across Canada is as follows:

- There are no lengthened seasons, no increase to the number of tags available nor any price reductions on tags in order to reduce CWD populations.
- There are no restrictions on the field disposal of unwanted animal parts.
- Aside from receiving a tag for the next hunting season, hunters are not compensated for cervid head submissions that test positive

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas with a lengthening of the hunting season by 2 weeks (with no extra tags at current fee levels)	Increase the harvest of animals in high-risk CWD areas by doubling the number of tags available (at current fee levels within current seasons)

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

In high-risk CWD areas, provide the current number of tags in current seasons at no cost	Increase the harvest of animals in high-risk CWD areas with a lengthening of the hunting season by 2 weeks (with no extra tags at current fee levels)

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require hunters to dispose of unwanted animal parts at a centralized county dump site	Increase the harvest of animals in high-risk CWD areas with a lengthening of the hunting season by 2 weeks (with no extra tags at current fee levels)

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas with a lengthening of the hunting season by 2 weeks (with no extra tags at current fee levels)	Distribute $50 and a tag for the next hunting season to hunters who submit cervid heads that test positive for CWD

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas by doubling the number of tags available (at current fee levels within current seasons)	In high-risk CWD areas, provide the current number of tags in current seasons at no cost

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas by doubling the number of tags available (at current fee levels within current seasons)	Require hunters to dispose of unwanted animal parts at a centralized county dump site

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Distribute $50 and a tag for the next hunting season to hunters who submit cervid heads that test positive for CWD	Increase the harvest of animals in high-risk CWD areas by doubling the number of tags available (at current fee levels within current seasons)

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

In high-risk CWD areas, provide the current number of tags in current seasons at no cost	Require hunters to dispose of unwanted animal parts at a centralized county dump site

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Distribute $50 and a tag for the next hunting season to hunters who submit cervid heads that test positive for CWD	In high-risk CWD areas, provide the current number of tags in current seasons at no cost

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require hunters to dispose of unwanted animal parts at a centralized county dump site	Distribute $50 and a tag for the next hunting season to hunters who submit cervid heads that test positive for CWD

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Landowners

It is important to involve private landowners in the management of CWD as there are large amounts of private land in areas that are at high risk for CWD. To monitor the spread and prevalence of the disease, landowners in high-risk areas could be required to allow environmental sampling (e.g. fecal matter, soil, plants, etc.) to be conducted on their lands. Such monitoring programs would allow for more targeted population reductions.

Another approach would be to increase the harvest of cervid animals (i.e. deer, elk and moose) on private land at high risk for CWD. One way to increase harvests would be to support cooperative relationships between adjacent landowners in high-risk CWD areas in which they manage their combined lands better for hunting and thus increase the number of animals removed from the landscape. The government could provide support for such cooperative relationships through extension services or the provision of extra tags for people who agree to manage their land collectively through some sort of cooperative arrangement.

A summary of the current conditions across Canada is as follows:

- No environmental monitoring of materials (e.g. soil, vegetation, feces, etc.) for CWD occurs on private land.
- No landowner hunting cooperatives, with the goal of CWD management, exist on private land and there is no government support for their development

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require landowners in high-risk CWD areas to allow environmental sampling (fecal matter, soil, plants) on their private land, which would help direct CWD management options in an area	Provide extension services for landowner cooperatives that are designed to increase the harvest of animals on their combined private lands in specific high-risk CWD areas

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Provide extra tags to members of landowner cooperatives to help direct management options on their combined private lands in high-risk CWD areas	Require landowners in high-risk CWD areas to allow environmental sampling (fecal matter, soil, plants) on their private land, which would help direct CWD management options in an area

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Require landowners in high-risk CWD areas to allow environmental sampling (fecal matter, soil, plants) on their private land, which would help direct CWD management options in an area	Increase the harvest of animals in high-risk CWD areas on private land by allowing landowners to charge a fee for licensed hunters to access their land and hunt public wildlife

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Provide extension services for landowner cooperatives that are designed to increase the harvest of animals on their combined private lands in specific high-risk CWD areas	Provide extra tags to members of landowner cooperatives to help direct management options on their combined private lands in high-risk CWD areas

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Increase the harvest of animals in high-risk CWD areas on private land by allowing landowners to charge a fee for licensed hunters to access their land and hunt public wildlife	Provide extension services for landowner cooperatives that are designed to increase the harvest of animals on their combined private lands in specific high-risk CWD areas

Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

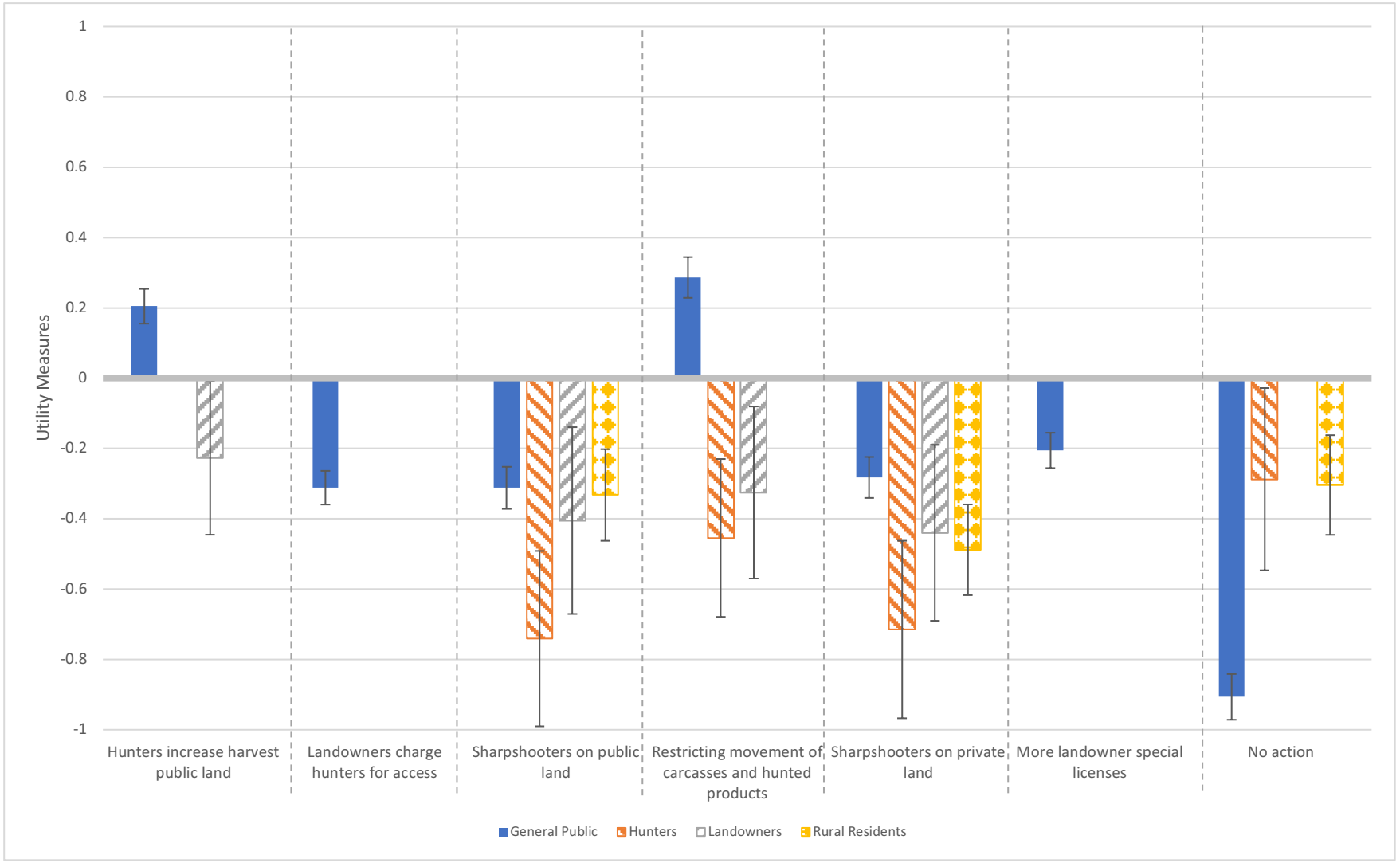
Assuming that the following management options have the same effect on reducing the spread and prevalence of CWD, please select the management option you prefer.

Provide extra tags to members of landowner cooperatives to help direct management options on their combined private lands in high-risk CWD areas	Increase the harvest of animals in high-risk CWD areas on private land by allowing landowners to charge a fee for licensed hunters to access their land and hunt public wildlife

