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Chronic Wasting Disease and the Canadian Agriculture and Agri-food Sectors:

Current Knowledge, Risks and Policy Options

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EXECUTIVE SUMMARY

Chronic Wasting Disease (CWD) is a prion disease that affects cervid (deer) species and has been found in both wild and farmed populations in the U.S., Canada and abroad. In this report policy options that may be relevant to reducing the impact of CWD on the Canadian agri-food and agriculture sector are described. Given the nature of the disease, policy options are relevant to either the farmed or wild sector or both, as appropriate. The policy options are situated in the context of the current state of knowledge, stakeholder and rightsholder risk perceptions and policy preferences.

The disease was initially observed in research facilities of Colorado and Wyoming in the late 1960s. In Canada, the first CWD cases were identified, retrospectively, in mule deer at the Toronto Zoo, from post-mortems on animal samples from deaths over the period 1973 to 1981 (7 positive animals found from deaths occurring over the period 1975 to 1979) (Dubé et al, 2006). The first farmed cervid was found with the disease in 1996 in a Saskatchewan elk farm (in captive elk that were imported from South Dakota (Williams and Miller, 2002)). In the following years, CWD was detected in farmed white-tailed deer and elk in Alberta and in wild cervid populations from Saskatchewan and Alberta (Kahn et al., 2004). CWD was found in a red deer farm in Quebec in 2018. CWD prevalence in North America has greatly increased in the last decade. Prion infectivity persists in the environment—animal carcasses, predator faeces, soil and plants—for more than 10 years, serving as a long-term source of infection (Georgsson et al., 2006).

To date, no natural transmission of CWD to species outside the Cervidae family has been documented in wild or domestic animal populations but research is on-going. The transmission of prions from one species to another is limited by a transmission barrier. The strength of this barrier depends on multiple factors including the primary sequence of the PrPC of the new host and the PrPCWD from the inoculum and the transmitted prion strain (e.g., Hill et al., 2000). Experimental data, however, has shown that the transmission of CWD to other species, such as cats, pig, sheep and rodents, is possible.

Of special concern is the possible transmission of CWD to non-cervid species used in the human food supply chain, especially cattle and other livestock, due to the potential emergence of prions with zoonotic capacity (as with bovine spongiform encephalopathy (BSE)). The interaction of cattle and cervids is common in CWD-affected areas of North America. CWD agents from different species (white-tailed deer, mule deer and elk) are transmissible to cattle after intracerebral inoculation (Hamir et al., 2005; Hamir et al., 2007b; Hamir et al., 2011b; Greenlee et al., 2012), and the characteristics of the disease are very different from BSE (Hamir et al., 2011b). In experimental treatments, no oral transmission of CWD to cattle has occurred, and no CWD prions were detected in cattle that were exposed to CWD-contaminated paddocks for 10 years (Williams et al., 2018). Thus, the risk of CWD transmission to cattle from normal interaction with cervids is currently believed to be very low. There is no evidence of transmission to humans, yet there are concerns about the zoonotic potential of CWD. Nonetheless, questions remain regarding CWD transmission to other wild and domestic animals, into the human food supply (in the case of untested animals and antler velvet) or to humans themselves. Further research into

these issues is needed. Furthermore, active disease management practices are warranted to minimize the risk of CWD transmission.

The perspectives of rightsholders and stakeholders impacted by CWD are important for future policies. Using primary survey data, supplemented by secondary data sources, we present the level of knowledge, attitudes and management preferences for CWD. Although the methods to elicit these perspectives has some variation due to the unique characteristics of each group, several trends were observed:

Canadian Public:

- Over time, the number of people who have ever eaten venison has increased. Eating frequency does not appear to be increasing across the population over time
- Awareness and knowledge of CWD has dramatically *declined* across time.
- The public is significantly interested in mandatory CWD animal testing before meat is marketed and continues to be interested in supporting tax increases to pay for management or surveillance. This implies that healthy cervid populations are important to the Canadian public.

Indigenous Rightsholders

- Ungulates (noting particularly caribou to whom transmission is possible) are a major component of food security for Indigenous peoples, but also contribute to significant cultural values including sharing networks.
- Concerns about cultural tipping points, arising from environmental conditions, costs, and time constraints of local people, have been expressed by First Nations. However, safety of ungulate meat is an important concern, given the dietary role of cervids.
- The Alberta Assembly of Tribal Chiefs, representing First Nations in Treaty 6, 7 and 8, passed a resolution in June 2019 supporting collaborative research on CWD surveillance.
- There are questions about how the continued spread of CWD, as well as management efforts (e.g., health advisories), has the potential to contribute to increased food insecurity among Indigenous communities, whose traditional economies are also compromised by other stresses, such as habitat degradation and climate change.
- A greater role of communities in disease surveillance (e.g., monitoring) and in decisions of wildlife management may contribute to both social and ecological resilience. Communication and management programs must be centered in the Indigenous communities with recognition of the importance of the cultural significance and context of wildlife.

Cervid Producers

- Cervid farming in Canada was a relatively new industry when CWD was discovered in the farmed sector in Canada.

- CWD caused a serious negative economic shock to the industry, which has been declining in total farms and total animals since CWD was found.
- Cervid farmers are very aware of and knowledgeable about CWD due to the significant economic impact on the industry
- The herd certification program (originally VHCP, now HCP), initiated in 2002 and revamped in 2018, is aimed at preventing CWD exposure, certifying safe cervid production for consumption or trade purposes, and is a prerequisite for the federal government undertaking destruction of a confirmed infected herd and compensating owners should CWD be discovered. Some provinces have complementary programs.
- Mandatory testing for all farmed cervids slaughtered (or other deaths) in Alberta, Saskatchewan, Manitoba, Quebec (rather than sampling as was done prior to 2018) and the Yukon makes testing rates for CWD among farmed cervids higher than in wild cervids; positive cases recently are lower in absolute numbers relative to wild cervids.

Alberta Hunters

- An extensive CWD monitoring and surveillance program, and hunter surveys in the province, have shown relatively constant hunter awareness and perceptions of CWD over time.
- License sales are not declining over time, indicating that hunters are not reducing their effort, even with moderately high levels of CWD present. Hunters are concerned about CWD impacts on wildlife herd health, and do not think eradication is likely.
- US research indicates reduced hunting effort occurs when CWD reaches high (>30%) prevalence levels. While this is not evident yet in Canada, increasing numbers of hunters are checking prevalence levels prior to draw submission, indicating a shift could occur if prevalence increases dramatically.
- Management options such as hunting season expansion can provide a high benefit-low cost approach to CWD management rather than financially and socially costly herd reduction approaches.
- The removal of the replacement tag program in Alberta in 2019 (for harvested deer that test positive) was not popular among some hunters although recent data suggests that the majority of hunters are not opposed to this change in program. (Source: Adamowicz et al. 2019, 2020).

Professional Outfitters

- Survey results show that outfitters had the highest awareness of the disease in wild cervids when compared with other stakeholder groups, yet did not support CWD management options that increase hunting of animals
- Their views about acceptable management strategies differ considerably from hunter views and from views of the public
- Even given the severity of CWD spread in parts of the country, CWD is not seen to be the most significant risk to outfitter livelihood associated with cervid populations.

Cow Calf Cattle Operations

- Wild ungulates are a concern in terms of disease transmission (CWD and other diseases) and feed consumption.
- Producers generally like cervids and do not want to see them eradicated from their properties and worry about costs of reducing contact between cattle and cervids.
- Preliminary results indicate limited concern over possible trade barriers impacting the beef industry due to CWD.

There are numerous policy response areas related to CWD that are being considered. The policy space is complicated by the potential for the disease to cross both wildlife and domesticated animals, as well as provincial and national borders. Commensurately, there are a complex set of agencies associated with parts of the policy environment. No one agency has authority over all of the recommended or identified policy areas considered below. Associated industries are also involved in policy making processes and could implement codes of conduct to address CWD. However, clarifying which and how policy options might be implemented (including identifying any coordinating agency responsibilities) is still to be determined. The disease is considered to have differing degrees of urgency among constituencies and development of policies based on risk assessments must be careful not to be too reactive as the trade-offs can be difficult to assess *ex ante*.

Despite these difficulties, we identify and discuss 10 policy options. The focus is primarily on policies that directly (cervid farm) and indirectly (through reducing spread and prevalence in the wild) affect the Canadian agri-food and agriculture sectors. The ten options chosen are those for which there are frequent recommendations or for which the outcomes seem clearer given previous policies applied across a range of North American jurisdictions and based on research findings to date. In most cases, due to limited publicly available data on the costs of programs which have been implemented by federal or provincial agencies, it is not possible to develop consistent measures of costs or benefits of the suggested policies to specific groups. Decisions around policy adoption in this area cannot purely be made on the basis of market costs and benefits as the disease being managed has the capacity to inflict high non-market costs. Significant research is necessary to properly assess public and private market and non-market values associated with the outcomes of policy choices. Furthermore, additional detail on a range of items including enforcement efficacy and cost, communication approaches and other elements will be required for a complete analysis. Nevertheless, we present an overview of ten policy areas which can be described as having the most potential for reducing the impact of CWD on the Canadian agri-food and agriculture sectors. Later in the document we identify a broader range of policy measures to be considered that include investing in research and other measures to address CWD concerns. The 10 briefly described policies are presented in the following table along with our recommendations regarding whether they should be implemented, recognizing the need for further information to provide a comprehensive final recommendation. The colors in the table reflect policies that appear more socially beneficial (green) to less so (red).

Option	Benefits	Costs	Recommendation	Comments
Preventing the spread to boreal caribou by targeted harvesting of deer and monitoring (AB and SK)	Reduced risk to a threatened species	Cost of targeted harvest increases by resident hunters and Indigenous communities could be small, or even negative (since increases in harvests generate economic benefits) but program costs and current and future costs arising from other users of deer need to be considered.	Strongly recommend	High benefit and low-cost opportunity to reduce risk to a threatened species – but the efficacy of targeted harvests on CWD spread must be monitored and assessed as well as impacts on other users.
Require animal testing for all farmed cervids slaughtered (dying) in Canada	Assured food safety and quality	One estimate suggests Alberta spent $500,000 in 2003 on farmed and hunted animal testing; this value will be higher now. The question of cost to cervid farmers is also important as is compliance from all sectors including hunt farms	Strongly recommend	Difficult to protect either Indigenous people or hunters in the same way as people who consume from farms and the risks are bigger

Option	Benefits	Costs	Recommendation	Comments
Make the Chronic Wasting Disease Herd Certification Program mandatory	This program is the way for farmers to be certified for export, have animals be destroyed with compensation if CWD is found, although not 100% of farmers participate. Program would provide the highest level of biosecurity which could reduce potential environmental spread to other farms	Costs are high for government to enforce and very high for farmers as if farmers are not registered the government does not depopulate. This approach will likely not reduce CWD prevalence in wild populations	This should be mandatory throughout the country to maintain safety and also protect trade and market access	Farmers may be unaware of the changes in regulations or speed of spread – modest incentives might encourage adoption although the requirements are stringent and costly for producers
Employ hunter harvest to reduce spread of CWD in wild populations (spatial targeting, etc.)	Reduce risk to caribou, and unaffected regions. Hunter benefits generated. This could reduce transmission from wild animals to the environment	Relatively small (additional administrative actions and program costs) but some sectors and users may be adversely affected at least in short run (outfitters) and impacts on other users in the longer term need to be evaluated.	Recommend	Positive incentives to hunters could be employed. But such programs must be evaluated for their efficacy (biological and economic) in an adaptive management fashion.

Option	Benefits	Costs	Recommendation	Comments
Increase monitoring / surveillance for CWD in wild populations (improve sampling, public investment in testing, other options).	Identify areas of new spread, act quickly to address.	Potentially significant (testing capacity, incentives to support submissions)	Recommend (supported by public and hunters), but funding and scale will be challenging.	May require positive incentives to hunters, landowners, others. Technology development important and necessary
Improvements in information provision about CWD.	Find low cost, targeted ways to provide more information with greater efficacy to all rightsholder and stakeholder groups.	Marginal cost to communicate findings from existing research projects	Recommend.	Simple and direct approach to increase awareness.
Prohibit or delay repopulation of CWD depopulated farms with cervids or other animals such as bison or cattle	Ensure safety for future animals and food supply, although there is one long term study showing no evidence of transmission of CWD from environment to cattle grazing, in this case precaution could be protective in an important industry	The costs would be very high for landowners – in particular affecting the commercial value of their land through reduced use options	Uncertain but likely recommend.	This will be unpopular for some groups. Research on time for disappearance of CWD from the environment on depopulated farms required.

Option	Benefits	Costs	Recommendation	Comments
Remediate sites known to have CWD present in soil, plants, etc.	Reduce risks to farmed and wild cervids	High cost except for very concentrated areas	Effective mechanisms at scale have not yet been developed suggesting no action except for testing / research on very focused sites	Continue research in the area to develop the technology, including products and processes to treat the environment
Provide incentives to address carcass disposal problems in hunting	Reduce risks of spread, transmission elsewhere.	Logistically difficult, dispersed and difficult to monitor. Hunters adversely affected.	Uncertain	Positive incentives, information required.
Close cervid farms	Closing farms would only reduce the risk of CWD in the farmed cervid food chains for provinces that currently do not mandate testing (AB, SK, QC, MB and Yukon currently require testing) resulting in minimal if any benefits. There are no apparent benefits to the broader Canadian agricultural sector. Risks to other agriculture sectors	Relatively small sector, but equity issues arise. The equity issues could be resolved by mandating testing and HCP participation- reducing costs and protecting wild animals and commercial food supplies.	No action	Not an effective policy option to reduce risks to the agricultural sector or wild populations.

Option	Benefits	Costs	Recommendation	Comments
	stemming from contamination by the wild cervid populations (e.g., cattle, grain, forages) will remain. Precautions such as licensing new farms and requiring farms to participate in the HCP and maintaining biosecurity protocols are recommended for regions with and without CWD. However, in provinces where the wild population has not yet been infected it would be prudent to take precautions to prevent the risk of spread from farmed populations to the wild. Such precautions include alternatives that do not involve closing all cervid farms.			

Further benefit cost analysis should be conducted to solidify rationale for intervention and to identify costs and benefits to particular groups. We have also identified a number of research areas in both the biological sciences and the social sciences that should be invested in to help assess policy options.

While policies can be implemented within Canada, international coordination is critical to future spread of a wildlife disease. Without coordinating CWD policies with the US, the Canadian policies may be less effective. Similarly, coordination between provinces, and between the provinces and the federal government, will continue to be important in the development and implementation of CWD policy.

Overall, data confirm that developing policy in this area is complex because, for any policy option, there are groups who perceive the approach as beneficial while others who perceive it as costly. Clarification and careful communication of the impacts of the policy on different sectors, will be critical for policy application.

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1.0 INTRODUCTION

Chronic Wasting Disease (CWD) is a prion disease that affects cervids (deer, elk, etc.) and has been found in both wild and farmed populations in the U.S., Canada and abroad. CWD in wild populations is spreading and prevalence is increasing in Alberta and Saskatchewan. In North America, the disease has been found in white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*) and moose (*Alces alces*). Outbreaks also occur in the cervid farming sector, including the finding of CWD on a red deer farm in Quebec in September 2018. CWD has also spread beyond North America. The disease has also been found in Finland, Sweden and Norway, in respectively, European elk (*Alces alces*), red deer (*Cervus elaphus*) and reindeer (*Rangifer tarandus*). In South Korea, CWD has been found in elk (*Cervus canadensis*) as well as other farmed deer species (CWD Alliance., n.d.; Yle, 2018; VKM, 2017).

There are many rightsholders, stakeholders and interested parties affected by CWD. Hunters and professional outfitters are affected because CWD affects their ability to hunt, earn a living and potentially acquire food. Landowners are affected, whether or not they are hunters, allow hunters on their land because wildlife can spread CWD on their property. Indigenous peoples are and will be affected by CWD because cervid species are an important food source and integral part of cultural identities. Cervid farmers are impacted by the disease as their products (animals, semen, meat, antler velvet) are only valuable if their animals have clean bills of health. The general public is also affected by CWD incidence and management costs through their appreciation of the importance of these animals on the landscape. Concerns about CWD also transcend the current species that are infected, in that agricultural producers and health officials are cognisant of the potential for CWD to spread to non-cervid agricultural species and even potentially spread to humans. CWD is also spread environmentally through soils and plants. Overall, the concerns related to CWD are broad, and increasing with CWD spread and prevalence.

Also concerned are wildlife managers and other government officials attempting to address the disease. Recent changes in the CWD management practices of the Canadian Food Inspection Agency (CFIA) may also affect the incidence of CWD in the farmed sector and the status of the industry as a quality supplier of meat and other cervid products. Wildlife managers and the public, who have concerns about spread in the wild, face challenges in coordinating management across domestic and international borders in the context of uncertainty about how the disease will evolve in the future. This review synthesizes the literature on CWD with a focus on current knowledge surrounding implications for disease spread and surveillance/management options, implications for wilderness and the agriculture and agri-food sectors, potential risks to these sectors, and policy options that may be considered to address CWD.

The sections of the review will include:

- The current state of knowledge regarding CWD transmission within cervid populations, and between cervid populations and other populations (humans, livestock, etc.), transmission through the environment to plants, crops, and soils and ameliorating factors.

- A description of the current state of CWD in Canada, including the regulatory structure surrounding CWD in farmed and wild populations.
- A synthesis of knowledge, preference and behavioural intention data collected across Canada from the general public, Indigenous communities, hunters, professional outfitters, livestock producers and others regarding perceptions of CWD risks and preferences for policy options.
- The current state of the farmed cervid sector, the economic sectors related to wild ungulate populations (tourism, hunting, outfitting, etc.), and related to extensive livestock production (cow-calf sectors).
- A review of international trade regulations relating to CWD in wild and farmed cervids and their products.
- A description of policy options to address CWD in wild and farmed populations and the evidence regarding costs and benefits of such policy options, including policy options that need more evaluation.
- Conclusions and recommendations regarding policy options, specifically those policy options that may relate directly and indirectly to CWD and the Canadian agriculture and agri-food sectors.

2.0 SCIENTIFIC BACKGROUND AND CWD TRANSMISSION[1]

What is Chronic Wasting Disease?

CWD is a prion disease, or Transmissible Spongiform Encephalopathy (TSE), affecting numerous species of cervids in North America, South Korea, and Scandinavia. TSEs are neurodegenerative diseases of mammals caused by prions, which are infectious, aberrant proteins generated by the misfolding of the cellular prion protein (PrPC). PrPC is a protein naturally present in high amounts in the Central Nervous System (CNS) of all mammalian species and is encoded by the PRNP gene (Bendheim et al., 1992; Prusiner, 1998b). The infectious protein (PrPCWD in CWD) has the ability to imprint its abnormal conformation onto endogenous PrPC and, once in the brain, triggers a progressive neurodegenerative process that always leads to death (Prusiner, 1982, 1998a). Along with scrapie, the prion disease of sheep and goats, CWD stands out for being highly transmissible, both directly through animal-to-animal interactions (Hoinville, 1996; Miller and Williams, 2003), and indirectly through environmental exposure (Miller et al., 2004; Georgsson et al., 2006). CWD is, however, unique among prion diseases because it is the only TSE found in both farmed and wild animals.

CWD in Cervids

History / Origins of CWD

Although the exact time and place of emergence of CWD remains unknown, the disease was initially observed in research facilities of Colorado and Wyoming in the late 1960s. The first cases of CWD were detected in captive mule deer (*Odocoileus hemionus*) and black-tailed deer (*Odocoileus hemionus columbianus*) in these facilities (Williams and Young, 1980). The disease was subsequently detected in Rocky Mountain elk (*Cervus canadensis*) from the same locations, and thereafter in wild, free-ranging mule deer and elk in southeastern Wyoming and northeastern Colorado (Williams and Young, 1980; Williams and Young, 1982, 1992). In the following years, the disease was identified in white-tailed deer (*Odocoileus virginianus*) from Nebraska and South Dakota and in moose (*Alces alces*) from Colorado and Wyoming (Spraker et al., 1997; Williams and Miller, 2002; Williams, 2005; Baeten et al., 2007). In Canada, the first CWD cases were identified, retrospectively, in mule deer at the Toronto Zoo, from post mortems on animal samples from deaths over the period 1973 to 1981 (7 positive animals found from deaths occurring over the period 1975 to 1979) (see Dubé et al, 2006) . The first farmed cervid was found with the disease in 1996 in a Saskatchewan elk farm (in captive elk that were imported from South Dakota (Williams and Miller, 2002)). In the following years, CWD was detected in farmed white-tailed deer and elk in Alberta and in wild cervid populations from Saskatchewan and Alberta (Kahn et al., 2004). In February 2013, a road-killed moose in Alberta also tested positive for CWD (Government of Alberta, 2013; CWD in moose in Alberta info sheet) and two moose were found to have the disease from

[1] This section was prepared by A. Otero Garcia, D. McKenzie, J. Aiken.

hunter head submission is 2019. Cervid migration and human transportation of infected animals may have contributed to the continuous expansion of the disease in North America, and to date, the disease is present in 26 U.S. States and 3 Canadian provinces: Saskatchewan, Alberta and Québec (Centers for Disease Control and Prevention, 2020). In Québec in 2018, CWD was first detected in farmed red deer (*Cervus elaphus*); the origin has not yet been identified (Gagnier et al., 2020). No cases of CWD have been detected in the North American species of caribou (*Rangifer tarandus* spp.).

The first outbreaks of CWD outside North America occurred in South Korean farms, after the importation of asymptomatic infected elk and deer from a farm in Saskatchewan (Sohn et al., 2002; Kim et al., 2005). CWD has since spread into South Korean red deer, sika deer (*Cervus nippon*) and crossbred animals (Lee et al., 2013a).

Finally, in 2016, CWD was identified for the first time in Europe, in a free-ranging Norwegian reindeer (*Rangifer tarandus tarandus*) (Benestad et al., 2016). Scandinavian countries sampled and tested thousands of cervids after this first diagnosis, which led to the detection of CWD in multiple reindeer, moose and in one wild red deer, across Finland, Sweden and Norway (Pirisinu et al., 2018; Hazards et al., 2019; Vikøren et al., 2019). The origin of CWD in Europe remains unknown. However, Mysterud et al. (2021) describe the two different kinds of CWD present in Scandinavia – a classic form found in reindeer with similar characteristics and ability to spread as the disease found in mule deer and white-tailed deer in North America and an atypical form of CWD found in moose and red deer, which is confined to the central nervous system and, to date, found in older animals with a limited possibility of horizontal transmission.

CWD prevalence in North America has greatly increased in the last decade. Prevalence of CWD positive animals can be higher than 45% in wild populations and higher than 80% in farmed herds (Keane et al., 2008). Prion infectivity persists in the environment for more than 10 years, serving as a long-term source of infection (Georgsson et al., 2006). Core areas of enzootic CWD in Wisconsin show a CWD prevalence greater than 50% (Wisconsin Department of Natural Resources, 2020). In the latest Alberta CWD update (2019 surveillance program), CWD was detected in 11.2% of the animals tested (up from 7.4% prevalence detected in the previous hunting season). As in previous years, white-tailed and mule deer in Alberta and Saskatchewan exhibit differences in prevalence between species and sexes. Data from the Alberta 2019 surveillance program shows the prevalence rank to be mule deer males>mule deer females>white-tailed males>white-tailed females (24.5%, 8.8%, 4.8% and 1.4%, respectively). Elk represent 1.3% of the CWD prevalence and, for the first time, CWD was detected in two hunter-harvested moose (Government of Alberta, 2020).

Deer herds with high CWD prevalence are experiencing population declines. Monello et al. (2014) attributed average declines in elk survival in Rocky Mountain National Park, from 2% in 2008 to 11% in 2010, almost entirely to CWD. Declines in free ranging cervids in Colorado were attributed to CWD prevalence greater than 13% (Dulberger et al., 2010; Monello et al., 2014). DeVivo et al. (2017) estimated that mean annual survival rates of CWD-negative and CWD-positive deer were 76% and 32%, respectively, supporting CWD as a significant contributor to mule deer population decline. Miller and colleagues tagged several infected and uninfected wild adult mule deer from a region of high CWD

prevalence. After two years, they found that 53% of the infected deer had died while 82% of the uninfected deer were still alive (Miller et al., 2008). CWD positive deer eventually succumb to the disease, but these animals are also more likely to be killed by predators or hunters and are more vulnerable to vehicle collisions.

Mechanisms of CWD transmission

Horizontal transmission of prions by direct animal-to-animal interactions is considered a major mechanism of natural transmission of CWD (Miller et al., 2000; Miller and Williams, 2003). Cervids, however, can also get infected indirectly through exposure to CWD contaminated environments (Miller et al., 2004; Mathiason et al., 2009). Exposure of deer to pasture, water, feed buckets and bedding that were previously used by infected animals led to CWD transmission (Miller et al., 2004; Mathiason et al., 2009). Environmental sources of CWD contamination are the decomposing carcasses of positive deer and urinary, salivary and fecal shedding from infected animals, secretions and excretions that contain considerable CWD infectivity (Miller et al., 2004; Mathiason et al., 2006; Haley et al., 2011). Adjacent areas to mineral licks have also tested positive for infectivity in CWD endemic regions, suggesting that such areas could represent a risk of transmission of the disease to cervids and other species (Plummer et al., 2018). TSE agents can persist in the environment for years (Georgsson et al., 2006), and soil, especially, serves as an important reservoir of CWD infectivity (Schramm et al., 2006). Prions bind with strong affinity to certain mineral microparticles present in soil, and this interaction can increment their infectivity (Johnson et al., 2006b; Johnson et al., 2007). The composition of soil is, however, highly variable between areas and the proportion of specific components, such as minerals or organic compounds, can highly modify the environmental persistence and transmission of CWD (Kuznetsova et al., 2014). For example, whereas the mineral montmorillonite strongly binds prions, increasing their infectious capacity (Johnson et al., 2007), humic acids, which are organic constituents, can decrease CWD infectivity (Kuznetsova et al., 2018). Though the detection of CWD prions in soils becomes more difficult with time, prion infectivity is not significantly altered, and therefore soils can be reservoirs of infectivity for extended periods (Kuznetsova et al., 2020).

Plants can also represent a risk for CWD transmission. Pastures can retain infectious CWD prions for at least 2 years post-exposure (Miller et al., 2004). Grass plants exposed to brain, urine or feces from CWD-affected cervids can bind and uptake prions, as detected by ultrasensitive techniques. In the same study, it was demonstrated that hamsters can be infected by ingestion of leaves and roots previously exposed to hamster prions (Pritzkow et al., 2015). Contrarily, a study conducted by Rasmussen et al. (2014), in which wheat roots were exposed to CWD, showed that these plants do not transport prions from the roots to the stems. The techniques used in this study were, however, less sensitive than those used by Pritzkow and colleagues.

Transmission of CWD from mother to offspring is possible, as evidenced by experimental transmission of CWD to muntjac deer (*Muntiacus reevesi*) and the detection of prions in maternal and fetal tissues from wild pregnant elk (Selariu et al., 2015; Nalls et al., 2017). Other studies, however, suggest that this transmission plays a minor role in CWD epidemiology (Miller and Williams, 2003). Cervids acquire

CWD predominantly through the oral route (Miller and Williams, 2004), although there is evidence that inhalation of prions can produce disease and, therefore, the intranasal route can be a contributing mechanism of exposure (Denkers et al., 2013).

In areas where cervids have been chronically exposed to CWD, the prevalence of the disease is much higher in males than females (Miller and Conner, 2005; Grear et al., 2006; Samuel and Storm, 2016). However, no differences in susceptibility have been detected between male and female deer in captivity (Williams and Young, 1980; Williams and Young, 1992; Miller et al., 1998; Miller and Wild, 2004). Several theories have been proposed to explain the difference in CWD prevalence between male and female wild deer. Male deer consume significantly more food than females, which increases their probability of exposure to environmental CWD contamination (Mysterud and Edmunds, 2019). Male probability of infection by animal-to-animal contact is also higher, especially before and during the breeding season since males move more widely and interact with more groups of deer than females (Koutnik, 1981).

Factors determining susceptibility to CWD in cervids

As previously mentioned, PrPC protein is encoded by the PRNP gene. Genetic variations at this gene (polymorphisms) lead to the encoding of different PrPC molecules. In cervids, these polymorphisms play an important role in CWD susceptibility. Epidemiological studies in CWD endemic areas have shown that deer expressing certain PRNP polymorphisms are underrepresented among CWD positive animals suggesting a protective effect against the disease (Johnson et al., 2003; O'Rourke et al., 2004; Johnson et al., 2006a; Keane et al., 2008; Kelly et al., 2008). This protective effect has been confirmed in experimental CWD transmissions to deer of these genetic backgrounds, which show a slower progression of the disease (Johnson et al., 2011). However, none of these polymorphisms confers total protection against CWD. Deer whose genetics are rarely found among CWD-positive animals have also proven to be susceptible to the disease (Haley et al., 2019).

Another important factor in CWD susceptibility is the prion strain to which cervids are exposed. Prions, like other pathological agents, exist in a variety of strains that produce different disease phenotypes and have different host ranges. Since prions do not contain genetic material (Prusiner, 1982), the biological information of prion strains is encoded in, and perpetuated by, their conformation (Bessen and Marsh, 1992; Hill et al., 1997). Several CWD strains, differing in their pathological characteristics and the variety of hosts that they can infect, have been identified (Angers et al., 2010; Duque Velasquez et al., 2015; Hannaoui et al., 2017; Herbst et al., 2017; Moore et al., 2020).

