Rapid Threat Assessment

CWD in Woodland Caribou in western and northern Canada

Prepared for the Wildlife Issues Unit, Wildlife Management and Regulatory Affairs, Canadian Wildlife Service, Environment and Climate Change Canada

Prepared by

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Purpose of the Assessment

The purpose of a threat assessment is to determine the credibility and seriousness of a potential threat to inform the need or priority of response to the threat[1].

The Wildlife Issues Unit, Wildlife Management and Regulatory Affairs, Canadian Wildlife Service, Environment and Climate Change Canada, requested a threat assessment on Chronic Wasting Disease specific to woodland caribou in western and northern Canada to determine actions to be taken on the disease to support the unit's mandate of preserving wildlife health in Canadian species and overall activities of policy development and implementation to that end.

Format of the report

This assessment was guided by the Situation and Response Analysis Framework for Wildlife Health prepared for ECCC in 2017 by the Canadian Wildlife Health Cooperative (CWHC). This is a rapid threat assessment as defined in that document meaning; (i) it was a desk top exercise using opinions of a limited number of experts and readily available information; (ii) the threat was qualitatively assessed and (iii) there was limited consultation with stakeholders.

Part 1: Threat screening

- Purpose - provide an executive summary assessment of the threat

Part 2: Problem description

- Purpose - provide context to the threat assessment and identify major issues, interests and impacts that inform the threat screening

Part 3- Vulnerability analysis

- Purpose – determine if there are plausible routes of exposure to the threat by sensitive individuals or populations

Appendices

- Overview of CWD control programs
- Cervid distribution maps
- Recent history of CWD surveillance results in western and northern Canada

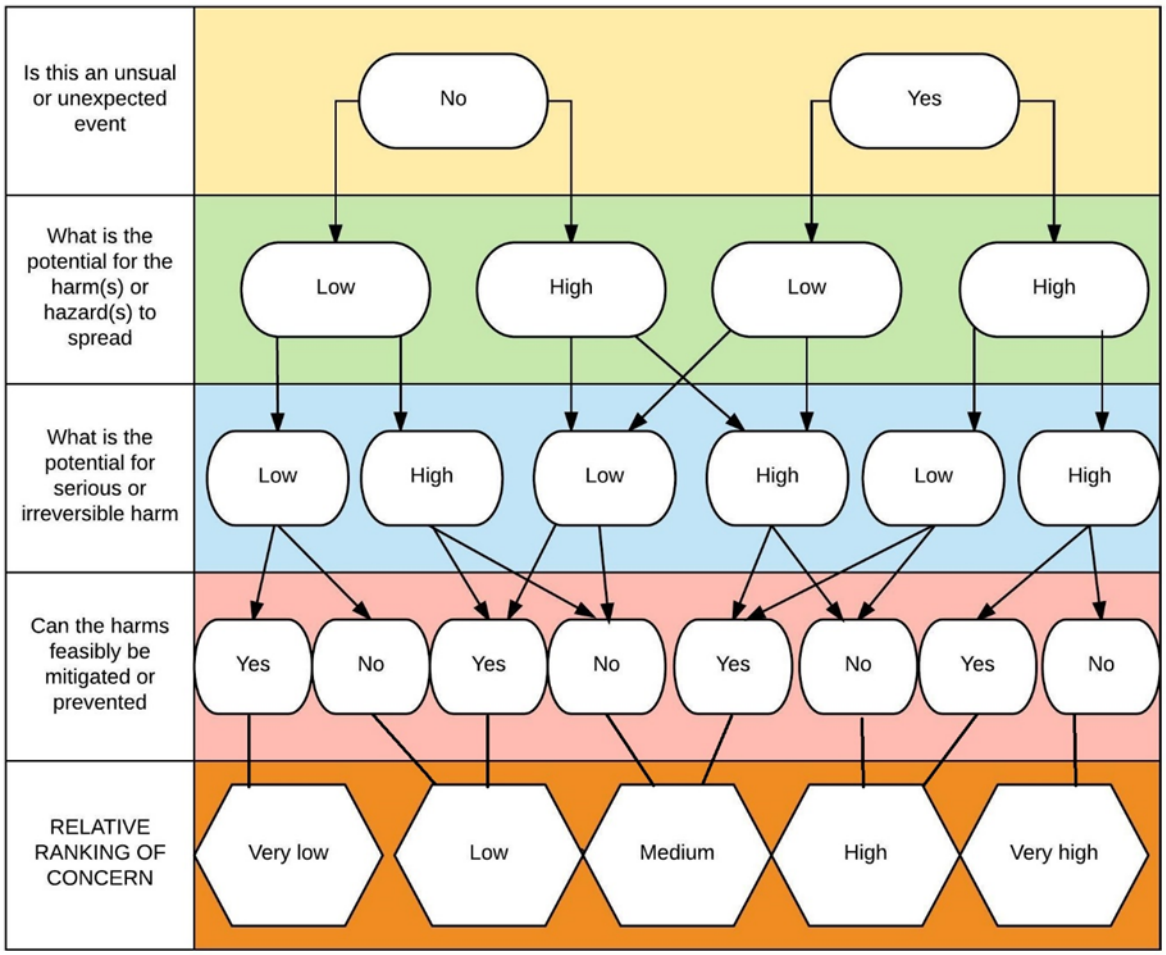
[1] A risk assessment, as opposed to a threat assessment, assesses for a hazard of concern: (i) the likelihood of release (introduction) into the area of concern; (ii) the likelihood that the species of interest will be exposed to the hazard once released; and (iii) the consequences of exposure.

Part 1- Threat Screening

The figure below was taken from the preliminary issue screening section of the Situation and Response Analysis Framework for Wildlife Health. Information needed to apply this figure was derived from the problem description (part 2) and vulnerability assessment (part 3)

SUMMARY RANKING

CWD is a threat of high concern for woodland caribou



RATIONALE FOR THREAT SUMMARY

Would CWD be unusual or unexpected if detected in woodland caribou?

- **No.** It would be unusual in the sense that CWD has not yet been diagnosed in caribou but given the occurrence of CWD in Norwegian reindeer, the presence of CWD in wild and farmed cervids on the southern fringes of woodland caribou ranges, and the northern movement of CWD in other cervids in Canada, it would not be unexpected if a woodland caribou was found to be positive for CWD.

What is the potential for CWD to spread if introduced?

- Unknown in woodland caribou habitat but a precautionary approach would be to assume it to be **high** rather than low. Given the transmissible nature and environmental persistence of the CWD prion, if introduced into woodland caribou habitats the prions are likely to persist. Spread via direct contact between caribou may be low due to their isolated nature, but other cervids species could perpetuate and spread CWD prions.

What is there potential for serious and irreversible harms?

- **High**. The lack of effective management strategies coupled with the conservation status of woodland caribou, their compromise from cumulative effects of other harms and hazards, and the potential loss of subsistence and cultural resources leads to the potential for a persistent and serious harm.

Can the harms be feasibly mitigated or prevented?

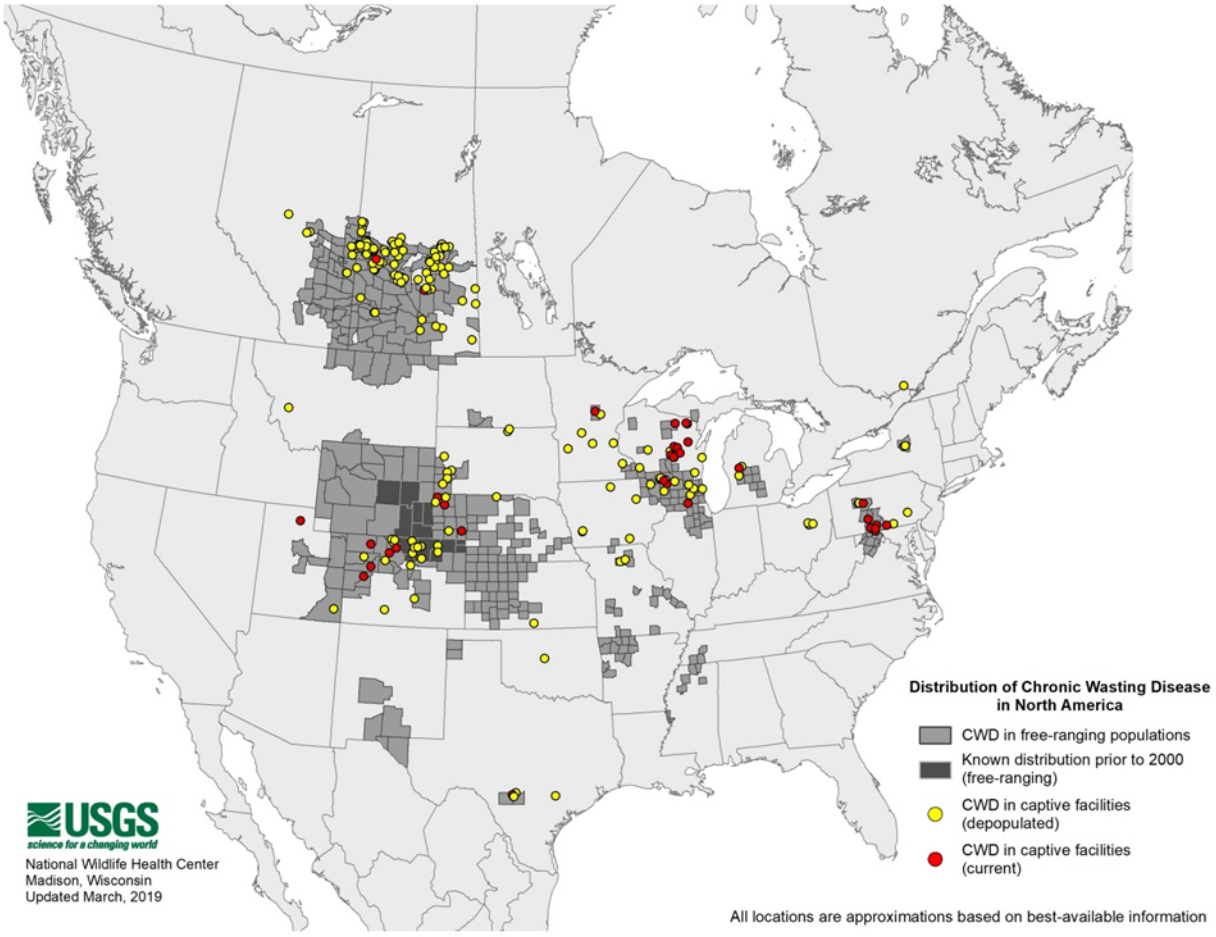
- **No**, under current conditions. The lack of proven means to prevent the spread or elimination of this disease in any affected wild or farmed population reduces confidence in the ability to prevent the effects of CWD in caribou. Innovations would be needed in policies and practices to prevent the disease from spreading to woodland caribou or in their habitat. There are no proven means to mitigate CWD once introduced into a cervid population. The general coping capacity of woodland caribou is compromised by a variety of human-associated changes linked to their threatened status.

