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Original Research & Wildlife Management Planning

Chronic Wasting Disease Surveillance Program and Proactive Response Plan for Ontario, Canada

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Abstract

To date (May 2014), Chronic Wasting Disease (CWD) has not been reported in free-ranging or farmed cervids in Ontario, Canada (except in captive Mule Deer (*Odocoileus hemionus*) at the Toronto Zoo during the late 1970s). However, the disease currently exists in adjacent jurisdictions including New York, Michigan, Pennsylvania, Wisconsin, and Minnesota. An economic impact analysis suggested that CWD being detected in Ontario could result in tens of millions of Canadian dollars (CAD) in economic losses. As a result, Ontario has taken a proactive approach to detect and control any potential cases of CWD, and has implemented regulations to restrict importation of high risk cervids and cervid parts into Ontario. A proactive CWD surveillance program for free-ranging cervids was initiated in Ontario in 2002. From 2002 to 2013, 9,987 White-tailed Deer (*Odocoileus virginianus*) and 41 Elk (*Cervus canadensis*) have tested negative for CWD. In addition, 1,964 farmed cervids were also tested for CWD during surveillance operations from 2006 to 2013 – all were negative. Initially, Ontario was divided into 14 zones for free-ranging cervid surveillance operations. Zones were tested in rotation. However, beginning in 2011, a CWD risk model was developed and implemented annually to determine high risk areas in Ontario. As a result, White-

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tailed Deer are collected and tested from the highest risk areas each year as opposed to on a zone rotational basis. A proactive response plan was also developed for Ontario which can be implemented if a case(s) of CWD is reported in the province. The keys to success at controlling and/or eradicating CWD if cases are reported in Ontario will be rapid implementation of the response plan as well as ensuring landowner and hunter cooperation as the majority of land in southern Ontario is privately owned.

Key Words: Chronic Wasting Disease, *Cervus canadensis*, CWD, Cervids, Elk, *Odocoileus virginianus*, Ontario, White-tailed Deer.

INTRODUCTION

Chronic wasting disease (CWD) is a fatal disease that infects members of the *Cervidae* family (Thorne *et al.* 2002). CWD is caused by abnormally folded proteins called prions which cause lesions in the brain and leads to death. The disease is not known to naturally infect species outside the cervid family (Thorne *et al.* 2002). CWD has become enzootic in several states in the western United States (e.g., Colorado and Wyoming) and in two western Canadian provinces (Alberta and Saskatchewan) (Kahn *et al.* 2004). More recently, the disease has also gained a foothold in the eastern United States in several states including Wisconsin and West Virginia (Osnas *et al.* 2009).

CWD was reported in Ontario in a captive Mule Deer (*Odocoileus hemionus*) at the Toronto Zoo in 1978 with additional cases at the zoo being detected retrospectively (Sifton and Stephen 2002; Dubé *et al.* 2006). However, to date (May 2014), there have been no cases of CWD identified in Ontario other than those at the Toronto Zoo. Although CWD is not known to exist in Ontario, it has been reported in five American states in close proximity to the province – Wisconsin (2002), Minnesota (2002), New York (2005), Michigan (2008), and Pennsylvania (2012) (http://www.cwd-info.org/index.php/fuseaction/about.timeline). In the primary infection area of the western USA, White-tailed Deer (*Odocoileus virginianus*), Elk (*Cervus canadensis*), and Mule Deer are highly susceptible to CWD (Thorne *et al.* 2002). In addition, <10 Moose (*Alces alces*) have tested positive for CWD, including a recent case in Alberta in 2012 (http://esrd.alberta.ca/fish-wildlife/Wildlife-Diseases/Chronic-Wasting-Disease).

Due to increasing concern about diseases in species such as White-tailed Deer and restored Elk populations in Ontario (Bellhouse and Rosatte 2005; Rosatte *et al.* 2007), the province began testing free-ranging Elk mortalities and hunter-killed White-tailed Deer for CWD in 2000 and 2002, respectively. A CWD surveillance program for free-ranging White-tailed Deer was implemented in Ontario in the fall of 2002. A CWD surveillance and response plan for free-ranging cervids was designed by the Ontario Ministry of Natural Resources (OMNR) in 2005 (Ontario Ministry of Natural Resources 2005), and a surveillance program to detect CWD in farmed cervids was in place in Ontario beginning in 2006. A CWD task team was established in the early 2000s to ensure Ontario was well positioned to respond to the threats posed by the disease. The team included representatives from the OMNR, the Ontario Ministry of Agriculture and Food (OMAF) and the Ministry of Rural Affairs (OMRA), the Ontario Ministry of Health and Long-term Care (MOHLTC), and the Canadian Food Inspection Agency (CFIA). Task team members worked collaboratively to prepare the Ontario CWD Surveillance and Response Plan (Ontario Ministry of Natural Resources 2005). The purpose of the plan was to establish a coordinated provincial approach to disease surveillance and response. The plan identified the risks of CWD to wild, farmed, and other captive members of the deer family, and provided for multi-agency coordination in five key areas: prevention, surveillance, control and eradication, recovery, and communications (Ontario Ministry of Natural Resources 2005). The CWD plan also identified the roles and responsibilities of government ministries/agencies related to potential response actions, and emphasized the need to collaborate with affected stakeholders and the public to ensure preventative steps and potential response actions are effective.

A social and economic impact analysis conducted by Stratus Consulting (2004), confirmed that CWD in Ontario could have significant primary and secondary effects on the provincial economy. An initial discovery of CWD in either farmed, other captive, or wild cervids could see a reduction of more than $11 million (Canadian dollars - CAD) in provincial revenues from the hunting community (Stratus Consulting 2004; Ontario Ministry of Natural Resources 2005). Discovery of CWD anywhere in the province would impact the ability of the cervid farming industry to market live animals or their products. In addition, if eradication of farmed or other captive cervids was necessary, compensation payments by CFIA to owners could amount to several millions of CAD (Stratus Consulting 2004; Ontario Ministry of Natural Resources 2005). Overall losses due to CWD in Ontario could be as high as tens of millions of CAD or greater if the disease was not controlled (Stratus Consulting 2004). Finally, a risk assessment was conducted by the Centre for Coastal Health in 2002 (Sifton and Stephen 2002). The risk assessment was primarily commissioned to determine the risk of importing CWD from Alberta to Ontario due to the translocation of wild Elk during 1998 to 2001 which was part of an Elk restoration program in Ontario (Sifton and Stephen 2002; Rosatte *et al.* 2007).

This paper reports on CWD surveillance activities in Ontario during 2002-2013, i.e., the development of tactics for an Ontario CWD response plan should a CWD case be reported, CWD detection tests, and the implementation of a CWD risk model. It also discusses other measures such as regulations to prevent the importation of CWD into Ontario.

MATERIALS AND METHODS

Despite an apparent absence of CWD in Ontario (other than the Toronto Zoo cases), OMNR believes that proactive planning is imperative to address the significant social, economic, and ecological risks associated with the disease (Ontario Ministry of Natural Resources 2010). Along with collaborators, we designed a proactive response plan should a case(s) be reported in free-ranging cervids in Ontario.

Free-ranging cervid CWD surveillance program in Ontario

Ontario is administratively divided into Wildlife Management Units (WMU) with specific harvest targets developed for each WMU. The CWD surveillance program for free-ranging cervids in Ontario relies on collecting samples from White-tailed Deer harvested by hunters in specific WMUs. Initially, the province was divided into 14 different CWD surveillance zones based on amalgamations of adjacent WMUs with similar landscape, White-tailed Deer population, and hunter-related attributes (Figure 1). Zones were prioritized and numbered from 1 (high risk) to 14 (low risk) based on a number of CWD risk factors including free-ranging White-tailed Deer population density, number of cervid farms, proximity to CWD cases in neighboring states and provinces, and Elk restoration release sites within the zone. Depending on resources, the number of zones sampled each year varied between 1 and 3 from 2002 to 2010. Beginning in 2011, a more comprehensive, spatially explicit risk model was used to predict which areas of the province were at the highest risk for CWD. As a result, the conglomeration of WMUs with the highest risk rating was sampled each year as opposed to rotating through the prioritized CWD surveillance zones.