Cervid species susceptible to CWD

CWD has the potential to infect most, if not all, cervid species. As we previously reviewed, natural cases of CWD have been found in mule deer, black-tailed deer, white-tailed deer, elk, red deer, moose, reindeer and sika deer. In North America, CWD transmits naturally between different cervid species (Williams,

2005). Although there are other species of cervids in which no natural cases have been reported, experimental inoculations have shown that they are susceptible to CWD. These include the Asian muntjac (*Muntiacus reevesi*) (Nalls et al., 2013), fallow deer (*Dama dama*) (Hamir et al., 2011a) and North American caribou (Moore et al., 2016).

As discussed above, the potential for CWD to infect caribou is concerning as these species are threatened and their numbers are declining in Canada (Hervieux et al., 2013). There are four subspecies of caribou present in Canada: Woodland caribou (*Rangifer tarandus caribou*), Grant´s or Porcupine caribou (*R.t. granti*), Barren ground (*R. t. groenlandicus*) and Peary caribou (*R.t. pearyi*) (Festa-Bianchet et al., 2011). Among these, Woodland and Barren ground caribou are the subspecies at a higher risk of contact with CWD since their ranges now overlap with CWD-infected deer (Richards, 2020). The PRNP gene, a critical factor in prion susceptibility, is identical between deer and caribou suggesting there will be no genetic barrier to transmission.

Potential for CWD transmission to other species

To date, no natural transmission of CWD to species outside the Cervidae family has been documented in wild or farmed populations. The transmission of prions from one species to another is limited by a transmission barrier. The strength of this barrier depends on multiple factors including the primary sequence of the PrPC of the new host and the PrPCWD from the inoculum and the transmitted prion strain (Pattison, 1965; Prusiner et al., 1990; Bartz et al., 1994; Supattapone et al., 1999; Hill et al., 2000). Experimental data, however, has shown that the transmission of CWD to other species is possible.

Livestock species

Of special concern is the transmission of CWD to non-cervid species used in the human food supply chain, especially cattle, due to the potential emergence of prions with zoonotic capacity, as with the bovine spongiform encephalopathy (BSE). The overlap of cattle and cervids is common in CWD-affected areas of North America. CWD agents from different species (white-tailed deer, mule deer and elk) are transmissible to cattle after intracerebral inoculation (Hamir et al., 2005; Hamir et al., 2007b; Hamir et al., 2011b; Greenlee et al., 2012), but the characteristics of the disease are very different from BSE (Hamir et al., 2011b). In experimental treatments, no oral transmission of CWD to cattle has occurred, and no CWD prions were detected in cattle that were exposed to CWD-contaminated paddocks for 10 years (Williams et al., 2018). Thus, the risk of CWD transmission to cattle following oral inoculation and/or environmental exposure is believed to be very low.

CWD has been also transmitted to sheep after intracerebral challenge with mule deer and elk prions (Hamir et al., 2006; Mitchell et al., 2015; Madsen-Bouterse et al., 2016). Transmission of mule deer prions, however, led to incomplete attack rates since only 2 out of 8 inoculated sheep developed a TSE (Hamir et al., 2006). As with CWD in deer, the sequence of the PRNP gene (genotype) is one of the most important factors determining the susceptibility of sheep to prion diseases (Goldmann et al., 1990; Westaway et al., 1994; Belt et al., 1995; Bossers et al., 1996). Certain PRNP genotypes provide almost complete resistance to scrapie and, therefore, animals of these genotypes have been selected as breeders

in sheep flocks from countries where scrapie is endemic. This genetic selection has led to the almost complete eradication of scrapie in certain areas (Hagenaars et al., 2010; Nodelijk et al., 2011; Arnold and Ortiz-Pelaez, 2014). Interestingly, it was shown that sheep expressing genotypes associated with resistance to scrapie were also resistant to CWD inoculation (Hamir et al., 2006). No oral transmission of CWD to sheep has been reported.

Moore et al. (2017) demonstrated that pigs can propagate CWD prions at a low-level, showing a strong transmission barrier. Contrary, however, to transmissions in cattle and sheep, oral transmission of CWD (prions from white-tailed deer) has occurred. In these CWD-challenged pigs, prions were detected, using ultrasensitive techniques, in animals that were euthanized at 8 months of age (e.g., market weight). These results suggest that pigs can act as a reservoir of CWD, which could represent a risk for deer populations since feral pigs share the habitat with CWD-affected cervids (Moore et al., 2017).

Other wildlife species

The genetic similarity between different species of ungulates that inhabit CWD endemic areas, suggests that pronghorn (*Antilocapra americana*), bighorn sheep (Ovis canadensis) and the mountain goat (*Oreamnos americanus*) may be susceptible to CWD, while bison (*Bison bison*) may be less susceptible (Cullingham et al., 2020). No experimental challenges of these species to CWD have yet been performed.

Numerous species of rodents including hamsters, voles and wild mice have been infected with CWD from different sources (Raymond et al., 2007; Kurt et al., 2009; Heisey et al., 2010; Lee et al., 2013b; Herbst et al., 2017). Several wild rodents that cohabitate with cervids in CWD-endemic areas have proven to be susceptible to the disease. These species are meadow voles (*Microtus pennsylvanicus*), red-backed voles (*Myodes gapperi*), white-footed mice (*Peromyscus leucopus*), and deer mice (P. maniculatus), which are native North American rodents (Heisey et al., 2010). Rodents are scavengers, making them likely to be exposed to CWD contaminated material. Therefore, they could act as a reservoir of CWD and perhaps represent a risk for CWD transmission, since a small proportion of rodent tissue enters the livestock food chain by contamination of grain and forage (Heisey et al., 2010).

Among wildlife species that share habitats with CWD-infected cervids, carnivores are the ones at a higher risk of exposure. Several species of carnivores have been infected with CWD prions experimentally. Ferrets (*Mustela spp*.) are highly susceptible to CWD and can develop the disease after inoculation through different routes (Bartz et al., 1998; Sigurdson et al., 2008; Perrott et al., 2012, 2013). In Canada, the only type of ferret found in the wild is the black-footed ferret (*Mustela nigripes*). This species is, however, one of the most endangered in North America and therefore, is unlikely to significantly contribute to the epidemiology of CWD. Mink (*Mustela vison*) are susceptible to CWD, but only by intracerebral inoculation (Harrington et al., 2008).

Domestic cats (*Felis catus*) appear to be susceptible to CWD as both oral and intracerebral transmission of mule deer CWD results in disease (Mathiason et al., 2013). Domestic cats scavenge deer carcasses and could represent a risk for human health as they could act as a reservoir for CWD. The genetic similarity between domestic cats and mountain lions (*Puma concolor*) suggests that these predators, which selectively hunt CWD-affected deer (Krumm et al., 2010), may be susceptible to CWD (Stewart et al.,

2012). Raccoons (*Procyon lotor*) are poorly susceptible to CWD and can be infected only after intracerebral challenge with CWD from certain species (Hamir et al., 2007a; Moore et al., 2019).

Canids, by contrast, are considered to be the most resistant species to prion diseases; the key for their resistance is a unique amino acid present in their PrPC (Fernandez-Borges et al., 2017). After the oral exposure of coyotes (*Canis latrans*) to a large volume of infectious CWD brain, infectivity could be recovered from some of the coyotes' feces. No evidence of CWD accumulation in coyote tissues was detected (Nichols et al., 2015). It has been suggested that canine predators, especially wolves (*Canis lupus*), which target weak prey such as CWD-infected deer, could be an important natural tool to limit CWD contamination of the environment (Wild et al., 2011).

Humans

There is no clear evidence that CWD can be transmitted to humans, in contrast with BSE, which is clearly zoonotic (Bruce et al., 1997). Numerous epidemiological studies have assessed whether there is a link between Creutzfeldt-Jakob disease (CJD) in humans and CWD. No clear link between CWD exposure and an increase in CJD frequency has been observed in epidemiological studies that assess whether there are more cases of prion diseases in people living in CWD endemic areas (MaWhinney et al., 2006; Abrams et al., 2018; Waddell et al., 2018; Maddox et al., 2019). Studies examining CJD outliers (e.g., young individuals succumbing to CJD) have not provided a link to CWD. For example, no causal relationship between the two prion diseases was found in three young CJD patients who were regularly exposed to, or consumed deer meat (Belay et al., 2001). Similarly, in a surveillance program for CWD, two individuals who had potentially been exposed to CWD developed dementia symptoms. However, these patients were diagnosed with early Alzheimer´s and a rare genetic prion disease, respectively. No correlation could be established between these pathologies and the potential exposure of these patients to CWD (Anderson et al., 2007). The evaluation of the zoonotic potential of CWD through this type of studies is, however, difficult. There are potentially a variety of CWD strains in the environment that could pose a differential risk to humans and the incubation period of prion diseases in our species can last decades. The identification of the zoonotic properties of an agent through epidemiological studies requires the detection of a high number of human cases within a particular geographical location or period, which necessitates a large number of human exposures to the disease. The prevalence of CWD in endemic areas has exponentially increased only in the last ten years and, therefore, there may have not been a sufficient level of exposure to the disease to identify CWD cases in humans.

The zoonotic properties of CWD can be assessed, however, experimentally by inoculating CWD prions in non-human primates and humanized transgenic mice and through in vitro studies of the human transmission barrier to CWD. Squirrel monkeys (*Saimiri sciureus*; considered a universal host of prion diseases) are susceptible to CWD from multiple cervid species after oral and intracerebral inoculation (Marsh et al., 2005; Race et al., 2009). The susceptibility of cynomolgus macaques (*Macaca fascicularis*), which are genetically more similar to humans, is still inconclusive. No signs of prion disease were observed in CWD exposed macaques 13 years after the inoculation (Race et al., 2018). A separate study, presented at a conference but not yet published, however, has found that macaques inoculated with CWD show signs of prion neuropathology in spinal cords (Czub et al., 2017). This study, in which macaques were exposed to several isolates of CWD via different routes, was initiated 10 years ago, and the presence

of infectivity in these macaques is still to be confirmed (Schwenke et al., 2019). A recent conference presentation (Schaetzl, 2020) provided an update on Czub et al. (2017) presentation and related work. This update illustrates that there is zoonotic potential in CWD. Macaques were infected including from oral ingestion treatments. The presentation also suggests that although the species barrier from cervids to human is high, it may be surmountable, and there are concerns arising from the evolution and adaption of prions. However, Race et al have observed similar depositions of pathology in the spinal cords of non-infected age-matched macaques (Race et al., 2018). In other studies, transgenic mice expressing the human prion protein have been challenged with multiple CWD isolates in seven different studies. None of these studies has found clear evidence of transmission to these mice, suggesting that the transmission barrier of humans to CWD is very strong (Kong et al., 2005; Tamguney et al., 2006; Sandberg et al., 2010; Mitchell et al., 2011; Wilson et al., 2012; Kurt et al., 2015; Race et al., 2019). However, a more recent study found low levels of amyloid seeding in four mice expressing human PrPC and inoculated with elk and white-tailed deer prions, suggesting that a transmission may have occurred. These results should be interpreted with caution, as these mice were analyzed using an ultra-sensitive technique [real-time quaking-induced conversion (RT-QuIC)], the reactions were inconsistently positive, and the mice overexpressed the human PrPC at levels much higher than those found in the human brain (Race et al., 2019).

Finally, the zoonotic potential of CWD has been studied using another ultra-sensitive technique for the detection of prions, Protein Misfolding Cyclic Amplification (PMCA). Barria and colleagues reported successful conversion of human PrP using different CWD isolates. Their studies showed that some CWD prions can convert human PrP more easily than others, with CWD from elk and reindeer having the highest zoonotic potential, followed by white-tailed deer prions and, finally, mule deer CWD (Barria et al., 2011; Barria et al., 2014; Barria et al., 2018). It should be noted, however, that PMCA facilitates the crossing of the transmission barrier and that in a living organism, there are many factors limiting the propagation of prions that are not present in in vitro systems.

Given the continuing geographic spread of CWD, the increasing prevalence of the disease in enzootic areas and the impact on cervid populations, questions that remain include CWD transmission to other wild and domestic animals, into the human food supply (in the case of untested animals) or to humans themselves. Further research into these issues is needed. Furthermore, active disease management practices are warranted to minimize the risk of CWD transmission.

3.0 CURRENT STATE

There are many unknowns about the current state of CWD. Over time, testing for the disease among wild and captive cervids has been partial and somewhat sporadic. Nonetheless, in a general sense, it is evident that the prevalence and spread of CWD are increasing. Figure 1 shows changes that have occurred over time by depicting the distribution of CWD in North America in 2008 and 2020. The graphics indicate a substantial spread in free-ranging populations, and an increase in the prevalence of cases in captive populations.

2008 July 2020

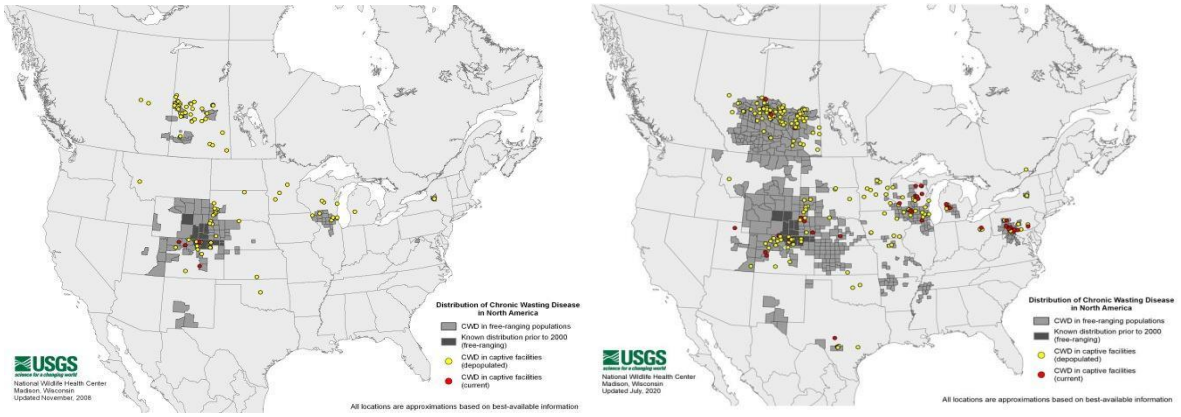


Figure 1. Distribution of Chronic Wasting Disease in North America in 2008 and 2020 (Source: Richards, 2020)

More localized examples for Alberta and Saskatchewan are shown, respectively, in Figures 2 and 3. In Alberta, figures depict cases of infected male mule deer in 2010 and 2019, which, again, show that the spread and prevalence have increased substantially. Similarly, in Saskatchewan the number and extent of CWD positive cases has grown, with large numbers, relative to past years, appearing in 2018 and 2019. Though most of these cases are with respect to mule deer, the second panel of the figure indicates that, as of 2019, there are cases appearing in other cervid species.

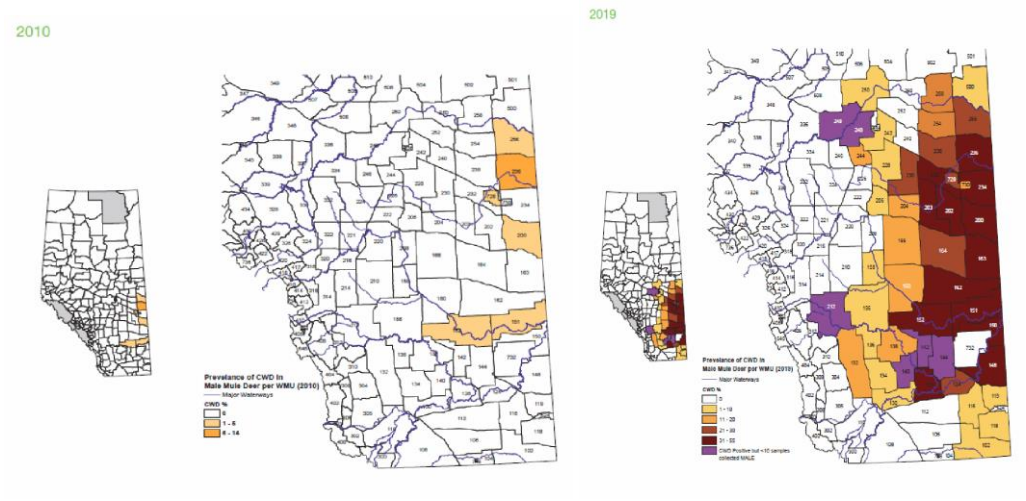


Figure 2. Prevalence of CWD in male mule deer in Alberta in 2010 and 2019. Source: Government of Alberta (2020a)

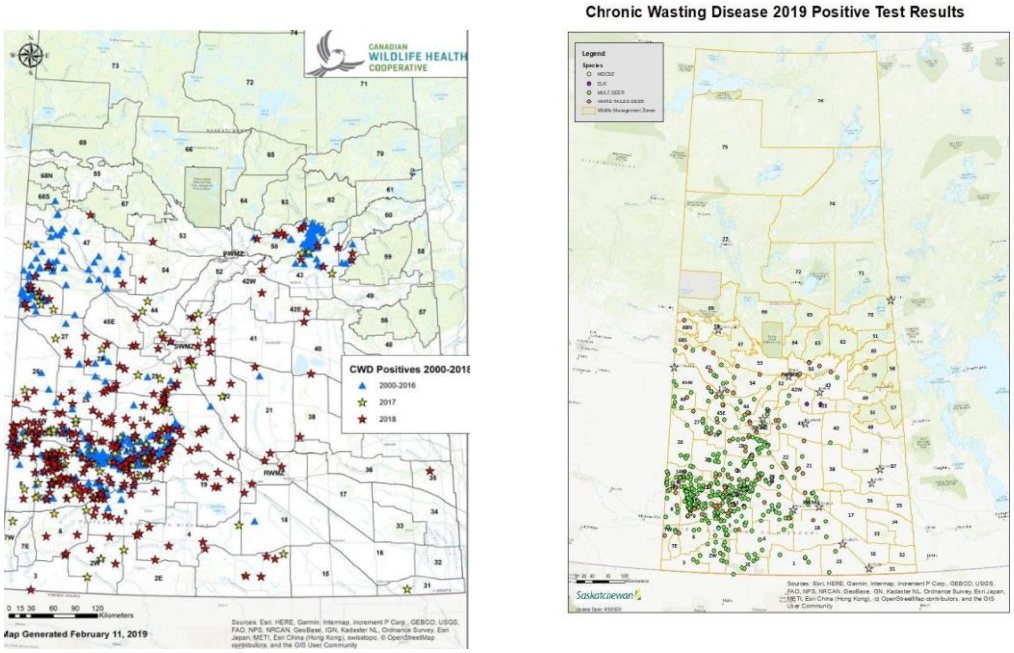
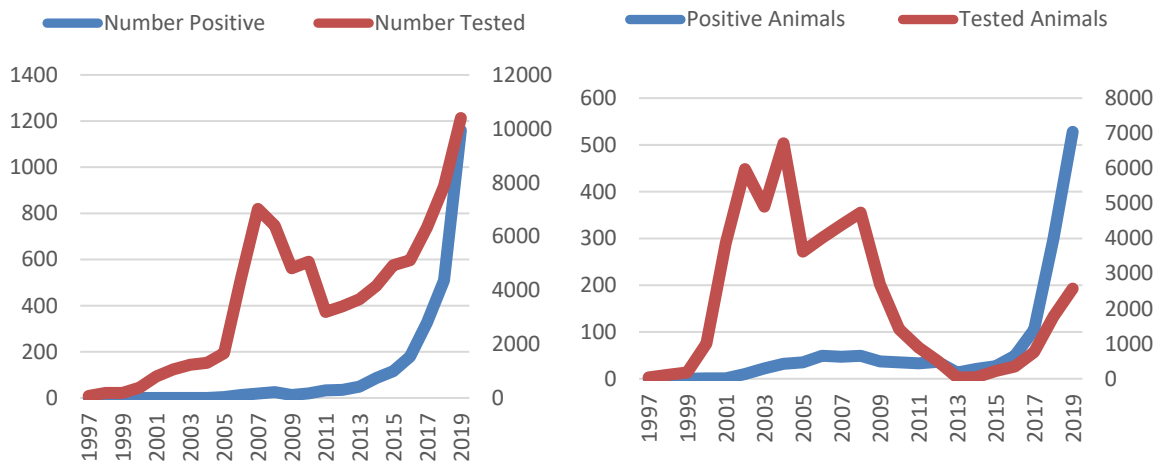


Figure 3. CWD prevalence and species infected in Saskatchewan (Source: CWHC, 2020; Government of Saskatchewan, 2029)

Despite these trends, prevalence and spread can be difficult to interpret given their reliance on testing, which has been variable. Figure 4 shows the number of wild animals tested, and the number of positive

cases found, for Alberta and Saskatchewan, over time. Though the number of positive cases, starting in about 2016, has grown substantially over time in both provinces, testing has been sporadic. Both provinces had large dips in testing prior to 2016 and testing in Saskatchewan had remained relatively low as recently as 2018.



Alberta Saskatchewan

Figure 4. Number of wild cervids tested and positive cases in Alberta and Saskatchewan (Source: CWD Alliance, n.d.)

In addition to variability in provincial testing programmes, there have also been federal CWD programmes evolving over time. There is variability in the testing of farmed cervids across the country (mandatory in some jurisdictions, voluntary in others) although for provinces such as Alberta and Saskatchewan testing of farmed cervids represents more animals than in the wild population. The CWD Herd Certification Program (HCP), which is directed towards cervid farmers, provides assistance and guidance regarding procedures to follow to maintain high biosecurity and prevent CWD infection when possible. Certification requires farm operators to i) maintain accurate and complete herd inventories, ii) test all slaughtered and dead cervids, iii) limit herd introduction to cervids enrolled at similar or higher certification level, and iv) implement biosecurity measures (CFIA, 2020). Compliance with national standards and operating procedures for enrolled farmers is mandatory, but participation in the program is optional.

Woodland Caribou and CWD

As discussed above, CWD has implications for many groups in society. One particular issue is its potential impact on the Woodland Caribou, a species at risk for which many of these people are concerned. Woodland caribou (*Rangifer tarandus)* and the boreal population or ecotype were listed as "Threatened" in Canada in 2003 (Government of Canada, 2019). (https://species-

registry.canada.ca/index-en.html#/species/636-252). Woodland caribou are also listed as At Risk under the *Alberta Wildlife Act* (https://extranet.gov.ab.ca/env/wild-species-status/default.aspx). Both Alberta and Saskatchewan have entered into agreements with the Federal government for the conservation and recovery of caribou. These agreements focus on development action plans for protection of critical habitat and other activities to support caribou conservation.

This type of caribou relies on intact boreal forest with few disturbances. Boreal caribou live in herd areas in Canada's boreal forest, including areas in Alberta and Saskatchewan as indicated in the maps below. Boreal caribou have been under threat from a combination of predators, forest access, and disturbance related to development (Hervieux et al., 2013). The majority of herds in Alberta are in decline and are indicated as non-self-sustaining according to the *Species at Risk Act* (Government of Canada, 2019). The status of herds in Saskatchewan is slightly better than those in Alberta.

CWD occurs in the *Rangifer* species as illustrated by the cases discovered in Norway in 2016. As caribou are a member of the cervid family, there is a concern that CWD will occur in Boreal caribou, adding to the risks of extirpation and extinction already facing the species. The areas with cases of CWD in wild populations (mostly deer) in Alberta and Saskatchewan are illustrated in the figures below, as are the caribou herd boundaries. The potential for overlap and infection of caribou is clear. The boreal populations of caribou—an iconic Canadian species—are already quite fragile and may not withstand infection with CWD.

There are also concerns about the spread of CWD to other caribou ecotypes and sub-species, including those in Northern Canada. In addition to concerns about wildlife conservation, there are concerns about the impact of CWD on caribou as a food source, particularly for Indigenous People, which are discussed further below. Note that if CWD is detected in caribou a number of critical challenges will arise including developing strategies to address CWD while recognizing the importance of caribou to Indigenous People, and the interaction with policies and practices to protect and support this threatened species such as *Species at Risk Act* recovery plans.

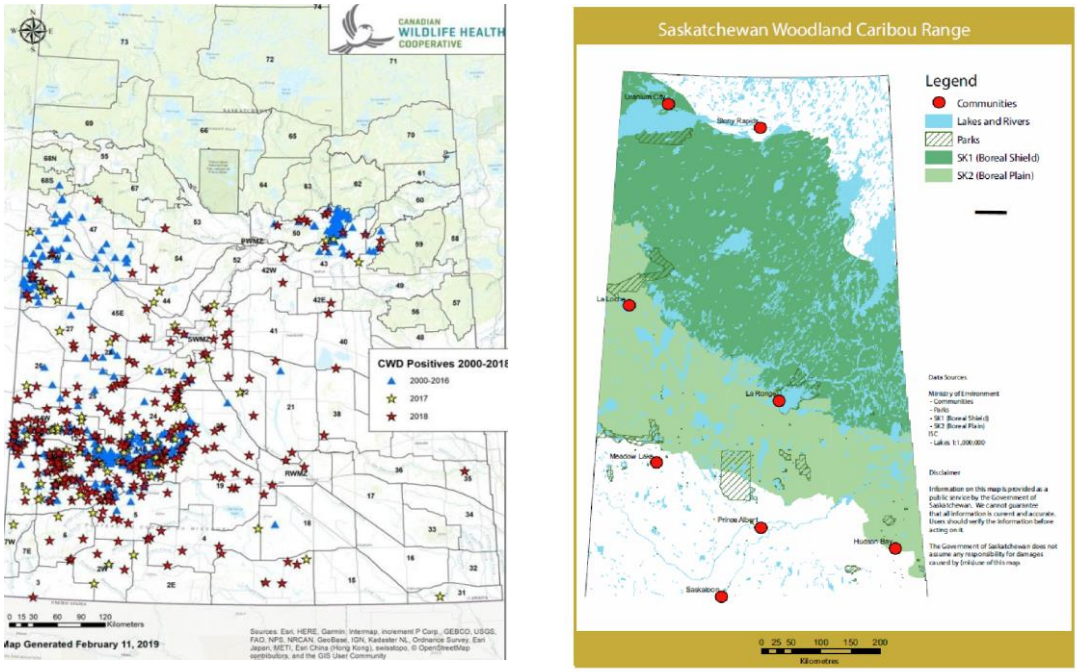


Figure 5. CWD Positive Cases (left) and boreal caribou herd areas (right) in Saskatchewan (Source: CWHC, 2018; Government of Saskatchewan, 2017).

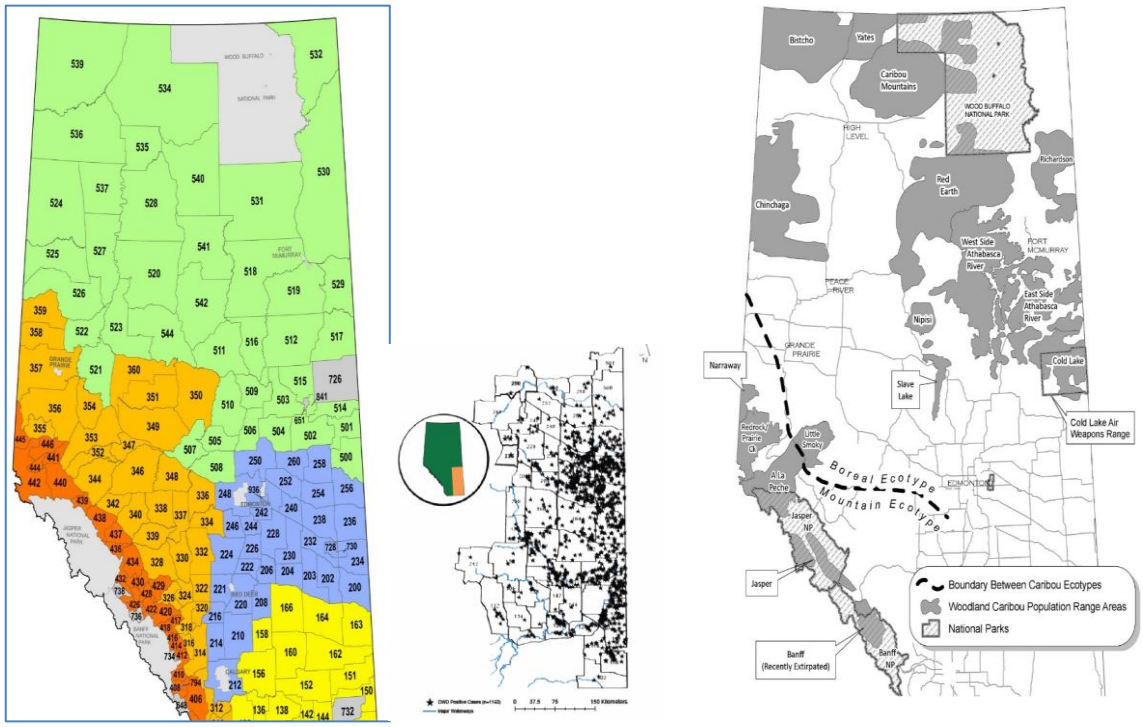


Figure 6. CWD positive cases and Wildlife Management Units (left) and boreal caribou herd areas (right) in Alberta. (Source: Government of Alberta, 2020; Hervieux et al., 2013)

Jurisdictional Issues

Management for CWD in farmed and wild cervids is conducted within a complex framework of provincial and national legislation. This complexity is exacerbated by the array of legislation and management approaches in U.S. states and Canadian provinces and the fact that wildlife moves between jurisdictions.[2] In addition, ministries for management of wildlife are usually different from ministries regulating the management of farmed cervids and their policy mandates often differ. For example, the Canadian Food Inspection Agency (CFIA) has some responsibility for CWD oversight in farmed cervids and responsibility for international movement of cervid animals and products (antler velvet as a natural health product is administered through Health Canada). Changes to their program initiated in 2018 will have only farms registered under the Herd Certification Program (VHCP originally, HCP now) eligible

[2] A summary of regulations and approaches across North American can be found in Michigan Department of Natural Resources (2020).

for destruction should CWD be confirmed. For herds not depopulated by CFIA, provincial agencies have taken on the role of managing CWD confirmations.