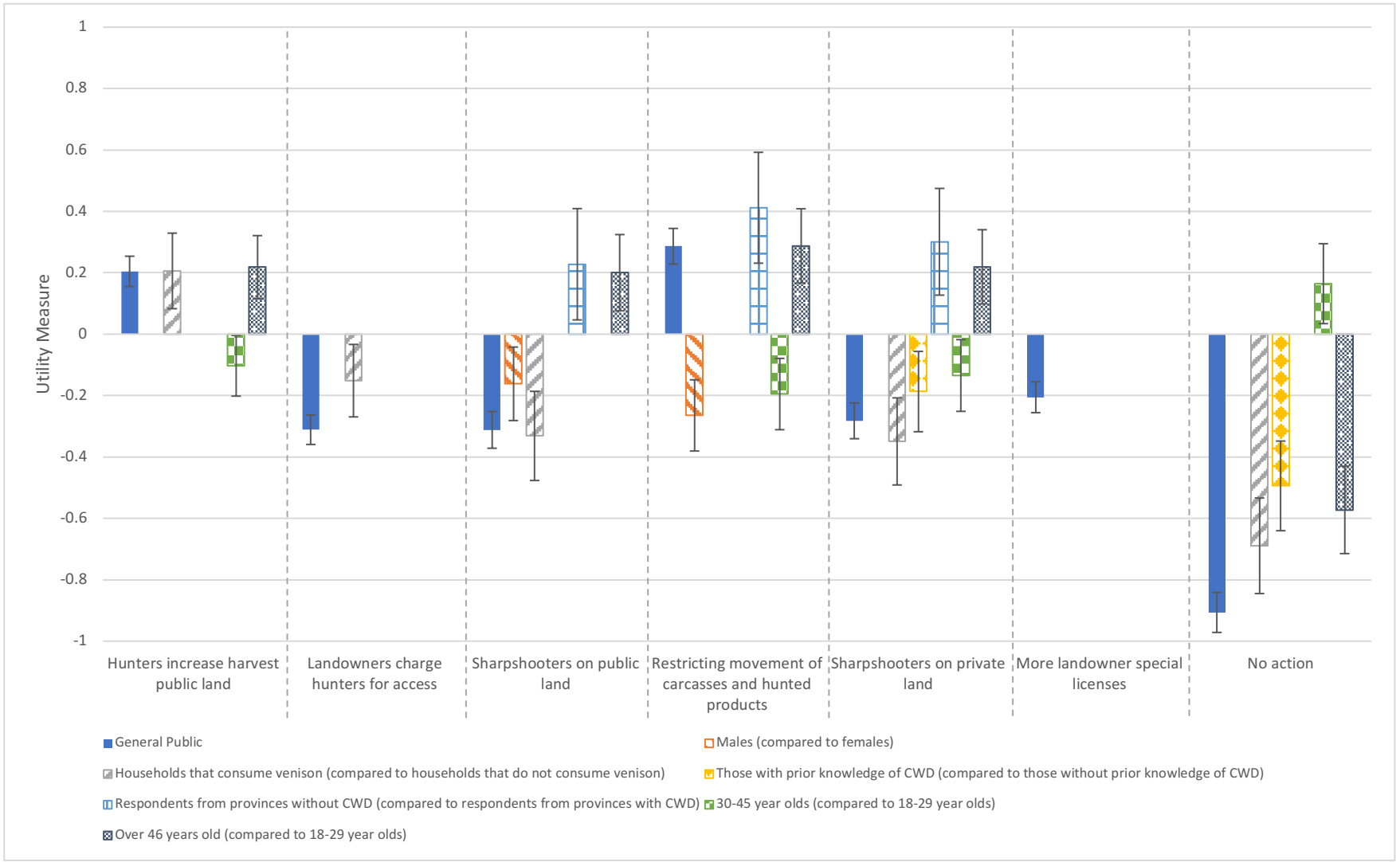
Would you prefer that those managing the issue of CWD use the option you selected in the previous pair, or took no action?