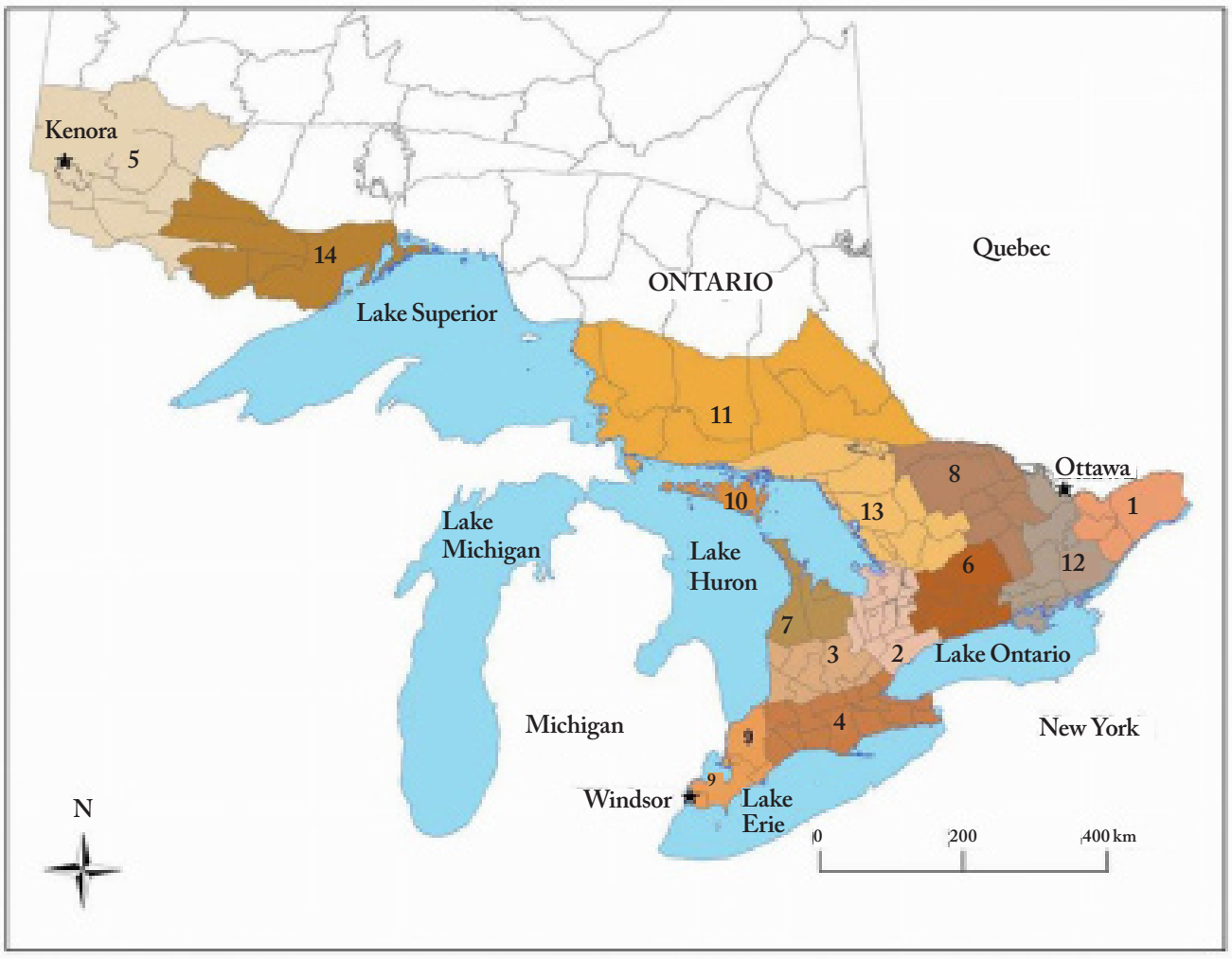

Figure 1. Map of Chronic Wasting Disease surveillance zones in Ontario, Canada. Numbers from 1 to 14 represent areas of high to low risk, respectively, regarding the likelihood of a CWD case occurring there. They also represent the prioritization of areas for sampling.

Samples for the Ontario CWD surveillance program for free-ranging White-tailed Deer were collected annually during the fall by relying on voluntary participation from hunters. Small crews of OMNR staff roamed a pre-determined patrol area in the surveillance zone, asking hunters for permission to remove a brain sample (a portion of the brain stem, medulla oblongata, containing the obex) and retropharyngeal lymph node samples from their harvested White-tailed Deer. These samples were used to screen for CWD. Hunters also had the option of dropping off White-tailed Deer heads at depot locations within the surveillance area. In 2002, White-tailed Deer samples (obex) were collected from the Grey-Bruce county area in southwestern Ontario during a pilot program. The Ontario CWD Surveillance program for free-ranging White-tailed Deer became operational in 2003. Samples from free-ranging Elk that succumbed to various causes were collected opportunistically beginning in 2000.

The estimated number of White-tailed Deer in each of the 14 CWD zones in Ontario ranged from 3,400 to 64,500 individuals >1 year of age during the surveillance program (Ontario Ministry of Natural Resources 2005). Based on the sample size requirement table noted in Cannon and Roe (1982, page 30), a sample size of 460 White-tailed Deer is required to be 99% confident of detecting at least one positive animal if CWD was present in the population at a prevalence of 1% or greater. This assumes that sample collection, the White-tailed Deer population, and any infected White-tailed Deer, are all evenly distributed throughout the entire sampled area. It was decided that the target sample size of White-tailed Deer for each CWD zone sampled would be ≥460 White-tailed Deer from 2003 to 2013 so that a theoretical confidence level of 99% would be achieved.

Farmed cervid CWD surveillance program in Ontario

The OMAF in partnership with producers, veterinarians, and meat processors implemented the Ontario Voluntary CWD Surveillance Project for Farmed Cervids in 2006 (http://www.omafra.gov.on.ca/english/livestock/alternat/facts/cwdproject.htm). The objectives of the program were to increase CWD surveillance in farmed cervids in Ontario and to encourage participation in the National CWD Voluntary Herd Certification Program. Herd certification allows owners of cervid farms to be certified as elite with respect to CWD (http://inspection. gc.ca/animals/terrestrial-animals/diseases/reportable/cwd/herd-certification/eng/1330187841589 /1330187970925). Funding became available for the CWD testing of farmed cervids in Ontario starting April 1, 2006. Prior to that, producers paid for all testing/laboratory costs. As such, detailed data on species of farmed cervids tested, number of slaughtered animals, and farm mortalities were only available from 2006 to 2013. However, some data, i.e., the number of animals tested, were available from the Animal Health Laboratory (AHL), University of Guelph, for the period 1998-2005. Samples (obex and/or retropharyngeal lymph nodes) for CWD screening were collected from farmed cervids from either slaughtered animals or from on-farm mortalities.

CWD risk model

A CWD risk model for Ontario was developed by OMNR in 2011 to identify areas of the province which are at highest susceptibility to an incursion of CWD (Figure 2). CWD surveillance operations would then be directed to the geographic areas identified by the model that were at highest risk. Because sample collection and testing are expensive and Ontario's White-tailed Deer range encompasses a large area (>100,000 km^2), only relatively small geographic areas can be feasibly and systematically surveyed for CWD each year (Ontario Ministry of Natural Resources 2012). For the development of the CWD risk model, risk factors previously identified by the Ontario CWD task team in the Ontario CWD Surveillance and Response plan were used (Ontario Ministry of Natural Resources 2005). Building from that report, new research findings available from the scientific community were used to compile a prioritized list of 8 risk factors which elevate a geographic area's chances of attaining and/or amplifying a CWD occurrence. Risk factors in order of weighted importance included: 1) number of cervid farms; 2) free-ranging White-tailed Deer density; 3) distance from nearest known CWD case (and years since that infection); 4) years since area was last surveyed for CWD; 5) other cervid considerations (Elk, escaped farmed or captive cervids); 6) free-ranging White-tailed Deer aggregations (yards); 7) soil composition (clay-based soils); and 8) previous winter's severity (snow depth) (Ontario Ministry of Natural Resources 1997, 2012; Bellhouse and Rosatte 2005; Johnson *et al.* 2007). Some of the risk factors are dynamic and require calculation every year, i.e., previous winter's severity, while other risk factors remain unchanged, i.e., soil composition.

Data for each risk factor of the model were compiled separately from available vector and raster data sources, and were converted to raster format using a consistent pixel resolution of 250 m, so the smallest feature that was picked up was 6.25 km^2. All factor data were combined in ArcGIS Ver. 9.3.1 (ESRI 2009) according to equation 1, which weighted factors individually depending on their importance within the model (Table 1). Equation 1 consisted of the following: [*CervidFarms*] + ([*DeerDensity*] x 0.9) + ([*AdjacentCases*] x [*YrsSinceInfection*] x 0.8) + ([*PriorSampling*] x 0.7) + ([*ElkHerdProximity*] x 0.6) + ([*AggregationAreas*] x 0.5) + ([*ClaySoils*] x 0.4) + ([*WinterSeverity*] x 0.3). *YrsSinceInfection* = 1 – (years since infection/10). PriorSampling corresponded to years since last sample effort is reduced by 20% for each additional time it was sampled in the last five years.