The Canadian Council for Chief Veterinary Officers made recommendations related to the management of CWD on farms in 2018 (CCVO 2018). Their recommendations included implementing an aggressive response to the finding of CWD on a farm in regions not previously known to have CWD. They proposed that the CFIA and provincial/territorial wildlife agencies undertake joint response activities, including epidemiological investigation, movement controls, depopulation and compensation of farmed cervids, cleaning and disinfection of the infected premises, combined with an intensive wild cervid harvest and testing in the surrounding area. Given the different agencies involved in this issue the aggressive response would need to be coordinated between CFIA and provincial agriculture and wildlife managers. They also proposed zoning management when CWD is found on farms, changes to the compensation practices previously covered by CFIA and recommendations that all farms participate in the HCP.

With the finding of a red deer farm with CWD in 2018 in Quebec, the aggressive strategies proposed above were undertaken by provincial agencies to test and cull wild animals around the farm to reduce the possibility of farm to wild CWD transmission. To date, this aggressive response to CWD, in a new vicinity (Quebec in this case), appears to have been successful in preventing establishment of the disease in wild deer around the farm (Gagnier et al., 2020). Provincial agencies have responsibility for licensing game farms and mandating testing of farmed animals. Provincial agencies did originally develop Herd Certification Programs and now work with CFIA and industry groups in further developing the programs.

The institutional frameworks that surround Indigenous People and their rights must also be considered in the context of CWD management. The complexity of the policy landscape is illustrated in a comparative table developed by the Michigan Department of Natural Resources (2020), which describes CWD regulations in North America and highlights the differences across jurisdictions. Given these differences, achieving collaborative management can be a challenge. The summary presented below provides some (but is illustrative not comprehensive) basic background on jurisdiction approaches in Canada.

Canadian National Wildlife Management Frameworks

Federal responsibility includes protection and management of migratory birds as well as nationally significant wildlife habitat (particularly wildlife on designated federal lands including national parks), responsibilities for endangered species and species at risk, control of international trade in endangered species, research on wildlife, and the ability to enter into international agreements on behalf of Canada. The federal government is also responsible for identifying and defining National Wildlife Areas. Environment and Climate Change Canada provides the framework to guide decision making on the monitoring of wildlife, the maintenance and improvement of wildlife habitat, the enforcement of regulations, the maintenance of facilities, and permitting. Species whose populations are at risk due to small size or significant declines may receive further protection under the Government of Canada *Species at Risk Act* (2002).

Wildlife management across Canada is governed by *The Canada Wildlife Act* (Government of Canada, 2020a). However often the details of wildlife management are found in specific legislation associated

with provinces/territories. Indigenous peoples in Canada have hunting and fishing rights stemming from treaty rights and aboriginal rights.

Provincial and Territorial Wildlife Management
Provincial and territorial ministries are responsible for other wildlife matters, largely through their responsibilities for Crown lands and natural resources. These include conservation and management of wildlife populations and habitat within their borders, issuing licenses and permits for fishing, game hunting, and trapping, guidelines for safe angling and trapping and outfitting policies. Provincial wildlife policies have similarities but also reflect the unique characteristics of each region.

At the provincial level, wildlife management is coordinated by the relevant ministries who establish legislations, policies and procedures for managing fishing and hunting activities, and for the allocation of fish and wildlife resources for recreational and commercial use. Wildlife management activities include monitoring, analysis, evaluation, mitigation, research and innovation, communications, public outreach and stakeholder engagement, habitat conservation and planning, policy and regulation. Regulations provide specific rules about hunting and harvest of game wildlife, season dates, reporting requirements, restrictions on firearms and other gear types, etc. Specific examples of these are discussed in the property rights section and detailed in the Appendices 1-4.

Pan-Canadian Structures and Support Organizations
Pan- Canadian structures, which involve coordination across federal/provincial/territorial governments, include the Canadian Wildlife Director's Committee. The committee is co-chaired by Environment Canada and a province or territory on a rotating basis, and is comprised of federal, provincial and territorial wildlife directors, including representatives from Environment Canada, Fisheries and Oceans Canada, and the Parks Canada Agency. This organization has some similar roles to the Association of Fish and Wildlife Agencies in the US. The Canadian Wildlife Directors Committee also participates in the Canadian Wildlife Health Cooperative, a centre related to the veterinary colleges in Canada. Other pan-Canadian organizations include the Committee on the Status of Endangered Wildlife in Canada and the Canadian Endangered Species Conservation Council.

Provincial ministries establish partnerships with community, industry, universities and colleges, NGO's and other agencies to pursue wildlife and conservation goals, enforcement and development of guidelines and regulations. There are many governmental organizations that support wildlife management across the country. Organizations like the Canadian Wildlife Federation and Wildlife Preservation Canada take a cooperative approach to wildlife management—working with people, corporations, non-government organizations, and governments to inspire collaboration in pursuing wildlife conservation. Such organizations partner with federal and provincial ministries and parks, habitat-oriented charities and land trusts, zoos, universities and colleges, and local grassroots volunteer groups. Wildlife organizations also focus on creating public awareness, sharing information and holding the governmental organizations accountable.

First Nations and Indigenous People

Wildlife management activities across provinces are not allowed to infringe on asserted or established Aboriginal or treaty rights as established by the *Constitution Act* and the *Indian Act*. Indigenous peoples in Canada have rights to hunt fish and trap on lands where they have legal rights and primary responsibility for wildlife and biodiversity (the federal government retains responsibility for fisheries management). However, aboriginal persons are not exempt from adhering to the laws and guidelines set out in some national legislation such as the *Fisheries Act (Health of Animals Act)*, modernized to better reflect rights of Indigenous peoples (Government of Canada, 2020b).

Recent wildlife management approaches have included commitment to co-management—by local and federal government agencies (Clark and Joe-Strack, 2017). Co-management can be defined as "local to regional-scale institutional arrangements that are intended to share some measure of control and authority for decisions about specific resources" (pg 71). However, such approaches can be challenging (Popp et al., 2018) identify successful co-management strategies for moose in Canada.

Cervid Management and CWD

On 18 September 2004, the Ministers Council, representing federal, provincial and territorial government ministries with responsibilities for wildlife, mandated the Canadian Wildlife Directors Committee to develop a national strategy to respond to and control CWD in Canadian wild animals. This strategy was to be modelled on Canada's National Wildlife Disease Strategy and was to serve as an urgent application to one disease, CWD, of the broader Wildlife Disease Strategy. This recommendation resulted in the Canada's National Chronic Wasting Disease Control Strategy (IOC, 2005). This report built on the report entitled CWD in Canadian Wildlife: An Expert Opinion on the Epidemiology and Risks to Wild Deer in 2004 (CWHC, 2004). The National Chronic Wasting Disease Strategy recognized the need to have the strategy address wild, farmed and captive cervids—a broader mandate than just considering the disease in the wild populations. The National Chronic Wasting Disease Strategy was updated in 2011 based on updated research findings and addressing more components of wildlife governance including Indigenous communities (http://www.cwhc-rcsf.ca/docs/technical_reports/A_Proposal_for_a_National_CWD_Control_Strategy_2011_final.pdf) . The 2011 strategy outlines a set of initiatives that would have to be implemented if the plan were to be adopted as government policy. The document states that:

"A partial list of these includes:

- *Coordination of governance activities.*

▪ *Regular review of Strategy implementation and relevant new science.*

▪ *Regular review of design and outcome of CWD management activities.*

▪ *Creation of consensus guidelines on importation, exportation and within-Canada movements of cervids and cervid parts.*

▪ *A national assessment of human exposure to CWD prions.*

▪ *Establishment of a program to obtain and map all data from CWD surveillance in Canada.*

▪ *Creation of a consensus document on best practices for responses to CWD occurrences, with review and updating every 2 to 3 years.*

▪ *Systematic epidemiological analysis of each new occurrence of CWD.*

▪ *Dialogue with research funding agencies on priority research areas to enable CWD management.*

▪ *Establishment and management of a communications plan.*

▪ *Coordination of risk communication."* (page 3 http://www.cwhc-rcsf.ca/docs/technical_reports/A_Proposal_for_a_National_CWD_Control_Strategy_2011_final.pdf)

Provincial Agencies and CWD

In some provinces (e.g., Alberta, Saskatchewan, Quebec and Ontario) CWD wildlife management focuses on the short- and long- term effects of CWD. This management includes mandatory or optional surveillance programs aimed at defining where CWD occurs in the wild. Provinces also regulate hunting towards CWD management ends through mandatory testing of harvested animals. In all of these provinces, there are active, ongoing analysis and discussions regarding future options for CWD management.

There have been efforts to collaborate on CWD management principles and best practices as illustrated by the Western Association of Fish and Wildlife Agencies (WAFWA) and their recommendations for adaptive management (WAFWA, 2017).

Table 1. Provincial agencies responsible for wildlife management and CWD in Canada.

Province	Provincial Regulations
Alberta **Ministry of Environment and Parks**	Alberta Wildlife Act Alberta Animal Health Act (Chief Veterinary Officer)
British Columbia **The Ministry of Forests, Lands and Natural Resources**	Wildlife Act, Forest and Range Practices Act, Oil and Gas Activity Act, Ecological Reserves Act , Park, Conservancy and Recreation Area Regulation Land Act B.C. Reg. 150/66 Animal Disease Control Regulation (B.C. Ministry of Agriculture and Lands)
Ontario **Ministry of Environment Conservation and Parks and Ministry of Natural Resources and Forestry**	Fish and Wildlife Conservation Act, 1997 Migratory Birds Convention Act. • Endangered Species Act • White-tailed Deer Management Policy for Ontario • Moose Management Policy • Caribou Conservation Plan • Elk Management Plan Animal Health Act (Ontario Ministry of Agriculture, Food and Rural Affairs)
Quebec	Act Respecting the Conservation and Development of Wildlife Animal Health Protection Act (Ministry of Agriculture, Fisheries and Food)
Manitoba **Department of Conservation and Climate**	The Wildlife Act C.C.S.M. c. W130 The Animal Diseases Act C.C.S.M. c. A85
Saskatchewan **Ministry of Environment**	The Ecological Reserves Act The Environmental Management and Protection Act, 2010 The Wildlife Act, 1998 The Wildlife Habitat Protection Act The Fisheries Act (Saskatchewan), 1994 The Environmental Assessment Act Animal Health Act, SS 2019, c A-20.01(Saskatchewan Department of Agriculture)
Nova Scotia **Department of Land and Forestry**	• Wildlife Act • Endangered Species Act • Conservation Easements Act • Animal Health and Protection Act (Ministry of Agriculture and Marketing)
New Brunswick **Department of Natural Resources**	Wildlife Act Diseases of Animals Act (Minister of Agriculture, Aquaculture and Fisheries)
North West Territories **Department of Environment and Natural Resources.**	Wildlife Act Mackenzie Valley Resource Management Act Species at Risk (NWT) Act Migratory Birds Convention Act. Species at Risk Act

Yukon	Wildlife Act Animal Health Act (Chief Veterinary Officer)

4.0 STAKEHOLDER DATA SYNTHESIS

Following the discussion above, there are numerous stakeholders who have interests in the effects and management of CWD. In the following paragraphs, we synthesize some of the information and ongoing research on what is known about stakeholder perceptions.

Canadian Public

Background

With the initial cases of BSE in 2003 and CWD findings from 2002 in Alberta (earlier CWD in Saskatchewan) public interests were piqued, and a focus on targeted management of CWD (in Alberta and in Saskatchewan) emerged between 2004 and 2009. For example, culling of animals in certain areas of Alberta where CWD animals had been found was not popular with the public and the targeted winter kills (sometimes by helicopter) were stopped.

Cervid farming was encouraged as a method of agricultural diversification in the 1980s and 1990s. CFIA has regulated management of the disease spread on farms (working with provincial agricultural ministries in most provinces) and supported depopulation of all farms found to have CWD up until 2018. When farms were depopulated, even the topsoil was removed in an attempt to eradicate the disease. From the beginning, where the disease was believed to be resulting from an imported animal to a farm in Saskatchewan, there has been public controversy about whether or not cervid farming should be allowed in the country. A continual theme in discussions of CWD management is that farms should be eradicated. It is important to remember that CWD is spreading significantly within the US wild populations (and farmed) and likely could move to Canada from the south in numerous places.

Given the spread and the potential impacts of CWD on wildlife, economic activities related to cervids, the continuing debate about the potential transmission of the disease to humans and domestic animals and the costs of surveillance and management, the Canadian public is a stakeholder in the management of the disease. Accordingly, perspectives of the public related to CWD, from results of national surveys, are presented.

Results

Three national online surveys were conducted in 2009, in 2011 and in 2018 (Klotz et al. 2020a) with slightly different objectives but many common questions. All surveys were conducted with the assistance of national market research companies and were administered online. Descriptions of survey characteristics are provided in Table 1. In the 2018 survey, rural respondents were over-sampled.

Table 2. National Survey Characteristics.

Survey Year	Sample Size	% Rural (e.g., outside major metropolitan area)	% Hunters (e.g., respondents that are hunters or eat hunted meat frequently)	Company
2009	1516	35.5	6.3	Leger Marketing
2011	6480	40.8	7.7	Nielsen Co Ltd
2018	5237	46.7	8.6	Asking Canadians

Results are summarized for three different components of the survey. The first results highlight the sense of concern about CWD, including the awareness of CWD in the population prior to the survey being conducted. Secondly, the acceptability of various CWD management strategies is summarized across samples. Thirdly, for the 2009 and 2018 surveys, there were economic decision questions which are briefly summarized—in 2009 a stated preference question for 100% animal testing for CWD was assessed, in 2018 a referendum-type question about willingness to pay taxes to support more CWD surveillance was included. Although there could be some hypothetical bias associated with the responses to these questions, the results are presented to highlight the significance of national concern about the disease.

Within each of the surveys, we asked questions about respondent awareness of CWD, and for the 2009 and 2018 surveys, knowledge about CWD (both farmed and wild animals, in Alberta and Saskatchewan). After presenting information about findings of CWD infected animals in wild and farmed populations, we asked questions related to risk perceptions about CWD and preferences for different management options. These data are presented in Tables 2 and 3.

Table 3. Survey results on CWD awareness, knowledge and risk perceptions (Source: Klotz et al. 2020a).

Question	Survey 2009			Survey 2011			Survey 2018		
	Total	Non-hunter	Hunter	Total	Non-hunter	Hunter	Total	Non-hunter	Hunter
Sample Size	1486	1391	94	6916	6418	498	5236	4786	450
					%				
Have ever eaten venison	59	56	88	54	51	99	80	78	97
					% aware CWD prior to survey				
CWD Awareness	39	39	41	37	36	49.5	29	27	46

prior to survey									
	Average Score out of 4 (answered yes to questions about disease in wild, farmed animals in Saskatchewan and Alberta)								
CWD Knowledge Score	0.48	0.47	0.88				0.48	0.42	1.13
	Roselius Ranking Score (group strongly agree minus group strongly disagree) as percentage of total sample – deemphasizes neutrality and don't know scores								
Sample Size	1470	1373	94	6916	6418	498	5236	4786	450
The threat of CWD has been exaggerated	-1.08	-2.60	21.28				-14.72	-15.80	-3.33
I, or my family, have concerns about eating elk and deer meat because of CWD	-7.69	-6.26	-27.66				13.71	17.63	-28.00

Three notable trends are evident in the table. First, over time, the number of people eating venison has increased. Second, awareness and knowledge of CWD has dramatically declined across time. Finally, even for people unaware of CWD before the survey, there is much stronger disagreement with the statement 'The threat of CWD has been exaggerated'. All respondents disagreed that they worried about eating elk and deer meat because of CWD in 2009—in 2018 only hunters have maintained strong disagreement with the statement. Hunters do have, by far, the highest awareness and knowledge of CWD of these groups.

Table 4. Acceptability of different CWD management options (Source: Klotz et al. 2020a).

Question	**Survey 2009**			**Survey 2011**			**Survey 2018**		
	Total	Non-hunter	Hunter	Total	Non-hunter	Hunter	Total	Non-hunter	Hunter
Sample Size	1486	1390	96	6916	6418	498	5236	4786	450
	% Agreement (Roselius Ranking Measure)								

Cull Elk	22.84	23.05	19.79	39.60	39.11	45.98	57.64	57.61	58.00
Cull Deer	23.08	23.16	21.88	41.69	41.03	50.20	58.77	58.84	58.00
Mandatory submission of heads	56.91	56.81	58.33	62.85	62.39	68.88	66.79	67.22	62.22
Voluntary submission of heads	39.80	38.92	52.63	42.68	41.77	54.42	49.43	48.29	61.56
Educational materials	57.90	57.68	61.05	60.83	60.45	65.66	76.41	76.06	80.22
Open public meetings	54.06	53.58	61.05	62.62	62.34	66.27	72.57	72.44	74.00
Mailouts	56.42	55.96	63.16	59.95	59.80	61.85	64.21	64.15	64.89
Freezer locations	47.93	47.57	53.13	55.38	54.61	65.26	58.33	57.46	67.56
Additional hunting tags	48.63	47.85	60.00	50.46	49.66	60.84	64.36	63.33	75.33
Take no action	-54.85	-55.18	-50.00	-56.81	-56.51	-60.64	-53.00	-52.05	-63.11

Table 3 indicates that, over time, agreement about management options for CWD has increased for all options and across all groups. The only option that is disagreed with is ‘take no action’ which has strong similar disagreement across time for the public and non-hunters but for hunters the disagreement level is growing across time.

In the 2018 survey additional data were calculated on public responses to new types of CWD management—specifically restrictions on using deer urine for baiting, the use of vaccination when such a vaccine is developed and the use of environmental testing when such tests become available. Vaccination and environmental testing would require public investment for vaccination and for incentives to undertake environmental testing. However, all three would also require public support.

Table 5. Acceptability of New CWD Management Options (Klotz et al., 2020a).

Question	**Survey 2018**		
	Total	Non-hunter	Hunter
Sample Size	5236	4786	450
	% Agreement (Roselius Ranking Measure)		

Restrict baiting (using deer or elk urine to attract animals to areas to be hunted) of animals for hunting purposes	39.95	40.89	30.00
When vaccines are developed, implement vaccination program for wild deer, elk and moose	70.78	71.23	66.00
When technology allows the testing of material from live animals, subsidize data collection of different samples (fecal samples etc.) which could be used to monitor CWD spread	73.40	73.36	73.78

** Red numbers highlight a result of particular interest.*

In 2008 and 2009, with a focus on eating venison, survey respondents were asked about their preferences for traceability of purchased venison back to a farm of origin, and a desire for 100% testing for CWD before meat is offered for sale (Table 4). Survey respondents were clustered based on their perceptions of venison safety and food safety risk. On average, respondents would like 100% animal testing for farmed animals entering the food chain, with the "concerned" group of respondents having substantially higher WTP. Until the finding of CWD on a red deer farm in Quebec in 2018, the only mandatory testing of all animals before entering the food chain occurred in Alberta Saskatchewan, Manitoba and the Yukon. Since CWD was found on a Quebec farm in 2018, mandatory testing has been expanded to all slaughtered animals in Quebec and to farmed cervids in Ontario.

Table 6. WTP for traceability and animal testing in venison purchases.

Comparison of WTP Estimates for Traceability and Animal Testing for CWD			
2008 and 2009 surveys			
	Traceable	Animal-tested	Traceable + Animal Tested
Aubeeluck (2010) ($/kg) Canadian beef steak			
Canada average	$17.41	$17.23	$19.34
Myae (2015) ($/500gm) venison steak			
Confident about venison and food safety	$5.07	$4.42	$7.76
Neutral about venison and food safety	$2.43	$2.85	$5.97
Concerned about venison and food safety	$11.15	$17.13	$14.93
CANADIAN-Average	$4.57	$5.5	$7.89

In 2018, survey respondents were asked about their willingness to pay taxes to support more CWD surveillance (for a ten-year period). As a test of different types of concerns, prior to the willingness to pay taxes for CWD surveillance, there were questions related to various risk issues (e.g., food safety, animal health, economic risks). The willingness to pay additional taxes is at the upper end of the possible range, as presented in the question (e.g., between $25.00 per year to over $300 per year for ten years) indicating that the issue is seen as worthy of public investment (similar results were seen in Forbes (2008) for Alberta). Of the three negative potential impacts from CWD, it appears that concern about animal health (predominantly wildlife health) is seen as the highest priority in the respondent's minds. For many people, the food safety issue can be resolved by choosing not to eat venison.

Summary

Given the spread and the potential impacts of CWD on wildlife, economic activities related to cervids, the continuing debate about the potential transmission of the disease to humans and domestic animals and the costs of surveillance and management, the Canadian public is a stakeholder in the management of the disease. Specific themes arising from national surveys over the last decade suggest:

- Over time, the number of people who have ever eaten venison has increased. Eating frequency does not appear to be increasing across the population over time
- Awareness and knowledge of CWD has dramatically *declined* across time. Even though the general level of awareness is down in 2018, there is much stronger disagreement with the statement 'The threat of CWD has been exaggerated', even from hunters than was found in 2009.
- The public is significantly interested in mandatory CWD animal testing before meat is marketed and continues to be interested in supporting tax increases to pay for management or surveillance. This implies that healthy cervid populations are important to the Canadian public.

Indigenous Rightsholders

Background

A key group of rightsholders in CWD impacts and management are Indigenous peoples. Indigenous peoples face many challenges in sustaining strong traditional economies based on hunting, fishing and gathering. Wildlife disease is among those stresses on ecosystems and communities in Canada, which has implications for broad community well-being (e.g., cultural continuity, economy, food security and human health).

Results

A number of studies have been undertaken with Indigenous communities regarding CWD. Parlee et al. (2014) recognize the important role of Traditional Knowledge in wildlife health monitoring and note that care is required in dealing with trust in information and risk communication. Chiu et al (2016) examine caribou consumption and substitution patterns with other foods such as store-bought meats, which are constrained by high costs in northern communities. Overall, findings indicate that caribou is an important food source contributing to nutritional quality and diet diversity. Along these lines, Natcher (2019), in an Alberta sample, found 49% of households harvested traditional foods, which made up on average 20% of household diet. In a longer, on-going study (Parlee et al., 2020), data has been collected from 2007-2018 with 105 harvesters from 22 northern Alberta communities, who reported hunting in roughly 53 wildlife management units (WMUs). Results suggest that elk, moose, and deer all contribute substantially to the diets of communities, specific animal contributions vary geographically. Average consumption of meat (for all species, for all years, and in all regions) was 0.8 meals/week with greater dependence on moose in the north and western parts of the province (1.35 meals/week). Hunters generally share hunted meat with immediate and extended family groups and across local and regional communities. Levels of concern regarding potential effects of CWD were high in all areas for all years, with lesser concern reported by hunters in western Alberta (in 2011) where CWD had not yet been detected. Given that the data were collected in different communities in different years, analysis and conclusions about changes over time are limited. Ongoing research collaboration between the University of Alberta and Indigenous communities is aimed at better understanding the significance of moose, deer, and elk to local diets, and the ways that concerns about the disease influence harvesting decisions and consumption of meat. The research also highlights the types and level of information individuals have about CWD, information (about 58% reported receiving some information) which can contribute to influencing harvest decisions. Although information/knowledge is higher in eastern Alberta (closer to areas currently known to have CWD presence) there does appear to be some lack of knowledge about CWD. This lack of knowledge is a potential barrier to proactive surveillance and management (even co-management) of CWD and may represent an important priority for future CWD activities.

Summary

Though information is somewhat scattered, in aggregate, the data add to our understanding about the significance of ungulates to food security of Indigenous peoples in western Canada, which include significant cultural values including sharing networks. Associated with these important values are concerns about cultural tipping points, arising from environmental conditions, costs, and time constraints of local people. Concerns held by Indigenous communities have been expressed by, among others, community leaders for Treaties 6,7 and 8. In response to a need expressed by First Nations, an All-Chiefs resolution was passed in June 2019, supporting collaborative research on CWD surveillance.

Work undertaken thus far raises questions about how the continued spread of CWD, as well as management efforts (e.g., health advisories), has the potential to contribute to increased food insecurity among Indigenous communities, whose traditional economies are also compromised by other stresses (e.g., habitat degradation, climate change). A greater role of communities in disease surveillance (e.g., monitoring) and in decisions of wildlife management may contribute to both social and ecological resilience. Moreover, Indigenous communities are supportive of an increased focus on CWD testing. Access to testing of harvested animals need to be provided, as they are in other parts of the provinces, to help provide health assurances and information to local peoples, and to help monitor the potential spread of the disease northward. Moving forward, academic/community researcher teams, under the guidance of the leadership of partnering communities, will collect data on temporal and spatial variation in cervid health based on Indigenous knowledge (e.g., observation, experience of elders and hunters). Using the same survey instrument as was used in other communities, the research team will coordinate with active hunters and households to understand similar themes (e.g., harvest, consumption patterns). Knowledge exchange of the zoonotic potential of CWD, a specific request by Indigenous partners, will provide an understanding of the variation in knowledge of the health benefits and risks of continued cervid harvest and consumption on human health. However, this will require collaboration with the communities on communications approaches and will require some assistance from government to be effective and widespread.

The implementation of such approaches is not optional but are central to the rights of Indigenous Peoples. CWD has the potential to infringe on hunting rights (see property rights in this section) which are constitutionally protected for Indigenous peoples. Moreover, the supreme court ruling, regarding the Hamlet of Clyde River, et al. v. Petroleum Geo-Services, confirmed the Crown's duty to consult and accommodate Indigenous People before decisions are made that affect their rights (https://scc-csc.lexum.com/scc-csc/scc-csc/en/item/16743/index.do). The case of CWD, and its current and potential future impacts, makes Indigenous Peoples key right holders who will be substantively involved in future decisions.

Farmed Cervid Sector

Background

Commercial cervid farming and ranching in North America originated in the 1960s and gained momentum in the 1980s based upon a desire for agricultural diversification (Geist et al., 2017; Telfer and Scotter 1975). In Canada, the earliest province to establish a cervid farm was British Columbia in 1981 and the most recent was New Brunswick in 2013.[3] Cervid farms now exist in all the Canadian jurisdictions except Prince Edward Island, Newfoundland and Labrador, the Northwest Territories and Nunavut (AAFC, 2019). Legislatively, cervid farming in Canada is shared between the provincial agriculture and environment ministries, while the Canadian Food Inspection Agency (CFIA) maintains oversight of slaughter, export and import of cervids, cervid products such as antler velvet (regulated as a natural health product under Health Canada) sold domestically and exported (AAFC, 2017) and public health issues, such as CWD on farms (CFIA 2017a).

Cervid farms were established for a number of different reasons. Some farms focussed on the export of elk antler velvet to Asia, mostly to South Korea—a trade that dried up with the finding of CWD in Canada (and also the Canadian export of CWD infected animals to South Korea from Canada). The restrictions on trade in antler velvet were a major factor influencing the decline in the industry, although exports of antler velvet have continued to other Asian countries. There was discussion in 2015 (MacArthur, 2015) about reopening trade in antler velvet products with South Korea, but it does not appear that that has moved forward. Some animals are farmed as part of hunt farms in Saskatchewan and Quebec, although this practice has not been allowed in Alberta or elsewhere in Canada. Many Alberta cervid farms raise animals for transport to Saskatchewan hunt farms (prior to CWD more animals were also exported to US farms and this export continues at a reduced level, deer are also exported from Quebec to Saskatchewan and US hunt farms (CFIA (2015)). Other farms sell products such as urine for baiting or use as a cover scent for hunting purposes.

The potential for ingestion of antler velvet to infect people, should CWD be found to cross the cervid-human barrier, has been noted for some time (Angers et al., 2009). Given that current tests for CWD are post-mortem tests, testing antler velvet for the presence of the disease before sale is currently not feasible. Should CWD ever be found to be transmissible to people, this potential route of transmission would need significant attention. Currently sales of antler velvet are regulated through the Health Canada Natural Health Products Regulations.

Cervid producers are an important stakeholder in CWD discussions for a number of reasons. First, the initial case of CWD in Canada ostensibly came from a domestic elk imported to Saskatchewan in 1996, although with no testing of wild animals before that, it is not possible to say if the disease was previously present or not. Second, cervid producers are at significant economic risk from CWD, due to export market

[3] British Columbia in 1981; Manitoba and Saskatchewan in 1982; Alberta in 1984; Ontario in 1997; Quebec in 1993; Nova Scotia in 1989; the Yukon Territory in 1996; and New Brunswick in 2013.

volatility and the high costs associated with CFIA biosecurity requirements, such as fencing, CWD testing, handling facilities and wash stations—both to contain possible outbreaks on their farm and to prevent infection from wild cervid populations. The discussion of disease control in wild cervids has implications for domestic herds, and vice versa.

Numbers of cervid farms are on a steady decline since 2000 largely because of the declining economic opportunities associated with cervid farming (Figure 7). The industry had been encouraged by government programs, particularly in Saskatchewan and Alberta, as a source of diversification in the livestock industry. The average number of animals per farm has flattened out after also declining between 2006 and 2011. The number of animals being farmed (estimated to be 19,927 elk and 32, 182 deer in 2018, AAFC) in the country has declined significantly[4].