Part 2-Problem description

2.1 Overview of the hazard

Chronic wasting disease (CWD) is a fatal disease of wild and farmed members of the deer family (cervids) including mule deer, white-tailed deer, moose and elk. It is considered the most important disease threatening North American cervids (1). It was first discovered in the late 1960s in a research facility in Colorado and has since spread to 24 states and 3 provinces (Fig. 1).

Figure 1: Distribution of Chronic Wasting Disease in North America, March 2019. Source: USGS National Wildlife Health Center. https://www.usgs.gov/centers/nwhc/science/expanding-distribution-chronic-wasting-disease?qt-science_center_objects=0#qt-science_center_objects



It is not yet possible to determine if CWD first occurred in captive or wild animals, but it was introduced to Canada in 1996 with farmed elk imported to Lloydminster, Saskatchewan. It was first detected in wild deer in Canada near this farm in 2000. Surveillance in the wild population began in Alberta and Saskatchewan in 1996/1997. Alberta's first CWD case in the wild was detected in 2005. CWD has been found in farmed deer and elk in Alberta, Saskatchewan and Quebec (2).

The disease is widespread in the Canadian prairies and has been spreading north and westward (Fig. 2 and 3)[2]. CWD continues to spread across North America through movement of infectious animals or materials, in migrating /dispersing wild populations, or through movement of infectious live animals, carcasses, or other materials (3).

What causes CWD?

CWD is a transmissible degenerative brain disorder characterized by tiny holes that give the brain a "spongy" appearance, hence the name transmissible spongiform encephalopathy (TSE). It is caused by prions. Prions are misfolded proteins. The world prion is short for "proteinaceous infectious particle". CWD prions have been found in numerous tissues and excretions including the nervous system, urine, feces, saliva and blood (4). CWD prions can persist inside and outside of the animal. CWD prions can be found throughout a diseased host, including skeletal muscle, cardiac muscle, fat, a wide range of glands, organs, and peripheral nervous tissue, and in the highest concentrations in the central nervous system (5).

CWD is highly contagious. CWD prions likely spread between animals through body fluids like feces, saliva, blood, or urine, either through direct contact or indirectly through environmental contamination of soil, food or water. The natural routes and mechanisms of CWD prion uptake are incompletely described (4). It can take up to 3 years before an exposed animal shows signs of the disease (5). The passage of prions between mother and fetus has been demonstrated throughout the gestational period (6).

Prions are very resistant to degradation. They can be maintained in the environment for many years, acting as a reservoir for the disease. Depopulating an entire herd may not eradicate the disease because of untreatable and widespread environmental persistence of infectious CWD prions. Prion contamination of surfaces commonly present in the environment (e.g wood, rock, metals) can be a source of disease transmission in experimental models (7). Studies have shown prions adsorb strongly to soil components, clay-based soils in particular, and remain infectious and persist for years (8).

[2] Spread depicted in figures 2 and 3 should be considered estimates due to variation in surveillance efforts over time and space.

Figure 2: Spread of CWD between 2000 and 2018 in Saskatchewan, March 2019. Source: Canadian Wildlife Health Cooperative.

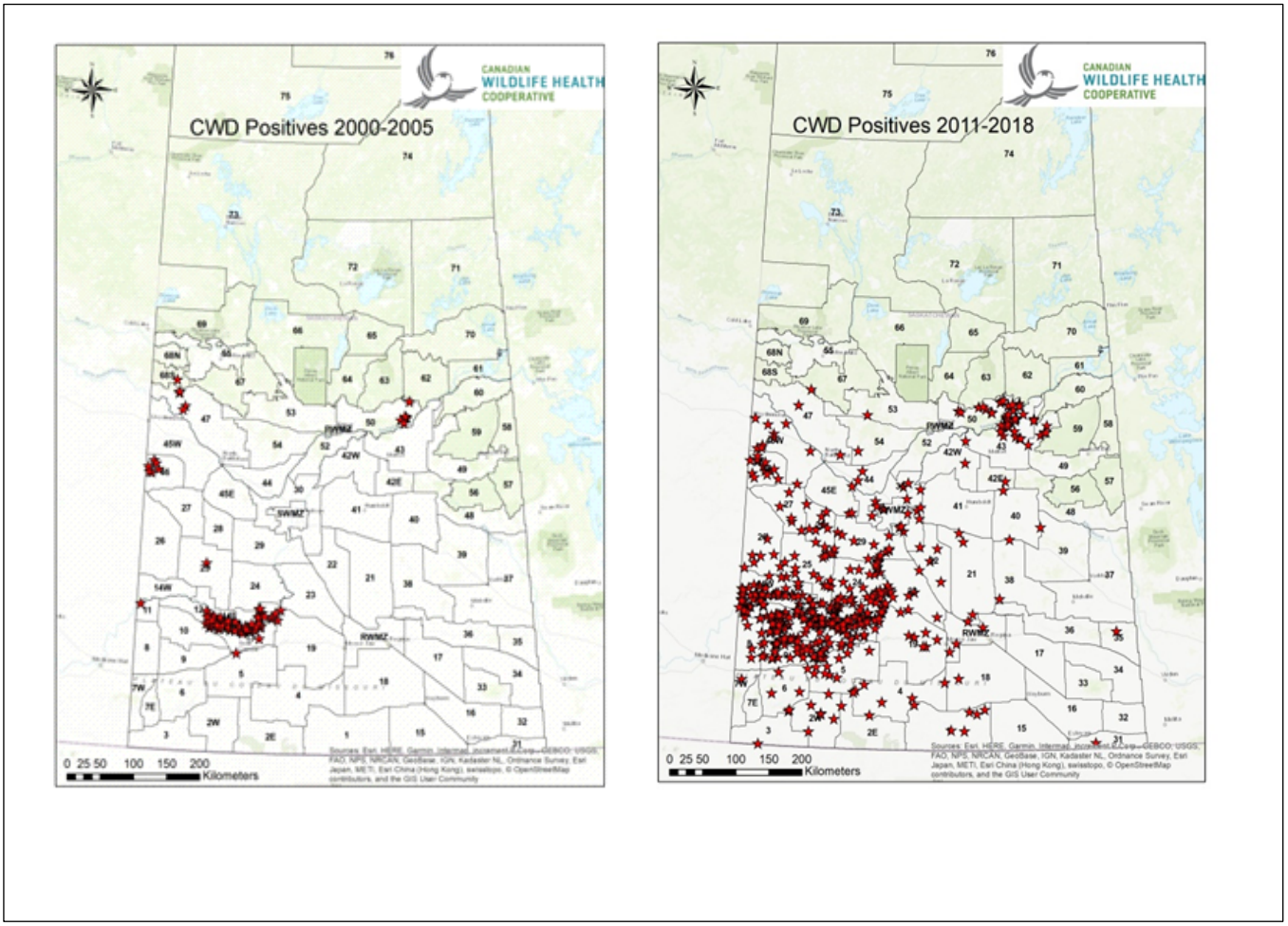
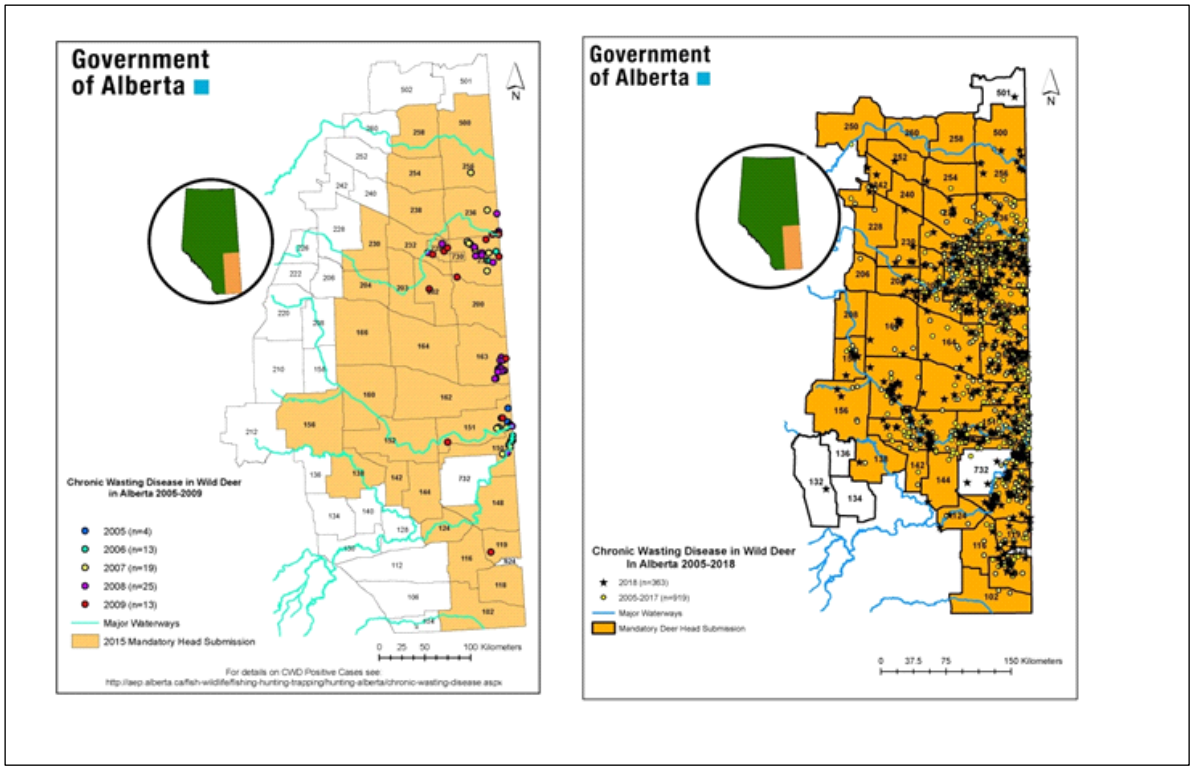