[Previously selected option]	No action

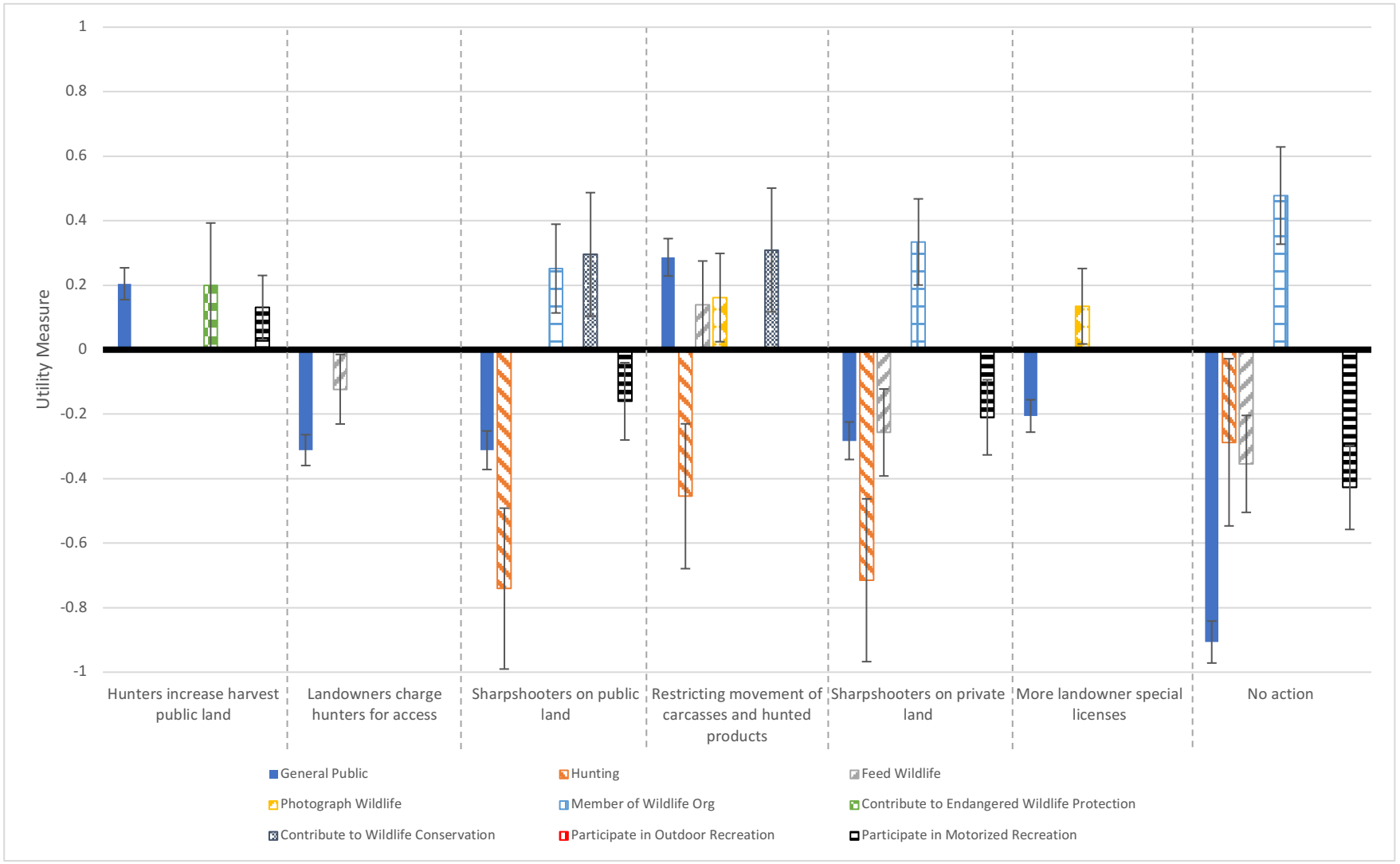
Appendix 4: Comparing the utility measures for the general public paired comparisons by stakeholder