Each risk factors' data was collected at a different scale. Some factors were calculated at the WMU scale, some were collected at the county (regional subdivision) scale, and some were collected at a distance from a point scale. Each risk factor was tabulated at its own scale before all were combined to produce a spatially

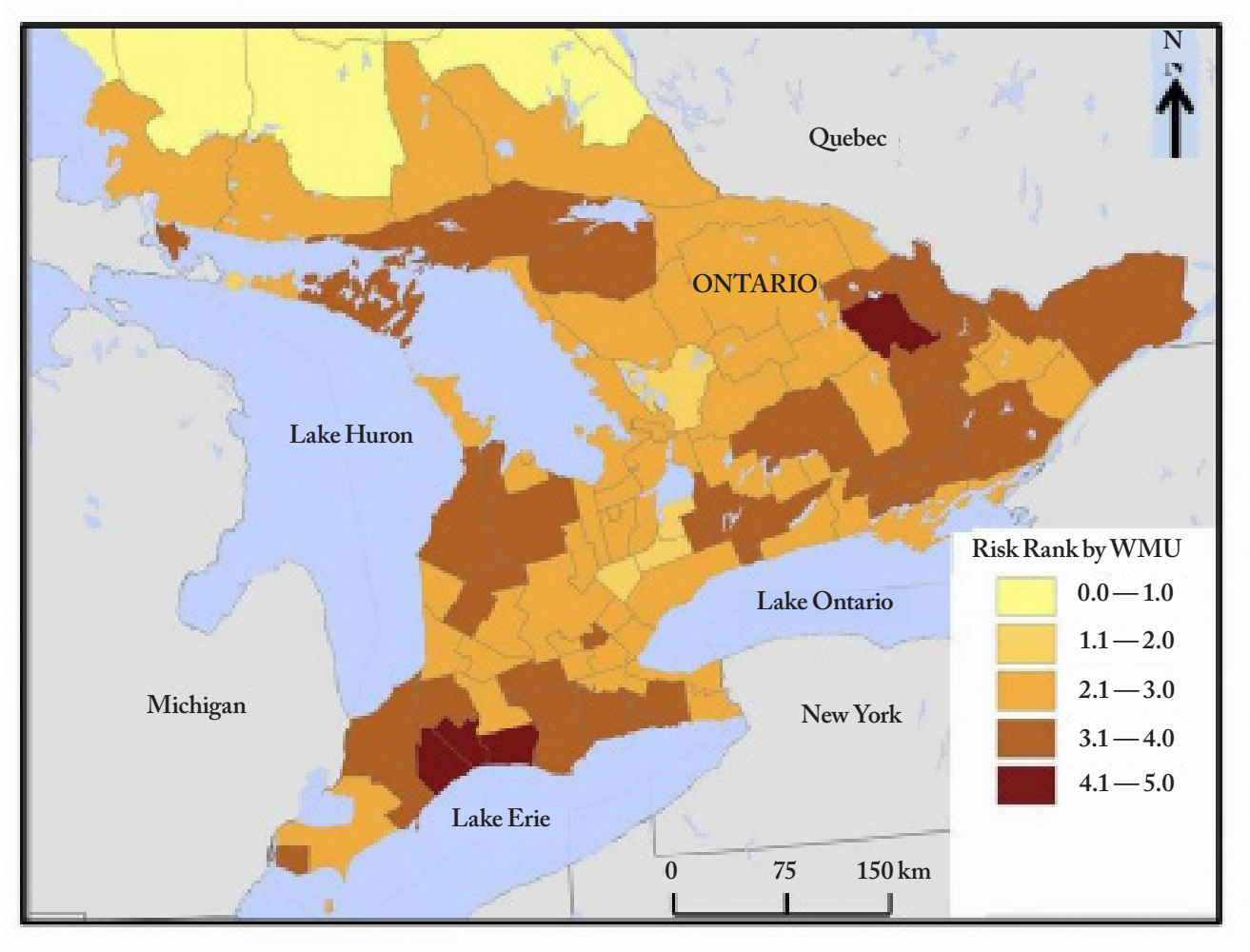

Figure 2. Map of the Ontario Chronic Wasting Disease risk model output for 2012 (WMU: Wildlife Management Unit; the Risk Rank from 0.0 to 5.0 denotes the lowest to highest CWD risk areas with the greatest risk being 5.0).

explicit risk score, which was interpreted as the relative risk that each particular part of the province was at for having CWD discovered there. Because the risk factors were prioritized, higher prioritized risk factors are given more weight in determining model outcome than lower prioritized factors (Table 1) (Ontario Ministry of Natural Resources 2012).

Once the high risk areas were identified, the size of the area to sample was calculated. This was determined based on knowledge of White-tailed Deer density, hunter success, the probability of successfully acquiring the required sample size of 460 White-tailed Deer samples, as well as budgetary and labor restrictions. In addition, all of the areas had been sampled previously, which provided a fairly accurate estimate of how many samples would be expected to be collected from each WMU. The size of each sampling area in southern Ontario since 2011 was approximately 12,000 km^2.

Processing, purification, and testing of samples for CWD

Obex and retropharyngeal lymph node samples from farmed as well as free ranging cervids to be screened for CWD were submitted to the AHL, University of Guelph, Ontario. Some of the free ranging Elk carcasses/samples were initially submitted to the Canadian Cooperative Wildlife Health Center (CCWHC) in Guelph and then sent to the AHL for CWD testing. In addition, a few samples were tested by the CFIA, Nepean, Ontario. Once the samples were received by the AHL, sub-samples (each 200 ± 20 mg) from farmed and free ranging White-tailed Deer were collected from 2-3 different areas of the cortex of the retropharyngeal lymph node. For farmed Elk, Red Deer (*Cervus elaphus*) and Fallow Deer (*Dama dama*), as well as free ranging Elk, sub-samples were extracted from the obex (if an obex sample was submitted). The sub-sample was then homogenized using a large bead in the grinding tube of a Precess 48 homogenizer at a speed of 6,500 rpm for two cycles at 45 sec each. Samples were then treated with proteinase K, concentrated and solubilized with a TeSeE™ Purification Kit (Bio-Rad, France). Purified samples were subjected to an Enzyme-linked Immunosorbent Assay (ELISA) using the TeSeE™ SAP Detection Kit (Bio-Rad, France). Both purification and ELISA steps were carried out as recommended

Table 1. CWD Risk model risk factors and weights[a].

Risk factor	Units	Values	Importance weighting	Maximum value[b]
Cervid farms	Number per 100 km^2 (county)	0 – 5	1	5
Deer density	2013 harvest/harvest rate (WMU)[c]	0 – 5	0.9	4.5
CWD outbreaks	Buffer from source	0.2 – 5.0	0.8	4
CWD outbreaks	Years since last outbreak	0.1 – 1.0		
Previous sampling	Years since last sample (WMU)	0 – 5	0.8	4
Previous sampling	Number of times sampled	0.1 – 1		
Elk locations	Buffer from source	0 – 5	0.6	3
Other cervids	Core area + 10 km buffer – increase elk risk by 1	Elk + 1		
Deer aggregation	Mapped areas (wintering areas)	0, 2.5, 5	0.4	2
Soils	Percent clay — mapped units	0 – 5	0.5	2.5
Winter severity	Cumulative SDI^3 (interpolated from SNOW^3)	0, 2, 5	0.3	1.5

[a] To run the model, all the risk factors are tabulated and entered into the following mathematical formula: *[CervidFarms] + ([DeerDensity] * 0.9) + ([AdjacentCases] * [YrsSinceInfection] * 0.8) + ([PriorSampling] * 0.7) + ([ElkHerdProximity] * 0.6) + ([AggregationAreas] * 0.5) + ([ClaySoils] * 0.4) + ([WinterSeverity] * 0.3).*

[b] Highest possible score = 26.5

[c] WMU = wildlife management unit; SDI = snow depth index; SNOW = snow network Ontario wildlife.

by the manufacturer. The ELISA has been used to screen samples for CWD since December 2004 to the present (May 2014). Samples collected from the late 1990s until the fall of 2004 were screened for CWD via the presence or absence of the abnormal protein PrPres on immunohistochemistry (IHC) (http://www.omafra.gov.on.ca/english/livestock/alternat/facts/11-025.htm).

The additional submitted tissues (i.e., obex from White-tailed Deer and retropharyngeal lymph nodes from Elk, Red Deer, and Fallow Deer) not used during initial testing were frozen and held by the AHL or OMNR until the initial test was completed. Those remaining tissues were to be used by the CFIA Reference Laboratory to perform confirmatory testing on suspect and inconclusive cases.