Figure 3: Spread of CWD between 2005-2018 in Alberta, March 2019. Source: Government of Alberta.

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



Mineral licks can serve as reservoirs of CWD prions and thus may facilitate disease transmission in wild cervids (9). Green plants can take up and transport infections prions (10). The persistent, infective, environmental contamination caused by the prion means that wildlife management agencies have few options to prevent this disease after the prions are introduced into an environment.

There are different strains of CWD prions which differ in presentation, survival period and distribution of lesions (11). The Canadian Food Inspection Agency (CFIA) verifies and strain types all CWD positive cases from across Canada using a variety of techniques (G. Mitchell, 2019 Mar 18, personal communication).

<u>Population and individual effects of CWD</u>

No case of CWD has been reported in caribou in Canada to date, therefore, there are no data to describe effects of CWD on caribou. Information on the possible effects of CWD on woodland caribou must rely on proxy information from studies of other North American cervids or on

Norwegian reindeer (see below for more information on reindeer). The reliability of these proxy data is unknown.

The effects of CWD on affected individuals is well described (12). CWD has a very long incubation period (2-4 years) and pre-clinical signs are hard to distinguish from normal behaviours. Once in the late stages of the disease, the animal will begin to lose body condition and coordination. Excessive salivation, lack of voluntary coordination of muscle movements, dull hair coat and drooping head and ears are all common clinical signs of the disease. Animals are usually isolated from the herd or unable to maintain fitness. Animals with clinical signs of the disease die within 5 to 12 months (13). No vaccine, treatment, or medical cure exists for CWD.

Less is known about the population effects of CWD in part due to the challenges of attributing changes in population ecology to a single hazard, such as a disease, as well as to the challenges of determining the population impacts of a slow, chronic and persistent infection. This is compounded by lack of information on cervid population abundance diversity and distribution.

The infrequency of linking population monitoring data with disease surveillance information challenges making generalized conclusions of the population effects of CWD in Canada, although there are studies that have implicated CWD as a cause of deer and elk population declines. Results of modelling exercises forecasting long-term outcomes of the disease range from relatively low disease prevalence and limited host-population decline to host-population collapse and extinction (14). Studies in Wyoming and Colorado have shown population declines in both mule and white-tailed deer over time as the prevalence of CWD rises (15). Monello et al (2014), concluded that CWD can exceed natural rates of mortality, reduce survival of adult females, and decrease population growth of elk herds in a US National Park (16). Factors such as human land use, hunting pressure, cervid density and demographics, CWD control efforts and others are believed to impact the prevalence and impacts of CWD in wild populations (1,17, 18).

Although an effect on reproduction has not yet been shown (19), some populations with a very high prevalence of CWD have been unable to sustain themselves. Animals with CWD are more vulnerable to predation and also hunter harvest (20). This could be due to a number of factors including decreased mobility and reaction time to stimuli (20). Information available for this review was insufficient to characterize trends in cervid population abundance and distribution in response to CWD in Alberta and Saskatchewan.

Public health agencies have made precautionary recommendations that hunters establish that cervids are free of CWD prior to consumption based largely on; (i) experimental evidence of susceptibility to the disease in non-human primates; (ii) the capacity for other prion diseases

(i.e. Mad Cow Disease) to be spread to people by eating infected animals and (iii) lack of absolute proof of a species barrier between CWD-affected cervids and humans. Epidemiological investigations and risk assessments carried out to date have found no association between the occurrence of neurological disease in people and exposure to CWD (21, 22).

2.2 Values at risk

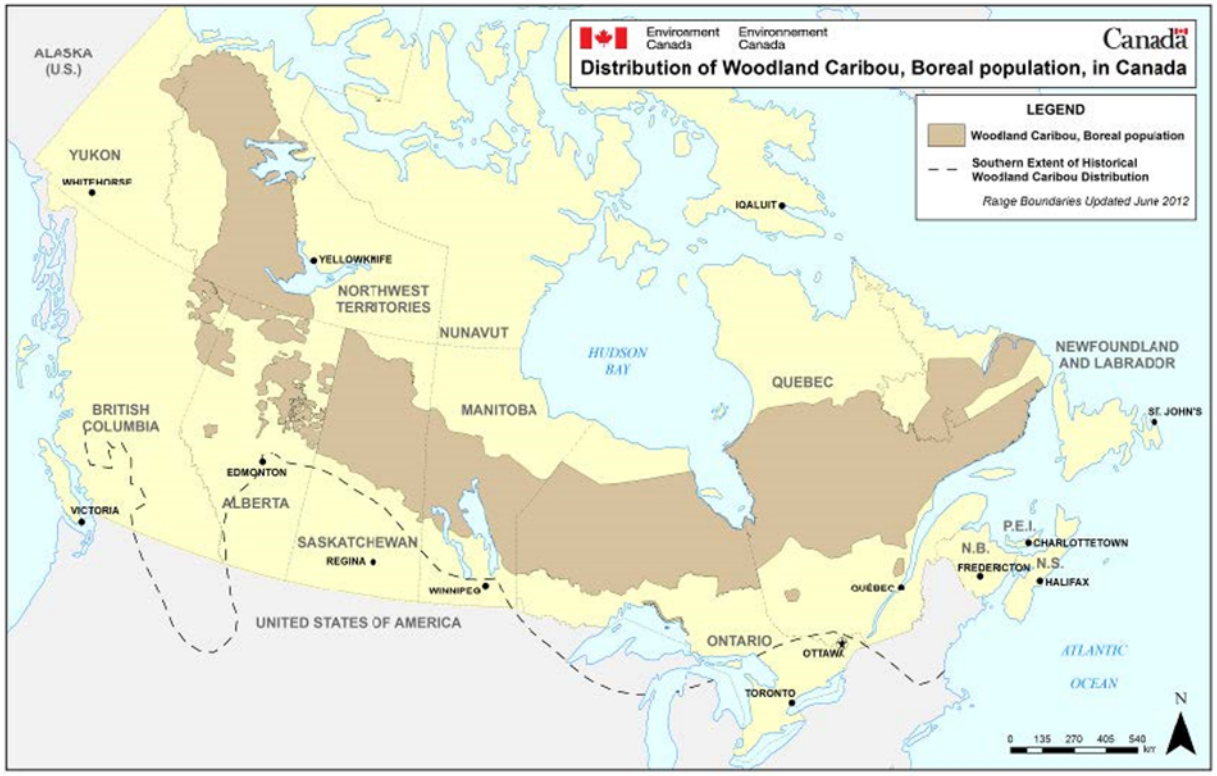
Woodland caribou, also known as boreal caribou (*Rangifer tarandus caribou*), are found across nine provinces and territories in boreal forests and the open taiga forests along the Hudson Bay coast (Fig.4). Unlike barren ground caribou, woodland caribou tend to stay alone or in small groups and do not migrate long distances between seasons. They require large tracts of undisturbed habitat consisting of old growth forest, muskegs, bogs, peats and upland areas with abundant lichen, which is their main food source. They maintain low population densities across the landscape and have a low reproductive rate. Females don't reproduce until three years old and only have one calf per year (23).

Woodland caribou were listed in 2002 as Threatened in accordance with Canada's Species at Risk Act (SARA) based on a >30% population decline over three caribou generations. Woodland caribou are protected under provincial legislation in Ontario, British Columbia, Alberta, Manitoba, Labrador, Northwest Territories and Quebec. Environment and Climate Change Canada (ECCC) is the federal lead for caribou protection and recovery, as per the Species at Risk Act. Population estimates at the time of publishing the federal species recovery strategy was ~34,000 across Canada.

CWD is not considered in either the recovery strategies or action plans produced by ECCC or four provinces (MB, SK, AB and BC). The Yukon and NWT both mention CWD as threat to caribou with the northwards expansion of other cervid ranges (24, 25).