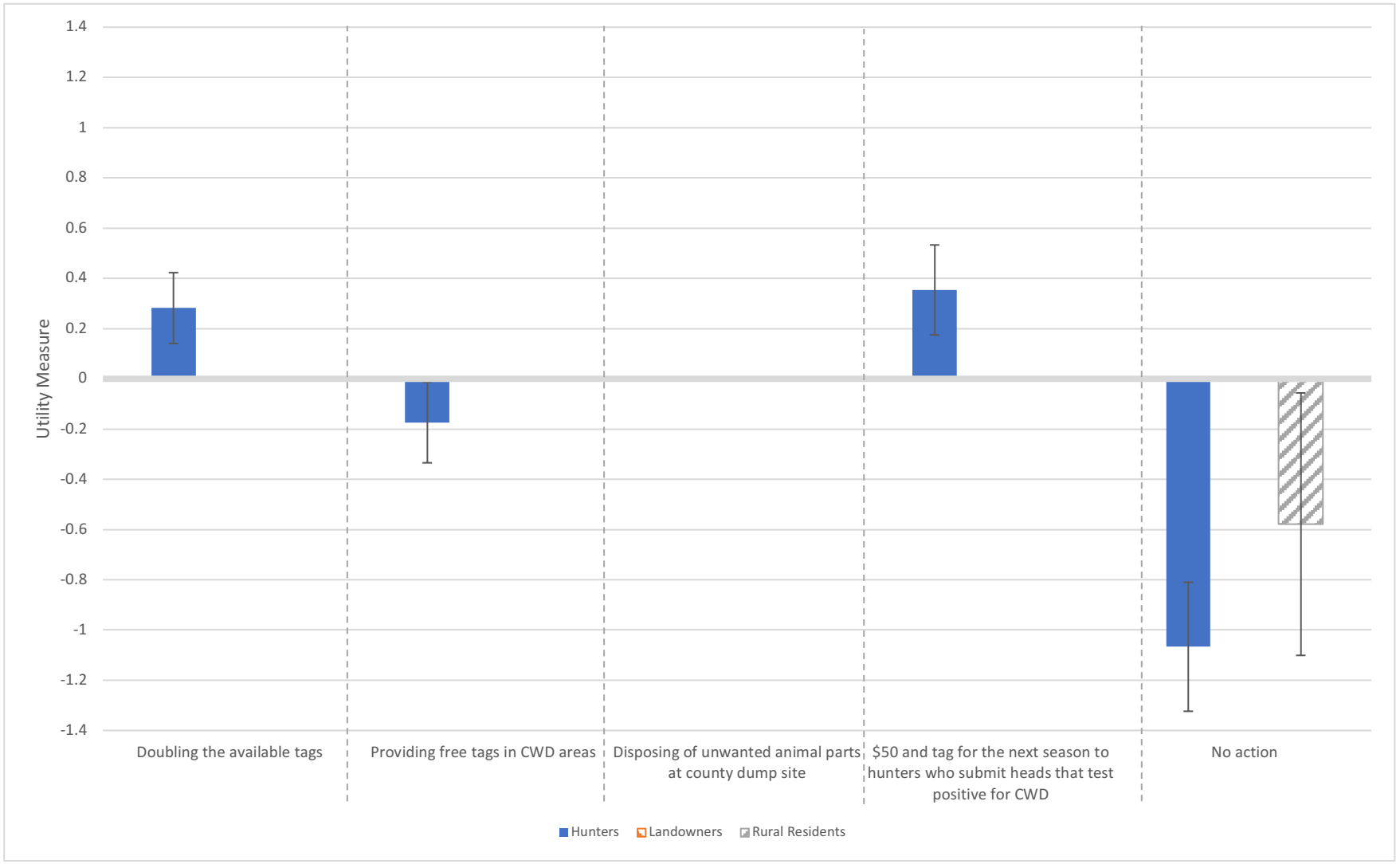
Appendix 5: Comparing the utility measures for the general public paired comparisons by demographic



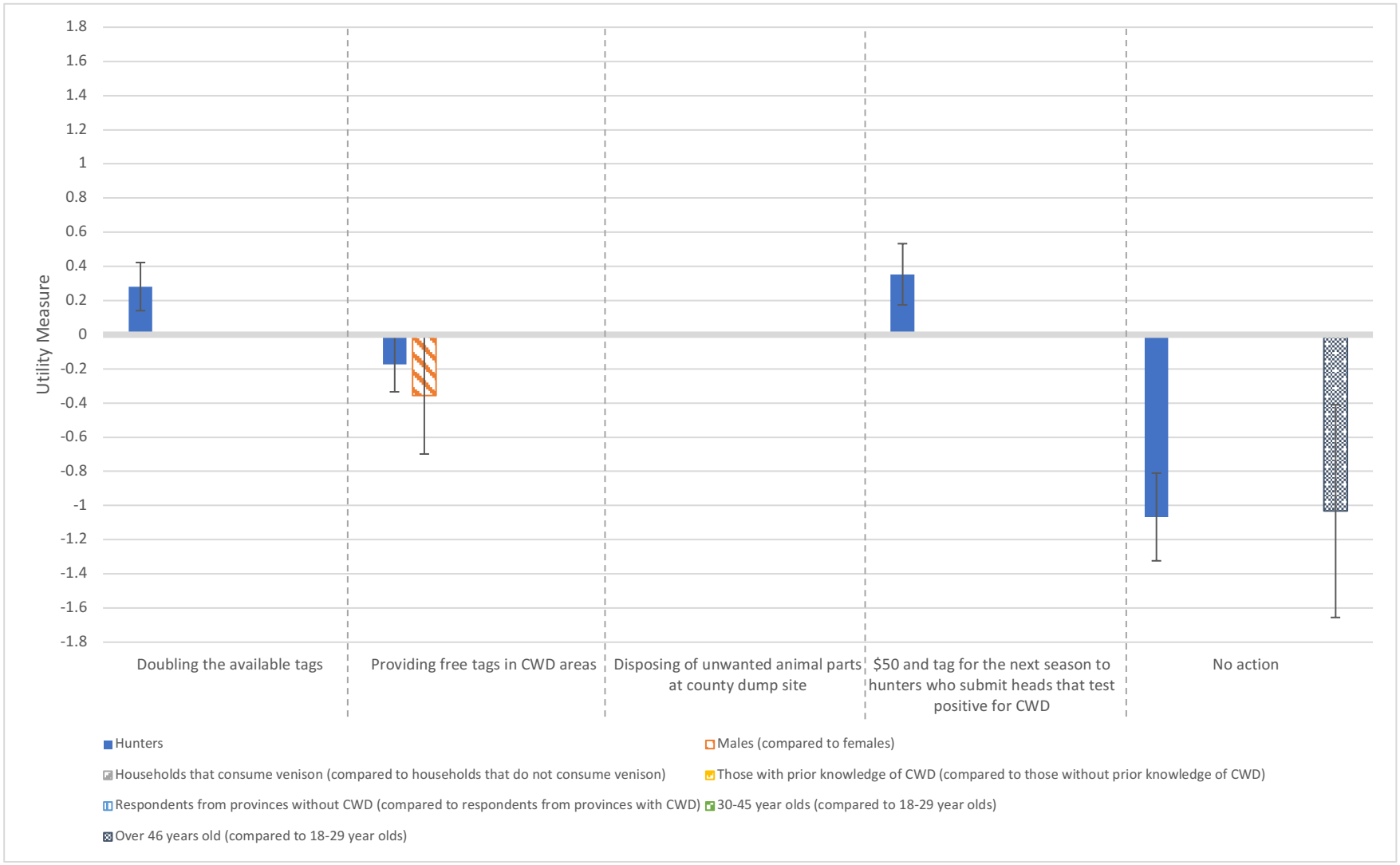
Appendix 6: Comparing the utility measures for the general public paired comparisons by respondent activity