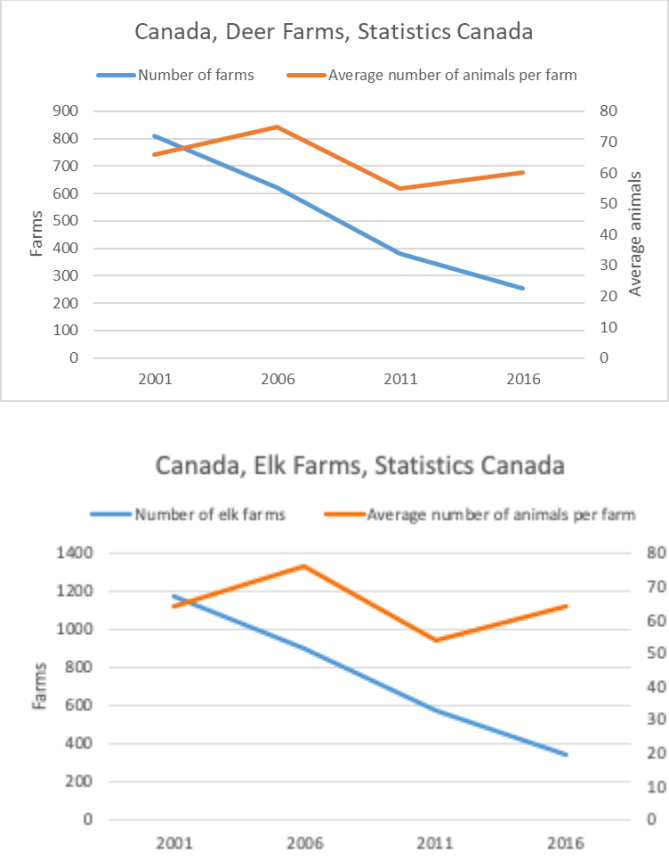


Figure 7. Number of Canadian deer and elk farms and average animals per farm from 2001-2016. (Source: AAFC, 2019)

[4] To put the farmed cervid data in perspective in terms of harvest and consumption, farmed cervid consumption likely makes up a relatively small part of total cervid consumption (farmed plus wild). For example, in Alberta alone approximately 50,000 deer are harvested annually by licensed hunters. This includes almost 14,000 mule deer in 2019 (https://open.alberta.ca/publications/hunter-harvest-report-mule-deer-estimated-resident-harvest-for-mule-deer) and almost 38,000 white tailed deer in 2019 (https://open.alberta.ca/publications/hunter-harvest-report-white-tailed-deer-estimated-resident-harvest-for-white-tailed-deer)

Cervid farming is different across the country with red deer farm animal numbers dominating in Eastern Canada, elk farm animal numbers dominating in Alberta and Saskatchewan (Figures 8, 9, 10, 11). This directly affects the possibility of transfer from wild animals to farmed animals and vice versa given different geographic ranges for each of the wild species.

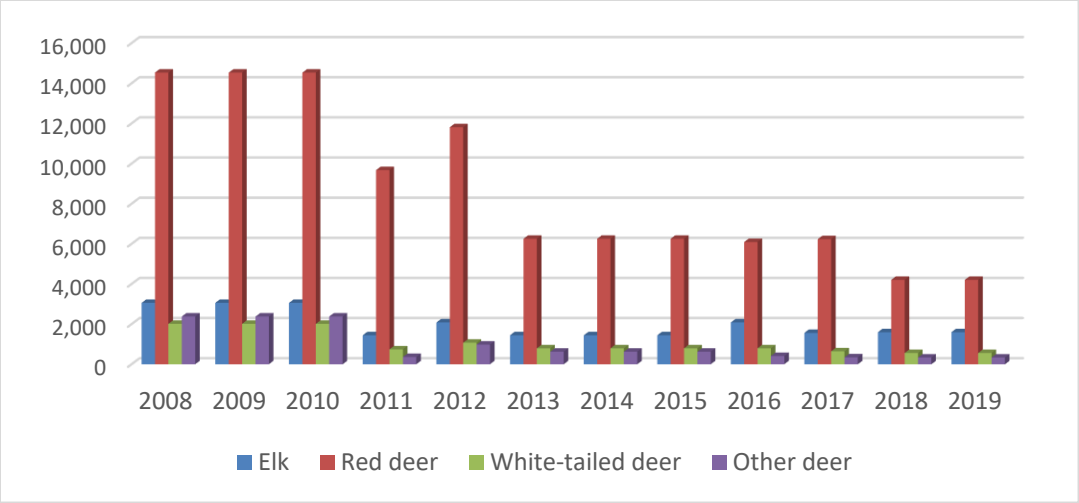


Figure 8. Number of farmed cervids by species in Quebec between 2008-2019 (Source: AAFC, 2019).

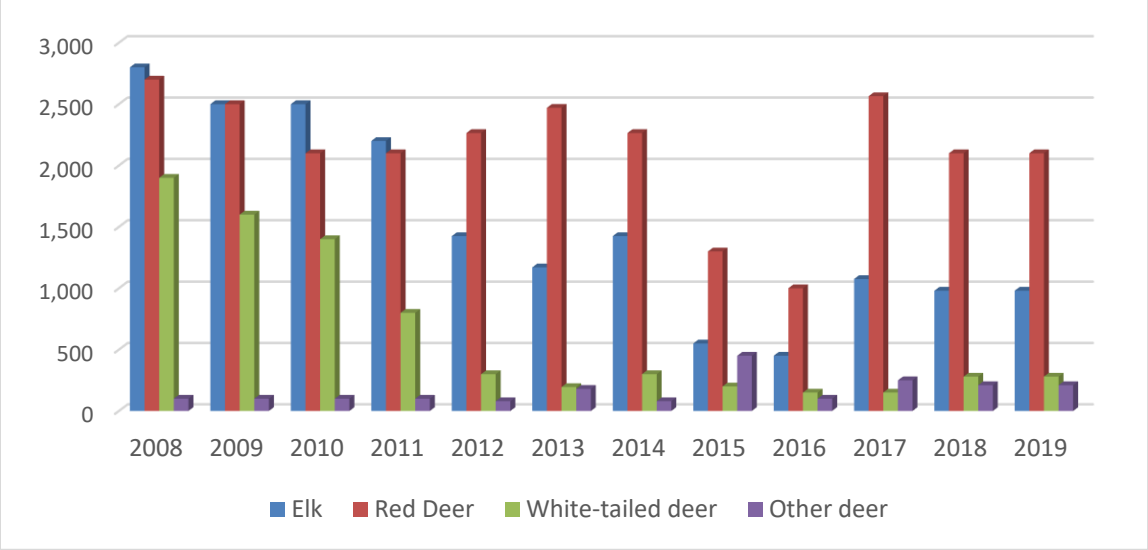


Figure 9. Number of farmed cervids by species in Ontario between 2008-2019 (Source: AAFC, 2019).

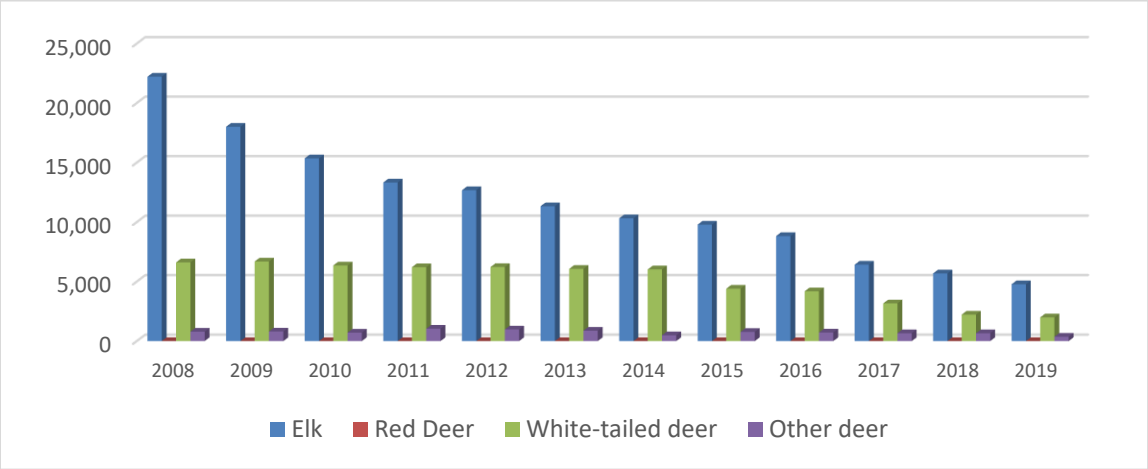


Figure 10. Number of farmed cervids by species in Saskatchewan between 2008-2019 (Source: AAFC, 2019).

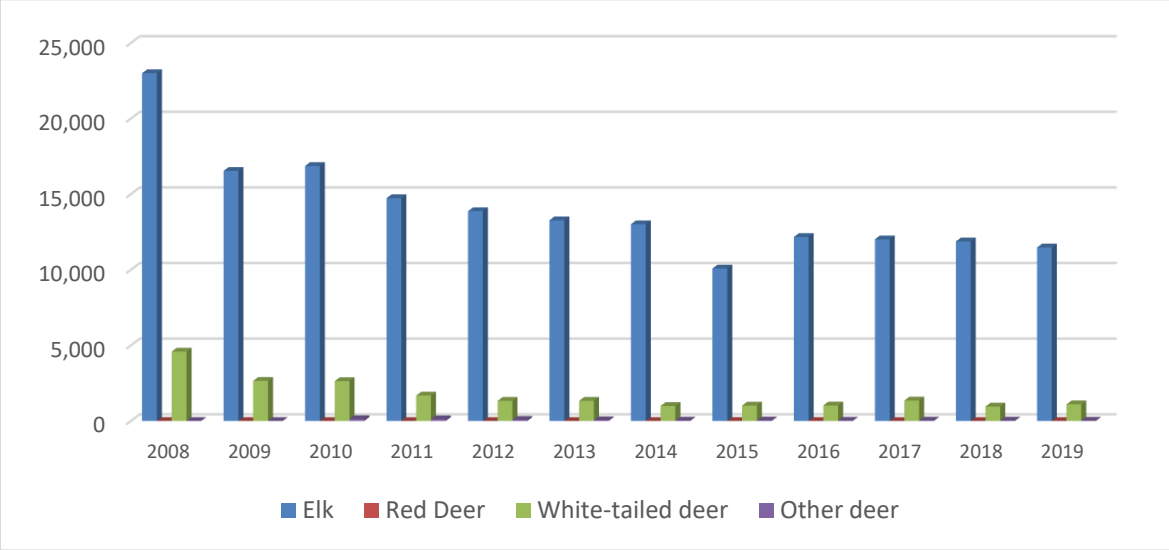


Figure 11. Number of farmed cervids by species in Alberta between 2008-2019 (Source: AAFC, 2019).

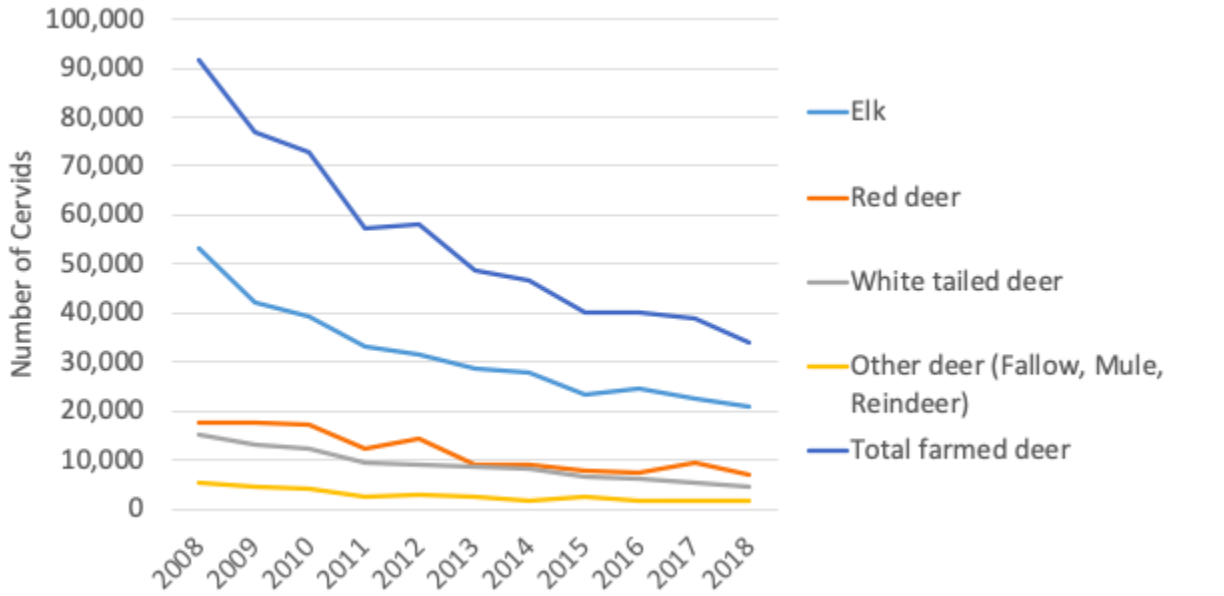


Figure 12. Domestic cervids in Canada 2008 - 2018. (Source: AAFC, 2019)

The arrival of CWD had a devastating economic impact on the cervid producing industry, as shown in the trends in the previous Figures. Initially all Asian countries banned the import of cervid (elk) antler velvet from Canada although South Korea has maintained this import ban, other Asian countries have relaxed the restrictions. As well, in 2002, the US banned the sales of trophy deer and elk from Canada to US hunt farms, although some trade resumed subsequently. As of 2021, 32 US states and 7 Canadian provinces prohibit imports of live cervids from any place CWD has been detected. A group of cervid farmers also sued the government (after approval to bring such a lawsuit from the Supreme Court) due to the damages they faced from CWD infected imported animals after the government had encouraged the development of the cervid farming industry. Saskatchewan producers also sued the provincial government for changes in their farmed animal health status after refusal to sign registration forms indemnifying the government. There was also dissatisfaction within the industry when the CWD "compensation program" (http://cwd-info.org/compensation-cuts-anger-deer-elk-farmers/) was changed in early 2004.

The federal government has subsequently invested over $1 million in the development of an industry traceability system (Salvage, 2010). Since the earliest finding of CWD on cervid farms, the industry has undergone CWD testing of all animals that die or are slaughtered from farms in Alberta, Saskatchewan, Manitoba, Ontario and the Yukon (Quebec since 2018 has returned to testing all animals rather than selected animals) before sale for consumption.

In response to the CWD outbreak in 2002, a CWD Voluntary Herd Certification Program (VHCP name changed to CWD Herd Certification Program (HCP) as of January 1, 2020) was established by the CFIA (CFIA 2002).[5] The intention was to provide owners with the "*opportunity to have their herds identified*

[5] The Canadian VHCP was modeled after the United States Department of Agriculture (USDA) CWD Herd Certification Program.

as elite with respect to CWD" (CFIA, 2017), and provide critical assurance for consumers of cervid products, in particular meat and elk velvet, of the safety of the product they were purchasing. A minimum of five years is necessary for a herd to be certified. There are currently six levels in the certification program: from entry level E up to Level A. The level of assurance is directly related to the time that the herd is enrolled in the program, and any producer that agrees to comply with the program is allowed to enrol (CFIA, 2017). As of April 2018 (announced December 2017), the destruction of and compensation for positive CWD cases will only be provided to producers enrolled in the HCP. If the producer with CWD infected animals is not certified, then the province manages the response to positive findings. A transition period in 2018 was established to allow producers to enrol, and from January 2019, CFIA response and compensation only applies if the producer has been enrolled and compliant for 12 months (CFIA, 2017). According to the CFIA (2019), the program is based on the World Organisation for Animal Health's concept of compartmentalization, where a group of animals are identified as having a distinct health status based on biosecurity management and husbandry practices.

CFIA has managed the process of resolving CWD findings on farms over time. Although there remains a small number of farms being found with animals having CWD every year (Figure 13), the 35 farms found in 2000 and 2001 are dramatically higher than any other year. 2020 appears to be heading for another reasonably high level of farms found as of October. Given the steadily increasing numbers of wild animals being found in Alberta and Saskatchewan recently, the relatively flat numbers of farms (averaging 5 most years) being found with animals having CWD begs the question of whether the current trends in the disease suggest transmission from farms to wild or vice versa. Transmission is also possible from contaminated feed sources (Pritzkow et al., 2015). In 2014, the CFIA proposed a plan of zoning regions found with farms with CWD so that no animals (cervid products and some feed also included in the proposal) could be moved into or out of those areas, but the plan was ultimately scrapped (CFIA, undated). Depopulation and decontamination of soil and buildings is an expensive government program, and this may have contributed to the decision to encourage the farms to register for the HCP or not receive compensation if CWD is found on their farms. For non-enrolled farms, provincial governments will be responsible for managing the CWD outcomes. Interprovincial movement of cervids is also regulated.

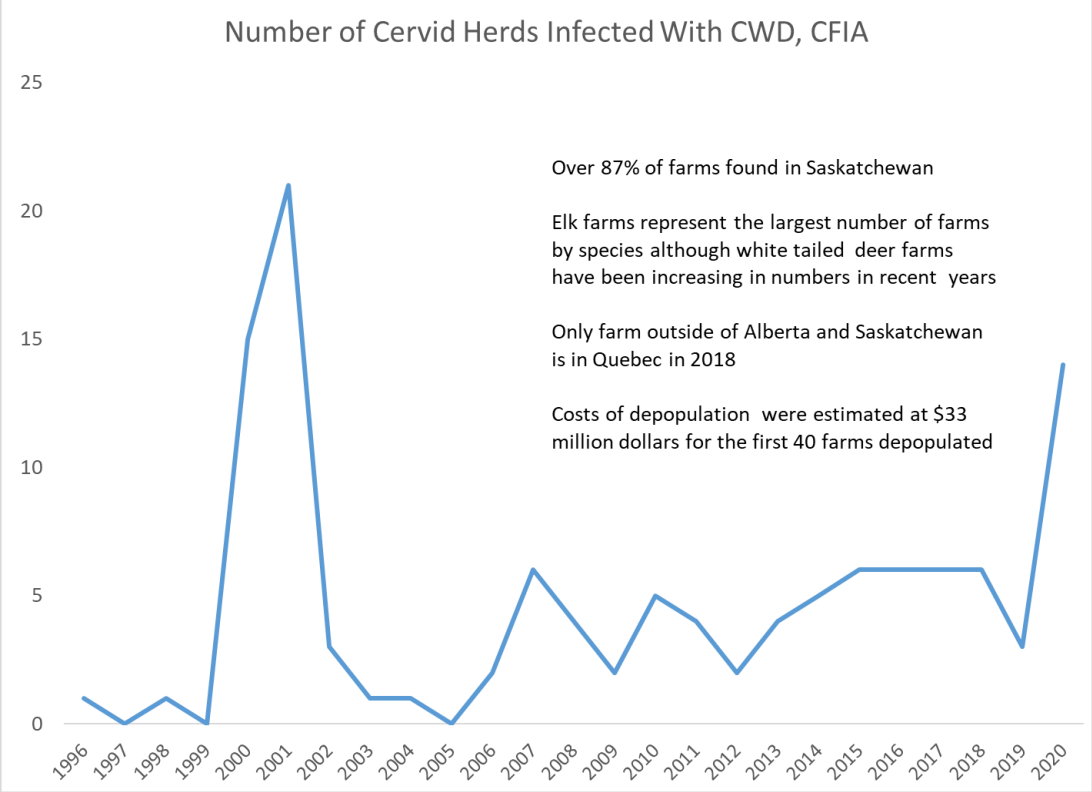


Figure 13. Number of cervid farms in Canada found with CWD (Source: CFIA, 2020).

Given the recurring call among conservationists, wildlife groups and some scientists to "close" the industry, which has been steady since 2002 (Canada NewsWire 2002; Globe and Mail, 2019), cervid producers are extremely concerned about the implications of a positive CWD case in their herds (and possibly in the wild in proximity to their farms). The current status of CWD on farms continues to suggest that the majority of farms with the disease have been in Saskatchewan (for the first time Alberta has had more farms as of October 2020, 8 elk farms compared to Saskatchewan; 3 deer and 2 elk farms). Those numbers have been relatively small and constant until 2020 when numbers have shown a significant increase over previous years. CWD individual animal cases from farmed cervids are far lower than those found in wild cervids, suggesting that eradicating farms might have little impact on prevalence in total cervid populations. One recent complication for the industry may be the finding of CWD in white tailed deer semen (Kramm et al., 2019). In an industry with restrictions on the movement of live animals from CWD endemic areas to others, restrictions on the movement of semen would make artificial insemination (and animal breeding in general) much more difficult for cervid farmers.

Results

In the 2018 Canada wide public CWD survey, there were 51 respondents who self-identified as cervid farmers. To elicit their perspectives relative to other stakeholders, we compare the results from these

respondents to those of hunters that completed the same survey. While acknowledging the issue of a small sample size, it is noticeable that cervid farmers agree that the threat of CWD has been exaggerated" and that "they and their families have concerns about eating elk and deer meat because of CWD". This response is the opposite to the levels of disagreement with the same statements for hunters.

Table 7. Cervid farmer survey results on CWD awareness, knowledge and risk perceptions (Source: Klotz et al., 2020a).

Question	Survey 2018	
	Cervid Farmer	Hunter
Sample Size	51	450
	% Yes	
Have ever eaten venison	84	97
CWD Awareness prior to survey	63	46
	Score between 0 (no knowledge) and 4 (high knowledge)	
CWD Knowledge Score	2.05	1.13
	Roselius Ranking (positive agreement, negative disagreement)	
The threat of CWD has been exaggerated	**31.37**	**-3.33**
I, or my family, have concerns about eating elk and deer meat because of CWD	**37.25**	**-28.00**

** Red numbers highlight a result of particular interest.*

Another distinguishing result arising from the survey is that cervid farmers are more knowledgeable about CWD (as measured by very basic statements related to location of the disease findings and the animals found with the disease) than most other groups (again forgiving the small sample properties), here compared to hunters. This makes intuitive sense, in that farmers in this industry are keenly aware of the health and economic risks associated with CWD to their operation—both from other domestic cervids or transmission from wild cervids and educate themselves accordingly. Multiple in-person meetings between our research team and members of cervid organizations in Canada qualitatively support this finding.

In terms of agreement with the various CWD management strategies that have been pursued by various governments in Canada, in general the strength of agreement with the management options is lower for cervid farmers (either disagree or neutral) than for respondents identified as hunters. However, cervid farmers (possibly interpreting take no action as applying to no action against CWD that might affect farmers as well as hunters) quite strongly agree with that option as compared to hunters who disagree quite strongly with the management strategy. The public disagreed even more strongly with the premise of taking no action against CWD which places the cervid farm industry at odds with most other

stakeholders. Cervid farmers are happy to see most other management options undertaken as they relate to hunting more than farming.

Table 8. Acceptability of Different CWD Management Options (Source: Klotz et al., 2020).

Question	Survey 2018	
	Cervid Farmer	Hunter
Sample Size	51	450
	Roselius Ranking Score	
Cull Elk	43.14	58.00
Cull Deer	41.18	58.00
Mandatory submission of heads	39.22	62.22
Voluntary submission of heads	35.29	61.56
Educational materials	50.98	80.22
Open public meetings	39.22	74.00
Mailouts	35.29	64.89
Freezer locations	43.14	67.56
Additional hunting tags	50.98	75.33
Take no action	**41.18**	**-63.11**
Restrict baiting of animals for hunting purposes	39.22	**30.00**
When vaccines are developed, implement vaccination program for wild deer, elk and moose	**43.14**	66.00
When technology allows, subsidize data collection of different samples (fecal samples etc.) to monitor CWD spread	**37.25**	73.78

** Red numbers highlight a result of particular interest.*

Figure 14 below visually presents a similar comparison of possible management options for CWD among general Canadian residents and cervid producers.

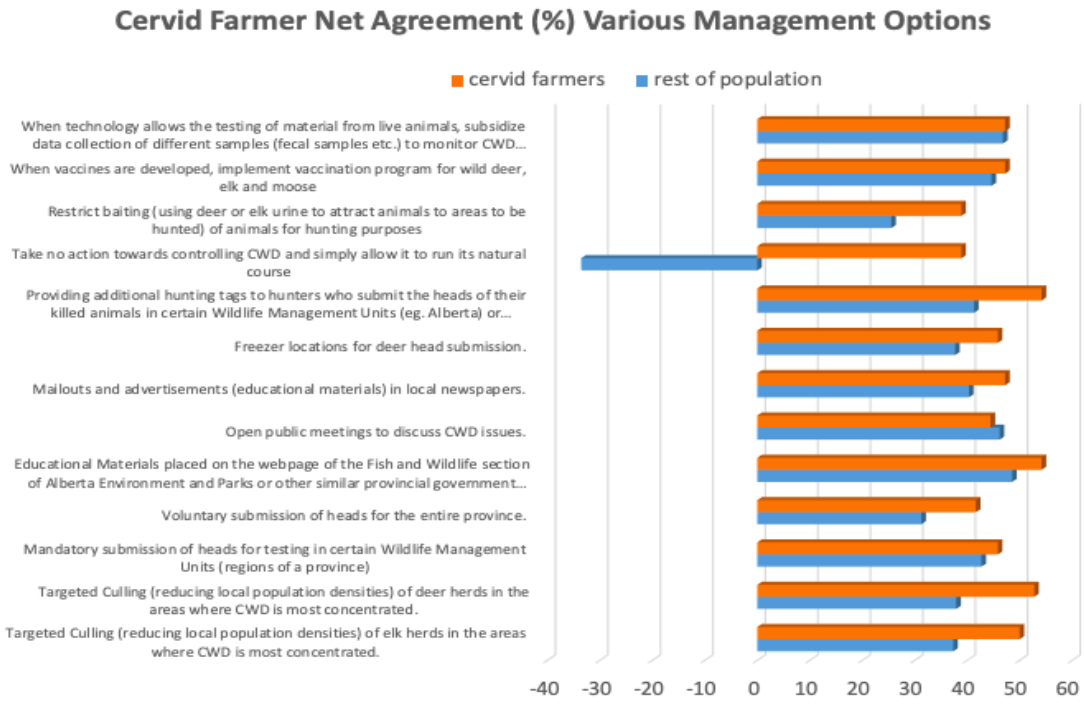


Figure 14. Cervid producer agreement with various management options vs the general population (Source: Klotz et al., 2020a)

Summary

Commercial cervid farming was a relatively new industry when the first case of CWD was discovered in Canada. It is worth mentioning that the cervid farming sector also includes hunt farms in Saskatchewan and Quebec that have their own unique CWD management issues, related to for example, size of operations and ability to regularly observe animals, that need to be addressed. Since the discovery of the disease and alleged actions of domestic cervid transport from the US, the industry has been in relative decline. Other salient points from the secondary data and primary survey data include:

- Characterized by government and opinions of hunters and wildlife managers as responsible for the arrival of CWD in Canada
- Cervid farmers have a high level of knowledge on CWD.
- Given the decline in the industry size, current producers are dedicated to preserving the industry they have been involved with over the last forty years and feel there is little evidence today to support the fact that they are responsible for continuing spread of CWD. (e.g., from 2002 it took until 2015 to find a second elk farm in Alberta with CWD, possibly related to the gradually increasing participation in the HCP which may facilitate detection of CWD).
- Continued requests to close cervid farms from different groups may make multi stakeholder policy agreement difficult to find.

Alberta Hunters

Background

The hunting community is an integral stakeholder in CWD and wildlife management discussions. They have a personal interest in maintaining healthy wildlife populations, they are on the land viewing wildlife patterns more than the general public, they consume deer meat on a regular basis, and they financially contribute to wildlife management through the purchase of licenses. As such, wildlife decision-makers across North America have engaged with this group to explore effective options for both surveillance and management of the disease (Pybus, 2012, Vaske and Miller, 2019).

In Canada, the importance of CWD has been recognized by provincial wildlife authorities, since the disease was first detected in Saskatchewan (1996) and Alberta (2002). Saskatchewan has implemented surveillance programs intermittently, and Alberta has established an ongoing CWD surveillance program through their mandatory head submission designated wildlife management units (WMUs). In 2019, Alberta hunters were required to submit mule deer and white tail heads from 42 WMUs in eastern and central Alberta; and voluntary submission of heads for all cervid species was encouraged across the province. Since the inception of this program, over 70,000 heads have been tested. Management strategies have ranged from herd reduction programs in 2008 (Pybus, 2012) to replacement tags for hunters that harvested CWD positive animals.

Results

The Alberta hunting community has been extensively surveyed by Adamowicz et al. (2008, 2019, 2020) with funding from the Alberta Prion Research Institute[6]. Specifically, surveys were distributed to Alberta hunters to outline their perspectives on the 2007, 2017, 2018 and 2019 hunting seasons. These surveys provide a comprehensive longitudinal dataset of hunters, their risk perceptions and management options for CWD in Alberta that has broad applicability to other provinces in Canada. These surveys and research surrounding them also provide information on the economic benefits and costs associated with the use of hunters in the management of CWD. Collaboration with the hunting community to support the management of CWD is supported by the public and by resident hunter populations. This information on benefits and costs is employed in the analysis of policy options outlined below.

[6] Adamowicz (2008) Research report to the Alberta Prion Research Institute. University of Alberta. Edmonton. Adamowicz, W., E. Goddard, M. Luckert, with L. Xie and J. Pattison-Williams. (2019, 2020). Research reports to the Alberta Prion Research Institute. University of Alberta. Edmonton.