Many factors have been associated with woodland caribou declines, including wildfire, predation, hunting, poaching, winter recreation, hydroelectric development, mining and mineral exploration, logging, corridor development (highways, railways), and human habitation (26). Many of these are interrelated threats that act cumulatively to impact woodland caribou. Disease is not considered to be one of the major threats affecting boreal caribou in the federal recovery strategy, although local effects and unanticipated effects from climate change on diseases are mentioned (23).

Figure 4. Distribution of Woodland Caribou. Environment Canada, March 2019. Source: https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/rs_caribou_boreal_caribou_0912_e1.pdf



Little information was found to estimate of socio-economic values from a search of PubMed, Google Scholar and the USask library website using the terms “socio-economic value woodland (or boreal) caribou.” A 2012 study in Alberta concluded that herds provided a net benefit to the province of $200 million per year and that the benefits of caribou conservation exceed the costs for the majority of the management strategies (27). A 1995 economic evaluation of woodland caribou in Northwestern Saskatchewan concluded woodland caribou conservation is very important to Saskatchewan resident and annual benefits of a conservation program to be approximately $10 million (28). “Declines of woodland caribou also allegedly violate Canadian Aboriginal treaty rights that have been challenged in court” (29). Woodland caribou are a food source for several First Nations. The small and dispersed woodland caribou populations make them an “incidental” food sources, but they are growing in importance with the decline of barren ground caribou (30). Population declines or impacts on consumer confidence in the safety of wild harvested cervids because of CWD may threaten indigenous rights to hunt and traditional ways of life.

CWD in other cervids has resulted in socio-economic impacts. A study in Alberta, for example, showed that hunters believed that hunting would decline with CWD which may lead to negative economic impacts for affected areas (31). Studies in United States stated that 49% of hunters

would stop hunting if CWD prevalence continued to rise above 50% which in turn would have detrimental effects on revenue for wildlife agencies and rural communities that depend on hunting (32).

2.3 Management overview

There are two interconnected manifestations of CWD; one in cervid farms and the other in wildlife. This results in different regulatory responsibilities and priorities between agencies responsible for CWD management. The management of CWD in captive cervid operations in Canada is a joint responsibility of captive cervid producers, provinces/territories, and the federal government. The CFIA has recognized that efforts to eradicate CWD in the farmed cervid population have been unsuccessful. As a result, the CFIA's new approach aims to reduce the risk of the disease spreading by encouraging producers to adopt risk mitigation measures and enroll in a Voluntary Herd Certification Program (VHCP) to help prevent the introduction of CWD to a farm. The VHCP requires enrolled producers to undertake ongoing surveillance testing of mature dead cervids and implement biosecurity measures.

Managing CWD in wild animals falls largely under provincial or territorial jurisdiction except on federal lands or where federally listed species at risk are involved. Provincial control programs vary (see appendix 1). Efforts range from restricting the movement of live animals, dead animals or animal parts, permission for game farming/ranching, and rules on baiting, attracting or feeding cervids. Regulations don't prohibit the movement of cervid carcasses or parts within a province (see appendix 1). There are voluntary provincial programs that encourage hunters to minimize the transportation of specified risk materials (those bodies part most likely to harbour prions in infected animals).

CWD is a reportable disease under the Federal Health of Animals Act. This means that individuals and laboratories aware of a diagnosis must report a case to the CFIA. Surveillance for CWD is inconsistent over time and location in Canada. In some cases, this reflects the apparent risk (i.e. surveillance in Alberta is more extensive than in New Brunswick due to the differing epidemiological situations). In other cases, this reflects resources available; and in still other cases, it reflects variation in interest, and the ability or compliance of hunters and other resources users to provide samples. Detection of CWD in captive and wild cervids is achieved through surveillance conducted by provinces and territories or their delegates. CWD targeted surveillance programs are active in 6 Canadian jurisdictions; British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and Quebec. These jurisdictions have programs that actively encourage submissions of animals for CWD testing, focussing on susceptible species. The CWHC and other agencies conduct scanning/opportunistic surveillance for wildlife including ungulates. Scanning surveillance refers to testing animal brought to a diagnostic centre to determine cause of death that were not recruited from targeted programs. Scanning surveillance augments

targeted programs and provides some level of surveillance in those jurisdictions lacking a targeted program. Appendix 1 includes summaries of recent results of western and northern Canadian surveillance programs based on publicly available information or data provided in response to requests made for this assessment.

2.4 CWD in Reindeer

The diagnosis of CWD in European reindeer (*Rangifer tarandus tarandus*) increased concern about the vulnerability of woodland caribou to the disease given that they are in the same species and genus.

The first case of CWD in Europe was in a Norwegian free-ranging reindeer in 2016 (33). The clinical and pathological signs and the prions found in this case resembled those found in North American cervids. By November 2017, intensive surveillance found CWD in eight free-ranging reindeer, three moose and one red deer. The moose and red deer were older animals and showed limited nervous tissue distribution of prion protein. This suggested an atypical, spontaneous mutation which could be termed atypical CWD (34). A case was also found in a moose in Finland but it also did not appear to be the North American, highly contagious form of CWD, instead resembling the atypical CWD diagnosed in Norway. The first report of CWD in Sweden was in a moose with suspected atypical CWD (reported on ProMed March 27. Details on the type and origin of this case were lacking when this report was prepared).

Norway undertook intensive culling along with other management actions to try to contain or eliminate CWD in reindeer. Since the discovery of CWD in 2016 over 72,000 animals have been tested from around the country with 19 confirmed positives in wild reindeer (35). There is currently no information about the source(s) of CWD in Norway.

The impacts of CWD in Norwegian reindeer cannot be estimated because; (1) insufficient time has occurred to determine the long-term implications of this slowly incubating disease and (ii) the Norwegian government undertook aggressive animal culling efforts in an attempt to eradicate the disease before it became established (35).

Part 3- Vulnerability assessment

Vulnerability assessment is composed to two parts; exposure assessment and sensitivity assessment. In this section we address the questions:

- Are there opportunities for woodland caribou to be exposed to CWD prions?
- Are woodland caribou sensitive to CWD?

3.1 Exposure assessment

Purpose: Exposure is defined as the process with which woodland caribou are in proximity and/or contact with the CWD prion to the extent that a harmful outcome is possible. No further assessment is warranted in absence of a viable exposure pathway.

Conclusion: An exposure pathway could not be established with certainty due to prevailing unknowns about the interactions of woodland caribou and CWD infected cervids or environments. However, the overlap of woodland caribou ranges with the northern extents of CWD infected wild and farmed cervids plus the prolonged environmental persistence of the CWD prion in the environment warrants a **conclusion of a plausible but unknown exposure route**.

The exposure assessment was guided by figure 5 which was taken from the Situation and Response Analysis Framework for Wildlife Health

Is there a viable route for the hazard to enter the environment?

CWD has been detected at the southern border of woodland caribou range in Saskatchewan in both wild and farmed cervids (Fig. 6 and 7). CWD infected animals shed the CWD prion through multiple excretions and secretions, creating a viable means for the prion to enter woodland caribou habitats. It is unknown if release has occurred in specific areas frequented by specific woodland caribou populations

There are no geographic barriers to the northern spread of CWD by the movement of animals. “Movement of infected live animals is considered one of the greatest risks for spreading CWD to new locations” (1). A study in Wyoming showed that migration plays an important role in the transmission of CWD with CWD-positive males migrating at a greater proportion than CWD-positive females (36). Migration and dispersal are well documented in deer populations; e.g. 60-89% of male mule deer fawns will disperse within the first year (37).

Climate change is expanding the extent of the northern range of some cervid species in the boreal forest (38). Climate change has been linked to northern expansion of white-tailed deer in

Alberta (38) and mule deer in the Yukon (39). This combined with increased human disturbance like logging increases potential contact between caribou and other species. (40)

Information online pertaining to game farm locations within caribou habitat range was out of date. Up-to-date information was not provided upon our requests to the CFIA and provinces.

The practical limitation to constraining the movements of free-ranging cervids makes isolation or quarantine impractical

Figure 5. Exposure assessment framework from the Situation and Response Analysis Framework for Wildlife Health.

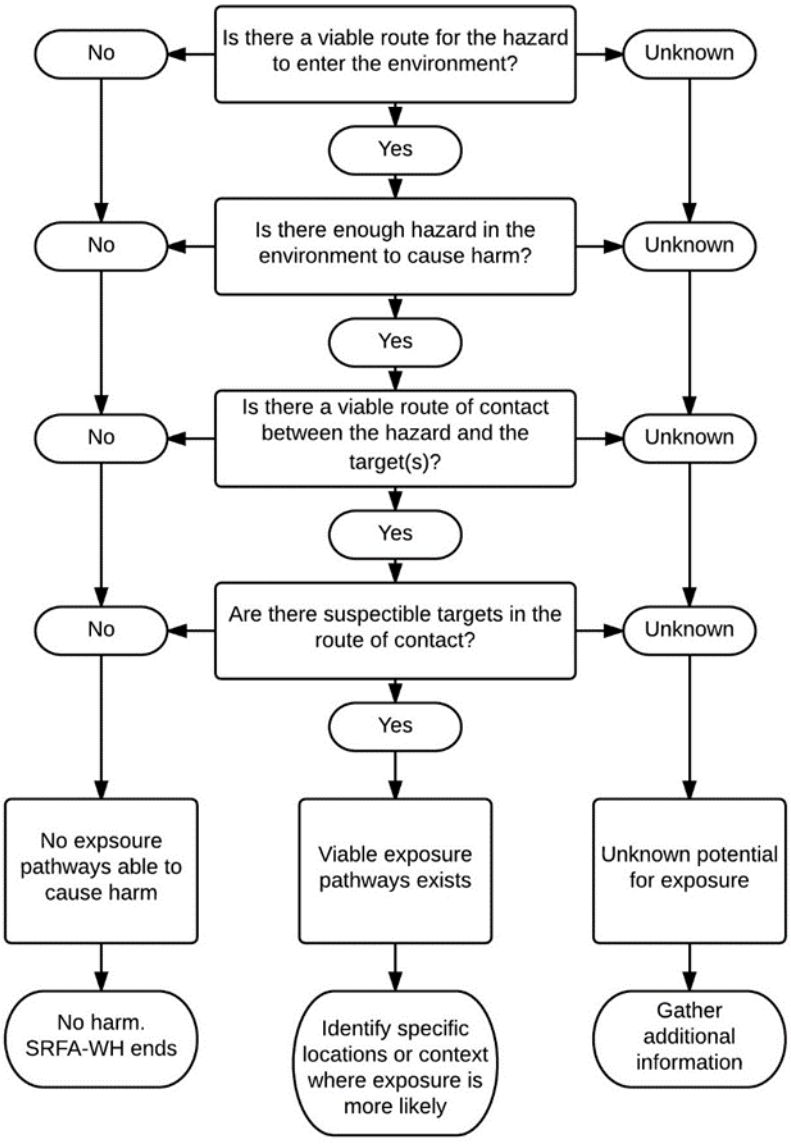


Figure 6. Overview of overlap of CWD range and the distribution of woodland caribou. CWD general locations are in pink. Government of the Northwest Territories, March 2019.