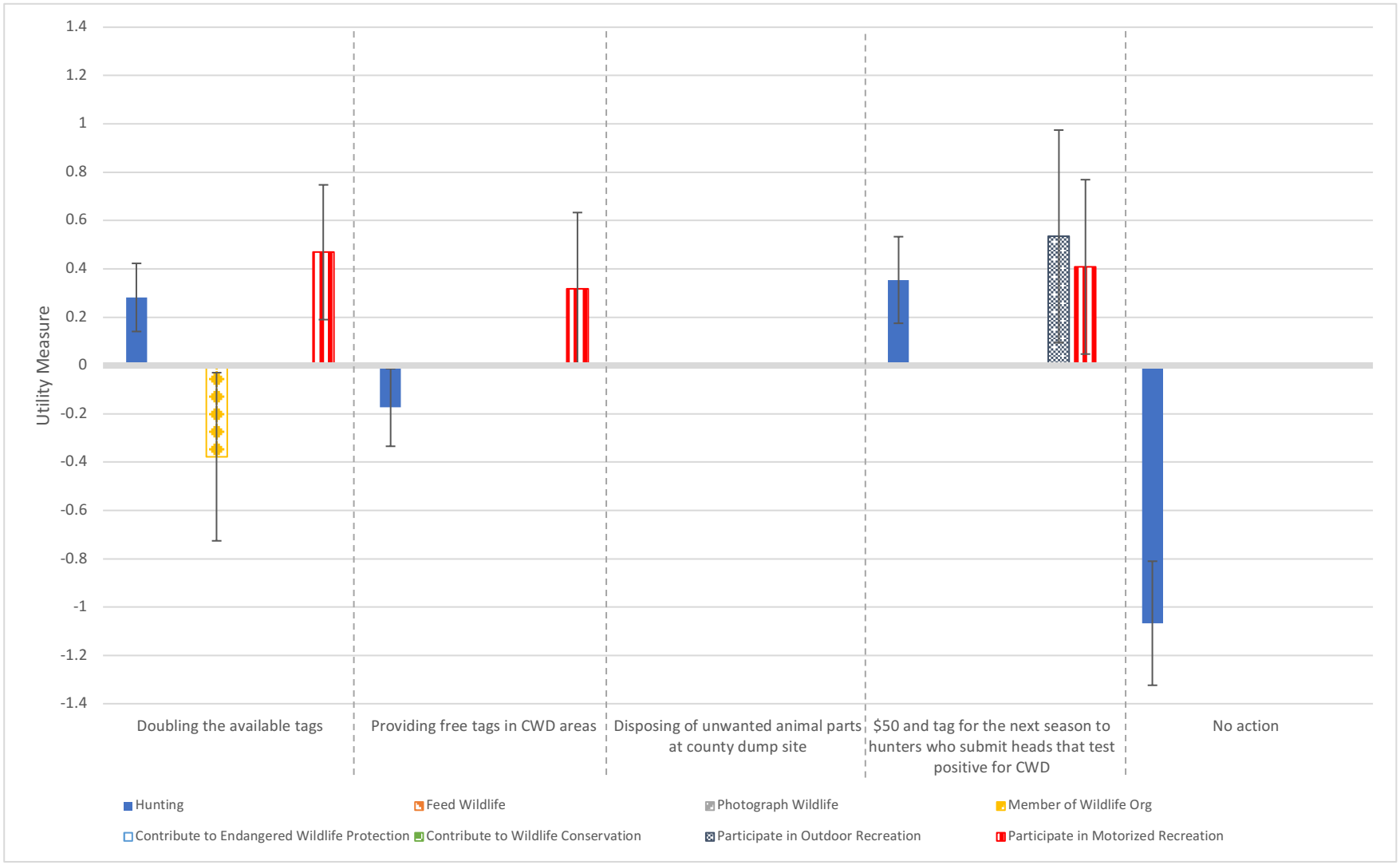
Appendix 7: Comparing the utility measures for the hunter paired comparisons by stakeholder