RESULTS

Ontario CWD response plan for free-ranging cervids should a case be reported in Ontario

We developed a response plan that includes a number of control options/tactics, and exact measures taken would depend on the extent and location of the outbreak. Depending on the objective of the control program, some or all of the following tactics could be implemented:

1. Establishing an Enhanced Surveillance and Response Zone (ESRZ) – OMNR will establish an ESRZ around the location where CWD has been confirmed. The size of the ESRZ will depend on local free-ranging cervid population density and dispersion. Depending on where CWD is detected, this zone may not conform to traditional WMU boundaries in Ontario (Ontario Ministry of Natural Resources 2010). OMNR, in consultation with the public and stakeholders, will determine the appropriate action to implement which could include monitoring disease spread, containing the disease, and/or complete eradication. Actions may be influenced by the number of cases detected, the cervid species present in the ESRZ, and the size of free-ranging cervid populations in the area.

2. Tactics to monitor CWD in Ontario – Following the initial detection of CWD in Ontario, OMNR may need to implement steps to determine the spatial extent and prevalence of the disease in the province. This information would be used to form decisions on potential disease management approaches. It is acknowledged that a large number of free ranging cervids would need to be tested to determine CWD prevalence in the vicinity of the case(s). As the use of live tests, e.g., tonsillar or rectal biopsy, to detect CWD in White-tailed Deer (Schuler *et al.* 2005) and Elk (Monello *et al.* 2013) are expensive and require the capture and anesthesia of animals, the following tactics could be used to obtain the required samples:

i) Collection of free-ranging cervid carcasses: OMNR could collect and test cervids killed by motor vehicles in the ESRZ;

ii) Symptomatic live cervids: OMNR may ask members of the public within the ESRZ to report cervids showing symptoms of CWD. OMNR would attempt to locate the animal and dispatch it for testing after confirming reported symptoms;

iii) Hunter-harvested cervids: OMNR could require that all cervid hunters within the ESRZ submit a sample(s) from their harvested animal(s) for CWD testing;

iv) Non-symptomatic live cervids: OMNR may need to use government staff or experts contracted by the Ministry to dispatch and test cervids within the ESRZ (Ontario Ministry of Natural Resources 2010).

3. Tactics to prevent the spread of CWD in Ontario – OMNR may take additional actions to contain CWD within the ESRZ. Potential tactics to prevent the continued spread of CWD in Ontario could include:

i) Carcass movement restrictions: OMNR may require that only processed carcasses (i.e., free of high-risk potentially infectious material such as brain, spinal column, eyes, and internal organs) be removed from the ESRZ;

ii) Feeding restrictions: OMNR may restrict feeding of wildlife within the ESRZ. OMNR may also discontinue all emergency winter feeding of free-ranging cervids within the ESRZ to contain the disease;

iii) Baiting restrictions: OMNR may restrict the use of feed for the purposes of hunting cervids;

iv) Cervid rehabilitation restrictions: OMNR may prohibit the rehabilitation of White-tailed Deer and other cervids found within the ESRZ (Ontario Ministry of Natural Resources 2010);

v) Farmed cervid movement restrictions: Upon establishment of the ESRZ, all movement of live farmed and other captive cervids and high risk cervid carcass parts (as defined in Ontario Regulation 561/05 under the *Fish & Wildlife Conservation Act*) would be restricted in the ESRZ zone (Ontario Ministry of Natural Resources 2007).

4. Tactics to manage and/or eradicate CWD in Ontario – Depending on the overall goal of the CWD response initiative, OMNR may take further actions to manage or eradicate CWD from Ontario. Potential tactics to manage and/or eradicate the disease include:

i) Free-ranging cervid population reduction: In response to a detection of a case(s) of CWD in a free-ranging cervid in Ontario, OMNR will establish free-ranging cervid population objectives for the ESRZ. The objective will be to remove animals that are infected with CWD and possibly to significantly reduce the free-ranging White-tailed Deer, Elk, and/or Moose populations within the ESRZ. To achieve this objective there are a number of tactics that could be utilized including increasing the White-tailed Deer harvest within the ESRZ. OMNR may increase the length of White-tailed Deer seasons, increase the number of antlerless validation White-tailed Deer tags available, decrease the fees for White-tailed Deer license tags, seals, and/or farmer's White-tailed Deer license tags, increase the number of additional seals available, and/or make changes to the White-tailed Deer removal authorization policy. OMNR may use other tactics aimed at decreasing free-ranging cervid populations including active removal of cervids within the ESRZ by ministry staff or experts contracted by the ministry, changes to predator management, and/or techniques intended to reduce White-tailed Deer reproduction (e.g., birth control). Attempts would be made to reduce the density of free-ranging cervids (White-tailed Deer, Elk, and possibly Moose) in the ESRZ to a point where the risk of transmission of CWD is minimized (e.g., <1/km^2). This effort may be achieved through hunting or through a combination of hunting and government culling;

ii) Research: Due to potentially significant ecological, social, and economic implications for Ontario, OMNR may conduct research on CWD. Surveillance and response actions would continue in the ESRZ until the area has been free of CWD cases for three consecutive years at which point the ESRZ designation would be lifted.

5. Tactics to assess the effectiveness of the response – To ensure Ontario's response is effective and adapts to changing conditions, the OMNR will assess actions through:

i) Annual review of free-ranging cervid management actions: OMNR may examine the impacts of any management actions on the cervid population within the ESRZ on an annual basis. This review will include an assessment of the number of cervids removed by hunting and other techniques as well as an assessment of the size and general health status of the cervid population in the ESRZ;

ii) Three-year review of all CWD response actions: OMNR may re-examine the social, economic, and ecological impacts of CWD response actions every three years (Ontario Ministry of Natural Resources 2010).

If CWD is detected in a farmed or other captive cervid, the CFIA would lead any response actions related to the case.

CWD surveillance program for free-ranging cervids in Ontario

During 2002 to 2013, 9,987 free-ranging White-tailed Deer were screened for CWD during the surveillance program in Ontario (Table 2). All were negative for CWD. Figure 3 depicts the number and distribution of White-tailed Deer samples collected per 100 km^2 in Ontario. The non-colored areas of Ontario generally represent areas of low or non-existent White-tailed Deer populations in northern Ontario, and areas in southern Ontario that were urban, protected areas, or had hunting restrictions. A total of 28 free-ranging Elk that died (road-kills, drowned, illegally shot) in Ontario during 2000 to 2010 were screened for CWD. In addition, 12 Elk samples acquired from hunters during the September 2011 hunt in Bancroft, Ontario, and one road-killed Elk found near Madoc,

Ontario during 2012 were tested. All 41 Elk were negative for CWD.

Farmed cervid CWD surveillance program in Ontario

There were 4,623 White-tailed Deer and Elk on 154 farms in Ontario in 2011 (Table 3) (http//www.statcan.gc.ca). This is down substantially from 2006 when there were 11,581 White-tailed Deer and Elk on 238 farms in Ontario (Table 3). From April 1, 2006 to December 31, 2013, 1,964 farmed cervids (63 herds) in Ontario were tested for CWD – all were negative (Table 4). Of these, 69% were slaughtered and 31% were farm mortalities (Table 4). Elk, Red Deer, and White-tailed Deer accounted for the majority (1,886/1,964 or 96%) of farmed cervids tested in Ontario during that period (Table 5). Of the 63 herds tested, 25 were Elk, 16 were Red Deer, 15 were White-tailed Deer, 5 were Fallow Deer, and 2 were Reindeer (*Rangifer tarandus*). Prior to initiation of the farmed cervid CWD surveillance program in 2006, an additional 925 farmed cervids were tested during 1998-2005 – all were negative for CWD.

CWD risk model

As per figure 2, the model output indicated that WMUs in the Sarnia/London and Ottawa areas had the highest risk for a potential case(s) of CWD during 2012. The risk rating for these areas was 4.1 to 5.0 (Figure 2). Free-ranging White-tailed Deer surveillance operations were conducted in WMUs 90B, 92 and 93 in the Sarnia/London area during the fall of 2012. The Ottawa area was flagged as a potential site for surveillance in 2013.

DISCUSSION

Potential impact if CWD is found in Ontario

Ontario is currently (May 2014) free of reported cases of CWD. However, the disease could have significant economic impacts on hunting as well as White-tailed Deer and Elk farming should a case(s) be detected in the province (Stratus Consulting 2004).