Table 9. Overview of surveys conducted of Alberta deer hunters (Source: Adamowicz et al., 2008, 2019, 2020) funded by the Alberta Prion Research Institute.

Year	Method	Sample Size
2007	700 hunters were randomly selected from the AEP hunter license data (50% rural whitetail deer license holders and 50% urban mule deer license holders)	90
2017	Designed by research team and distributed to a sample of 5,000 Alberta special license holders by the Alberta Ministry of Environment and Parks (AEP)	878
2018	Designed by research team and distributed to a sample of 5,000 Alberta special license holders by the Alberta Ministry of Environment and Parks (AEP)	399
2019	Designed by research team and distributed to a sample of 5,000 Alberta special license holders by the Alberta Ministry of Environment and Parks (AEP)	1,089

One question addressed in the surveys is whether CWD is influencing license sales. Surveillance data shows that the cervid species most susceptible to CWD in Canada are mule deer in general, particularly males (AEP, 2020). For example, the Alberta surveillance program indicates that in 2017 approximately 8% of mule deer tested in the province were positive for CWD. In 2018 this increased to 12% and 2019 season results indicates this is now 17% (AEP, 2020). As AEP only provides averages for the entire province in their published results, it should be assumed that some WMUs are facing much higher prevalence levels of the disease.

Despite this increase in CWD, to date Alberta mule deer hunters are not responding negatively to the presence of CWD. Despite 97% of hunters being aware of CWD in 2019 (and 69% of those having heard detailed information of the disease) and the publication of the prevalence levels on the opening pages of the annual hunting regulations (see Figure 1), mule deer license sales continue to increase (Pattison-Williams et al., 2020).

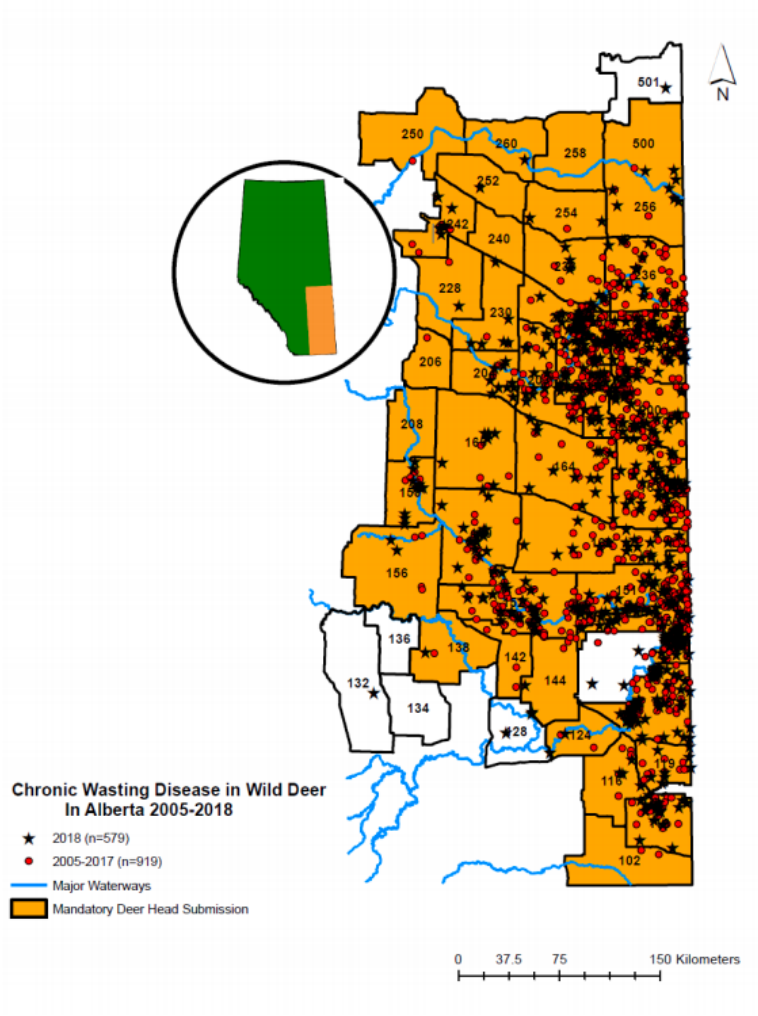


Figure 15. Chronic wasting disease in wild deer in Alberta from 2005 – 2018 (Source: AEP, 2019).

Further supporting this trend is that 77% of respondents who had received a positive CWD from an animal they had hunted in previous years indicated they had returned to the WMU where they had hunted the positive deer (2019 AB Hunter Survey, 2020). An interesting trend found by Adamowicz et al. (2019, 2020) over the last three years is that more hunters are checking for the presence of CWD in WMUs before applying for draws (Figure 3). The largest increase was between 2017 and 2018, possibly due to public media coverage of research indicating potential transmission to macaque monkeys (Czub et al. 2017).

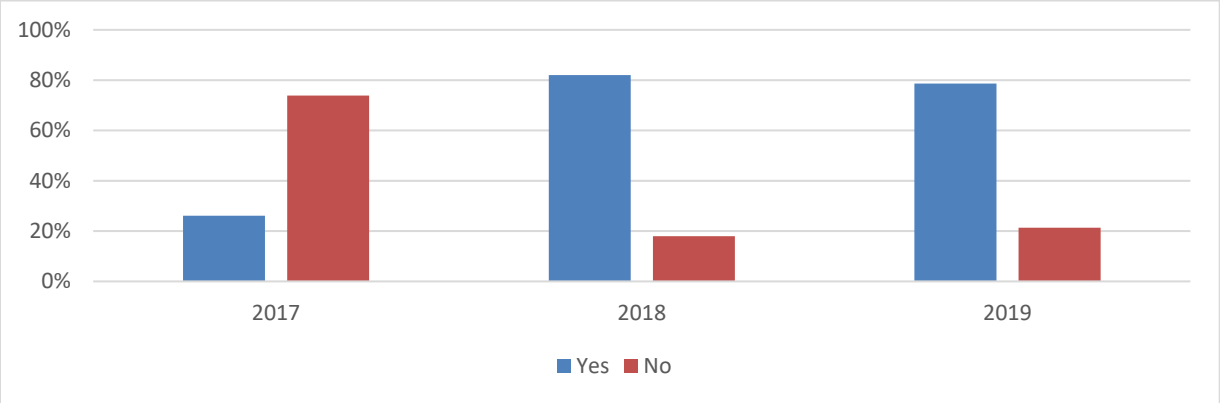


Figure 16. Percentage of hunters that check for CWD presence in WMUs prior to submitting draw applications based upon 2017-2019 hunter surveys (Source: Adamowicz et al., 2019, 2020).

The response of mule deer hunters in Alberta to CWD has been explored empirically in terms of license sales by Pattison-Williams et al (2020). Their findings support both these descriptive results, and published literature from CWD impacted states in the USA, which suggests hunters will not avoid CWD areas until prevalence levels become extremely high (Vaske and Miller 2019).

Risk Perceptions

The longitudinal hunter surveys by Adamowicz et al. (2019, 2020) also explored how hunters are perceiving the risks associated with CWD. Three categories were presented to respondents: risk to wildlife, probability of eradication, and risk to human health.

Overall, responses indicate very little change over time. Even with CWD spreading and prevalence increasing there has been little change in the perceptions and views of hunters in Alberta. This suggests that current levels of CWD are not affecting hunter perceptions. In 2019, approximately 70% of hunters agreed (somewhat or strongly) that CWD is a threat to wildlife herd health in Alberta; these same hunters generally think other hunters also believe it is a threat to wildlife herd health. However, only 3% of hunters believe that it will lead to the extinction of deer in Alberta, while over 60% of hunters do not agree with this sentiment. Over 50% of hunters agree or strongly agree that CWD will remain in Alberta at a low level and will not be eradicated; only 2% of hunters believe it will be eradicated or will disappear due to natural evolution. These numbers have not shown significant change over three years of data. A conclusion from this information is that many hunters are resigned to the reality of hunting with CWD in Alberta. Finally, very few respondents agreed that CWD is a threat to human health, though nearly half of hunters simply don't know (don't agree or disagree). Again, very little change over time occurred.

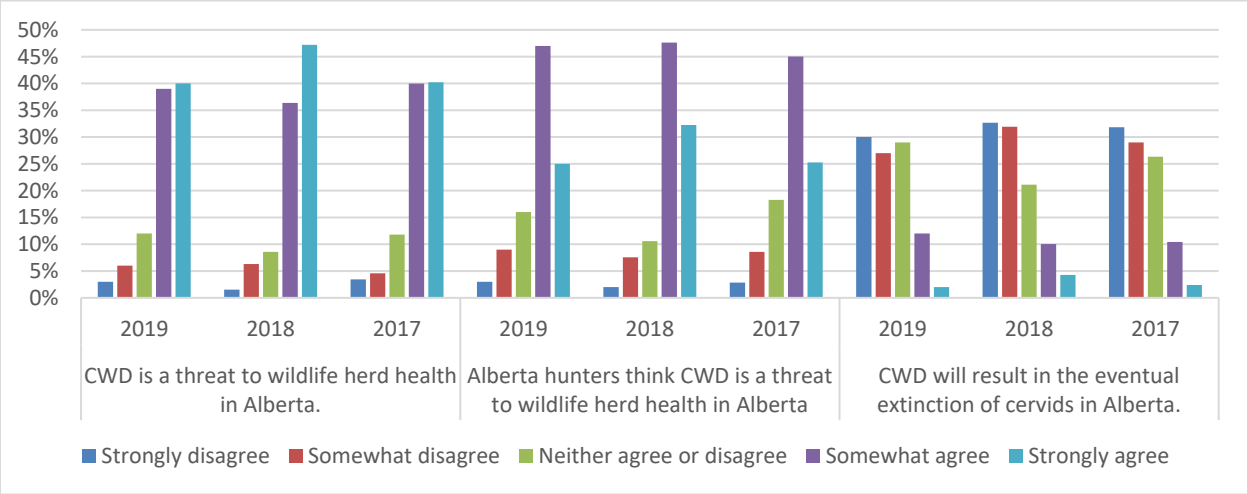


Figure 17. Alberta hunter perceptions of the risk of CWD to wildlife in Alberta (Source: Adamowicz et al 2019, 2020).

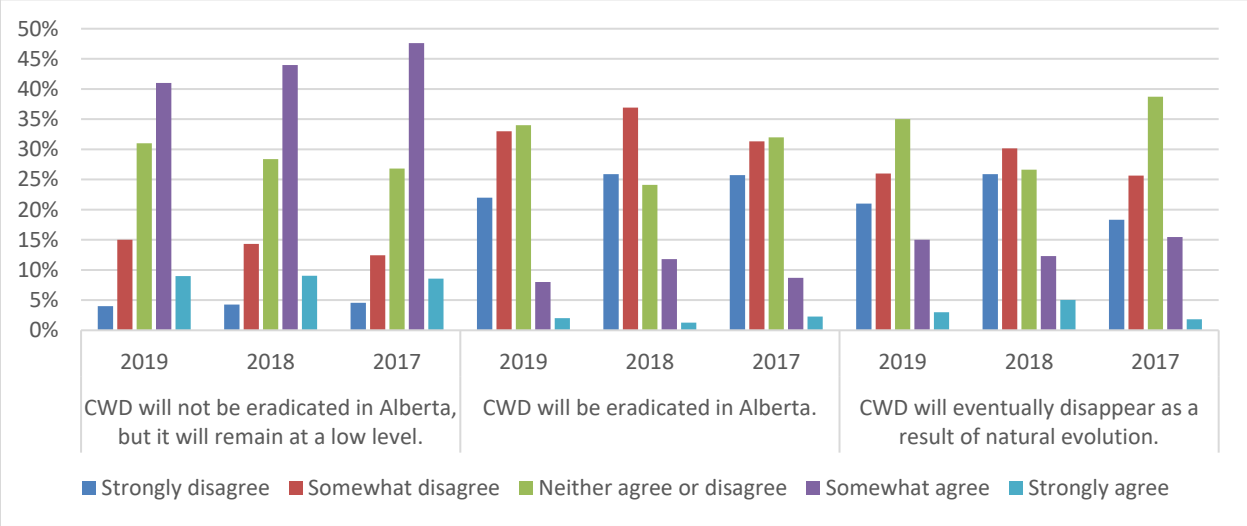


Figure 18. Alberta hunter perceptions of the future of CWD in Alberta (Source: Adamowicz et al., 2019, 2020).

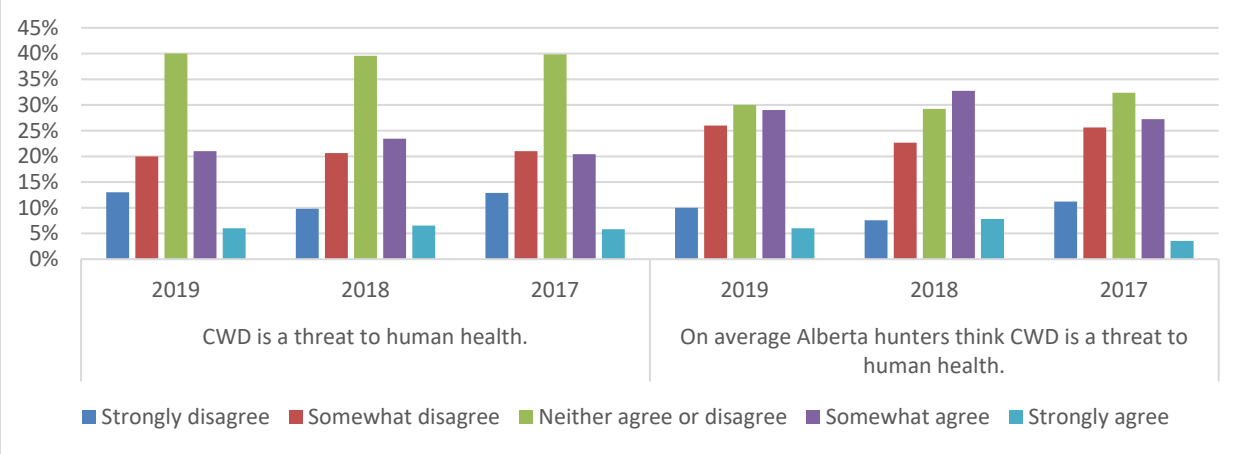


Figure 19. Alberta hunter perceptions of the risk of CWD to human health (Source: Adamowicz et al., 2019, 2020).

Respondents were also asked about actions that could reflect perceptions of risk. When asked their level of agreement with eating or giving away meat *before* receiving the CWD test results from their harvested animals, nearly 50% of people disagree (strongly or somewhat) with this action. Those that strongly disagree have increased over time, but those that slightly disagree have remained relatively constant. However, approximately 30% of people still agree (slightly or strongly) with eating or giving away meat prior to knowing the test result. Those that somewhat disagree are decreasing over time from 27% in 2007 to 17% in 2019; those that strongly agree have remained relatively constant over time, albeit with a slight increase—a difference from the previous sentiments.

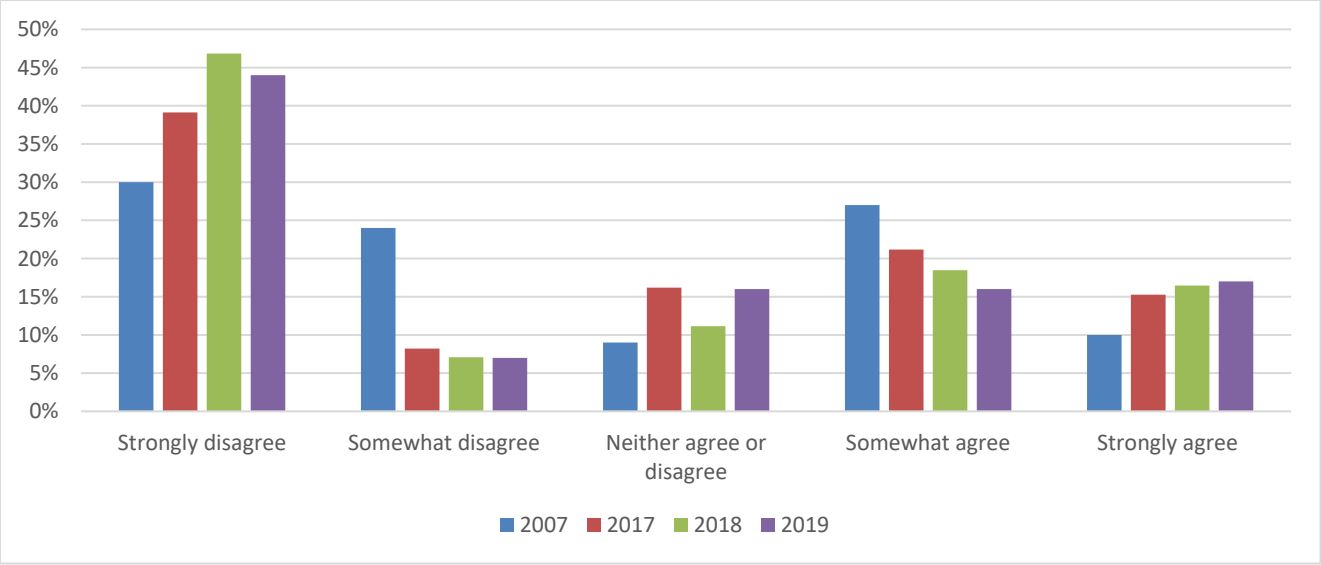


Figure 20. Alberta hunter perceptions of the risk of CWD to human health based upon willingness to eat or give away meat before receiving CWD test results (Source: Adamowicz 2008; Adamowicz et al, 2019, 2020).

Management Options

Respondents were also asked to indicate their level of agreement with a range of policy options that engage hunters in CWD management. All options involve some level of incentive for increased hunting, thereby reducing populations—and therefore transmission—of the disease in specific areas. A description of the management options is included in Table 9.

Table 10. Policy options described in the AB Hunter Surveys 2017-2019 (Source: Adamowicz et al., 2019, 2020).

Policy	Description
Expansion of hunting season	Extending current hunting seasons in high-risk CWD areas for two weeks into December (or one week in October).
E**xtra tags / licenses**	You can purchase one extra tag for mule deer if you win a special license draw for high-risk CWD areas. You can get an extra priority point in the draw system for mule deer special licenses for high-risk CWD areas if you submit one mule deer head.
Gift cards	You can get a gift card reward if you submit heads from high-risk CWD areas.
Donation	You can donate the monetary reward to a conservation organization if you submit heads from high-risk CWD areas.
Special quota hunts	To reduce deer populations in the most CWD prevalent areas have special quota hunts from December through February
Extra female tags	To reduce infected herd sizes, increase the number of female tags in high-risk CWD areas.
Three-point buck restriction	Reduce number of mature, infected males with a minimum 3-point restriction in high-risk CWD areas.

Over the three years, the most preferred option of Alberta hunters are additional tags, followed closely by the expansion of the hunting season. Donations and gift cards are not preferred options and therefore policies that use that approach are expected to have a lower success rate. The least preferred option is a three-point buck restriction. Again, there was little change over time between preferences.

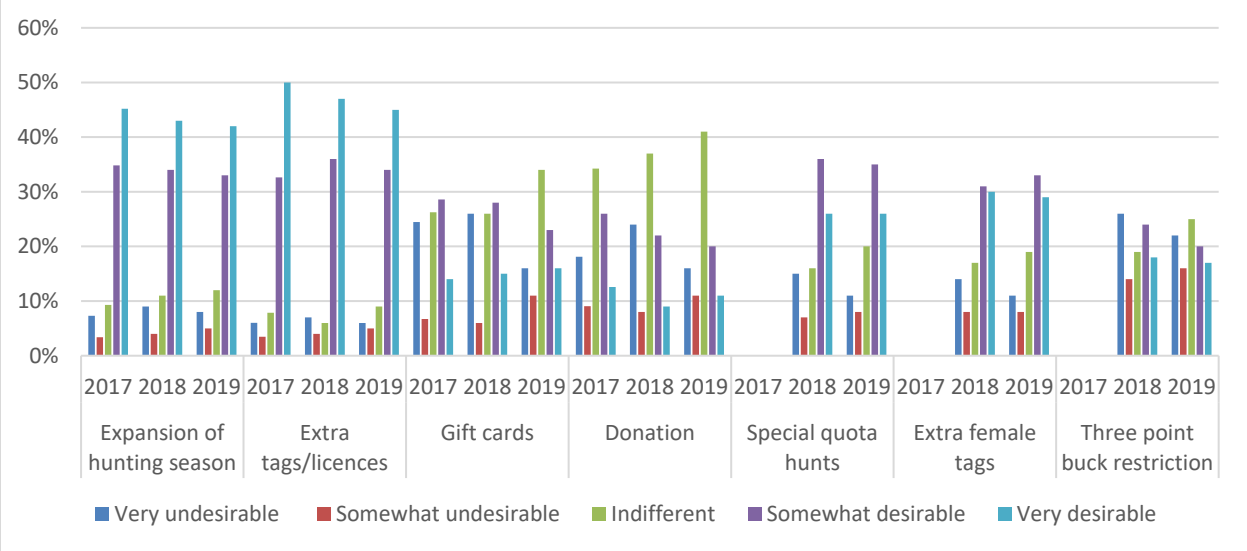


Figure 21. Alberta hunter preferences on CWD management options (Source: Adamowicz et al., 2019, 2020).

Additional analysis into the management option of season expansion has been completed by Xie et al. (2020). The authors estimate an econometrics model based on revealed preference (actual trips) and stated preference (intended trips) for recreational hunting trips in Alberta to estimate how individual hunters would respond to a longer hunting season. Results indicate that hunters substitute activities both spatially (where they hunt) and temporally (timing of their hunt) in order to increase the benefit they derive from hunting. These findings suggest that time flexibility could be used as an incentive to change behavior when decisions involve time, as in the case of expansion of the hunting season beyond the standard month of November and into October or December.

Indication that season extensions do impact the trip behaviour of hunters—in contrast to the presence of CWD, which currently does not (Pattison-Williams et al., 2020)—this result is important and timely for wildlife managers seeking alternative to slow the spread of CWD. It shows that there are benefits from hunters that are willing support the reduction in deer populations through extended seasons, which are financially more attractive that the costs associated with herd reduction programs. This benefit information is discussed in the policy options section.

Summary

A message conveyed from Alberta mule deer hunters through ongoing surveys is that action to reduce spread and prevalence of CWD provides individual hunter level benefits and regional economic benefits. While perceptions of CWD have not changed much over time, management actions should be implemented soon, as increasing prevalence levels occurring in Alberta and Saskatchewan may remove the attractiveness of several of the policy options. These insights are important for the assessment of

benefits and costs of policy options as outlined in the policy discussion section below. Other conclusions from this ongoing research indicates:

- Fairly constant hunter awareness and perceptions of CWD over time.
- License sales are not declining over time, indicating that hunters are not reducing their effort, even with moderately high levels of CWD present.
- Hunters are concerned about CWD impacts on wildlife herd health, and do not think eradication is likely.
- US research indicates reduced hunting effort occurs when CWD reaches high (>30%) prevalence levels. While this is not evident yet in Canada, increasing numbers of hunters are checking prevalence levels prior to draw submission, indicating a shift could occur if prevalence increases dramatically.
- Management options such as hunting season expansion can provide a high benefit-low cost approach to CWD management rather than financially and socially costly herd reduction approaches.
- The removal of the replacement tag program in Alberta 2019 was not popular among some hunters and should be reconsidered; although recent data suggests that the majority of hunters are not opposed to this change in program. (Source: Adamowicz et al., 2019, 2020).

Professional Outfitters

Background

Outfitted hunting is an important contributor to the economies of Canada and the USA, with particular benefit to rural and remote regions. In 2017, 730,000 clients were served by professional outfitters in Canada, and these clients spent over $3.8 billion (2017 CAD$) and supported nearly 37,000 jobs (CFOA 2018b). Many of these clients come from the US, where they spent approximately $58.6 billion (2007 USD) in 2007. Attracting more of these clients to Canada represents an enormous economic and conservation opportunity for the industry in Canada.

The potential for CWD to affect client choices makes the professional outfitting community an important stakeholder in CWD management discussion. Much like hunters, they have a personal interest in maintaining healthy wildlife populations, are on the land viewing wildlife patterns more than the general public, consume deer meat on a regular basis, and financially contribute to wildlife management through the purchase of licenses each year. As such, jurisdictions across North America that are experiencing CWD have engaged with these individuals (Pybus, 2012, Vaske and Miller, 2019). Despite this importance, there is no published academic research on CWD management approaches with professional outfitters in Canada.

Results

As an important stakeholder, we engaged with this group in 2019 and 2020 in order to gauge their willingness to participate in our research to assess preferences for CWD surveillance and management, their risk perceptions and current dealing with CWD. This survey was national in scope and was distributed to 957 outfitters found by an online search; it was implemented through the platform SurveyGizmo and yielded 89 complete responses and 113 partially complete responses. Survey results on awareness, knowledge of CWD, risk perceptions and preferences for various CWD management options are presented below.

Table 11. Professional outfitter survey design process 2020

Year	Method	Sample Size
2020	Online survey instrument to professional outfitters across Canada. Respondents identified by online searches and databases from professional organizations publicly available online. Survey design discussion enhanced through focus group discussion with professional outfitters. 957 outfitters were identified and emailed in February-March 2020. Response rate of 23%	89 completed 113 partial completes

Awareness and Risk Perceptions

It is notable that outfitters are more knowledgeable about CWD than hunters (from across Canada) and by implication the public and cervid farmers (forgiving the small sample properties) (Table 11). This may be a self-selection bias, where the outfitters most knowledgeable/most aware of CWD may have selected to complete the survey. It is also notable (although with small sample issues) that outfitters agree (small strength of agreement) that "the threat of CWD has been exaggerated" (unlike hunters who slightly disagree in 2018) and that they disagree that "they and their families have concerns about eating elk and deer meat because of CWD", similar to hunters.

Table 12. Survey results on outfitter CWD awareness, knowledge and risk perceptions (Source: Klotz et al., 2020b).

Question	Survey 2020	Survey 2018
	Outfitter	Hunter
Sample Size	89	450
	% Yes	
CWD Awareness prior to survey	97 (72 heard a lot)	46
	Score between 0 (no knowledge) and 4 (high knowledge)	
CWD Knowledge Score	2.61	1.13
	Roselius Ranking (positive agreement, negative disagreement)	
The threat of CWD has been exaggerated	**10.34**	**-3.33**
I, or my family, have concerns about eating elk and deer meat because of CWD	**-41.86**	**-28.00**

** Red numbers highlight a result of particular interest.*

Management Options

In terms of acceptability of the various management options that have been tried, outfitters find unacceptable any strategy that increases the number of animals to be hunted (culling either elk or deer or providing additional hunting tags) unlike hunters. Neither outfitters nor hunters find it acceptable to take no action to deal with CWD, although with their disagreement with some management options, it is not clear any of these management strategies are likely to be politically acceptable.

Table 13. Acceptability of Different CWD Management Options to Outfitters (Source: Klotz et al., 2020b)

Question	Survey 2020	Survey 2018
	Outfitter	Hunter
Sample Size	89	450
	Roselius Ranking Score	
Cull Elk	**-35.87**	**58.00**
Cull Deer	**-32.61**	**58.00**
Mandatory submission of heads	52.17	62.22
Voluntary submission of heads	50.00	61.56
Educational materials	58.70	80.22
Open public meetings	61.96	74.00
Mailouts	21.74	64.89
Freezer locations	59.78	67.56
Additional hunting tags	**-20.65**	**75.33**
Take no action	**-17.39**	**-63.11**
Restrict baiting of animals for hunting purposes	**-15.22**	**30.00**
When vaccines are developed, implement vaccination program for wild deer, elk and moose	**42.39**	66.00
When technology allows, subsidize data collection of different samples (fecal samples etc.) to monitor CWD spread	**55.43**	73.78

** Red numbers highlight a result of particular interest.*

Information Sources

One additional focus of the outfitter survey was their CWD information sources and information sharing about CWD with their clients. In Table 13, data on the perceived adequacy of information about various different aspects of CWD is presented. Although the majority of outfitters believe their information on many aspects of CWD is high, it is clear that it is far from complete for many outfitters. Outfitters in this survey are from across Canada and it is possible that outfitters outside Alberta/Saskatchewan know less about the disease than those in the Canadian hotspots (although with the spread to Quebec it should have become a bigger issue in other parts of the country). In addition, we asked the outfitters about their use of different sources of information (not including social media or social contact) and these agents do not use many of the public sources of information, including information on the potential implications of CWD for public health—something that would come from the Public Health Agency of Canada, for example. Given the importance of this group for the management of CWD in the wild it is clear that there needs to

be more effective dissemination of public reliable information if the disease is to be properly assessed by this group. In other survey data, the outfitters responded that they seldom discuss CWD with their clients.

Table 14. Outfitter perception of level of information about CWD (Source: Klotz et al., 2020b).

Prior to receiving this survey do you feel you had enough information about:	Precautions that hunters should take because of CWD	Where deer, elk or moose with CWD have been found in Canada	The symptoms of CWD in wildlife	What type(s) of wildlife species have CWD	What the provincial wildlife agencies are doing about CWD in Canada	What provinces have deer, elk or moose with CWD	When CWD was first identified in deer, elk and moose in Canada	How CWD first got to Canada
Mean	3.586	3.874	3.632	3.908	3.184	3.816	3.632	3.230
Frequency								
Strongly disagree	8	3	6	3	11	4	6	10
Slightly disagree	6	7	12	7	17	9	9	15
Neither agree nor disagree	19	14	12	11	16	13	20	24
Slightly agree	35	37	35	40	31	34	28	21
Strongly agree	19	26	22	26	12	27	24	17

Table 15. Professional outfitter CWD information sources and frequency (Source: Klotz et al., 2020b).