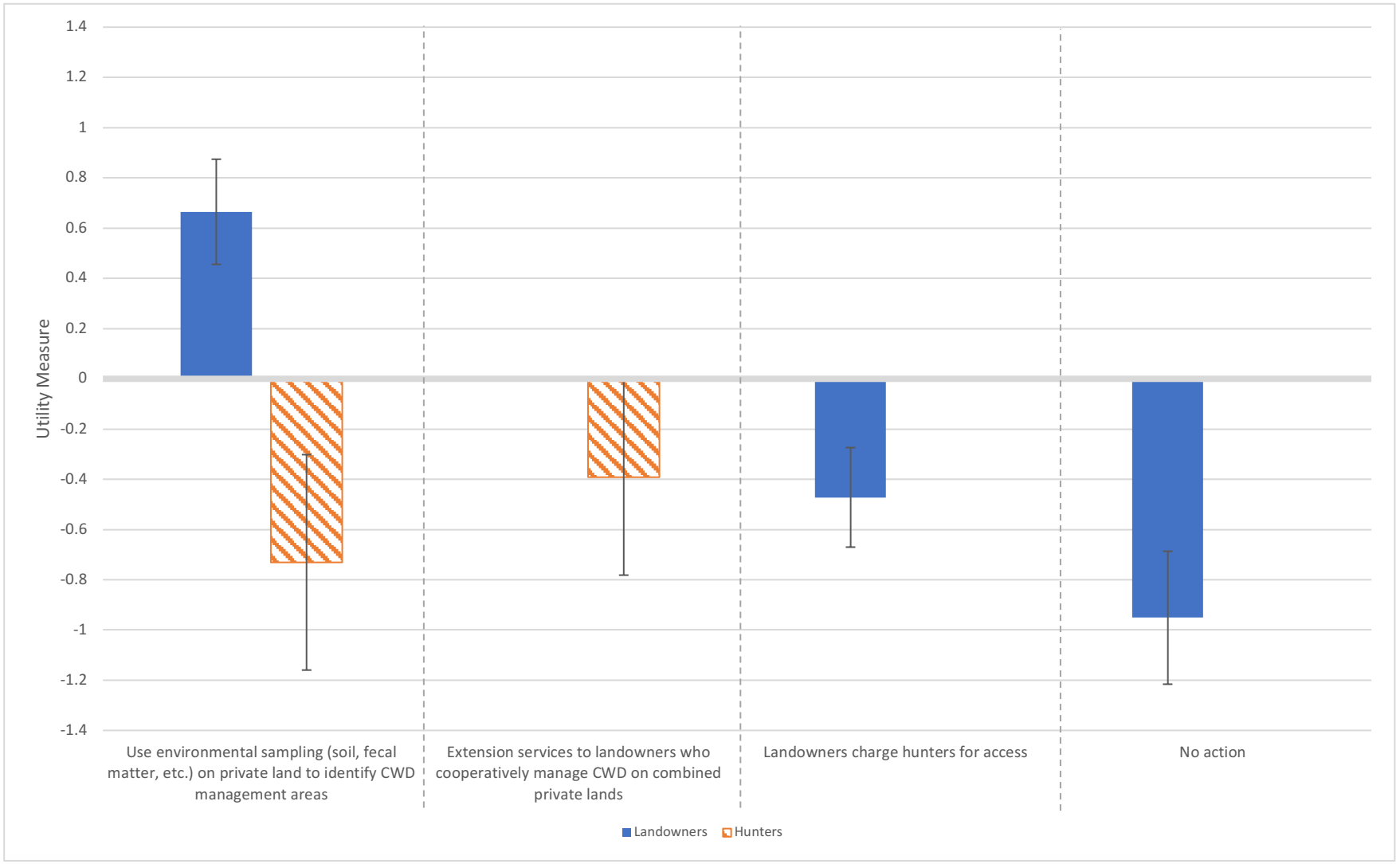
Appendix 8: Comparing the utility measures for the hunter paired comparisons by demographics