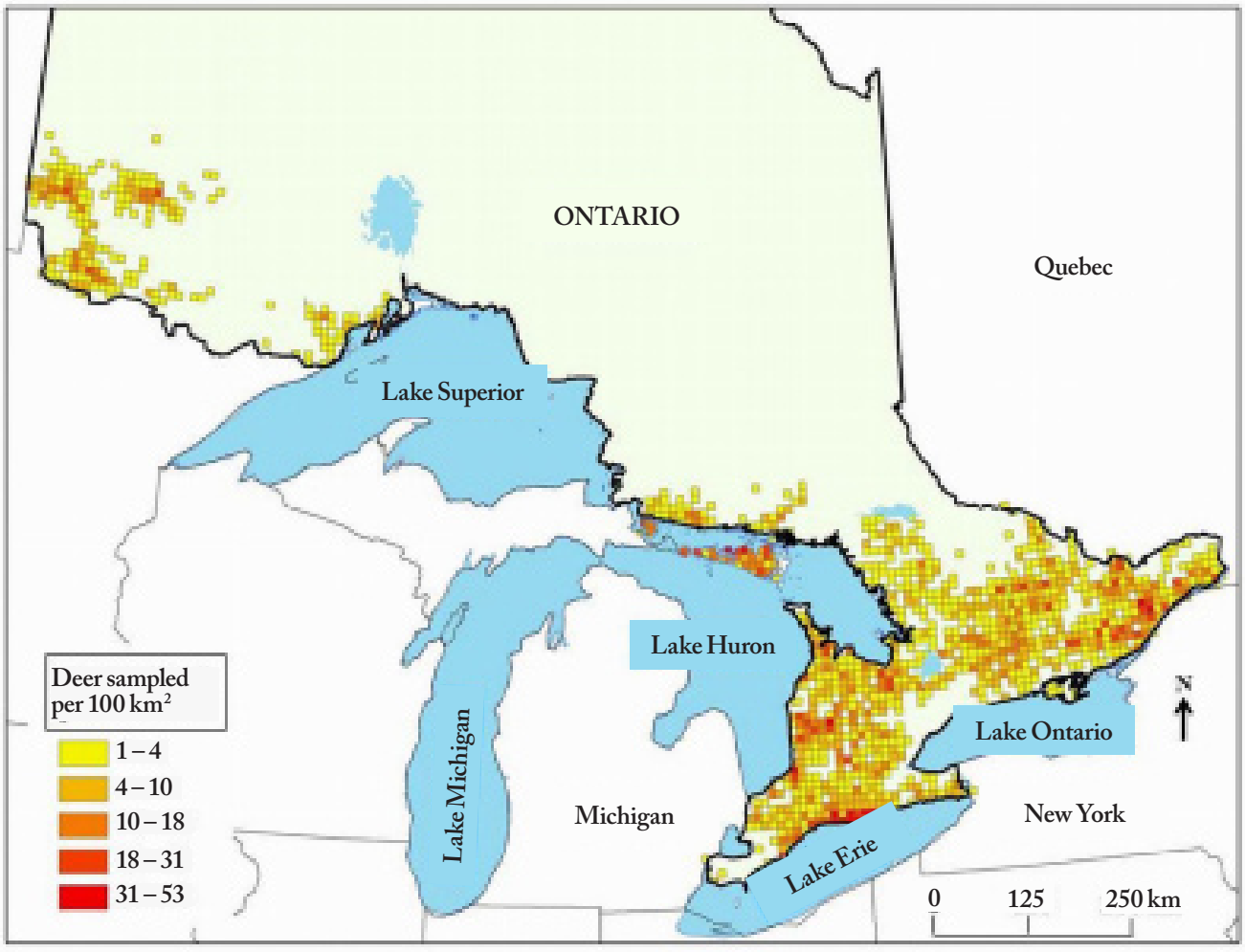

Figure 3. Map of the distribution of White-tailed Deer samples collected during the Chronic Wasting Disease free-ranging deer surveillance program in Ontario, Canada, 2002-2012 (2,204 White-tailed Deer samples collected in Ontario are not displayed in Figure 3 as location data was not collected at the 100 km² resolution). The non-colored areas in Ontario where samples were not collected generally represent areas of low White-tailed Deer density, urban or protected areas, or where hunting restrictions were in place.

There are currently >400,000 hunters in Ontario, many of them (about 200,000) participating in White-tailed Deer, Moose, and Elk hunting (http://www.ofah.org/hunting/we-are-hunters-conservation-community). The estimated revenue generated from hunting in Ontario exceeds $ 300M CAD annually (Bellhouse and Broadfoot 1998; Sifton and Stephen 2002). If CWD was reported in Ontario, the disease could impact the number of hunting participants (25% to 50% reduction) with a resultant negative impact on annual revenues (Stratus Consulting 2004). In support of this, results from a survey of hunters in the USA indicated that 42% of resident and 54% of non-resident hunters said that they would stop White-tailed Deer and Elk hunting if 50% of cervids in their state were infected with CWD (Needham *et al.* 2004). Nine months after CWD was reported in Wisconsin (2002), the state experienced the largest single year decline (11%) in White-tailed Deer license sales in the 20th century (Heberlein 2004). White-tailed Deer hunter participation in Wisconsin also declined by about 10% during 2002 (Bishop 2004). Loss of hunter expenditures in Wisconsin was estimated at $ 53M USD to $ 79M USD in 2002 and $ 45M USD to $ 72M USD in 2003 (Bishop 2004). In Colorado, the presence of CWD in White-tailed Deer and Elk is costing that state tens of millions of USD annually (Seidl and Koontz 2004). However, on the plus side, Magle *et al.* (2012) found no evidence that CWD was substantially increasing mortality rates of free-ranging White-tailed Deer in Wisconsin during 2003 to 2007.

In 2001, there were 334 White-tailed Deer and Elk farms in Ontario which equated to 17% of cervid farms in Canada (http://www.statcan.gc.ca/pub/23-502-x/23-502-x2007001-eng.pdf).

Table 2. Number of free-ranging White-tailed Deer surveillance samples tested for Chronic Wasting Disease in Ontario, Canada during 2002 to 2013.

Year	Surveillance Area	WMUs[a]	Number tested[b,c]
2002	Owen Sound - Hanover	82, 84	183
2003	Ottawa - Cornwall	64, 65, 66	471
2004	Toronto - Barrie	76, 77, 78B-E, 81	427
2005	Guelph - Goderich	79C, 80, 85, 86, 87A,C	269
2005	London - Niagara Falls	79D, 87B, D-E, 88, 89, 90, 91, 92	467
2005	Kingston - Brockville	62, 66A, 67, 68B, 69	500
2006	Kenora - Fort Frances	5, 6, 7, 8, 9, 10, 11A	491
2006	Lindsay - Peterborough	60, 71, 72, 73, 74, 75, 78A	520
2006	Owen Sound - Hanover	82, 83, 84	371
2007	Pembroke - Bancroft	48, 51, 55, 57, 58, 61	393
2007	Windsor - Sarnia	93, 94	249
2007	Sault Ste. Marie - Sudbury	36, 37, 38, 39, 45	239
2008	Kingston - Lanark	59, 62, 63, 67, 68, 69,70	487
2008	Manitoulin	43, 44	480
2008	Parry Sound - North Bay	42, 46, 47, 49, 50, 53, 54, 56	521
2009	Thunder Bar - Ignace	11B, C, 12, 13, 14, 28	110
2009	Ottawa - Cornwall	64, 65, 66	349
2009	Toronto - Barrie	76, 77, 78B-E, 81	298
2010	Guelph - Goderich	79C, 80, 85, 86, 87A, C, 92A	518
2010	London - Niagara Falls	79D, 87B,D-E, 88, 89, 90, 91, 92D	513
2010	Kenora - Fort Frances	5, 6, 7, 8, 9, 10, 11A	362
2011	Peterborough - Bancroft	57, 60, 74, 75	483
2012	London - Sarnia	90B, 92, 93	488
2013	Pembroke - Renfrew	48, 55, 58, 59, 63	495
Total	**All areas**	**All WMUs**	**9,987[b]**

[a] WMU = Wildlife Management Unit.

[b] The total includes 303 deer samples collected during 2005 to 2013 that are not in the table as either the surveillance area was unknown or they were sampled outside of the surveillance areas.

[c] A total of 41 Elk were also tested for CWD during 2000 to 2013 — all were negative.

Table 3. Number of deer and Elk on farms in Ontario, Canada during 1991-2011.[a]

Year	1991	1996	2001	2006	2011
Number of deer	7,408	14,377	14,464	8,031	3,022
Number of deer farms	135	234	234	158	103
Deer/farm	55	61	62	51	29
Number of Elk	1,021	1,358	5,902	3,550	1,601
Number of Elk farms	21	34	100	80	51
Number of Elk/farm	49	40	59	44	31
Number of deer and Elk	8,429	15,735	20,366	11,581	4,623
Number of deer/elk farms	156	268	334	238	154
Number of deer/elk/farm	54.0	58.7	61.0	48.7	30.0

[a] Data from Statistics Canada Census of Agriculture, http://www.statcan.gc.ca.