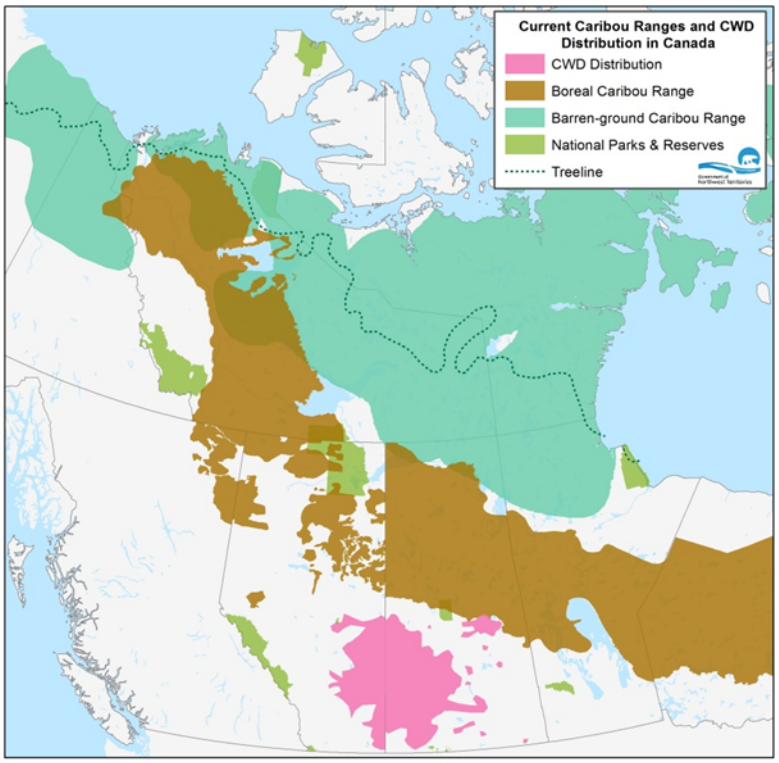
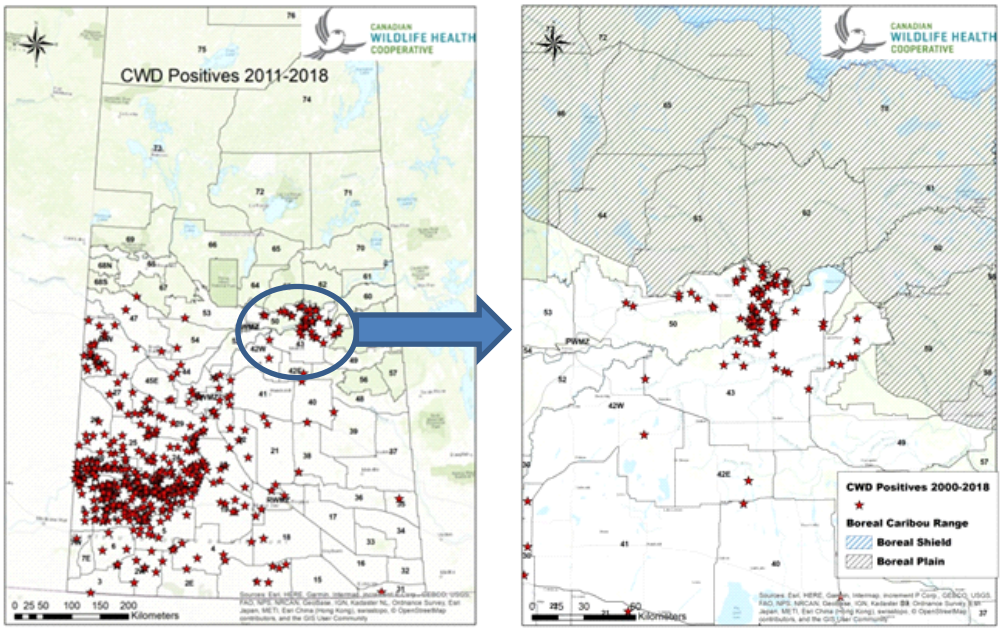


Figure 7: Details of northern distribution of CWD in Saskatchewan (insert shows the location of the enlarged area on the right) Canadian Wildlife Health Cooperative, March 2019



Is there enough hazard in the environment to cause harm?

No information exists to estimate the infectious dose for woodland caribou and to determine if this level of exposure exists within the plausible exposure pathway.

Caribou require large expanses of undisturbed habitat while other cervids such as moose and white-tailed deer prefer more open landscapes. Different habitat preference will modify the probability of exposure but the protective effect of the caribou life history (if it exists) is unknown.

Is there a viable route of exposure between woodland caribou and the CWD prion?

As CWD prions are shed into the environment and are environmentally persistent a plausible opportunity for woodland caribou to be exposed in their southern Saskatchewan range exists.

Crude range distribution maps suggest that there is overlap between the range of known CWD susceptible species such as moose, elk, white-tailed deer and mule deer with the range of woodland caribou (appendix 2). However, population surveys are infrequently conducted and/or are outdated, precluding precise conclusions of the contact between specific populations of woodland caribou and other susceptible cervids. Detailed information on specific locations of woodland caribou were either unavailable or not provided upon our requests.

The use of baiting stations for cervid hunting could increase the probability of exposure because alternative food sources (such as grain) and mineral blocks provide the greatest amount of contacts between individuals (41), increasing the probability of inter and intra-specific contact between infected and susceptible individuals. Areas of animal congregation are recognized to be increase sites of CWD prion exposure (42). Although no sightings of caribou using alternative food sources or mineral blocks have been reported in Saskatchewan, there have been reports of them using salted roads in both the winter and summer. (T. Trottier 2019 March 20, personal communication).

The frequency and amount of hunter or other human-assisted movement of carcasses or specified risk materials from CWD infected cervids into woodland caribou habitats is unknown.

Are susceptible woodland caribou in contact with the CWD prion?

No data exist to answer this question.

3.2 Sensitivity assessment

Purpose: identify factors that make a woodland caribou more or less sensitive to CWD, including consideration of their capacity to cope with and/or recovery from the disease.

Conclusions: The lack of effective preventive and mitigating measures that can be used in woodland caribou is the biggest determinant of their sensitivity. There remain significant unknowns about the susceptibility of woodland caribou to CWD. There is reason to believe the caribou will be susceptible to infection and if CWD prions enter woodland caribou habitat, they will persist. The ecology and behaviour of woodland caribou may reduce exposure and sensitivity, but the magnitude of their effect is unknown. The multiple hazards they are already facing may compromise population capacity to cope with newly introduced diseases, including CWD.

Is there direct evidence that woodland caribou are susceptible to CWD?

In the absence of a case of CWD in woodland caribou, there is no direct evidence the species is susceptible to CWD under natural conditions. Confidence in this conclusion is moderated by deficits in the examination of woodland caribou for CWD (see appendix 1 describing the surveillance efforts in woodland caribou)

In the past 25 years approximately 900 caribou of all sub-species were submitted through the CWHC scanning surveillance program. No CWD was diagnosed, but not all submissions had neurological examination or were subject to CWD testing. The British Columbia Boreal Caribou Health Research Program started in 2013. If there were samples available from dead animals suitable for CWD examination, they were tested for CWD. 13 animals were tested and were negative (C. Nelson, March 26, 2019, personal communication). The Saskatchewan Boreal Shield Woodland Caribou project were unable to collect samples for CWD testing due to the remoteness of the project field work (P. McLoughlin, 2019 Mar 19, personal communication).

Biological determinants of sensitivity

Individual level susceptibility

There are known species barriers for other transmissible spongiform encephalopathies, wherein infectious material from one species cannot cause disease in another. Based on CWD in Norwegian reindeer it is reasonable to expect no such barrier would exist for woodland caribou, but this has not been established as fact.