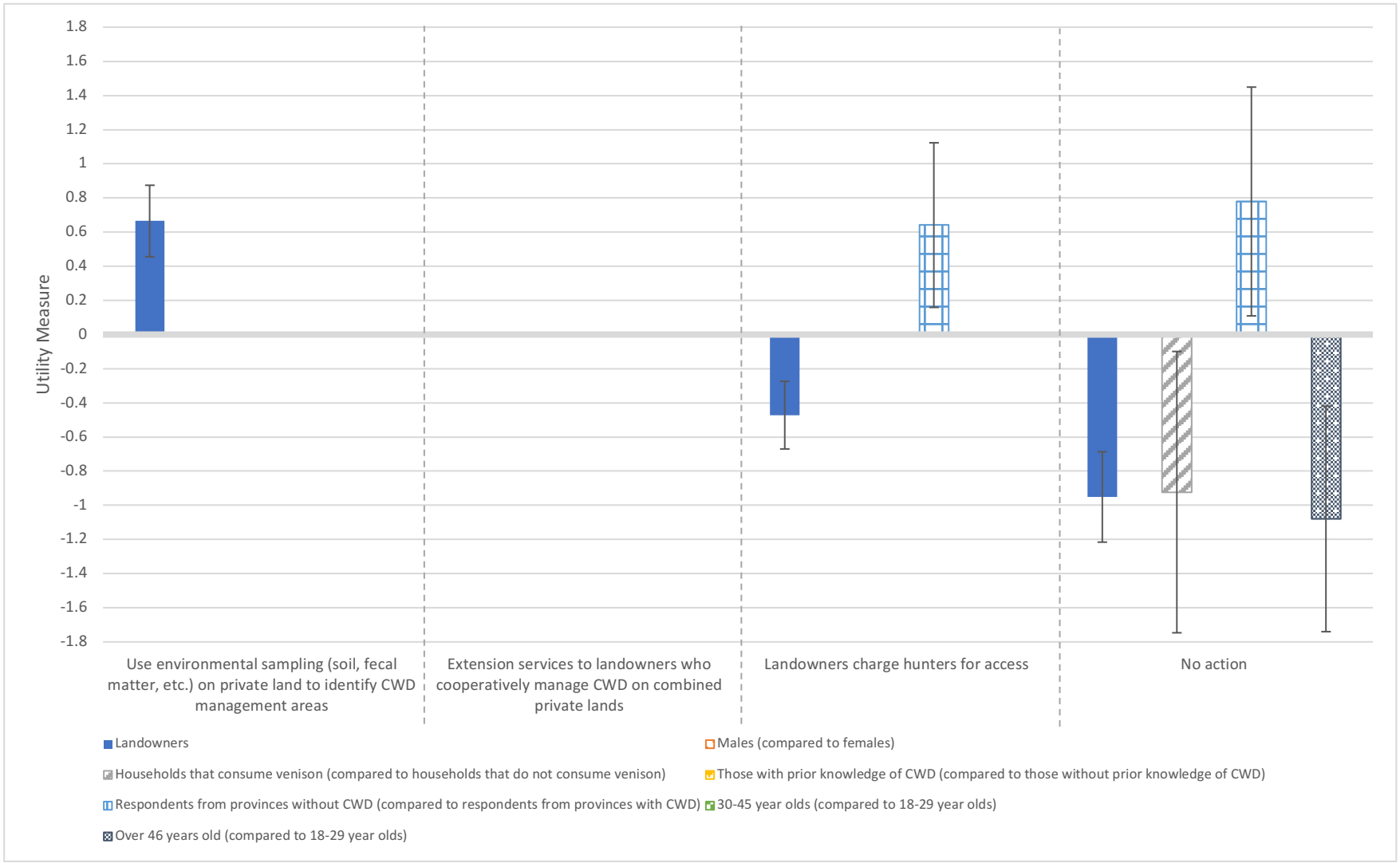
Appendix 9: Comparing the utility measures for the hunter paired comparisons by respondent activity



Appendix 10: Comparing the utility measures for the landowner paired comparisons by stakeholder



Appendix 11: Comparing the utility measures for the landowner paired comparisons by demographic



Appendix 12: Comparing the utility measures for the landowner paired comparisons by respondent activity