How often have you received CWD information from the following sources over the last year?	Television news	Radio news	Online news	Local newspapers	Provincial Hunting Regulations	Canadian outdoor / wildlife publications	Provincial wildlife agency newsletters	Provincial wildlife agency staff	Canadian Food Inspection Agency website	Public Health Agency of Canada website
Mean	1.278	1.167	2.111	1.444	2.368	1.895	1.737	1.389	1.056	1.056
Frequency										
Never	14	16	5	11	3	7	9	12	17	17
1-2 times	3	1	6	6	8	8	6	5	1	1
3-4 times	1	1	7	1	6	3	4	1	0	0
5 or more times	0	0	0	0	2	1	0	0	0	0

Summary

Professional outfitters are an important part of CWD management and engaging with this community has important practical implications for controlling the spread of the disease.

Specific conclusions from this ongoing research indicate:

- Outfitters had the highest awareness of the disease among stakeholder groups and did not support any of the CWD management options that increase hunting of animals.
- Their views about acceptable management strategies differ considerably from hunter views and from views of the public.
- Although there is a high degree of CWD severity in some parts of the country, CWD is not seen to be the most significant risk to professional outfitter livelihoods, because not all outfitters in Canada deal explicitly with cervids.

Cow Calf Cattle Operations

Background

The existence of CWD is interrelated with cow-calf sector properties as well as with public lands. Pastures are often grazed by cervids and cattle at the same time. Given the development of BSE in cattle there has always been heightened concerns about the possibility of transmission of CWD to cattle. However, experimental and long-term field research has suggested little possibility of transmission of CWD to cattle. In fact, Williams et al. 2018 found no transmission to cattle either orally or after "the environmentally challenged cattle were exposed to CWD-associated prions through common paddocks, feed, and water and via direct daily contact with known and potentially infected mule deer or wapiti (*Cervus canadensis*) throughout the decade-long study period" (pg. 460). While more research will be required to understand if cattle (different genetics perhaps) are resistant to all strains of CWD, the research to date does not suggest the possibility of transmission.

That being said there are other complications associated with CWD and ranches. It is not only the passage of cervids through properties that may spread CWD prions through their saliva, urine and feces. Nichols et al 2015 found experimentally that coyotes who were fed CWD-infected brain material could pass infectious prions in their feces. Other animals may also spread CWD if they ingest carcases of infected cervids, providing an additional challenge for cow-calf producers.

Results

Lee and Good (2015) undertook a survey of beef producers in Alberta (672 responses) on the impact of wildlife on their operations. Ungulates were identified as a major concern for beef producers in terms of disease transmission and in terms of consumption of feed. Feed availability was affected through ungulate consumption of forages and of stored feed. Forage competition was reported for white tailed deer (83%), mule deer (74%), elk (54%) with very few reports of moose competition. A majority of producers facing forage competition did not report forage losses for compensation (available through AFSC) for a variety of reasons, including the fact that returns were assessed as 'not worth the effort' and the fact that producers felt those losses were at acceptable levels (pg. 61). Stored feed is also negatively affected by the same cervids (for 70%) of beef producers and again producers seldom apply for compensation for similar reasons. 55% of the producers in the survey identified disease transmission from ungulates to cattle as being of concern (with 17% of those producers identifying CWD as of major concern) (pg. 67). In terms of implementation of measures to reduce the impact of ungulates on their operations, 85% reported measures to protect feed from ungulates, some producers reported measures such as allowing hunters to hunt on their land to reduce ungulate populations (pg. 69).

In our research, we are currently collecting data from Alberta cow calf producers on awareness, concerns about and preferred management options related to CWD (Goddard et al., 2021). Our initial data collected is too small a sample to be quantified at this point. However, for purely illustrative purposes, it does

appear that cow calf producers have a reasonably high level of knowledge of CWD (as compared to other groups). However, not all producers have high levels of concern about their cattle being exposed to CWD from ungulates, nor are they all observing more cervid carcases on the property recently. For the initial small group of producers there seems to be less concern about any possible trade barriers affecting the beef industry from CWD than the costs of a possible requirement to vaccinate cattle that might occur in the future. Of strategies that might arise in the surveillance for CWD, producers are somewhat more in favour of participating in reporting ill or dead ungulates or doing environmental testing than in allowing more hunters on their land. As more data becomes available, we will be able to see if a larger representative sample of cow calf producers in Alberta, Saskatchewan and Manitoba shows similar results.

Summary

The cattle industry in western Canada is a stakeholder in CWD management due to cross-use of wild cervids on pasture and agricultural lands. Themes expressed by beef producers include:

- Wild ungulates are a concern in terms of disease transmission (CWD, and other diseases) and feed consumption.
- Producers generally like cervids and do not want to see them eradicated from their properties and worry about costs of reducing contact between cattle and cervids.
- Preliminary results indicate limited concern over possible trade barriers impacting the beef industry due to CWD.

Property Rights

Property Rights and Wildlife

Concepts of property rights have long been part of investigations into wildlife management issues (Tober 1981, Lueck 2002, Cheever 2001, Child 1993). Despite the rich literature on wildlife and property rights, much of this knowledge remains at a highly conceptual level with little guidance as to how to apply these concepts to gain insights into specific, contemporary wildlife management issues such as CWD. As wildlife managers assess alternative management actions for CWD, current structures of property rights are germane to defining starting conditions regarding what benefits stakeholders receive, how these rights might be changed by alternative policies and to provide insights into potential impacts of policies on incentives of property right holders.

Many concepts of property rights have their origins in legal definitions of real property, which is non-movable, such as real estate (Kaplinsky and Percy n.d.). But such concepts of property rights are not very applicable when it comes to considering the multiple types of benefits that various stakeholders derive from migrating and wandering wildlife. Alternatively, concepts of Bromley (1991) are useful, where property rights are made up of some type of natural resource asset (e.g., wildlife) and sets of social conditions. Taken together, the asset and social conditions create a benefit stream, or property right, with associated incentives that influence the ways that rights are used by various stakeholders. Stakeholders

can obtain numerous types of benefit streams from cervid species: hunters benefit from harvesting and consuming animals; game viewers benefit from non-consumptive uses that put them in close proximity to animals; the general public benefits from passive-use values associated with just knowing a population is healthy and thriving.

Authors have used many different frameworks to describe and analyze property rights in resource management situations. In describing property rights to cervids, Durocher and Luckert (2020) employ a set of property right characteristics similar to those used by Luckert et al. (2011) for forest policy analysis. This framework can be used to facilitate the comparison of different CWD management actions, their effect on property rights of various stakeholders, and the trade-offs they imply. Appendix 1 describes the characteristics that apply for two stakeholder frameworks: the general public and landowner/hunters. Using these characteristics, Appendices 2 and 3 show the property right structures for, respectively, Alberta and Saskatchewan. For cervid stakeholders in Alberta and Saskatchewan there are marked differences in the types of benefit streams that are currently held by the general public (Appendices 2.1 and 3.1) vs. hunters and landowners (Appendices 2.2 and 3.2). Though hunters' benefit streams are described in terms of use values, the general public has stakes in CWD issues through passive-use values.

Information about property rights can be used in many different ways to help address CWD management issues. First, they may be used to compare and contrast situations in different geographical locations. For example, unlike Alberta, Saskatchewan allows cervid farmers to charge hunters access to hunt and harvest private animals on private land (Tourism Saskatchewan Canada, n.d.). Second, viewing CWD through a property rights lens can also draw attention to uncertainty; uncertainties that arise from unknowns about the spread of CWD and the complexities associated with social responses to the disease (e.g., Vaske 2010). Third, explicit characterizations of property rights can aid in describing changes in CWD policies. For example, the proposed policy options generated in section 2 were developed by changing selected starting conditions described in the Appendices. Appendix 4 describes how these characteristics relate to specific potential changes to CWD management options.

Preferences for Policy Options

Starting with current property right conditions, a number of policy options were identified for the three stakeholder groups: the general public, hunters and landowners. A paired comparison approach was employed allowing econometric estimates of utility (or disutility) associated with various policy options.[7] Table 1 presents a summary of the types of policy options that were proposed and summarizes results for the three stakeholder groups. The results suggest that the general public seems receptive to using hunters to reduce herd sizes, through increased tags and compensation for submitting positive tested CWD heads; and promoting environmental sampling on private land to detect CWD. In contrast, the public seems to dislike using sharpshooters to cull herds (on public or private land), and a number of options involving landowners, including increasing the number of licenses they may obtain, allowing them to charge hunters for access and providing them with extension services. Hunters tend to like the option to help

[7] See Durocher and Luckert (2020) for details on the approach and results.

control herd sized with increased hunter harvests, and support payments to provide incentives to submit harvested heads for testing. Landowners support the use of environmental sampling, even on private lands, to help track the spread of CWD. Another stark result of this study (results not shown here) is the remarkable homogeneity of preferences across different segments of society. There are very few cases with conflicting positive and negative preferences across groups.

Table 16. Summary of Results of Stakeholder Preferences for Proposed Policy Options (Source: Durocher and Luckert, 2020).

General Public	Hunters	Landowners
Government ***sharpshooters*** on ***public land*** ***X (widespread)***	***Doubling*** the ***number of*** available ***tags*** ***✓ (widespread)***	Using ***environmental sampling*** on ***private land*** to identify areas in need of CWD management ***✓ (widespread)***
Requiring landowners to allow government ***sharpshooters*** on ***private land*** ***X (widespread)***	Providing ***free tags in CWD-endemic areas*** ***X (many neutral)***	Allowing ***landowners*** to ***charge hunters for access*** to private land ***X (widespread)***
Using ***hunters*** to increase harvest on ***public land*** ***✓ (widespread)***	Requiring ***unwanted*** animal ***parts*** be ***disposed of*** at a ***county dump site*** ***Neutral***	Providing ***extension services*** to ***landowners*** who ***work cooperatively with their neighbours*** to ***manage*** their ***lands for CWD*** ***X (widespread)***
Restricted movement of ***carcasses*** and ***hunted products*** ***✓ (widespread, not hunters)***	Distributing ***$50 and a tag to hunters*** who ***submit heads that test positive for CWD*** ***✓ (widespread)***	Providing ***extra tags*** to ***landowners*** who ***work cooperatively with their neighbours*** to ***manage*** their ***lands for CWD*** ***(baseline, neutral)***
Allowing ***landowners*** to ***charge hunters for access*** to private land ***X (widespread)***	***Extending*** the ***hunting season*** by ***2 weeks*** ***(baseline, neutral)***	
Increasing the number of available ***landowner special licenses*** ***X (widespread)***		
Government ***compensation*** to ***landowners*** for providing ***access to hunters*** ***(baseline, neutral)***		

Summary

Thus far, the property rights concepts described above have only been used to consider management implications among select stakeholders. An important, but omitted, segment includes property rights and policy options for cervid farmers, whose benefit streams are derived from producing animals and their products. Another important segment is made up of the property rights held by Indigenous peoples, for whom cervids play important roles in traditional and ongoing livelihoods and cultures. However, given the potential for differences in property right concepts and systems for Indigenous peoples, it is not evident what type of property right frameworks would appropriately characterize the benefit streams that Indigenous peoples benefit from within localized social conditions. In order to investigate policy options and their acceptability to Indigenous peoples, future research will need to begin by investigating the applicability of alternative property right concepts in order to develop culturally appropriate property rights approaches.

Synthesis of Perspectives

This section has explored the perspectives of rightsholders and stakeholders impacted by CWD. Using secondary information and primary research methods conducted by members of this research team over the last fifteen years, we present the level of knowledge, attitudes and management preferences for CWD

of each of these groups. Although the methods to elicit these perspectives has some variation due to the unique characteristics of each group, several trends were observed:

Canadian Public:

- Over time, the number of people who have ever eaten venison has increased. Eating frequency does not appear to be increasing across the population over time
- Awareness and knowledge of CWD has dramatically *declined* across time. Even though the general level of awareness is down in 2018, there is much stronger disagreement with the statement 'The threat of CWD has been exaggerated', than was found in 2009.
- The public is significantly interested in mandatory CWD animal testing before meat is marketed and continues to be interested in supporting taxes to pay for management or surveillance. This implies that healthy cervid populations are important to the Canadian public.

Indigenous Rightsholders

- Ungulates are a major component of food security for Indigenous peoples, but also contribute to significant cultural values including sharing networks.
- Concerns about cultural tipping points, arising from environmental conditions, costs, and time constraints of local people have been expressed by First Nations. However, safety of ungulate meat is a driving concern.
- The Alberta Assembly of Tribal Chiefs, representing First Nations in Treaty 6, 7 and 8 passed a resolution passed in June 2019 supporting collaborative research on CWD surveillance.
- Work undertaken thus far raises questions about how the continued spread of CWD, as well as management efforts (e.g., health advisories), has the potential to contribute to increased food insecurity among Indigenous communities, whose traditional economies are also compromised by other stresses (e.g., habitat degradation, climate change).
- A greater role of communities in disease surveillance (e.g., monitoring) and in decisions of wildlife management may contribute to both social and ecological resilience.

Cervid Producers

- Cervid farming in Canada was a relatively new industry when CWD was discovered in Canada.
- CWD caused a serious negative economic shock to the industry, which has been declining in total farms and total animals since CWD was found.
- Cervid farmers are very aware of and knowledgeable about CWD due to the significant economic impact on the industry

- The voluntary herd certification program (VHCP) initiated in 2002 and (HCP) revamped in 2018 is a comprehensive program to prevent CWD exposure, certify safe cervid production for consumption or trade purposes, and enable access to federal compartment response (animal destruction) and related compensation should CWD be discovered.
- Mandatory testing currently for all cervids slaughtered in CWD endemic regions makes testing rates for CWD higher than in wild cervids; positive cases recently are lower in numbers relative to wild cervids.

Alberta Hunters

- Fairly constant hunter awareness and perceptions of CWD over time.
- License sales continue to increase, indicating that hunters are not reducing their effort, even with moderately high levels of CWD present.
- Hunters are concerned about CWD impacts on wildlife herd health, but do not think eradication is likely.
- US research indicates reduced hunting effort occurs when CWD reaches high (>30%) prevalence levels. While this is not evident yet in Canada, increasing numbers of hunters are checking prevalence levels prior to draw submission, indicating a shift could occur if prevalence increases dramatically.
- Management options such as hunting season expansion can provide a high benefit-low cost approach to CWD management rather than financially and socially costly herd reduction approaches.
- The removal of the replacement tag program in Alberta 2019 was not popular among some hunters and should be reconsidered; although recent data suggests that the majority of hunters are not opposed to this change in program. (Source: Adamowicz et al., 2019, 2020).

Professional Outfitters

- Outfitters had the highest awareness of the disease in wild cervids when compared with other stakeholder groups, yet did not support any of the CWD management options that increase hunting of animals
- Their views about acceptable management strategies differ considerably from hunter views and from views of the public
- Even given the severity of CWD spread in parts of the country, CWD is not seen to be the most significant risk to outfitter livelihood from cervid populations

Cow Calf Cattle Operations

- Wild ungulates are a concern in terms of disease transmission (CWD and other) and feed consumption.

- Producers generally like cervids and do not want to see them eradicated from their properties and worry about costs of reducing contact between cattle and cervids.
- Preliminary results indicate limited concern over possible trade barriers impacting the beef industry due to CWD.

Overall, the data confirms that developing policy in this area is complex because of the fact that in any policy option there are groups who perceive the approach as beneficial while others who perceive it as costly. Clarification and careful communication of the impacts of the policy on different sectors, will be critical for policy application.

5.0 INTERNATIONAL TRADE AND CHRONIC WASTING DISEASE

CWD interferes with trade of live animals of the cervid species, of products produced from either farmed or wild animals (such as antler velvet or deer urine), of trophy heads from hunted animals and of meat from (or other parts of carcases) from either farmed or wild animals.

From a Canadian perspective the farmed cervid industry was developed as a source of diversification of the agricultural sector based on low input costs and the use of relatively marginal land (for other agricultural purposes). Hobbs et al. (2000) pointed out that some Canadian provinces did not allow the development of certain deer farms due to the possibility of farmed animals escaping and breeding with wild animals. Initially the elk industry was developed significantly in Western Canada, but the primary economic output was antler velvet largely for the Korean market. The New Zealand cervid industry was developed on similar grounds. From the time of finding CWD in the Canadian market (on a farm) the Korean market was closed to exports of antler velvet from Canada (a boon to the New Zealand industry) and the USA (given the belief that CWD was brought to Canada in a farmed animal exported to Saskatchewan). There was talk of opening the market in 2015 but to date trade talks have not progressed subsequently. It is worth mentioning that Korea was one of the latest countries to relax trade restrictions on Canadian beef that emanated from the finding of BSE in 2003 (2012 with a temporary closure again in response to BSE in 2015). Although other Asian markets such as China did not close their markets permanently to Canadian exports of antler velvet, the Korean market is the biggest market and exclusion from that market had huge economic ramifications for the Canadian elk industry.

Awareness of CWD across North America have resulted in a variety of regulations at national and state /provincial levels. For example, with regard to live animal (and animal part movements), a summary report by the Michigan Department of Natural Resources states that "Thirty states and seven of the Canadian provinces listed prohibit the importation of live cervids from any county, region and/or state where CWD has been detected; have regulations that can prohibit importation from CWD areas; require that the state exporting the cervid be enrolled in an official CWD monitoring and certification program; and/or require only that there has been no diagnosis of CWD in the originating herd or imported cervid. Nineteen states and three of the Canadian provinces listed have banned all cervid imports. One state and one of the Canadian provinces listed have no specific rules listed. In Canada, national disease control of CWD falls primarily under the *Health of Animals Act*, and Health of Animals Regulations." (Michigan Department of Natural Resources, 2020, Page 1). These 2020 numbers show a steady increase in more restrictive trade policies for live animals across time in both countries. Given the increasing spread of CWD in Canada and in the US, measures to stop the flow of potentially infected animals are unsurprising. The USA does allow semen to be exported (even without permits from land with CWD exposure) from Canada, from New Zealand and Australia (protocol in development), as well as embryos from New Zealand and Australia.

In the European Union (EU) and specifically in the United Kingdom (UK) there are also bans on trade in live cervids, from any country known to have CWD which now includes Norway, Finland and Sweden. Finland and Sweden have changed their restrictions on their own findings of CWD. In addition, UK

restrictions (building on EU regulations) include the following: imports are banned into the UK of deer urine, deer faeces, and lures obtained from deer for use in deer hunting or other deer attracting activities which contain the above animal by-products, deer products cannot be imported into the UK if they were manufactured in the USA, Canada, South Korea and Norway (where CWD is present) or produced from deer products from those countries, deer products from countries free from CWD can only be imported under certain conditions. Korea also banned the importation of live elk subsequent to their import of infected animals from Canada. Russia has imported some live farmed cervids from Canada, with the criteria that the farm of origin satisfies a certain level of the HCP certification program.

Meat from cervid animals is not completely banned from trade (or carry from hunted animals). However full carcases are banned from movement between the majority of provinces/states (particularly given evidence of CWD) and across borders. However, for example, the state of Vermont allows imports (from provinces or states of the following: *i) meat that is cut up, packaged and labeled with hunting license information and not mixed with other deer or elk during processing; ii) meat that is boneless; iii) hides or capes with no part of the head attached; iv) clean skull-cap with antlers attached; v) antlers with no other meat or tissue attached; vi) finished taxidermy heads; or vii) upper canine teeth with no tissue attached.* (Government of Vermont, 2020). Meat processed through slaughter plants (from farms) is allowed if the animals have been tested for CWD.

Beyond trade regulations on actual cervids and their products, Norway has imposed trade restrictions on hay and straw to be used for animal feed, imported from countries/regions outside the European Economic Area (EEA). The restrictions include the following: *i) Hay and straw must have been stored for two months before import or use. (Alternative 1 is that the product must be accompanied by a declaration from the producer that the hay/straw was stored for at least two months before export. Alternative 2 is a requirement that the hay/straw is stored two months after import and before use, except for products that were accompanied by a declaration from the producer that the hay/straw was stored for at least two months before export.); ii) Hay and straw from the USA and Canada must be accompanied by attestation from an official veterinarian certifying that the product was harvested in a state or province where Chronic Wasting Disease has not been detected.* (European Commission, 2018). These Norwegian restrictions were based on their own expert risk assessment associated with CWD and the scientific findings that CWD can exist in the environment and in plants after being exposed to CWD from infected wildlife or farmed animals. To date no other countries have imposed similar trade restrictions. At the time of the discussion of zoning as a preventative measure against the spread of CWD (2014), there was the possibility of including restrictions on movements of forage from inside the zone to outside the zone as well. However, these were domestic movement restrictions.

As an example of the development of regulations related to CWD, the European Food Safety Authority (EFSA) has made the following recommendations to protect human health in terms of exposure to CWD: i) *Systematic testing: Only allowing human consumption of meat, meat products and offal sourced from animals that have been tested negative for CWD; ii) Targeted measures: Prohibition of harvesting/hunting susceptible species or the introduction of compulsory testing of animals before human consumption in/from declared infected premises/areas (e.g. a farm, or a surveillance, region, country,*

etc.); and ii) Systematic removal of high-risk tissues from all cervids intended for human consumption with no requirement for testing (EFSA, 2019).

Although these recommendations have not been imposed yet in the EU, it is clear that implementing these regulations would have implications for the import of cervid meats. While these recommendations have varying levels of safety attached to them and also have varying levels of difficulty of implementation, the progression of regulations within North America appears to be following a similar evolution.

Risks associated with contamination from CWD infected animals are being recognized from some countries sensitive to exposure to their own cervids. For example, Australia has an Assessment of Bulk Wheat from Canada in terms of its Animal Biosecurity Risk (Biosecurity Animal Division, 2019). In that assessment they include Chronic Wasting Disease among other livestock diseases. To mitigate against CWD they require pre-export conditions on farm production measures (product must be from broad acre cultivation, mechanically harvested and on farm storage in bags or under cover must be short term in nature, measures to reduce the potential contamination by infected cervids).

Canada also exports hay (see Table 17 below), again trade that could be affected by CWD contamination.

Table 17. Hay Industry Trade, Canada

Hay Industry	000 dollars	2016	2017	2018	2019	2020
All Countries (Total)	Total Exports	121719	138394.9	160015.5	166441.1	178813.7
	Total Imports	15772.25	16162.1	21200.15	29734.22	22586.19
	Trade Balance	105946.8	122232.8	138815.3	136706.9	156227.5

Source: Trade Data Online (accessed: February 17, 2021)

Given the economic impact of trade issues that could occur related to trade in grains and feed, there are significant research needs. For example: how contaminated are feeds—are we monitoring hay in pastures where cattle and cervids graze—over at least the medium term; although we know hamsters can get CWD from eating contaminated feed (Pritzkow et al., 2015) have we any other animal trials ongoing—do we know the possible rate of infectivity; can we accelerate research on pasture treatments that can reduce infectivity without harming animals or plants (e.g., Kuznetsova et al 2018)?

Should CWD ever be found to be transmissible to cattle (although Williams et al. (2018) suggests not likely to date):

- cattle/beef exports would be directly and immediately affected
- it might become necessary for cow calf properties to restrict access by cervids although the costs of protecting cattle in this way are very high

-the development of a vaccine for cattle would potentially become of importance (if such a vaccine is developed for cervids) however vaccination shows up in some tests as animals having been exposed to the disease and this in and of itself could interfere with live animal trade. New genomic tools to distinguish

between vaccination and actual disease evidence in development would be a priority if CWD is ever found to be transmissible to cattle.

While none of these trade restrictions are currently in place it is essential that the potential risks associated with the continuing CWD spread be considered a significant potential trade irritant. Organizations such as the OIE (and considerations at the WTO under the Sanitary and Phytosanitary Regulations on trade) could advance protections and allowable trade restrictions against CWD should the disease continue to spread across countries. Following a One-Health perspective, CWD clearly needs a multiple agency and country focus.

6.0 POLICY OPTIONS

A number of different policy options surrounding CWD have been discussed in the literature. These vary depending on whether the focus is on farmed cervids or wild cervids, the current CWD situation in the region, and numerous other issues. In this section we begin to assess some of these policy options. We first outline the principles we employed in assessing policy options. We provide examples of such approaches that have been considered in other contexts and jurisdictions. We then examine a list of specific policy options related to CWD that might be useful to consider in Canada. The focus is on policies that directly (cervid farm) and indirectly (through reducing spread and prevalence in the wild) affect the Canadian agri-food and agriculture sectors.

For each policy option we outline the benefits and costs of the policy. Often these benefits and costs are measured qualitatively or in a relevant range, as there are gaps in the data that are required for quantification. For example, information on monetary benefits of human health risk reductions is available, but the measure of health risk change associated with the policy may not be available in quantitative form. We provide a recommendation regarding implementation (or not) of each policy option based on the benefits, costs and other information. We also provide a commentary for each case. Some policy options are regional in nature, while others are national. We also list options where there is little information and thus an inability to make a recommendation. In these cases, we make recommendations regarding future research needs. Given the uncertainty associated with various aspects of CWD (transmission within cervids, impacts on cervid populations, transmission to other species including humans, etc.) our recommendations are made based on the most current available information and our judgement of the data and knowledge base. New information and findings will undoubtedly affect such assessments; thus, the recommendations we make could be revised in the future as information and conditions change.

An economic analysis of policy options typically includes an assessment of the costs, benefits and distribution of impacts on a region or population. The options considered may be regulatory or "command and control" policies or incentive-based policies. In general, CWD can be viewed as being costly as a disease because of its potential impact on wildlife populations, risk to livestock, and concerns about risks to humans. As a disease risk, CWD has spatial and temporal elements (spread and prevalence that changes over time). Perrings et al. (2014) describe "economic-epidemiology" as a framework for management of infectious diseases. Their framework differentiates between a private decision maker's problem and a social or public health problem. In the private context individuals make decisions regarding the trade-offs between actions that provide benefits (e.g., venison consumption) and the costs of the disease (health risks or risk mitigation costs). Private and public decision problems may differ if individuals do not take all the costs into account when making their decisions. For example, if individuals do not factor in risks to others when making an individual decision, then a classic externality arises and there will be a need for intervention to address the divergence between private and social outcomes. Further complicating the situation, CWD has many public good aspects. Wildlife health has private (e.g., hunting / harvesting) and public (existence value) characteristics. Public goods are typically underprovided and thus measures must be taken to address these values. Similarly, there are public good

aspects associated with the regulation of goods and services (e.g., food labelling, testing) when there are information asymmetries and uncertainty. All these elements suggest policy options or instruments ranging from strict requirements / regulations, to incentive-based approaches (penalties or rewards), to information provision or moral suasion. In some contexts, investments in technology (e.g., vaccines or rapid CWD tests) may be the best policy option.

It is noteworthy that many examples in the economic-epidemiology literature involve reducing outbreaks (e.g., invasive species) while there is relatively little literature on the treatment of endemic diseases like CWD. Maloney et al., 2020 is an example of the former—they conducted a cost benefit analysis of elk feeding grounds in the Greater Yellowhead Ecosystem. The feeding grounds were originally established to keep elk away from farms and minimize the spread of brucellosis to cattle. However, these feeding grounds increase the risk of the spread of CWD among feeding animals and risk of brucellosis when elk congregate around them. The results of the cost-benefit analysis suggest that in order to minimize the impact on wildlife, the use of feeding grounds should be avoided, and managers should look for other ways to keep elk away from farms. The benefits they consider include economic benefits for hunters, guides, outfitters, and other hunting-related businesses as well as benefits associated with viewing wildlife. The costs include increased rates of brucellosis and cost of elk depredation on private land for farmers.

Wilkinson et al., (2009) used cost-benefit analysis to assess whether culling badgers would reduce tuberculosis prevalence among cattle in Britain. The analysis indicated that although the culling practice would likely have positive impacts on the rates of tuberculosis, the economic cost would likely outweigh the benefits. The benefits in this case were calculated as the reduced cost to livestock while the costs included culling and trapping costs. In this case all benefits and costs were "private" while any public good aspects, including the value of badgers to the public, were not included.

While there are numerous other studies of the benefits and costs of policy options to address wildlife diseases or invasive species, their assessments depend, in large part, on data available for quantification of benefits, costs and risks. In some cases, the private costs or benefits are known, while public good components are generally limited. The case of CWD is complicated because of the issues of farmed cervids, wild cervids, uncertain transmission risks, limited knowledge of costs and significant public good aspects. As well, the data available on costs is inexact and difficult to assess from other jurisdictions.

A general categorization of benefits of CWD reduction include reduced human health risks, wildlife population risks, and economic (trade, tourism, industry) risks. Reduction of CWD could result in reduced costs of waiting for CWD test results, enhanced ability to verify disease free status in trade disputes or for food safety concerns, reduced spread of disease to other cervids and non-cervids, etc. Costs include costs of surveillance programs (including more labs / staff for testing), management (including enforcement amongst other activities) programs, technology investments, potential adverse impacts on consumers, hunters, industry, trade, etc. The risks associated with CWD can be characterized as follows: Human health—still no conclusive evidence, no published studies find human transmission, but health agencies advise against consumption of hunted animals before testing. Wild populations currently infected (deer, etc.)—likely declines in deer (elk, moose) populations with high prevalence

which will affect harvesters and possibly food security in some contexts and will affect wildlife health values. Wild population not currently known to be infected (caribou)—potentially significant impacts on threatened species which will also affect harvesters and food security in the north. Wild population (other animals)—there is evidence to suggest CWD possibly will be transmissible to other animals (Escobar et al., 2020). Site contamination poses ongoing risks to wildlife, cervid farms, livestock properties, and agriculture. There are concerns about risks of spread to livestock (Escobar et al., 2020). And there is a possibility of trade barriers being developed in response to the presence of CWD—related to feedstuffs possibly.