Genetic determinants of susceptibility to CWD exists but there is inconclusive evidence of the prevalence or effect of genetic susceptibility traits in woodland caribou. The sequence of the prion protein gene (PRNP) affects susceptibility to prion diseases in many species (43),

therefore, the genetic basis of CWD susceptibility in free-ranging cervids is of great interest. PRNP sequences from three Alaskan barren land caribou populations were "similar to that of other cervids, especially mule and white-tailed deer, suggesting a very weak species barrier" (44). The authors of that study concluded that "genetics seems to permit the spread of chronic wasting disease from middle-latitude deer to high-latitude caribou in North America." Another small study in Alberta found an isolated woodland caribou population with evidence of a reduced genetic susceptibility to CWD, therefore indicating lower risk of disease when compared with other populations that were also declining. But the authors noted a similar genetic signature has not been described for other woodland caribou populations (45). An earlier small study suggested some genetic resistant to CWD specifically in reindeer (46). There remains debate over whether a partial genetic resistance to CWD infection, or delayed progression, might have positive or negative effects on disease dynamics on the landscape (43).

Population level determinants

Aggregation and gregarious species are at increased risk of exposure (42). Woodland caribou are neither gregarious nor do they aggregate.

Caribou have specific habitat requirements, have low densities on the landscape and slow reproductive rates. Preferred habitat of woodland caribou does not overlap with other cervids other than moose during caribou calving but logging and seismic lines are increasing contact between woodland caribou and other cervids (38). The implications of these habitat overlaps for CWD transmission are unknown.

Woodland caribou are already dealing with multiple stressors[3] including habitat alteration from human land-use activities and forest fire, predation, and climate change (23).

Management determinants of sensitivity

Management actions to date have not prevented the spread of the disease. The CFIA has concluded that eradication of CWD is not achievable on farms

While culling has been used widely in domestic animals to remove susceptible hosts in the face of a CWD outbreak, this is unlikely to work in the woodland caribou because; (1) woodland caribou have legal protection due to their conservation status; (2) there are limited surveys and methods to differentiate preclinical infections from uninfected animals, thus precluding selective slaughter of animals before they are actively contaminating the environment and (3) there are ethical issues and public perceptions that speak against culling as an option. The effectiveness of culling in wild cervids has yet to be established. There have been mixed results

[3] See federal, provincial and territorial recovery strategies for details on stressors and hazards

to date. For example, Colorado's capture-test-cull approach was very costly and time consuming. It slightly decreased CWD prevalence in males but the prevalence in females remained the same (47). Illinois and Wisconsin both implemented CWD cull strategies when CWD was first detected in 2002. Illinois maintained a cull program for 10 years (2002-2012) while Wisconsin discontinued the program in 2007 due to public resistance. The prevalence of CWD remained constant in Illinois at about 1% while in Wisconsin the prevalence continued to rise (48).

No treatment, vaccinations, or cures are available for this disease.

Table 1. Summary of CWD control options for free-ranging wildlife

Generic control option	Viability
Medical treatment	No drugs or chemicals available for CWD treatment
Immunization	No effective vaccines exist
Depopulation	Legal, ethic and spiritual impediments reduce the likelihood of this as an acceptable option
Quarantine or isolation	Difficult to recognize contagious animals before onset of signs, especially for widely dispersed species like woodland caribou. Few practical ways to constrain wildlife movements. No practical way to identify uncontaminated environments
Hygiene	No means to remove the prion from contaminated environment
Promote resilience to cope with the threat	No specific information on how to do this for CWD and woodland caribou are facing multiple concurrent pressures that decrease their resilience

Compliance with recommended management actions for wild cervids has been variable in many jurisdictions. Problems with hunter compliance with CWD recommended control actions have been reported (49-51).

Appendix 1

Overview of CWD surveillance efforts and outcomes in Canada

Summary of current CWD surveillance programs in western and northern Canada

Jurisdiction	Surveillance program summary
British Columbia	Target sample collection volunteered from hunters in the Peace and Kootenay regions (300 samples per region), Will also accept and examine hunter volunteered cervids heads from all over the province.
Alberta	Mandatory testing in certain wildlife management units (WMUs) along the Saskatchewan border and west.
Saskatchewan	Combination of hunter-based and scanning surveillance managed by the CWHC Western/Northern region
Manitoba	Mandatory testing of hunted animals along Saskatchewan border and a voluntary testing along the U.S border
Northwest Territories	Opportunistic CWD sampling efforts
Yukon	Mandatory testing of hunted elk combined with effort to obtain voluntary samples from the other species (mule deer, barren-ground and woodland caribou, moose and bison).

Summary of recent wild cervid surveillance efforts and results

Province	Program Type	Years of testing	Total # tested	# of Positives
British Columbia	Voluntary-Target zones	2002- 2018	3666	0
Alberta	Mandatory-Target areas	1996 – 2018	70000*	1066
Saskatchewan	Voluntary-province wide	1996-2012,2015-2018	49000*	956
Manitoba	Mandatory-Target areas	2010-2018	2852^	0
Northwest Territories	Opportunistic	2013-2018	120	0
Yukon	Voluntary/ Mandatory	2012- 2018	297	0

^ Information provided by CFIA.

* 2018 surveillance programs still on-going. Final numbers not reported yet.

Wild cervid surveillance program notes

Saskatchewan: As of March 2019, over 2400 animals were tested with 356 positives for the 2018 season. The disease continues to be found in new areas of the province and for the first time two moose tested positive from the hunter surveillance program. In 2015, a moose tested positive for CWD. It was found dead and was suspected to have died from CWD.

Alberta: Expansion of mandatory testing zones continues every year when new positives are found. As of January 2019, they had tested over 2300 samples this year and have 147 positives.

Northwest Territories: Currently there are ~100-200 samples waiting for testing and there are ongoing discussions with neighbouring jurisdictions on how to assist with surveillance in the future. (H. Fenton 2019 Mar 4, Personal communication)

CWD surveillance on game farms

Jurisdiction	Attributes and outcomes
British Columbia	Allows fallow deer and reindeer farms but no farming of native cervids. Voluntary CWD testing.
Alberta	Mandatory testing for farmed cervids since 2002 when 3 positives were detected. Since then over 75,000 cervids have been tested with 4 positives.
Saskatchewan	Follow CFIA's Voluntary Herd Certification Program (VHCP). Information on numbers and locations of positive farms is difficult to find in public sources. Information was not provided upon our request in time for this report
Manitoba	Mandatory testing on all ranched cervid deaths. Ban on importing elk from jurisdictions where CWD was detected in the past five years.
Yukon	Elk are the only farmed cervid. Moratorium exists to prohibit import of game farmed animals.
Northwest Territories	One semi-domestic reindeer herd. No known CWD testing.

Information compiled using Chronic Wasting Disease and Cervidae Regulations in North America MI Department of Natural Resources April 2018. Available at: https://www.michigan.gov/documents/emergingdiseases/CWDRegstableState-Province_402847_7.pdf

In 2018 the first CWD positive was detected in Quebec in a red deer farm. A total of 10 deer tested positive out of 1775 examined. The Quebec government also culled free-ranging cervids surrounding the farm and all of them tested negative to date (52).

Summary of CWD Provincial/Territorial Wildlife Regulations for Hunter-Killed Cervids in western and northern Canada (source H. Hunt, Canadian Wildlife Directors Committee). This is not a summary of all CWD regulations. Hunter-killed cervid regulations were emphasized as part of the exposure risk assessment and the role of animal movements in spreading the disease.

Jurisdiction	Regulation Summary regarding hunter-killed cervids
Alberta	None
British Columbia	Import of intact cervid carcasses harvested outside BC is prohibited to reduce the risk of introduction. It is prohibited to possess the head, hide, hoof, spinal column, internal organ or mammary gland of any animal of the family Cervidae (deer, elk, moose) that was killed outside British Columbia. Possession of an out-of-province Cervidae hide that has been treated in a manner that removes all tissue, or antlers or parts of skulls that have had all tissues removed is permitted. As of 2018, it is prohibited to use any part or derivative of a cervid (i.e. urine-based scents) produced outside of B.C. for the purpose of hunting or trapping. CWD surveillance is ongoing. Submission of hunter killed cervid heads for CWD testing in voluntary.
Manitoba	It is illegal to bring into Manitoba a cervid (deer, elk, moose or caribou) that has been killed in another province or state without first removing the head, hide, hooves, mammary glands, entrails, internal organs, and spinal column. These parts must remain in the place of origin. There is an exemption for a moose or caribou that is killed; (a) in the part of Saskatchewan north of the 55 degree parallel of latitude and east of the 105 degree meridian of longitude; (b) in the part of Ontario north of the 51 degree parallel of latitude; or (c) in Nunavut or the Northwest Territories Antlers and connecting bone plate that have been detached from the remainder of the skull and has had all hide and other tissue removed, may be brought into the province, provided the bone plate and antler bases are treated with a solution of not less than two percent (2%) chlorine. Raw capes and hides that have been detached from the animals must be placed in a sealed waterproof container to ensure that no fluids, tissue or hair can escape. Once this process has been done, they may be

	brought into the province provided that they are delivered, within five (5) days of entry, to a licensed taxidermist or a licensed facility for chemical processing into a tanned product. Feeding and attracting cervids in the Bovine TB and CWD Surveillance Zones is prohibited. Baiting of cervids for the purpose of hunting is illegal in Manitoba and it is illegal to hunt within 0.8 km of a substance that is acting as a cervid bait. Mandatory submission for CWD testing is required for elk and deer heads from some game hunting areas. Possession of any product that contains urine, feces, saliva or scent glands of a cervid is prohibited.
Newfoundland and Labrador	None
New Brunswick	None
Northwest Territories	There are no current CWD-specific regulations. However, expected to be in force July 1, 2019, are new regulations under the *Wildlife Act* preventing the import of mule or white-tailed deer parts ,essentially preventing anything other than boned-out meat. This restriction also includes professionally prepared taxidermy mounts or commercial products (such as urine). Restricted parts may only be lawfully possessed in the NWT if tested to the satisfaction of the Department of Environment and Natural Resources.
Nova Scotia	None except NS is now suspending any live cervid imports using existing general authorities under the Wildlife Act
Nunavut	None
Ontario	In November 2005, possession in Ontario of high-risk parts of harvested white-tailed deer and elk from all other jurisdictions was prohibited by regulation. Hunters must ensure dressed carcasses and antlers/skull cap/hide are kept contained such that nothing can escape into the environment prior to treatment by a tanner or meat processing facility (Part II.1, O. Reg. 665/98). In August 2010, this regulation prohibiting possession in Ontario of high-risk cervid parts was expanded to include moose and caribou. Also introduced was a prohibition on the use, for the purpose of hunting in an area usually inhabited by wildlife, of any product that contains or purports to contain the faeces, urine, blood, gland oil, saliva or other bodily fluids of a cervid (the ban does not, however, prevent the possession or use of such attractants for purposes other than hunting, [e.g. wildlife viewing; photography] O. Reg. 665/98, ss 71. (1)).
Prince Edward Island	None