Table 4. Number and class of farmed cervids in Ontario, Canada tested for Chronic Wasting Disease from April 1, 2006 to December 31, 2013.[a]

Year	2006[b]	2007	2008	2009	2010	2011	2012	2013	Total
Slaughtered	213	219	239	173	240	140	76	45	1,345
On farm mortalities	78	156	108	105	60	67	32	13	619
Total	291	375	347	278	300	207	108	58	1,964

[a] An additional 950 farmed cervids in Ontario were tested for CWD during 1998 to March 31, 2006. There were 25 cervids tested from January 1 to March 31, 2006 (prior to the establishment of the Ontario Voluntary Chronic Wasting Disease Surveillance Project for Farmed Cervids) that were not categorized as either slaughter or on-farm deaths.
[b] April to December only.

Table 5. Species of farmed cervids tested for Chronic Wasting Disease in Ontario, Canada from April 1, 2006 to December 31, 2013.

Cervid species	2006	2007	2008	2009	2010	2011	2012	2013	Total
Elk	194	200	149	156	102	103	57	40	1,001
Red Deer	21	63	97	24	129	38	17	0	389
White-tailed Deer	76	91	94	98	49	46	28	14	496
Fallow Deer	0	20	5	0	19	18	3	4	69
Reindeer	0	1	2	0	1	2	3	0	9
Total	291	375	347	278	300	207	108	58	1,964

The value of the animals in these farms was estimated at $ 78M CAD (Sifton and Stephen 2002). By 2011, there were 54% fewer cervid farms in Ontario and they only housed about 23% as many animals as in 2001 (Table 3). Similarly, Colorado has experienced a decline in farmed cervid demand and production (Seidl and Koontz 2004). The presence of CWD in Canada and the USA likely had a pronounced effect on the decline of cervid farming in Ontario.

Ontario CWD risk assessment and the proactive surveillance and response plan

As CWD would have significant social and economic impacts if it was reported in the province, Ontario has taken a proactive approach to detecting the disease. This included commissioning an early risk assessment, creating a CWD task team, drafting a CWD response plan, and implementing proactive CWD surveillance programs for both free ranging and farmed cervids. The risk assessment concluded that the probability of introducing CWD to Ontario through transport of wild Elk from Alberta was extremely low, but not zero (Sifton and Stephen 2002). The assessment also concluded that the economic impact of introducing CWD to Ontario was variable but potentially high (Sifton and Stephen 2002). A recommendation of the assessment was to delay or stop any further transport of Elk from Elk Island National Park, Alberta. Ontario concurred with the assessment and shipment of wild Elk to Ontario from Alberta for restoration purposes was halted in 2002 (Rosatte *et al.* 2007; Rosatte 2013, 2014).

Free-ranging White-tailed Deer and Elk range and density in Ontario

When and if a case of CWD is detected in Ontario, the prevalence and rate of spread will be influenced by the density and dispersion of free-ranging White-tailed Deer (and to a lesser extent Elk) in the province. As the prevalence of CWD in male Deer is normally higher than in females (Lang and Blanchong 2012), dispersal of male White-tailed Deer in Ontario will likely play a crucial role in the dissemination of the disease. Free-ranging populations of White-tailed Deer live in southern, central, and northeastern Ontario, and along the Minnesota border in northwestern Ontario (Bellhouse and Rosatte 2005). Approximately 123,185 km^2 of Ontario is estimated as suitable White-tailed Deer habitat. Biologists estimate the province's population of free-ranging White-tailed Deer at about 400,000 animals (Ontario Ministry of Natural Resources 2005; Bellhouse and Rosatte 2005). Some White-tailed Deer in Ontario migrate seasonally and travel distances that range on average from 11 km in more southerly locations to more than 30 km in northern areas. Therefore, seasonal migration could contribute to the spread of CWD in Ontario. Knowledge such as this will allow resources managers in Ontario to design and focus CWD control efforts on potential White-tailed Deer dispersal routes should a case be detected.

It was estimated that the number of White-tailed Deer in each of the 14 CWD surveillance zones in Ontario varied from 3,400 to 64,500 free-ranging White-tailed Deer (Ontario Ministry of Natural Resources 2005). Summer densities of southeastern and central Ontario White-tailed Deer vary from 1.4 to 7.0 animals/km^2; winter densities vary from 8.5 to 46.3 animals/km^2 (Bellhouse and Broadfoot 1998; Bellhouse and Rosatte 2005; Ontario Ministry of Natural Resources 2005). White-tailed Deer densities in Wisconsin were 12 to 14/km^2 (30 to 35/square mile) following attempts at CWD eradication (Heberlein 2004). Given the lower White-tailed Deer densities typically found here, control of CWD in Ontario by culling or increased hunting pressure should not be as much of a daunting task as it was in Wisconsin.

Elk once resided in Ontario, but the combined effects of harvest and habitat loss eliminated them in the late 1800s. During 1998 to 2001, 443 Elk were transported from Elk Island National Park, Alberta, and released at four sites across Ontario as part of a restoration program (Rosatte *et al.* 2007; Rosatte 2013). Ontario's Elk population in the four core release areas is currently (2013) estimated at about 750 to 1,100 individuals (Rosatte 2014). Although Ontario's Elk population is small, it is still at risk to CWD infection if it becomes established in the White-tailed Deer population as Elk share range with White-tailed Deer in Ontario (Jenkins *et al.* 2007; Rosatte *et al.* 2007).

White-tailed Deer and Elk hunting in Ontario provide a management tool for reducing White-tailed Deer and/or Elk density should a case of CWD be reported in the province. During 2011 to 2013, there was a small regulated hunt for Elk near Bancroft, Ontario. The total number of White-tailed Deer hunters in Ontario is estimated at about 195,000. Although it is unpopular with hunters, localized culling is a disease management tactic that is capable of maintaining low CWD prevalence while minimizing impacts on recreational White-tailed Deer hunting (Manjerovic *et al.* 2013).

Surveillance and response plan for free-ranging Cervids: CWD control and eradication

CWD risk model – Because sample collection and testing are expensive and Ontario's White-tailed Deer range encompasses a massive area, only relatively small geographic areas can be feasibly and systematically surveyed for CWD each year. To help decide which area is the highest priority each year, a risk-based computer model was developed to incorporate dynamic risk factors and output areas where limited resources would be best directed in a particular year. Since switching to the dynamic risk model from the previous method of a scheduled rotation of CWD surveillance, we have been able to focus our resources on the most vulnerable areas of the province. With increased vigilance in these vulnerable areas we should be able to provide greater security to the province as a whole. The inherent risk with this approach is that there will be greater lengths of time between surveillance in areas of the province deemed to be at lower risk..

Because the risk model is dynamic, it is easily adjusted or fine-

tuned as new research on CWD risk factors becomes available or if flaws in our current approach become evident. Instead of re-inventing the wheel, we were able to build off the work previously accomplished by the Ontario CWD task team and researchers from other jurisdictions. This provided a significant head start for building the model, as most of the CWD risk factors specific to Ontario had already been considered and weighted. We simply ensured that newer research was also considered and lessons learned from the past decade of field experience conducting CWD surveillance were also incorporated. Additional risk factors can and will be incorporated into the model as they are identified.

Proactive surveillance program – During the initial years of the Ontario CWD surveillance program for free-ranging cervids, CWD zones were sampled on a rotational basis. Using this tactic, all of the 14 zones were sampled at least once during a 7-year period (2003 to 2009). Since development and implementation of the CWD risk model in 2011, only those zones or areas that were deemed to be the highest risk for CWD are sampled during the surveillance program. This tactic optimizes use of available resources given the size of Ontario and the limited funding available for CWD surveillance initiatives. In support of this tactic, Rees *et al.* (2012) noted that identifying where and how many White-tailed Deer to sample to detect CWD can improve surveillance programs using hunter harvest as a basis for sample acquisition.

During 2002 to 2013, 9,987 free ranging White-tailed Deer and 41 Elk were sampled and tested for CWD in Ontario – all were negative. There were a number of assumptions that had to be met in order to be 99% confident that our sample sizes were adequate to detect at least one CWD positive animal if the disease was present at a prevalence of at least one percent. Attempts were made to satisfy the assumptions of the Cannon and Roe's (1982) sample distribution table by sampling White-tailed Deer evenly throughout the CWD surveillance zones. However, as OMNR crews relied on the distribution of hunters to collect samples, even distribution of samples was not always possible. As the majority of samples were in the 1 to 10 White-tailed Deer sampled/100 km^2 range, we can assume that White-tailed Deer distribution throughout the sampled areas was fairly even.