One other technical issue surrounding CWD policy is the fact that different agencies at different levels of government are involved and the disease is spread through wildlife movements which make it international in scope. Added to that is the significant importance of the affected species to food and culture in Indigenous communities requiring their participation to undertake effective (efficacious) management. Normal policy is often difficult within a jurisdiction managed by one agency—the co-operation required makes this a particularly unwieldy co-management policy process. The process is also hampered by uneven awareness and knowledge about the disease across the jurisdictions at a national level implying different levels of priority for management of the disease.

Array of Options

Policy Option 1: Preventing the spread to boreal caribou by targeted harvesting of deer and monitoring (AB and SK).

Introduction: As discussed above, Boreal caribou are a threatened species. Wild cervids infected with CWD are either near or overlapping, the range of herds of boreal caribou in Saskatchewan and Alberta. Based on the most recent assessments of caribou, herds in Alberta are at most risk (Environment Canada, 2011). They are described as non-self-sustaining and in some cases are well below self-sustaining population levels. A spatially targeted program to prevent CWD spread to caribou is necessary to reduce the risk to this threatened species. It would also help identify spread of CWD into Caribou herd areas through monitoring of hunter harvest head submissions. Such a program would combine ecological models of CWD spread with targeted hunter harvesting measures.

Benefits and Costs: The costs of caribou conservation are substantial (Hauer et al., 2018; Schneider et al., 2011, 2010). Costs of recovering herds in Alberta to self-sustaining status range from $5.8M to $1.7B in a low energy price scenario (Hauer et al., 2018). Any adverse impact on caribou associated with CWD would exacerbate these costs. The public goods benefits of caribou conservation are also significant as illustrated using stated preference valuation methods (Harper, 2012) or focusing only on revealed economic trade-offs (Maher et al., 2020). Estimates from Harper (2012) suggest an annual provincial net benefit (benefits – costs) of caribou conservation of approximately $250M for three to eleven herds. Note

that this is the value for Alberta alone. Maher et al (2020) using a very conservative revealed valuation approach suggest that Alberta has a conservation debt of approximately $800M in net present value terms associated with caribou decline. The benefits associated with avoiding impacts on Indigenous communities and associated cultural significance and food security threats are also high. Note that there may be complementarities between actions to prevent the spread of CWD to boreal caribou, and strategies that have been suggested to support actions to create self-sustaining caribou populations. Landscape level fencing strategies have been proposed to protect caribou by excluding predators (wolves) and deer (https://www.cosia.ca/uploads/documents/id33/Hab-Tech%20-%20Fenced%20Caribou%20Safe%20Zone%20Feasibility%20Study.pdf). These mechanisms appear to be components of cost-effective methods for the recovery to self-sustaining caribou herds (Hauer et al., 2018).

The cost of preventing the spread of CWD into caribou habitat is uncertain, but if it involved targeted harvest increases by resident hunters and Indigenous communities, it could be small, or even negative (since increases in harvests generate economic benefits see (Xie et al., 2020)). Zimmer et al. (2012) report a cost of approximately $1M (in 2007) for a concentrated CWD management program. Estimates from Wisconsin suggest that $48M has been spent over the years on monitoring and spread/prevalence reduction for the entire state. Even this cost estimate of $48M is low relative to the benefit estimates provided above. However, there may be costs on other current users of wildlife resources (e.g., Outfitters) and if there are effects on wildlife population structure in the future, such a program could involve additional costs on future users. Careful bio-economic modelling is required to assess these dynamics. In addition, consultation with Indigenous Communities and other affected groups will have to be undertaken.

Recommendation: This option is strongly recommended. While the efficacy of hunter focused CWD management programs is mixed (Uehlinger et al., 2016; Miller et al, 2020) other potential control actions are also available and are likely effective in this context. Consideration of specific means to reduce the risk of spread to Caribou is warranted. These programs should be monitored for their ecological and social-economic efficacy (see Policy Option 4).

Note that if CWD is found in Boreal caribou herds this will create a very challenging situation.[8] As caribou are a threatened species that is of particular cultural significance to Indigenous communities, traditional actions that have been taken in other countries (e.g., culling) may not be acceptable or possible given institutional frameworks. This provides additional evidence to support the attempt to reduce the chance of spread to caribou populations. Nevertheless, it would be prudent to begin to develop and assess options to address such a situation.

Policy Option 2: Require animal testing for all cervids slaughtered (dying) in Canada.

[8] We thank Dr. Penny Greenwood for raising this issue.

Introduction: Required animal testing for all dead (including slaughtered) cervids from the farmed sector before the animals enter the food chain seems a sensible policy given current research outcomes about potential human transmission. However, this requirement seems to be decided at a provincial/territorial level currently and on occasion, the mandatory testing for all animals only appears to happen after the disease is found within a province/territory. For example, OMAFRA had a voluntary testing protocol for farmed white tailed deer and elk and covered the costs of the tests for farmers pre-2014 (Rosatte et al., 2014). This has since become mandatory. Quebec tested samples from 9500 farmed animals sent for slaughter between 2007 and 2018 but is now testing all animals. Given the role of CFIA in the regulation of the farmed sector, this national requirement is legislatively straightforward to implement within the country. The addition of the provinces and territories not currently covered by the current testing requirements might be incremental given that the majority of provinces/territories with farmed cervid industry are already mandated. Would it be popular; absolutely not, in spite of the fact there is a clear economic value of testing for the public.

Benefits and Costs: The main benefit to this policy is the potential human health impact should the disease ever be found to cross the human species barrier. There may also be a benefit to the industry, if it continues, in terms of consumer appreciation of proactive action (to ensure consumer awareness would require all tested meat to be labelled, something the industry is currently unwilling to do, possibly due to the fact that testing is not required in all provinces so there could be a stigmatizing effect of labeling meat as tested and other meat with no label). In addition, there would be a benefit from better surveillance for the disease. Since the disease is spread in both wild and farmed populations there is the very slight possibility that farms in certain provinces that do not currently test may have the disease in early aged animals and at low incidence levels. Knowledge of where there are farms with the disease across all provinces could help in determining targeted areas for other management options.

Costs are significant for both private and public agents. First of all, the capacity must exist to provide tests in a timely manner, for all animals requiring it. More capacity requires more labs and more people. Manitoba (which has had no disease findings to date) is improving testing capacity through the building of an additional lab (possibly due in part to the loss of earlier biocontainment space, CBC, 2020). Second, the longer term per test costs must be either picked up by the farm or shared between the farm and the relevant government. Given the potential public good aspects of this testing it might be prudent to pick up some of the costs publicly, as Ontario is doing, and as Saskatchewan does for animals older than 12 months with some recent changes for younger animals).

Recommendation: To protect public health and to help monitor CWD incidence this is strongly recommended for the country.

Policy Option 3: Make the Chronic Wasting Disease Herd Certification Program mandatory.

Introduction: Beyond the requirements for testing all dead animals from cervid farms, participation in the voluntary herd certification protocol requires record keeping, traceability, biosecurity protocols such

as those related to the use of equipment, perimeter fencing requirements and monitoring and restrictions on movement of animals between non-certified and certified farms. The farmers must work with accredited veterinarians on regular inspection and assessment of herd health. As of July 2020, 73 farms in Alberta (64 elk, four deer, five combined elk/deer- one with reindeer) were enrolled (Government of Alberta, 2020). As of May 2020, two farms in Manitoba, six farms in Ontario, four farms in Quebec and 13 in Saskatchewan were enrolled (Canadian Sheep Federation, 2020). The Yukon reports one farm enrolled in the CWD HCP as of October 2020 (Yukon Government, 2020). Even with declining numbers of cervid farms in the country these levels of enrolment do not suggest complete participation. Mandating that all farms participate was recommended by the Council of Chief Veterinary Officers in 2018.

Benefits and Costs: The benefits to the enrolment of all cervid farms in the program are both public and private. Public benefits include detailed information on the status of all farms and much higher probability of reduced CWD findings on cervid farms. Animal health will likely be improved by the regular monitoring by veterinarians and the biosecurity protocols embedded in the program. Private benefits include the possibility of better domestic and international market access for cervids and their products with certification from the program and increased acceptability of cervid products, particularly meat, within the domestic market. The federal government may have the means to discuss rolling back international trade restrictions in particular countries based on enrolment status of producers. These are difficult to quantify at the current stage of enrolment but could clearly be important to the economic survival of the sector.

As one example of costs, Arnot et al. (2009) identified the costs of double fencing for cervid farms in Alberta of up to $17 million dollars. While the bulk of the costs of participation in the program are private (record keeping, satisfying new biosecurity protocols and upgrades as required by the program) there are also public costs that include administration, monitoring, and enforcement costs. The CFIA must continually update and assess needed requirements of the program as CWD status changes across the country. For controversial requirements, engagement with stakeholders could be a lengthy process. In addition to managing and operating the programs, the records and verification status must be maintained in national databases—agencies are required to manage the process at provincial levels and for Manitoba, Ontario, Quebec and Saskatchewan the Canadian Sheep Federation is managing the verification program data on behalf of the industry, at a cost.

Recommendation: As a policy which could enhance CWD management on farms (and through that, make some contribution to reducing spread in the wild) and improve economic opportunities for cervid farms, this requirement is clearly a relatively easy decision. However, likely cervid farms will not appreciate being mandated to participate in something that will change and restrict the way they do business and increase their costs. It will also be necessary to consider all aspects of the industry including the production of animals for use on hunt farms as part of the protocol to incentivize 100% participation.

Policy Option 4: Employ hunter harvest to reduce spread of CWD in wild populations (spatial targeting, etc.)

Introduction: While policy option 1 discusses hunter harvest in terms of reducing the risk of spread to caribou populations, this policy option is aimed at collaboration with hunters to reduce the spread (and potentially prevalence) of CWD in wild populations in general.

Benefits and Costs: The benefits of reducing CWD in wild populations include the benefits to the public associated with healthier wildlife populations (Forbes, 2011; Muringai and Goddard, 2018), benefits to Indigenous People associated with reduced risks of wild food declines and health risks (Parlee et al., 2014; Maye and Goddard, 2020) and benefits to licenced hunters in terms of reduced risks of wildlife population declines and avoidance of testing. The costs of this option depend on the scale of activity, but in some cases the costs could be *negative* in that allowing increased hunter harvests may generate benefits (Xie, et al., 2020). The costs will also have to include consultation with Indigenous Communities and other affected groups. The costs of such programs will increase if the targeted areas are not as desirable in terms of hunting locations or if there are conflicts with landowners or other impacts on other wildlife users (e.g., outfitters). The Association of Fish and Wildlife Agencies (AFWA) report on CWD management (Gillin et al., 2018) indicates that Wisconsin has spent $48M since 2002 on the management of CWD (monitoring and culling programs). But it is not clear how much of these costs are monitoring and how much is management. The costs will also be higher, and public acceptability lower, if professionals are used for culling populations or if other large-scale measures are taken (Durocher and Luckert, 2020). However, there may be significant costs on other users of wildlife resources and if future wildlife populations are affected there may be impacts on future economic benefit streams. This suggests a careful bio-economic assessment and monitoring process be conducted.

Recommendation: As mentioned above, the efficacy of hunter harvest programs is mixed (Uehlinger et al., 2016) but more recent evidence suggests that hunter harvests are effective tools in CWD management (Miller et al, 2020). Improved knowledge of hunter behavior and wildlife behavior is increasing the efficacy of CWD management using harvesting. Given the significant benefits associated with reducing spread, and potentially prevalence, relative to the costs (which may be small if hunters are interested and engaged)—we strongly recommend this option. However, there should be on-going (and long-term) testing and monitoring of the ecological and economic effectiveness of such programs, including impacts on other harvesters (Indigenous People) and guides/outfitters. Research in ecology and social sciences should be integrated with the management programs (e.g., adaptive management) to assess their impacts and modify the approaches used if necessary.

Policy Option 5: Increase monitoring / surveillance for CWD in wild populations (improve sampling, public investment in testing, other options).

Introduction: While monitoring of hunter harvest of wild cervids has been on-going in Alberta and Saskatchewan for some time, and programs (passive surveillance largely) have been initiated in other provinces in Canada, relatively little is known about CWD outside of hunting areas, and in particular, outside of mandatory hunter head submission zones. Recent research has shown that hunter harvest monitoring can be biased (Connor et al., 2020). To obtain accurate information on CWD prevalence, monitoring information is critical. Such information will inform both the wildlife management aspects of CWD and the human health concerns. But monitoring is costly and thus widespread monitoring programs have not been initiated. Also, monitoring has primarily used collection of cervid heads, while new technologies such as live animal tests and tests of fecal matter are being developed. We include a discussion of these emerging technologies and their role in surveillance in the section on "Technology Options" below.

Benefits and Costs: The costs of monitoring are difficult to determine. Testing costs reported in the literature range from $100 per test (Walsh and Miller, 2010) to as little as $10 per test (although the latter cost may be for tests that are not consistent with government protocols and standards). Hunters also incur costs of testing (preparing the submission, locating the freezer, etc.). In 2019-20, Alberta tested approximately 10,000 submitted heads. That provides some insight into the level of testing currently being conducted, and the approximate costs. Recent studies suggest that the public (Klotz et al., 2020) and hunters (Pattison-Williams et al., 2020) would be willing to support improved monitoring. Hunters, for example, supported an additional $20 fee annually to improve surveillance across the province (Pattison-Williams et al, 2020). Using this value for enhanced monitoring and applying it to the 125,000 hunters in the province yields $2.5M in benefits accruing to hunters alone. The size of these benefits, especially if benefits to the general public were included, would support a much larger program than currently being carried out. It is difficult to determine exactly the scale of the program given current estimates of benefits and costs, but the benefit estimates support a program considerably larger than the current program.

Recommendation: Expansion of the monitoring program for wild cervids is strongly recommended. The benefits appear to significantly exceed the costs using modest estimates of benefits. The lessons being learned from the COVID-19 crisis illustrate the importance of monitoring, especially in sensitive areas (sensitive in either a wildlife or a human health sense). Therefore, we strongly recommend increases in surveillance of wild populations. Some examples of areas where increased surveillance is important are areas where rapid actions can be taken to avoid outbreaks (e.g., B.C.), in areas where there is concern about CWD and support from Indigenous Communities, and in areas where risks of transmission to other species (e.g., caribou) are high. Appropriate incentives could also lead to technology development in this area, reducing the cost of testing and allowing more widespread testing. There should also be positive incentives associated with proper disposal for those who have infected animals. Discussion of the disposal issue is presented below.

Policy Option 6: Improvements in information provision about CWD.

Information for stakeholders and rightsholders, including hunters / harvesters, game meat processors, Indigenous people, and game consumers will be crucial in containing the spread of CWD and potentially

ensuring the health of cervid consumers (meat consumers specifically). Though such information is increasingly available, improvements could be made in the way that it is targeted and presented. Information for hunters, including Indigenous people, is frequently not placed where hunters will be forced to take note. For example, in Alberta, when a hunting tag is awarded/sold in a high risk CWD zone, the hunter does not receive targeted information about CWD presence and practices.

Information for game meat processors is also crucial. But there is a great deal of variation between jurisdictions regarding information and required practices. Many jurisdictions provide information and requirements about the disposal of animal parts (e.g., bones) after processing. For example, in Alberta, there are specific disposal requirements for dead animal parts after processing. Similarly, the American Meat Processing Association states that the "The most common alternative for processors to dispose of this material is an approved landfill" (https://www.aamp.com/documents/RenderingAlternatives.pdf). But information about how to manage equipment used to process deer with risks of CWD is more variable. Some of the most stringent practices have been recommended by Michigan State University Extension. These include:

> *Isolate and do not cut or process the carcass or meat products that have been tested for chronic wasting disease until negative results are obtained. Process carcasses individually and avoid mixing meat from multiple carcasses into ground meat products if venison is from a zone where chronic wasting disease has been found. …Use 50% bleach, 50% water sanitizing solution and soak processing equipment and surfaces for at least 1 hour.* (MSU, 2018).

However, in many regions, it is not feasible to wait for CWD tests because the meat would spoil long before the test results are received. Moreover, the added processing costs of isolating animals and cleaning equipment in processing facilities could entail substantial costs for meat processors, some of which would likely be passed on to hunters. Given the zoonotic potential discussed above, there is a good case to be made that recommendations such as these should be required. But such requirements would have to be accompanied by government investments in testing capacity, and further research into processing practices (some of which would be hopefully cheaper to follow), which could prevent cross-contamination or blending of meats from different harvested animals.

Providing and sharing in information with Indigenous peoples is also crucial. With game meat making up large proportions of many Indigenous peoples' diets (Natcher, 2019, Chiu et al., 2016), they are likely to be especially susceptible to risks associated with infected meat (See the Indigenous Rightsholders section above). In this context the sharing of information about risks to wildlife, health risks, and understanding other concerns of Indigenous peoples, is paramount. However, such information provision must be done within the cultural context of Indigenous communities with recognition of the role of traditional knowledge and community leadership. The information provision may be best focused on the need for testing. Moreover, extending CWD testing facilities to some of these more remote regions will be crucial in ensuring safety for cultural traditions.

Benefits and Costs: While specific information about benefits and costs of providing information is rare, this is an area that seems promising for policy application. If large amounts are spent in researching

options for CWD (see the "technology options" section below), then it would make sense to spend the marginal amounts necessary to communicate these findings. Moreover, costs to existing communication efforts might not necessarily increase, if information is better packaged and targeted to areas that could improve risk reduction.

Recommendation: Find low cost, targeted ways to provide more information with greater efficacy.

Policy Option 7: Prohibit or delay repopulation of depopulated farms with cervids or other animals such as bison or cattle.

Introduction: Given the novelty of the disease and its transmission properties, historically there was not a hard and fast policy of permanent depopulation of cervid farms (risks were assessed and some farms were allowed to repopulate with an outcome of some farms requiring depopulation a second time). Research (and practice) has shown the potential for CWD prions to continue in the environment, including soils and plants for significant periods of time. Given that, strategies to remove CWD from a farmed property are much more extensive than depopulating animals. Beyond trace out of animals in contact with infected animals, CFIA strategies to clean farms include decontamination (often removal) of soils and decontamination of housing. However, the CFIA announced in 2018/2019 that their policies had changed. "*Since the CFIA's original CWD eradication program started in 2000, the North American CWD picture has changed dramatically. Wild and farmed cases of CWD have continued to increase despite the CFIA's aggressive attempts to eradicate it. A significant re-occurrence rate has also been seen in Canadian herds that were previously depopulated, cleaned, decontaminated, and permitted to re-stock. This led to a program review and to the ultimate conclusion that eradication measures, using quarantines and stamping-out actions in areas where the disease is endemic in wild cervids, are both ineffective and unsustainable. Based on all available information, a decision was made to switch from an eradication policy to one of control*" (CFIA, 2020). Given this change in strategy, farms who do not follow appropriate biosecurity protocols will not qualify for the HCP and would only receive compensation for depopulation requirements if they were enrolled for a twelve-month period. Given the uncertainty of the active level of prions in the environment it could be prudent to not allow repopulation of farms found to have CWD at a level requiring depopulation (recognizing that in the US, farms are allowed to restock after two years following depopulation (Rivera et al., 2019)). Given the change in focus of the CFIA, farms with findings of CWD, who are not participants in the HCP will be 'managed' by provincial agencies. Adoption of this policy could reduce the management requirements for CWD, although provinces always have the authority to remove licenses for operations with CWD should they so desire.

Benefits and Costs: The benefits of such a strategy could reduce costs of monitoring and managing cases of repeated CWD outbreaks on the same facilities for federal government (although reenrollment will not be allowed for HCP properties that develop CWD) in the case of farms who are members of the HCP and provincial governments in the case of farms that are not members of the HCP. It is possible that this will reduce the findings of CWD on farms, reducing spread of the disease. Funds not spent on second or third depopulations might be spent on more active surveillance. The private costs of such a policy are very

high. Undoubtedly farmers who have invested both time and capital in developing a farm will face significant barriers to using their land for a different agricultural pursuit. Not allowing repopulation of farms may also not be a perfect solution given the lack of knowledge of transmission of CWD from the environment to other livestock, if that should be the alternate activity farmers choose. There is research suggesting the lack of transmission of CWD from the environment to cattle which might make the transition easier (Williams et al., 2018).

Recommendation: Recognizing that farmers may need support to make a transition in the type of agriculture they practice this recommendation is easy to implement. Both public and private costs are associated with this policy. It may be politically unfeasible, and it is possibly more palatable if there are definite timelines associated with it such as—no repopulation for ten years. Further research on the environmental contamination associated with CWD could provide clues about the appropriate length of time before repopulation. We recommend that this option be further evaluated with a continued focus on environmental contamination.

Policy Option 8: Remediate sites known to have CWD present in soil, plants, etc.

Introduction: Sites that have been known to have CWD prions present, including sites where either farmed and/or wild cervids have lived, may contain prions for some time (Kuznetsova et al., 2020). While still in early stages, new approaches to remediate soil are being investigated and appear to be promising in their ability to reduce prion contamination.

Benefits and Costs: The benefits of such actions include reduced risk to farmed animals (especially if deployed on former farmed cervid sites) and wild cervids. However, relatively little is known about the costs of these approaches or the ability to conduct such remediation activities at larger land scales. There are also questions about the marginal benefits of treating small areas if infection is widespread. At this time costs are expected to be relatively high, suggesting that research continue into the development of the approaches.

Recommendation: Given the uncertainty of the technology and the costs and extent to which these approaches can be used in larger scale application, the net benefits of such approaches are uncertain at this time. We recommend continued research investment in the approach with additional focus on the cost and benefits of remediation.

Policy Option 9: Provide incentives to address carcass disposal problems in hunting.

Information: Transport of materials from hunter-harvested animals can result in the spread of CWD. Some jurisdictions have suggested disposal procedures for hunters. For example, in Alberta, guidance to hunters is “All hunters should properly dispose of their harvested carcasses, particularly animals taken in

the CWD Risk Area. Where possible, debone meat making sure you keep the required evidence of sex and species. Hunters may prefer to avoid the spinal cord when deboning. Leave remainder of carcass at the kill site. If the carcass is transported elsewhere, remove all useable meat, then burn, bury, or dispose of the remains in a landfill." (Government of Alberta, 2020). However, carcass remains that are left on site are consumed by other animals (coyotes, wolves, etc.) and can result in CWD spread. There have been recommendations that specific portions of carcasses, especially of those animals harvested in endemic CWD areas and transported outside of the region, be removed and disposed of in an effective and safe manner (e.g., composting or landfills, Gillen et al, 2018). However, there are concerns that landfills may not accept carcasses because of the risk of disease concentration and contamination. These refusals lead to concerns about where carcasses will be disposed if landfills are unavailable. An alternative would be to follow along the lines of Minnesota regulations that do not allow whole carcasses to leave CWD zones until negative tests are confirmed (CIDRAP, 2019). High risk portions (including the head and spinal column) could be removed and disposed of in specific dumpsters and or processing stations set up within CWD zones. This approach would still leave internal organs (e.g., "gut piles") at harvest sites, but logistics to transport gut piles seem prohibitive.

Benefit and Costs: The benefits of appropriate carcass disposal are reduced risks of spread especially if the carcasses are moved into areas where CWD is not currently present. This applies especially to CWD positive animals and disposal of animals harvested in areas of high CWD infectivity risk. Costs of such actions include the costs of information provision and potentially incentives (positive or negative) associated with proper carcass disposal that would address costs to hunters of disposing of carcasses, as well as monitoring and enforcement costs. Making disposal easy, with easily accessed disposal sites (e.g., provision by government agencies) could support proper disposal practices. However, given the difficulty of monitoring and enforcement, regulatory approaches will have to be carefully constructed. Positive incentives associated with proper disposal will be important.

Recommendation: It is unclear if the benefits exceed the costs for more stringent requirements associated with carcass disposal, which are likely to be quite different depending on the specific policy. Disposal of known positive carcasses should be carried out as per current requirements / practices. But the efficacy of more stringent requirements to move all risk materials to landfills or government dump sites, when internal organs are left behind, is unknown. Information provision should definitely be employed. Positive incentives, including reducing the costs of accessing disposal options, should also be considered.

Policy Option 10: Close cervid farms

Introduction: Closing cervid farms has been an often proposed but likely politically unpalatable solution to the problem of CWD spread in Canada (also in the US). What is certain is that the industry was encouraged through government policy to become established (Hobbs and Kerr, 2000). Given that encouragement and the ensuing reallocation of resources to the industry there may have been reluctance on the part of farmers and the various governments to consider shutting the industry down so soon after it

was established, when CWD was first found on a farm. The federal government has continued to provide some support for the industry through investment of $1 million dollars in the development of a traceability system and some smaller investments in marketing development. The continual investment of CFIA in attempting to eradicate CWD since 2000 has been significant as well (including costs of depopulating and cleaning as well as costs of compensation). The number of farms that have been found to have CWD was not increasing across time since the peak in 2001-2002—although there was a recent spike in 2019-20 (see Figure 13). Often a farm found to have CWD has very few animals that show positive for the disease. It is worth mentioning that some farms allowed to repopulate after depopulation due to CWD have been found to have CWD a second time, reflecting either environmental contamination or contact with wild infected animals or feedstuffs, but given the requirement of the HCP program this repopulation will likely not occur in the future for farms found to have CWD. The CFIA has pursued very restrictive policies on movement of farmed animals which may have reduced the spread through the farmed population. Enrolment in the CWD HCP requires even more limited movement and then only between farms with the same or higher levels within the certification programs which should even further limit the spread of the disease in the farmed animal population.

Our mandate is to consider policies that would reduce the potential impact of CWD on the Canadian agri-food and agriculture sector. The cervid industry is a component of the agriculture sector. However, for other sectors such as cattle or grain production the CWD impact will more likely emanate from wild cervid CWD spread not from cervid farming CWD, given current approaches to CWD on cervid farms. These efforts suggest that there would be limited reduction of the risk of CWD impact on the Canadian agri-food and agriculture industries from eliminating the possibility of cervid farming in the country. If cattle production is ever to be affected by CWD environmental contamination, then that effect is more likely to arise from wild cervids than from farmed cervid properties.

Another strategy might be not to license (approve, allow as appropriate) new cervid farms throughout the country, and possibly not allow existing cervid farms to be sold as continuing cervid farms. For example, some provinces do not allow ownership of cervids and others require licenses to operate cervid farms. This option would reduce any possibility of expansion of the current industry and would allow the industry to slowly disappear. Regulations such as this would still require compensation for current cervid farms since it would be reducing the commercial value of the farms by government policy properties. The industry does seem to be declining without any such policy so such a policy might only need to be implemented if other policies for cervid farming are not implemented (for example, CWD testing on all slaughtered or dead animals) as necessity arises. Tight monitoring of cervid farms, participation in the CWD HCP, following rules related to movement of cervids and cervid products including semen, urine etc. can all obviate the need for specific policies to reduce the impact of CWD on other agricultural sectors.

However, there is a potential risk to wild populations of cervids in those areas where wild populations are not infected. Given the potential spread of CWD between wild and farmed cervids and the costs of managing infection of wild populations it would be prudent to take action to reduce these risks. The measures outlined above (testing of all farmed animals, restrictions on movement, etc.) should reduce these risks. Other measures may also be necessary including registration / licensing of cervid farms (if

they are not), monitoring and possibly other risk reduction practices such as double fencing (Arnot et al, 2009) if they have not already been implemented. These measures would attempt to internalize the costs of the externality arising from the risk of spread to wild cervids. Should testing ever identify links between farmed cervids and disease outbreaks in wild animals (genomic tests on particular CWD strains, for example) then the policy of allowing any farms might need to be revisited.

Benefits and Costs: The assumed benefits of eliminating cervid farms are associated with reduced CWD spread in the wild cervid populations in the country. This was likely a reasonable assumption in 2000. However, the disease in the wild is spreading continually across the US and Canada. It is conceivable that in many places in Canada (Alberta/Saskatchewan, Ontario/Quebec) the disease would spread into Canada from the US, even if not from any other source. This is evident when the maps of disease spread in the US are examined, highlighting the much higher prevalence of the disease along the border of these provinces now than in 2008, for example. It is possible that if the farmed population did contribute to the spread of the disease in the wild population it is unlikely that the farms are the major contributor currently. This is particularly true if you consider that the farmed population has dramatically declined since 2000. In provinces where there is no evidence of CWD in wild populations, special care is necessary in the management/allowance of cervid farms. Given that CWD can spread both from wild to farmed and from farmed to wild populations, appropriate farming practices are essential to mitigate risks to both populations.

The costs of eliminating the cervid farms would remain a significant public expenditure even with the industry at its current size. Whether there is a benefit to that expenditure that outweighs its costs remains an open question and needs to be considered relative to other approaches such as those outlined above. While it is clear that the disease was transmitted to South Korea from an exported farmed animal from Canada—restrictions on exports of live animals and cervid products could ensure that the disease is not exported anywhere else from Canadian farms, in the future.

Recommendation: This policy is unlikely to reduce the spread of the disease in the wild from current levels as long as appropriate precautions are taken on farm. It will be a costly measure without the possibility of large impact and other policies could deal with the risks of CWD spread from the farmed sector to other agricultural industries. This option is not a high priority.