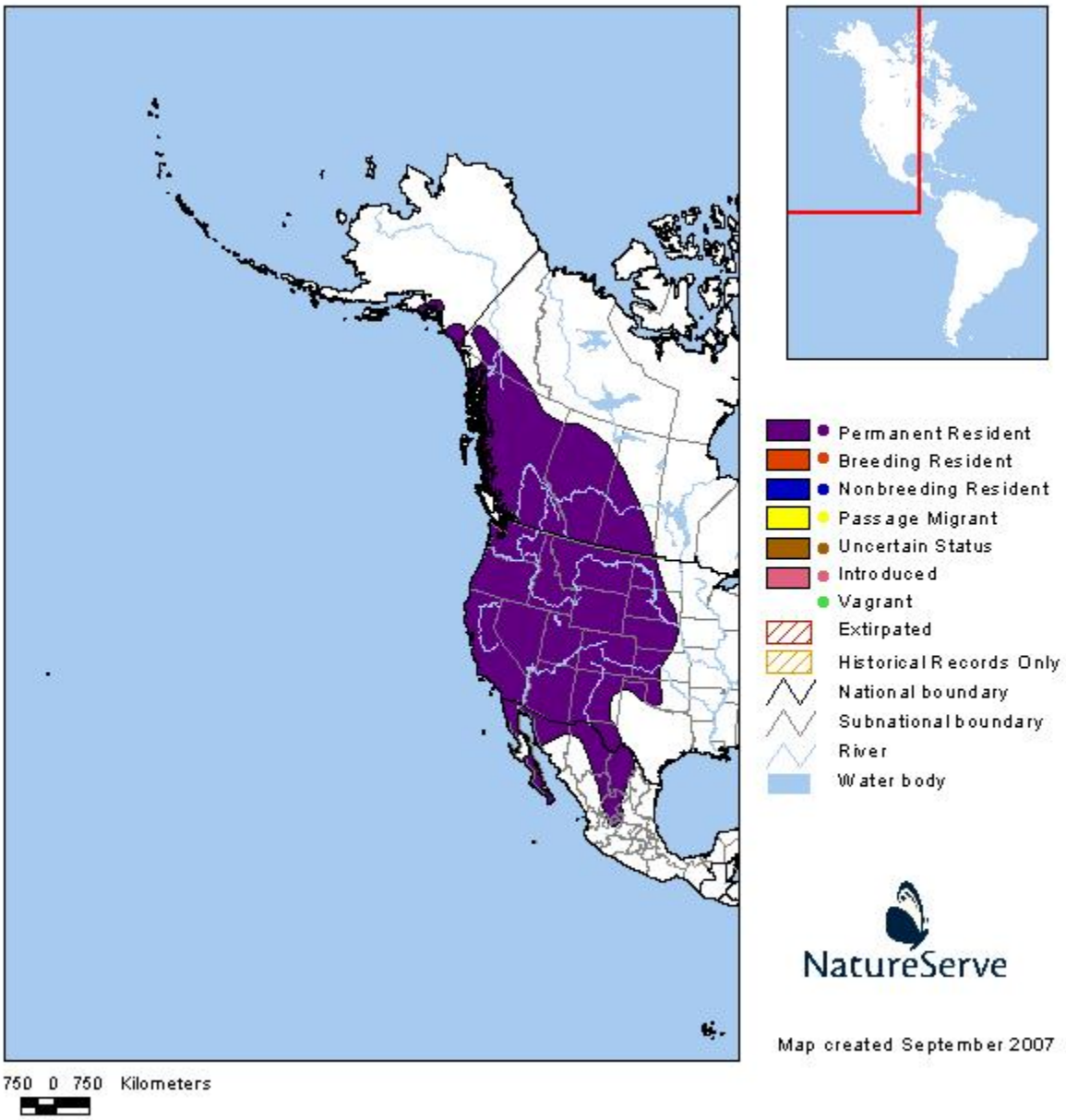
Québec	As of January 2012, the possession of full carcasses or high-risk parts (any part of the brain, spinal cord, eyes, retropharyngeal lymph nodes, tonsils, testicles or internal organs) of cervids (except caribou) killed outside Québec is prohibited. That prohibition does not apply to the following body parts: boneless meat, quarters without pieces of spinal column or head attached, degreased or tanned skin and hide, antlers without velvet, disinfected skull plates without attached meat or tissue, teeth without attached meat or tissue and any piece mounted by a taxidermist. After the first case of CWD was discovered in a cervid farm in September 2018: High-risk parts of cervids killed within a 45-km radius of the CWD known cases must never leave the hunting zone where the animals were killed and the 45-km radius. Cervids killed within an Enhanced monitoring area must be submitted for CWD analysis.
Saskatchewan	None
Yukon	Yukon CWD regulations under the Wildlife Act came into effect in 2013. The import of a whole cervid carcass or portions of a carcass into Yukon is banned. The exceptions to this rule are a cleaned skull cap with antlers, cleaned teeth removed from the head, edible meat completely detached from head and backbone, finished taxidermy mounts, and tanned hides. Cervid carcasses or parts may be transported through Yukon temporarily if in a protective container. All butchering scraps and bones should be properly disposed of in a landfill so they are not scattered by animals. The only exception to this rule are cervids harvested either in the Northwest Territories or in the two northern hunting zones in B.C. Some scent lures sold for the hunting of cervids contain animal urine or glands and could spread disease agents (particularly CWD prions) to new locations. The sale and/or possession of some of these lures is prohibited. Compulsory submission for CWD is required for all Hunter-killed elk. All elk harvested from Game Farms or road killed are also submitted for CWD testing as part of the Yukon ongoing surveillance programs. Hunter harvested and road killed deer are also sampled for CWD.

Compiler's Note: The information in this table (an update of a 2015 scan subsequently updated in 2017) was accurate and current as of February 2019, and verified by the jurisdictions (H. Hunt, 2019 Feb 28, personal communication).

Note: Michigan Department of Natural Resources maintains an up-to-date listing of North American CWD Regulations, Carcass Movements and Testing Results at this website link (http://www.michigan.gov/documents/emergingdiseases/CWDRegstableState-Province_402847_7.pdf)