CWD response plan – The Ontario CWD surveillance and response plan is based on three broad goals: 1) preventing entry of CWD into Ontario, 2) early detection and effective response in the event of a case(s) of CWD, and 3) effective management and recovery following the response to a case(s) of CWD (Ontario Ministry of Natural Resources 2005). If a case of CWD is reported in Ontario, all potential response and management options will be reviewed. The Ontario CWD task team will seek involvement and cooperation of the member agencies, local governments, and stakeholders to take the most effective action to manage CWD in free-ranging, farmed, or other captive White-tailed Deer and Elk or to control its spread (Ontario Ministry of Natural Resources 2005). The agency or agencies responsible for responding to a confirmed positive case of CWD in Ontario will be determined based on whether the disease is detected in farmed, other captive, or a free-ranging White-tailed Deer or Elk (Ontario Ministry of Natural Resources 2005). If CWD is detected in Ontario on a farm, zoo, or other collection, the CFIA would implement the eradication response protocol. Protocol response actions include communications, premise control activities, quarantine, herd depopulation, trace-in and trace-out investigations, and/or surveillance of farmed or other captive cervids (Ontario Ministry of Natural Resources 2005). However, CFIA's response to a case of CWD is currently (2014) under review. OMNR would coordinate surveillance in free-ranging cervids in a predetermined radius around the affected farm or other captive facility as soon as it is reasonably possible after disease confirmation (Ontario Ministry of Natural Resources 2005).

If CWD is detected in wild White-tailed Deer or Elk, the CFIA will give official confirmation of positive test results to the Ontario CWD task team. The team will determine the next steps according to the CWD control and response plan (Ontario Ministry of Natural Resources 2005). The task team will also meet with stakeholders to determine and recommend effective response actions. OMNR would lead an enhanced surveillance program in a pre-determined radius (e.g., 10 to 30 km) around the location of the infected free-ranging animal to determine the extent and prevalence of the disease (Ontario Ministry of Natural Resources 2005). The degree of population reduction will be determined at that time. Mateus-Pinilla *et al.* (2013) suggested that in Illinois frequent and continued culling by sharpshooting is needed to reduce CWD prevalence in White-tailed Deer.

During a response to a CWD case(s) in Ontario, there could potentially be hundreds of White-tailed Deer carcasses following a depopulation or cull operation, or via the harvest. Disposal of those carcasses would occur either at a licensed landfill, through incineration at >850°C, or via tissue digestion which is based on alkaline hydrolysis using sodium or potassium hydroxide solution (Northeast Association of Fish and Wildlife Agencies 2006). The most economically feasible option is disposal at a landfill. As per a directive from the Ontario Ministry of the Environment, disposal of carcasses that are CWD negative (classed as non-hazardous industrial waste) can occur at an Ontario waste disposal site that is approved under the Environmental Protection Act (EPA) and Ontario Regulation 347 (General Waste Management under the EPA). If carcasses are CWD positive, they would be classed as pathological waste under Ontario Regulation 347. As such, those carcasses may be disposed of at a site/facility that has a valid Certificate of Approval authorizing them to accept and handle pathological waste. However, the disadvantage of the landfill option is that the prions from CWD infected animals are not immediately destroyed. The disadvantages of incineration and tissue digestion are the cost as well as the capacity of the incinerator and the digester.

CWD control measures would be continued in a response zone by OMNR until no evidence of CWD is detected in free ranging White-tailed Deer during three consecutive years of enhanced surveillance (Ontario Ministry of Natural Resources 2005). Following completion of the control program, agencies represented on the CWD task team will collaborate with stakeholders to assess the effectiveness of CWD management efforts. This will be done through continuous surveillance and monitoring of White-tailed Deer populations, hunters, landowners, and other affected stakeholders within the response zone during a recovery period of not less than three years.

Lessons learned from a CWD eradication program targeting free-ranging White-tailed Deer – In Wisconsin, it was recommended that the culling of free-ranging White-tailed Deer to eradicate CWD be focused on geographic areas that had the highest prevalence of CWD to increase the probability of removing CWD infected individuals (Joly *et al.* 2006). It was also observed that CWD prevalence in White-tailed Deer in Wisconsin declined from a central location and was correlated with White-tailed Deer habitat abundance (Joly *et al.* 2006). Wisconsin's CWD eradication programs were designed to reduce White-tailed Deer density through hunting. As such, the key to any success was dependent on hunter and landowner participation (Blanchong *et al.* 2006). In view of this, it would be prudent for Ontario resource managers to promote hunter access to lands, hunter participation in White-tailed Deer hunting, and landowner cooperation, through proactive government/landowner dialogue well before CWD is reported in Ontario.

There are many lessons to be learned from Wisconsin's strategy to eradicate CWD in free-ranging White-tailed Deer. The disease was reported in Wisconsin in 2002, in three wild White-tailed Deer (Heberlein 2004). The eradication strategy included reducing the population density statewide, eradicating of the White-tailed Deer herd in an approximate 1,036 km^2 area (400 square miles) in the vicinity of the CWD cases, and ending recreational feeding (Heberlein 2004). The plan essentially failed as White-tailed Deer density was still 12 to 14/km^2 (30 to 35/square mile) after two years of culling. In fact, Storm *et al.* (2013) postulated that absence of strong density-dependent transmission rates indicated that controlling CWD by reducing White-tailed Deer density was going to be very difficult. The CWD eradication strategy also failed as hunters killed fewer White-tailed Deer than expected in the eradication zone, and efforts to end recreational feeding failed. In essence, the biological and social goals of the strategy were not achieved (Heberlein 2004). Due to the failure of the Wisconsin program in eradicating CWD, Illinois decided not to consider eradication tactics when the disease was reported in that state (Heberlein 2004). Furthermore, Williams (2005) postulated that eradication of CWD from free-ranging cervid populations using current management techniques was unlikely. Ontario's response plan for CWD control will need to avoid the pitfalls of the Wisconsin eradication program to succeed at controlling or eradicating CWD if/when it is reported.

Surveillance and Response Plan for Farmed Cervids

Both White-tailed Deer and Elk are farmed, and kept in zoos and private collections. Ontario farmers also raise Fallow Deer, Red Deer and Red Deer/Elk hybrids, and zoos often have Mule Deer. Since the mid-1980s, Ontario farmers have raised White-tailed Deer, Elk and White-tailed Deer/Elk hybrids for venison, velvet antler, hides, and live animal sales. Farmers sell live animals for breeding or for export to hunting preserves in jurisdictions outside of Ontario. Ontario does not permit hunting of White-tailed Deer, Elk, Elk hybrids, or imported species such as Red Deer in enclosures.

A CWD disease control and eradication policy was implemented in Canada by the CFIA in October 2000. Ongoing surveillance varies within each province of Canada. CWD testing of farmed cervids is currently mandatory in Manitoba, Saskatchewan, Alberta, and the Yukon but is voluntary in Ontario as well as in the other provinces (http://www.inspection.gc.ca/animals/ terrestrial-animals/diseases/reportable/cwd/fact-sheet/eng/1330189947852/1330190096558). Under the Health of Animals Act, facilities must report to the CFIA any cervid death suspected to be caused by a reportable disease such as CWD. All suspected cases of CWD in farmed and other captive cervids must be reported to the CFIA for immediate investigation and all herds in which an animal tests positive for CWD are quarantined. CFIA also tracks the movements of animals to and from the affected premises and exposed animals are normally destroyed (http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/cwd/fact-sheet/ eng/1330189947852/1330190096558).

Cervid farms are not licensed provincially but are regulated federally in Canada. Movement of cervids between farms or to an abattoir requires a CFIA cervid movement permit. A herd test (for brucellosis and tuberculosis) is required every five years, and if negative, farms will have a negative status and can ship to either other farms or abattoirs (still requiring a CFIA cervid movement permit). If farms do not maintain brucellosis and tuberculosis testing, farms will have a restricted status and can only transport animals to abattoirs (still requiring a CFIA cervid movement permit). If live White-tailed Deer, Elk, Moose, or Woodland Caribou (*Rangifer tarandus*) are transported into Ontario from other jurisdictions, they require an OMNR permit.

As of 2001, there were approximately 20,366 White-tailed Deer and Elk on 334 cervid farms in Ontario (Table 3). There were 4,852 farmed cervids slaughtered in Ontario in 2004, which was the peak year. The number of farmed White-tailed Deer and Elk processed has decreased by 87% to only 638 in 2012 largely due to lack of market infrastructure and the impacts of CWD on the markets for live cervids and their meat and antler products (Ontario Ministry of Natural Resources 2005).