Additional policy options:

The ten policy options presented above have sufficient information to make a recommendation regarding whether the options would be socially beneficial (benefits exceeding costs). However, there are several other potential policy options or areas of potential public investment where additional research is required to be able to make a recommendation with confidence. These additional options and the recommendation regarding research required are outlined below.

Feeding and bait bans

Feeding wild cervid populations leads to animals gathering and potentially transmitting CWD with higher frequency than without feeding (Mysterud et al., 2019). Baiting is assumed to have similar impacts as it attracts cervids in groups. But feeding is common in areas where individuals find wildlife viewing beneficial, and as a lure for animals for hunting. Feeding and baiting also support the agricultural sector by purchases of feeding products. The Association of Fish and Wildlife Agencies (Gillen et al., 2018) recommends banning feeding and baiting, especially in locations where CWD has been found as it increases congregation of animals that increases the risk of spread from infected animals and contamination of sites. However, Gillen et al. (2018) also outline arguments that suggest that bans on baiting and feeding will result in lower harvest levels and reduce the potential for CWD control through harvest. While definitive research on this issue that examines the benefits and costs of feed and bait bans has not been conducted, restrictions on feeding and baiting in areas where CWD is present or in adjacent areas, should help prevent the spread and increasing prevalence. Additional research is required on the loss of economic benefits, including impacts on hunting behavior, arising from such bans. It is also worth noting that these bans are generally unpopular with outfitters and some hunters who may mount political opposition. A recent summary of CWD regulations indicates that "Twenty-two states do not allow the baiting of cervids and, fourteen states have certain restrictions on baiting. Three of the Canadian provinces listed have banned baiting and one province restricts baiting" (Michigan Department of Natural Resources, 2020, page 1).

Requirements for wild cervid processors.

Meat processors prepare meat from hunted animals that has not been tested for CWD, and practices used to clean processing equipment between animals are not typically sufficient to prevent cross contamination of CWD. For example, recommendations include: "Use 50% bleach, 50% water sanitizing solution and soak processing equipment and surfaces for at least 1 hour. Rinse all equipment and surfaces with hot, potable water after soaking in bleach solution." (Michigan State University, 2018). At a minimum, information should be provided to processors regarding CWD, risks of cross-contamination, proper handling and disposal, and other aspects of CWD. But given the costs of such practices, voluntary compliance could be minimal. These costs could also be problematic if protocols were required. Alternatively, meat processors could require that a negative test result be confirmed before processing the meat. Such a practice would be welcomed by some hunters as a sign of careful processing practices. Michigan has outlined protocols for processors associated with CWD including practices to follow if deer are identified as positive (MSU, 2020). But such an approach would require much faster turnaround times for tests (processing times in Alberta are typically months) to prevent meat storage costs and spoilage. Investments in more test processing are likely warranted given the potential for consuming meat from CWD positive animals arising from processing practices.

Encourage natural predators of wild cervids

There has been discussion of the use of natural predators of cervids (wolves, cougars) as a CWD reduction strategy. In particular, as discussed above, increased predation by wolves has low risk associated with cross-species infection. Predators could be "encouraged" through landscape management

approaches or other means. Such approaches were mentioned in the 2000s in Alberta, and the recent B.C. CWD management plan lists low predator numbers as one of the potential causes associated with CWD spread/prevalence (Nelson and Schwantje, 2019). CWD itself will have an impact on predator-prey relationships (Miller et al, 2008) and CWD prevalence may result in (temporary) increases in predator populations. To the best of our knowledge there are no studies that rigorously measure the impact of a predator management plan on CWD. Therefore, in the absence of information this is not a recommended policy. Additional research is required on this topic.

Investment in technologies—including new testing approaches, vaccines, and gene drives.
A number of technological approaches to address CWD have been proposed. Recognizing that while these technologies are in early stages of development there is merit in these examining options in the context of potential research investments. Considerable effort has been made on developing CWD tests that can be effective at identifying the disease in live animals, but a completely effective approach has yet to be found (although very promising approaches are being found, see Realtree (2020)). A live animal test would be quite valuable, especially for the farmed cervid sector. Such tests would increase confidence in consumers and would provide a pathway to identifying resistance to CWD in farmed cervids. Such a test would also be useful in reducing risk from transporting animals (in farmed or wild settings). And such tests could make testing of harvested wild animals quicker, thereby potentially precluding the processing of infected animals. Similarly, tests that can identify CWD in fecal matter have been suggested and are being assessed (e.g., Cheng et al, 2016). Such tests can help identify CWD presence in farmed settings or in wild settings and could be used to identify the spread of CWD in areas where few heads are submitted using traditional surveillance approaches. The challenges with these testing approaches include their accuracy, cost, and effective deployment. Accuracy continues to increase. Little is known about the cost of such tests in practice. Similarly, it is not clear whether tests like fecal matter tests will be administered by harvesters of wild cervids (although survey results do suggest that there would be support from various stakeholder groups if collection of samples supported wildlife conservation). Should effective live animal and/or fecal matter tests be available, provision of incentives for their use in farmed and wild cervid areas would be an effective policy option. Indigenous communities, landowners, hunters, outfitters and others could participate in passive approaches to CWD monitoring and surveillance.

Significant progress has been made on the development of a CWD vaccine (Abdelaziz et al., 2018). There is also public support for the development of and use of vaccines. They could be of significant value in farmed settings, and potentially in wild setting through an oral vaccine. But vaccine development is costly and the extent of demand for a vaccine is unclear. Additional research is required to identify this demand and assess the potential use of a vaccine under different CWD scenarios (e.g., vaccinating all farmed cervids, vaccinating selected wildlife populations).

Gene drives, or gene editing of wild cervids to increase resilience to CWD or potentially to result in cervid species that cannot contract CWD, have been proposed at the conceptual level. There has been research investigating gene editing and gene drives for invasive mammal species (introduced squirrels in the UK) and programs involving gene edited mosquitos (Whitelaw, 2020). While gene drives may be an effective approach, biological risks associated with changing genetic structures is likely to be desirable only if all other approaches are ineffective or if costs of CWD rise rapidly. There is still considerable

research to be done on the potential consequences of gene drives on the ecosystem. Public acceptability of such approaches will also be an important aspect, as well as communications of the science, benefits and risks. At this point gene drives are worthy of investigation from a research perspective, but they are a considerable distance from policy implementation in a wild cervid species. The use of gene drives in such contexts has been described as a "last resort" if costs of CWD are very high and there are no known alternatives to address the problem.

Transportation / Trade Restrictions

Agencies have suggested that a transport ban on live animals for breeding as well as slaughter – unless there is a live animal test that confirms a negative case – be implemented to reduce spread of CWD. Gillen et al.'s (2018) recommendations range from a total ban on anthropogenic (human-assisted) movement of live cervids to prohibiting movement from CWD-endemic areas. Until there is a validated, highly sensitive ante mortem test available, all anthropogenic movement of live cervids presents a risk for CWD spread.

Similarly, the Association of Fish and Wildlife Agencies have suggested that trade in cervid material (e.g., urine, semen, embryos) be limited or banned to reduce CWD risks. AFWA recommendations (Gillen et al. 2018) have identified the sale and use of products that contain cervid urine as a potential risk factor. Cervid urine is collected in captive cervid facilities and is sold in various products for use as a scent lure. CWD prions have been detected in the urine of infected cervids, suggesting that the use of these products could be a risk for disease spread. The AFWA report highlights the lack of existing regulations within the cervid urine business and expresses concern that saliva and feces, which could contain higher doses of infectious CWD prions, can be accidentally mixed with urine during collection. Subsequent use of these products from CWD-infected cervids could serve as a risk for indirect disease spread as they enter the environment. Following best management practices, AFWA states that products containing natural cervid urine should not be used, and synthetic products could serve as an effective alternative. Comparably, AFWA highlights concern that reproductive tissues, such as embryos and semen, could be a source of CWD infections, and their use for selective breeding warrants regulatory consideration. As mentioned above, Kramm et al. (2019) have discovered evidence of CWD in semen. Therefore, reducing the movement and use of reproductive tissues would remove the risk of CWD transmission occurring via that pathway.

A related approach to restrict transport / movement, zone controls, that requires that no animals move in or out of an area with CWD (farmed and wild harvested), was proposed by CFIA (in which embryos, semen, all high-risk parts of carcasses, urine, and certain highly contaminated parts of feed products would all have been restricted movement out of the primary control area) but did not proceed in 2014.

These practices have benefits in that they will reduce the risk of spread of CWD. However, the costs of the restrictions are unclear. They may be minimal (e.g., as a synthetic product substitutes for natural urine) but they could also impose costs on individuals and firms. An inexpensive rapid test would reduce these costs in the case of live animal or harvested wild animal movement but does not yet exist. Further investigation is required to assess the efficacy of these restrictions and the feasibility of monitoring and enforcement. Given current information, it seems wise to consider some forms of these restrictions

especially in high CWD areas. Further, given the existence of these restrictions in certain parts of Canada it would be prudent to apply consistent regulations throughout the country.

Policy Unknowns

The biggest problem associated with CWD is the potential risk to human health from eating infected animals. There may also be a risk to consuming antler velvet (an aspect of cervid product commercialisation that was not a focus in this project), since the antlers are collected from animal shed and the animals cannot be tested ante mortem although research has shown the presence of prions in antler velvet. Currently infected animals include cervids although it is known that other wild animals can be infected. If CWD is ever shown to be transmissible to people eating the meat (or velvet) from infected animals, then the policy fix is somewhat unclear[9]. The European Food Safety Association Panel on Biological Hazards recently recommended that human consumption only be allowed after testing and they recommend a prohibition of hunting and harvesting if testing is not possible (EFSA, 2020). It will be easy to require all cervid animals to be tested from farms and we have recommended above that this requirement should be extended to areas that have not currently been found to have CWD, as a precaution. The problem is on the wild cervid side. Although recommendations could be made to test all hunted animals before eating, this recommendation currently exists in CWD endemic areas and many hunters either do not submit materials for testing or do not wait for tests before eating the meat. However, to be proactive the testing requirement should be beyond CWD endemic areas and will of necessity include Indigenous community hunters. It is unclear that there is capacity for the required level of testing that a mandatory national testing regime would require. Although there are costs associated with the testing infrastructure, there are also costs associated for all hunters in terms of delivering materials for testing, storing carcases until tests are completed and then deciding what to do with the carcass should it be found to be positive. Particularly in the case of isolated communities these costs may be prohibitive.

Clearly in a country such as Canada prohibiting hunting because of the potential human health risk is not possible. Eliminating cervid farming is unlikely to be sufficient to remove the human health risk should human transmission be found to be possible. These characteristics suggest the urgent need for more research, faster development of ante mortem and environmental tests that can easily be applied by many people in many geographies and other treatments such as vaccines.

A second major category of policy unknowns has to do with the divergences of opinions related to a variety of management options that do currently exist. There are few management options that achieve general agreement across different stakeholder groups such as the public, hunters, outfitters, and cervid farmers. Other stakeholder groups also exist, and their opinions need to be included in the development of a policy regime. If it is difficult to achieve consensus across policy options in the current environment and given the diversity of agents who will contribute to policy options with no single authority nationally

[9] A recent summary of policies and regulations in the U.S. and Canada can be found at Government of Michigan (2020).

or internationally on regulations, then the situation will become more difficult as the disease continues to spread. The determination of acceptable effective management options is particularly troublesome, given the requirement for cross border agreement to have any possibility of success. Policies that were unpopular to some stakeholders, such as zoning, recommended by the CFIA in the past, have ultimately not been adopted. This recent outcome suggests even as the disease continues to spread disagreement on the causes and solutions to the problem of CWD will continue to make the 'best' management options difficult to determine. We need to be able to test the efficacy of different management options in order to make more reasoned recommendations and to have even the slimmest possibility of reaching consensus among groups that have diverging interests.

Summary

The policy space is complicated for an animal disease that crosses both wildlife and domesticated animals, crosses provincial and national borders and has a somewhat complex set of agencies associated with parts of the policy environment. No one agency has authority over all of the recommended or identified policy options. Industry could clearly implement codes of conduct to deliver some of the policies we recommend. However, clarifying how the policy options might be implemented (and with what level of authority in charge of regulation) is still to be determined. The disease is treated with differing degrees of urgency in different constituencies and development of policies based on risk assessments must be careful not to be too reactive as the trade-offs can be difficult to assess *ex ante*.

Clearly, the development of regulations for another prion disease, BSE, was much easier once the ramifications of the disease were better known. However even in the case of BSE and the concurrent threat of CWD, different agents have modified BSE regulations. For example, the use of specified risk materials (SRMs) in fertilizer requires that "*Fertilizers and supplements containing certain animal proteins known as prohibited material (described in the Health of Animals Act) must be appropriately labelled, recorded and controlled.*" (CFIA, 2019), and includes the possibility of the use of specified risk materials but with specific precautions.

From our perspective, certain policies make sense while others that could be easy to implement may be costly without necessarily having the potential to deliver similarly sized benefits. Some of the policies we recommend are proactive and as such may face resistance from deeply affected groups. Further benefit cost analysis should be conducted to solidify rationale for intervention and to identify costs to particular groups. We have also identified a number of research areas in both the biological sciences and the social sciences that should be invested in to help assess policy options. It is worth remembering that wildlife is considered by the majority of the population to be important and for which protection is critical.

While policies can be implemented within Canada, international coordination is critical to future success of a wildlife disease. Without similar CWD policies in the US, the Canadian policies may be less effective. Similarly, coordination between provinces, and between the provinces and the federal government, will be important in the development and implementation of CWD policy.

Table 18. Benefit cost analysis summary of policy options for CWD management in Canada.

Option	Benefits	Costs	Recommendation	Comments
Preventing the spread to boreal caribou by targeted harvesting of deer and monitoring (AB and SK)	Reduced risk to a threatened species	Cost of targeted harvest increases by resident hunters and Indigenous communities could be small, or even negative (since increases in harvests generate economic benefits) but program costs and current and future costs arising from other users of deer need to be considered.	Strongly recommend	High benefit and low-cost opportunity to reduce risk to a threatened species – but the efficacy of targeted harvests on CWD spread must be monitored and assessed as well as impacts on other users.
Require animal testing for all farmed cervids slaughtered (dying) in Canada	Assured food safety and quality	One estimate suggests Alberta spent $500,000 in 2003 on farmed and hunted animal testing; this value will be higher now. The question of cost to cervid farmers is also important as is compliance from all sectors including hunt farms	Strongly recommend	Difficult to protect either Indigenous people or hunters in the same way as people who consume from farms and the risks are bigger

Option	Benefits	Costs	Recommendation	Comments
Make the Chronic Wasting Disease Herd Certification Program mandatory	This program is the way for farmers to be certified for export, have animals be destroyed with compensation if CWD is found, although not 100% of farmers participate. Program would provide the highest level of biosecurity which could reduce potential environmental spread to other farms	Costs are high for government to enforce and very high for farmers as if farmers are not registered the government does not depopulate. This approach will likely not reduce CWD prevalence in wild populations	This should be mandatory throughout the country to maintain safety and also protect trade and market access	Farmers may be unaware of the changes in regulations or speed of spread – modest incentives might encourage adoption although the requirements are stringent and costly for producers
Employ hunter harvest to reduce spread of CWD in wild populations (spatial targeting, etc.)	Reduce risk to caribou, and unaffected regions. Hunter benefits generated. This could reduce transmission from wild animals to the environment	Relatively small (additional administrative actions and program costs) but some sectors and users may be adversely affected at least in short run (outfitters) and impacts on other users in the longer term need to be evaluated.	Recommend	Positive incentives to hunters could be employed. But such programs must be evaluated for their efficacy (biological and economic) in an adaptive management fashion.

Option	Benefits	Costs	Recommendation	Comments
Increase monitoring / surveillance for CWD in wild populations (improve sampling, public investment in testing, other options).	Identify areas of new spread, act quickly to address.	Potentially significant (testing capacity, incentives to support submissions)	Recommend (supported by public and hunters), but funding and scale will be challenging.	May require positive incentives to hunters, landowners, others. Technology development important and necessary
Improvements in information provision about CWD.	Find low cost, targeted ways to provide more information with greater efficacy to all rightsholder and stakeholder groups.	Marginal cost to communicate findings from existing research projects	Recommend.	Simple and direct approach to increase awareness.
Prohibit or delay repopulation of CWD depopulated farms with cervids or other animals such as bison or cattle	Ensure safety for future animals and food supply, although there is one long term study showing no evidence of transmission of CWD from environment to cattle grazing, in this case precaution could be protective in an important industry	The costs would be very high for landowners – in particular affecting the commercial value of their land through reduced use options	Uncertain but likely recommend.	This will be unpopular for some groups. Research on time for disappearance of CWD from the environment on depopulated farms required.

Option	Benefits	Costs	Recommendation	Comments
Remediate sites known to have CWD present in soil, plants, etc.	Reduce risks to farmed and wild cervids	High cost except for very concentrated areas	Effective mechanisms at scale have not yet been developed suggesting no action except for testing / research on very focused sites	Continue research in the area to develop the technology, including products and processes to treat the environment
Provide incentives to address carcass disposal problems in hunting	Reduce risks of spread, transmission elsewhere.	Logistically difficult, dispersed and difficult to monitor. Hunters adversely affected.	Uncertain	Positive incentives, information required.
Close cervid farms	Closing farms would only reduce the risk of CWD in the farmed cervid food chains for provinces that currently do not mandate testing (AB, SK, QC, MB, ON and Yukon currently require testing) resulting in minimal if any benefits. There are no apparent benefits to the broader Canadian agricultural sector. Risks to other agriculture sectors	Relatively small sector, but equity issues arise. The equity issues could be resolved by mandating testing and HCP participation- reducing costs and protecting wild animals and commercial food supplies.	No action	Not an effective policy option to reduce risks to the agricultural sector or wild populations.

Option	Benefits	Costs	Recommendation	Comments
	stemming from contamination by the wild cervid populations (e.g., cattle, grain, forages) will remain. Precautions such as licensing (approve, allow) new farms and requiring farms to participate in the HCP and maintaining biosecurity protocols are recommended for regions with and without CWD. However, in provinces where the wild population has not yet been infected it would be prudent to take precautions to prevent the risk of spread from farmed populations to the wild. Such precautions include alternatives that do not involve closing all cervid farms.			

7.0 COVID-19 IMPLICATIONS

COVID-19 has had wide-ranging impacts on society and the economy, and the effects will likely continue for some time. The impacts of COVID-19 on issues related to CWD are uncertain, but in this section, we offer a few insights on potential outcomes.

The COVID pandemic has affected income and employment with more adverse impacts on some specific sectors of the economy (e.g., service sectors, airlines, etc.). Government programs such as the Canada Emergency Response Benefit (CERB) have provided relief, but the length of these programs will be limited. Shocks to income and employment will affect demand for consumer products including food products, and thus may impact consumption of venison consumed in restaurants (Deaton and Deaton, 2020; Goddard, 2020). The shock to jobs and incomes also affects the value of time which may result in an increase in recreational hunting activity. The labour-leisure trade-offs involved in recreation (e.g. (Lloyd-Smith et al., 2020, 2019) suggests that recreational activities will increase with a reduction in the value of time in labour and thus increases in demand for hunting days may be realized. There is also literature suggesting linkages between increased unemployment rates, reduced incomes, and increases in hunting activity (Boman et al., 2013). Similar patterns are evident in Indigenous communities relating harvesting activities and employment opportunities (Myae and Goddard, 2020; Natcher, 2019). An increase in hunting may result in increases in the consumption of potentially CWD infected meat but increases in hunting activity may also result in less dense populations, and more widespread monitoring through the submission of wildlife heads for testing.

Heightened perceptions of zoonotic risks may arise from the information presented about COVID-19 in media and other information sources. This may affect risk perceptions about CWD and zoonotic diseases. Finally, provincial and federal governments have incurred significant deficits by financing programs to address COVID-19. These expenditures may result in a reduction in funding for other programs, including CWD monitoring and control, and CWD research.

As mentioned, these linkages between COVID-19 are speculative and tentative, but there will undoubtedly be impacts via incomes and employment on food demand, and potentially through other channels, that will increase “exposure” to CWD.

8.0 CONCLUSIONS

In assessing the relationship between CWD and the Canadian agricultural and agri-food sector, a number of things become quickly apparent. First, CWD is a disease for which there remain many unknowns, and those unknowns are often associated with how CWD affects agriculture. Second, regardless of the uncertainty associated with CWD and agriculture, policies related to CWD need to be broader than agriculture if there is to be any sustained impact on CWD spread, prevalence and impact on agriculture. In addition, the most significant impacts of CWD appear to be the potential impacts on wildlife populations including threatened caribou populations. Third, effective policies and management options for CWD must be coordinated among provinces and countries that share borders as CWD cannot be controlled in a region/country that shares borders with other CWD endemic regions/countries. Fourth, CWD is unlikely to be eradicated, so there will need to be coordinated proactive and often targeted policies across different agencies and levels of government implemented to manage the ongoing disease (Mysterud et al, 2019). Attempting to prevent spread to sensitive areas and species may be the most important policy approach, along with monitoring, surveillance, and information provision. Fifth, although many groups, and Canadian society as a whole, have significant interests in CWD, there is a relatively low level of knowledge about the disease and its existence in Canada. Finally, risk perceptions and economic interests in the disease vary considerably across groups in our society, making policies somewhat more difficult to implement.

The current state of science with respect to CWD has many yet to be researched issues. There are very few studies (although there has been one exceptional long-term study) about the possibility of transmission of CWD to cattle from contact with infected ungulates, other animals or through ingestion of infected feedstuffs. The science is progressing on the possibility of transmission of CWD to humans through oral transmission, but the complete assessment of this possibility remains to be done. Transmission between ungulates and other wild animals to domesticated animals and the environment has not been exhaustively studied. The development of ante mortem tests for CWD and/ or vaccines could reduce the risks of the disease through antler velvet sales to agriculture and to society. Further research on remediation of sites affected by CWD as a mechanism to reduce risks of spread is also important. More social science research is required to address the benefits, costs, and efficacy of these different CWD policy options. In particular, the policy of increased hunter harvest to prevent spread needs to start with careful research on whether such harvests (or which approaches) are effective and have benefits that exceed costs. This approach means simultaneous trials on ecological and economic aspects of this policy option.

The jurisdictional responsibility for CWD is complex given the existence of a wildlife disease and a concurrent farmed sector. This complexity applies to Canada, the US, Korea and some other jurisdictions in Scandinavia. Within Canada, wildlife management is distributed between federal and provincial, territorial governments and includes Indigenous communities. For the farmed sector, the CFIA has major responsibility for managing the cervid farm industry, but provinces have some authority over encouraging further development of the industry, for licensing game farms and will have some responsibility for managing disease outbreaks for farms not enrolled in the CWD HCP. Moreover, provinces could restrict

movement of animals and some cervid products. Without coordinated approaches between the wild and farmed sectors, managing the spread and prevalence of the disease will be very difficult.

With CWD spreading in the US, the threat of spread may soon be stronger from the US than from other areas in Canada. It is not clear whether the regulatory policies currently in place are sufficient to protect all Canadian provinces and monitor the spread of the disease from the US. Harmonizing CWD policies and regulations associated with wildlife may be difficult but there could be significant implications of spread in wildlife that need to be monitored.

There is now no possibility of eradicating CWD within North America so policies and regulations to monitor and reduce spread of the disease are increasingly important. Research on the methods, efficacy, benefits, and costs of targeted harvests to prevent spread is essential. Encouraging higher participation in voluntary/mandatory hunted head submission for CWD testing, mandating testing of all farmed animals that enter the food chain and regulating movement of animals and animal products from wild untested animals are all current policies that can reasonably be considered. No policy, however, will be popular with all interested parties.

There are widely varying levels of knowledge about CWD across society, even within groups who have close connections to hunting and eating venison from hunted animals. Sensible precautions related to only eating tested animals, and other precautions in terms of handling hunted animal carcasses and parts, are not uniformly applied within the country or responded to by all agents. Information about testing, and the availability of convenient testing options is limited in many contexts. Similarly, information for wild game processors, and between processors and their customers, requires improvement. Increasing knowledge might increase adoption of safety practices but can also significantly enhance monitoring. It is particularly important that Indigenous communities engage with wildlife health knowledge dissemination, are included in CWD testing protocols and participate in information sharing about the human safety of venison as the research about that evolves.

Research results suggest strong and oppositional opinions about acceptable CWD management strategies across different groups. One example is our preliminary assessment that professional outfitters are opposed to CWD management strategies that involve increased hunting activities. Another example, cervid farmers are more supportive of taking no action to manage CWD (possibly thinking of action taken to manage disease on the farm) and feel less strongly about most other CWD management strategies than do other groups. Even within groups, such as resident hunters in Alberta, there is a wide range of views on the risks of CWD to humans and the policy options that should be employed, even though the vast majority view CWD as a concern for wildlife health. Many groups see eradicating cervid farming as a solution to CWD although it is clear that this approach would have small, if any, effects on the prevalence or spread of CWD. Developing consistent effective policies for CWD requires navigating difficult space with well entrenched opposing attitudes to many currently existing and potential policies.

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Appendix 1: Property right characteristics used for describing cervid benefit streams for the General Public and Hunter/Landowners (Source: Durocher and Luckert, 2020).

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 used here.

Appendix 2: Cervid Property Rights in Alberta

Appendix 2a: 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 2b: Cervid Property Rights Framework for Hunters and Landowners 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: Cervid Property Rights in Saskatchewan

Appendix 3.1 Cervid Property Rights Framework for the General Public in Saskatchewan

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 Saskatchewan 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 Saskatchewan 1998

Appendix 3.2 Cervid Property Rights Framework for Hunters in Saskatchewan

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 licenses. 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 regulations apply for hunting in Provincial Parks and Recreation Sites.[b] Firearms cannot be discharged in National Parks.[c]
Exclusiveness	Hunters have non-exclusive rights to pursue cervids (along with other hunters) on public lands within wildlife management units (WMZs). 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] In the case of leased land, hunters must obtain permission from the leaseholder prior to hunting.[b] Harvest rights are exclusive to a tag holder who harvests and tags an animal.[a] Rights to the products derived from a harvested animal are exclusive to the hunter.[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 500m of an occupied building, across or along roads; no hunting one half hour before sunrise or one half hour after sunset; no hunting from a moving vehicle, boat, etc.; hunters must abide by weapon and caliber requirements; hunters cannot use vehicles, boats or aircraft to pursue animals.[b] 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.[a]
Levies and Fees	Costs for purchasing hunting rights include: $15 for a wildlife habitat certificate; the purchase of tags (eg. for Saskatchewan residents): $40 for a general white-tailed deer licence, $30 for an antlerless white-tailed deer licence; $45 for a mule deer draw; $40 for a moose licence, $65 for a moose draw; $40 for a general elk licence, $65 for an elk draw.[b] Fees are higher for non-residents and vary with choice of weapon.[b]

Security	There is a long history of the Saskatchewan government allocating rights to hunt, implying that the allocation of hunting rights will continue into the future.[d] Hunting and other practices of wildlife utilization are protected under law.[d] However, the conditions under which rights are granted are continuously changing. For example, whether licenses will be available in all WMZ may vary between years.[a] The priority pool system and the investments hunters make into their hunting locations show their level of confidence in the continued availability of hunting rights.[e]
Initial Allocation of Rights	Hunting rights are allocated by the province of Saskatchewan through signing up for a Hunting and Angling License (HAL) account and by purchasing a wildlife certificate and licenses (some of which are generally available and some of which are draws).[b]
Residency and Age Requirements	An applicant for a hunting license must be a resident of Saskatchewan and be 12 years of age. Generally, in order to hunt without supervision an applicant must be 18 years of age, however 16-17 year olds may hunt unsupervised provided that they meet firearms regulations.[b] Resident Canadians and non-residents can only hunt with guides or outfitters, except in the case of resident Canadian hunters (from outside Saskatchewan) who are hunting white-tailed deer, who can do so without a guide if they wish.[b]
Size Specification	A single adult resident hunter may hold (allowing the hunting of a single cervid): a first Saskatchewan resident license, first Saskatchewan resident antlerless license and a second Saskatchewan resident antlerless white-tailed deer license; a Saskatchewan resident elk license and a Saskatchewan resident elk draw; a Saskatchewan resident moose license and a Saskatchewan resident moose draw; a Saskatchewan resident archery mule deer license, a Saskatchewan resident mule deer draw, a first Saskatchewan resident antlerless mule deer draw and a second Saskatchewan resident antlerless mule deer draw.[b] However, notwithstanding these allotments, a hunter may not hold both a regular and draw big game license for the same species and they may not hold two licenses of the same license type in any one year.[b] The number of draws available often depends upon population numbers and meeting specific conservation goals.[b]
Allotment Type	Quantities of animals harvested are controlled by the number of licenses issued.[b] Allocated licenses specify the WMZ(s) within which they may be used.[b]
Transferability	Licenses and draw applications are non-transferable.[a] Landowners may charge for access to their land if they are operating a hunt farm. Some products derived from hunted animals can be moved within the province and out of province with the appropriate license or an export permit.[f]
Duration	Licenses or draws are allocated annually and subject to set seasons based upon the weapon of choice and the WMZ in which rights are granted.[b,e] Although licenses are granted annually, hunters have expectations of repeated availability. The priority pool system allows hunters to increase in priority as years go by in order to increase draw probabilities.[e]

[a] Government of Saskatchewan 1998
[b] Government of Saskatchewan 2019
[c] Government of Canada 2017
[d] Government of Saskatchewan 2010
[e] Government of Saskatchewan 2020
[f] Government of Saskatchewan 1981

Appendix 4: Potential CWD management actions and the corresponding affected property right characteristics for hunters and landowners (Source: Durocher and Luckert, 2020).

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.