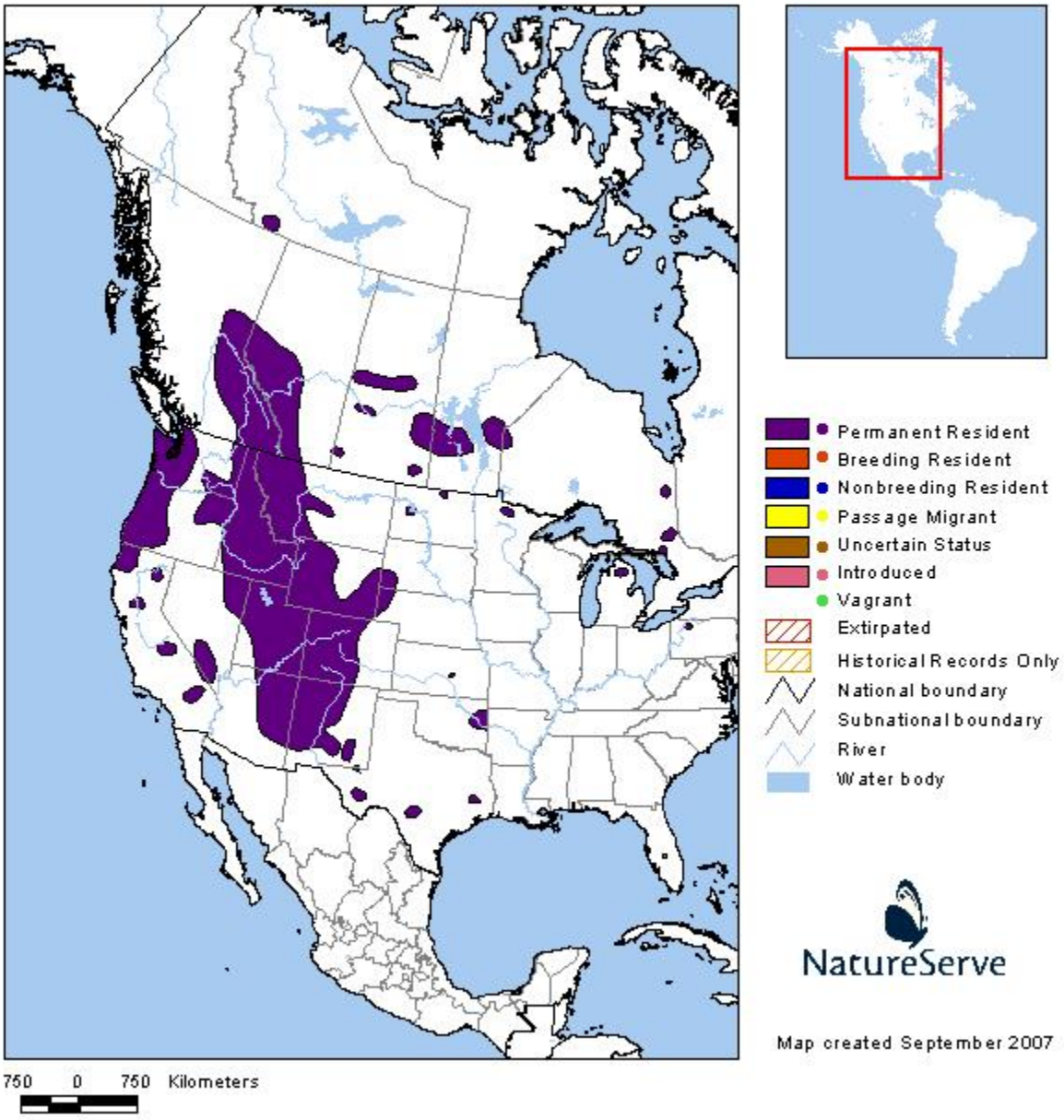
Appendix 2: Cervid range maps

Mule Deer Range



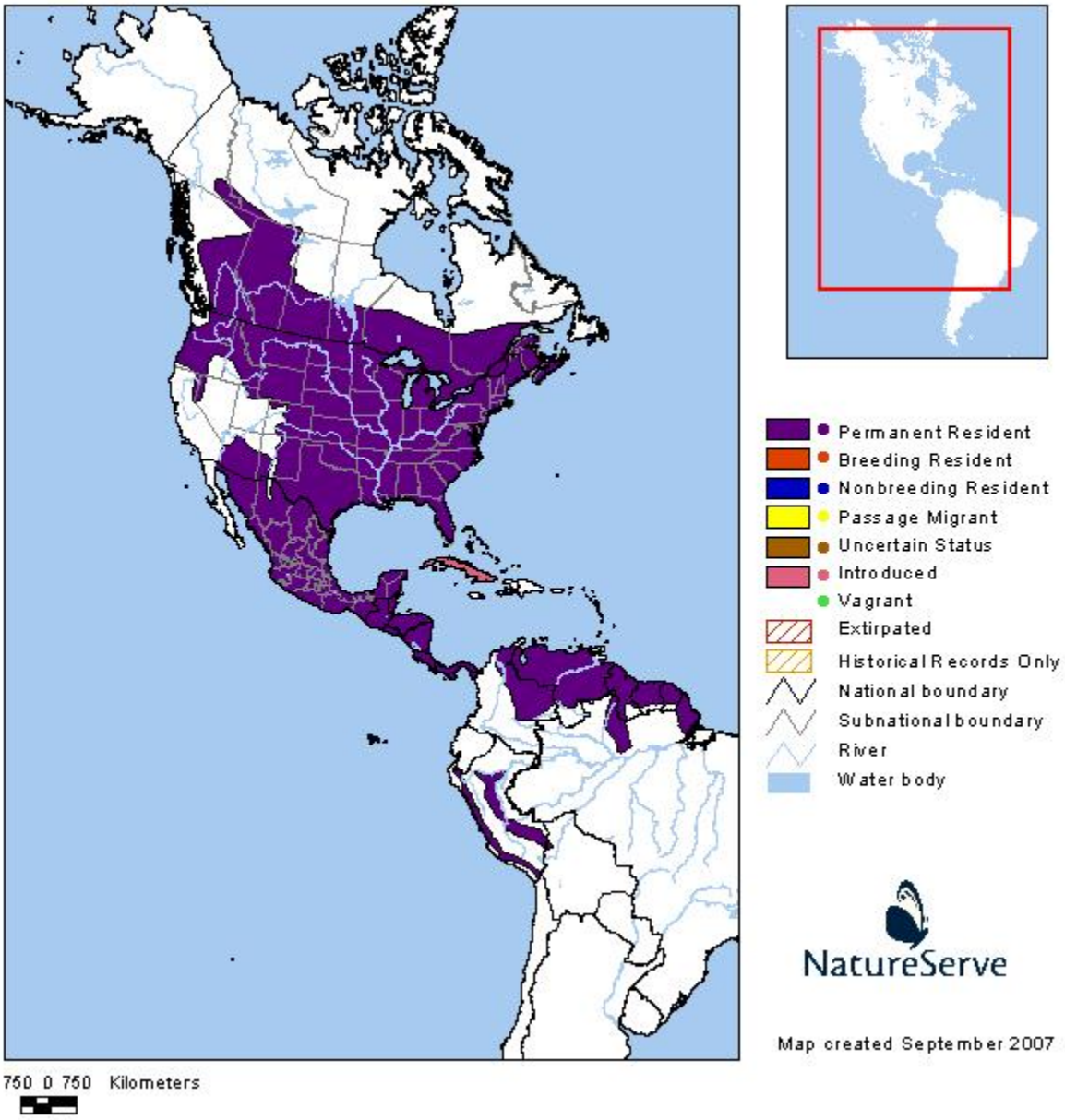
Mule Deer — Odocoileus hemionus. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on March 27, 2019, from http://FieldGuide.mt.gov/speciesDetail.aspx?elcode=AMALC02010

Elk North American Range



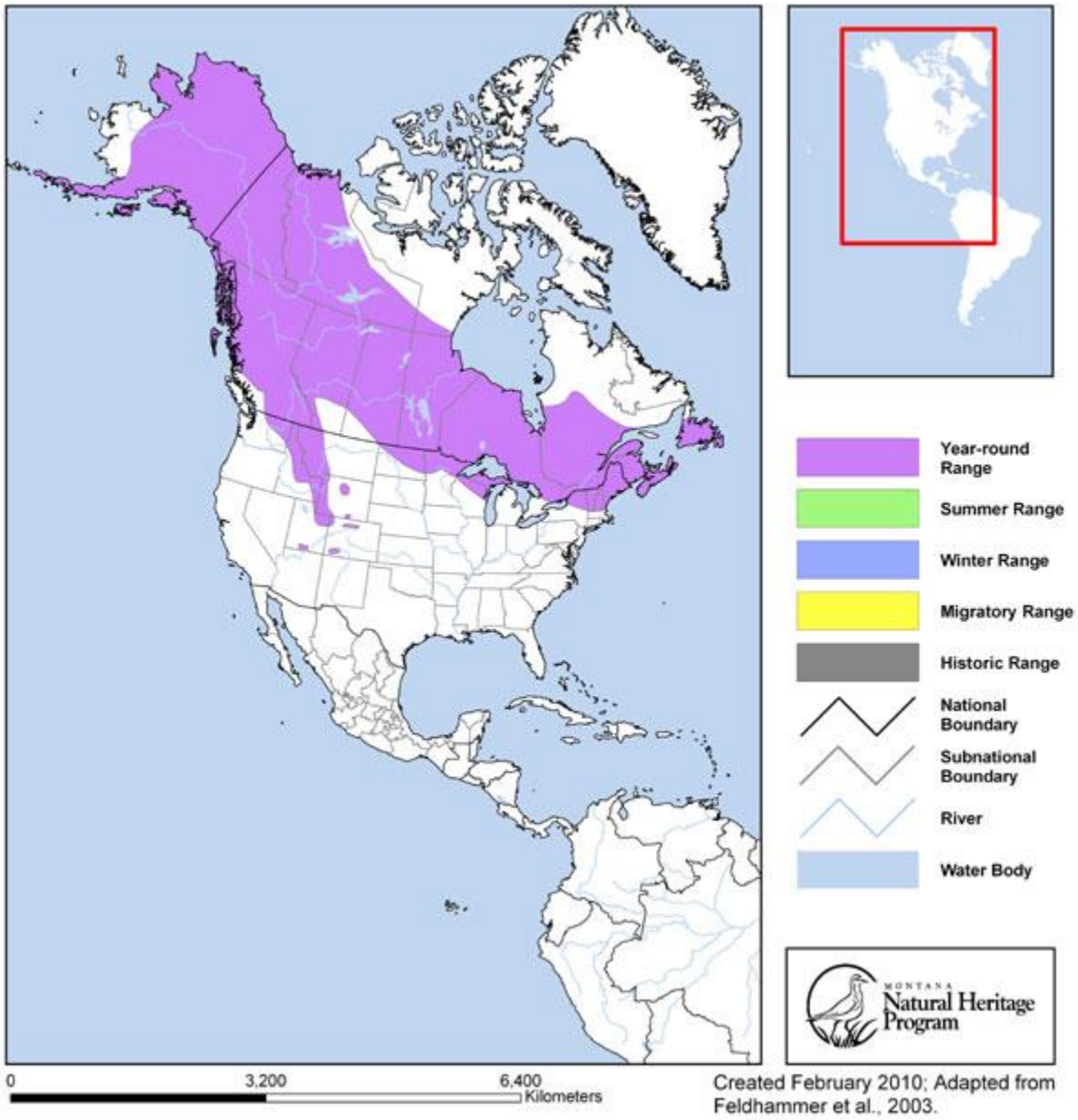
Elk — Cervus canadensis. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on March 27, 2019, from http://FieldGuide.mt.gov/speciesDetail.aspx?elcode=AMALC01010

White-tailed Deer North American Range



White-tailed Deer — Odocoileus virginianus. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on March 27, 2019, from http://FieldGuide.mt.gov/speciesDetail.aspx?elcode=AMALC02020

Moose North American Range:



Moose — Alces americanus. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on March 27, 2019, from http://FieldGuide.mt.gov/speciesDetail.aspx?elcode=AMALC03010

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