The OMAF and MRA in partnership with cervid farmers, veterinarians and meat processors implemented the Ontario Voluntary Chronic Wasting Disease Surveillance Program to encourage surveillance in farmed White-tailed Deer and Elk. It is important to test a sufficient number of animals to be confident CWD is not in Ontario's farmed cervids, or if it is detected, so that timely control measures can be taken. In addition, more and more jurisdictions are requiring participation in a CWD herd certification program and/or 100% testing of mature cervid mortalities (on-farm deaths and slaughter animals) as a requirement for live animal imports (http://www.omafra.gov.on.ca/english/livestock/alternat/facts/cwdproject.htm).

To encourage increased surveillance from farmed cervids OMAF and MRA's voluntary CWD surveillance program pays laboratory testing costs and provides producers with a sampling allowance ($ 45 CAD/sample for on-farm deaths and $ 35 CAD/sample for slaughter animals). Unfortunately the surveillance submissions have decreased by 71% from 2007 to 2012, primarily due to the significant decline in the size of the Ontario cervid farming sector. The sharp decrease in CWD surveillance is not surprising given the 60% reduction in the provincial cervid farming herd from 2006 to 2011 (Table 3).

Other measures

Prevention of CWD entering Ontario from other jurisdictions – As outlined in the Ontario CWD surveillance and response plan, there are several ways the disease could enter Ontario including: 1) movement from the USA or other provinces of live CWD-infected cervids onto White-tailed Deer or Elk farms or zoos; 2) movement of CWD-infected cervids for release into the wild; 3) migration of CWD-infected free-ranging cervids across borders; 4) infection of farmed or captive cervids through illegal use of animal protein feed; and 5) importation of CWD-infected dead cervids or parts of cervids (Ontario Ministry of Natural Resources 2005). In view of the above, Ontario's primary goal is to prevent the entry of CWD into the province. According to the Ontario CWD Surveillance and Response plan (2005), current activities that relate to CWD risk reduction include: 1) conditions on permits to manage movement of live cervids – including intra-provincial transfer and release, export, and import; 2) management of the disposal of dead captive cervids – including disposal of whole or parts of cervids by governments, farmers, zoo managers, abattoir operators, and wildlife custodians; 3) CWD surveillance of free-ranging, farmed, and other captive cervids; 4) CWD herd certification programs that allow cervid farms to be certified as elite with respect to CWD; 5) Regulation of the use and possession of natural attractants; 6) public/staff awareness of CWD symptoms and risks. Potential activities relating to CWD risk reduction include: 1) regulation of feeding and/or baiting of wild White-tailed Deer/Elk; 2) development, with public and stakeholder input, of a strategy to develop and implement additional, effective preventative measures and control actions regarding CWD, should they be necessary, to ensure both biological and socioeconomic goals are met.

Regulations to prevent the importation of CWD into Ontario – To prevent CWD from entering Ontario through importation of hunter-killed White-tailed Deer outside of Ontario, regulations were put in place in 2005. In 2007, border surveillance in the vicinity of Sarnia and Windsor, Ontario, found that >50% of the hunters checked were not complying with regulations to prevent the spread of CWD into Ontario (Ontario Ministry of Natural Resources 2007). Regulations introduced in 2010 included a ban on the possession or use of attractants containing any body fluid (urine, blood, gland oil, etc.) derived from cervids for hunting. In 2005 and 2010, regulations restricting the importation of cervid parts were implemented in Ontario (http://www.mnr.gov.on.ca/en/Business/FW/2ColumnSubPage/STEL02_168766.html#possession). Those regulations (pertaining to cervid parts acquired outside of Ontario) found at the above website include: 1) it is illegal in Ontario to possess any part of the antlers, head, brain, eyes, tonsils, hide, hooves, lymph nodes, spleen, mammary glands, entrails, internal organs or spinal column of any member of the deer family that has been killed outside Ontario. This prohibition does not apply to finished taxidermy mounts, tanned skin, or canine teeth with no tissue attached. Hunters will still be allowed to bring in meat and other parts such as antlers and hides, if those antlers and hides are properly treated to reduce risk of CWD transfer as noted below; 2) antlers or antlers with a skull cap attached may be legally possessed as long as there is no tissue or skin attached to them and they are separate from the remainder of the skull. It is also legal to possess a hide or skin of the head of any member of the deer family if all other tissue has been removed, it is kept in a container from which nothing can escape, and it is delivered to a tanner or taxidermist within five days of coming into Ontario. If all or a portion of the hide or skin of the head identified above is disposed of, it must be done at a waste disposal site authorized under the Environmental Protection Act such as a municipal landfill site; 3) none of the above rules apply to the prohibited parts (noted above) of any member of the deer family if they are transported through Ontario to another jurisdiction in a container from which nothing can escape. The container must be labeled to show the species of cervid, the location where it was acquired, and the name and address of the person who owns the parts in the container; 4) if a person has transported a member of the free-ranging deer family into Ontario that was harvested or killed in another jurisdiction, and later determine that it has tested positive for CWD, the person must immediately notify an OMNR office and provide information as requested.

The above regulation applies to all members of the deer family from all states, provinces, or other jurisdictions regardless of whether CWD has been detected in that jurisdiction or not. However, the regulation does not affect hunters who have harvested an animal in Ontario. Persons who wish to export from Ontario, the carcasses

of free-ranging White-tailed Deer, Moose, Elk, or Caribou, should check with applicable jurisdictions should they wish to possess these Ontario cervids out of the province (http://www.mnr.gov.on. ca/en/Business/FW/2ColumnSubPage/STEL02_168766.html#possession). In addition, transporting live White-tailed Deer, Elk, Moose, Woodland Caribou, and their hybrids into Ontario now requires a permit under a new regulation under the *Fish & Wildlife Conservation Act*, 1997. This applies to the transport of the above species into Ontario for any purpose, including farming, slaughter, and display in zoos. Anyone wishing to transport live White-tailed Deer, Elk, Moose or Woodland Caribou into Ontario is required to meet new conditions to minimize the risk of spreading CWD. OMNR now requires written notice regarding the health status of the cervids to be transported, and documentation of a premise assessment from the Ontario Ministry of Agriculture and Food, and Ministry of Rural Affairs, before issuing a permit to transport these species into Ontario (http://www.mnr.gov.on.ca/ en/Business/FW/2ColumnSubPage/STEL02_168766.html#possession).

The provincial permit requires that the importing premises meet biosecurity requirements. If animals are imported for slaughter, they must be slaughtered immediately.

CONCLUSION

An economic impact analysis suggested that economic losses in Ontario could exceed tens of millions of CAD if CWD is detected in the province. Therefore, Ontario has taken a proactive approach in anticipation of CWD being reported in the province. Nonetheless, resource managers in Ontario must be vigilant to ensure that CWD is quickly controlled when and if a case(s) is detected. If the disease becomes well established, it will be nearly impossible to eradicate as demonstrated by jurisdictions where CWD has become enzootic (Saunders *et al.* 2012). If culling using recreational hunters is considered for controlling CWD in Ontario, resource managers will need to provide evidence to convince hunters that White-tailed Deer density reduction results in containing or eliminating CWD thereby increasing hunter confidence and buy-in for the culling tactic (Cooney and Holsman 2010).

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LITERATURE CITED

Bellhouse, T., and J. Broadfoot. 1998. Plan for the restoration of elk in Ontario. Ontario Ministry of Natural Resources, unpublished report, North Bay, Ontario, Canada. Available upon request by contacting OMNR at *mnr.nric.mnr@ontario.ca*.

Bellhouse, T., and R. Rosatte. 2005. Assessment of the potential for negative interaction between re-introduced elk (*Cervus elaphus*) and resident white-tailed deer (*Odocoileus virginianus*) in their wintering areas in Ontario, Canada. Mammalia 69: 35-56.

Bishop, R. 2004. The economic impacts of chronic wasting disease in Wisconsin. Human Dimensions of Wildlife 9: 182-192.

Blanchong, J., D. Jolly, M. Samuel, J. Langenberg, R. Rolley, and J. Sausen. 2006. White-tailed deer harvest from the chronic wasting disease eradication zone in south-central Wisconsin. Wildlife Society Bulletin 34: 725-731.

Cannon R., and R. Roe. 1982. Livestock disease surveys - A field manual for veterinarians. Bureau of Range Science, Department of Primary Industry, Australian Government Publishing Service, Canberra, Australia.

Cooney E., and R. Holsman. 2010. Influences on hunter support for deer herd reduction as a Chronic Wasting Disease (CWD) management strategy. Human Dimensions of Wildlife 15: 194-207.

Dubé, C., K. Mehren, I. Barker, B. Peart, and A. Balachandran. 2006. Retrospective investigation of chronic wasting disease of cervids at the Toronto Zoo, 1973–2003. Canadian Veterinary Journal 47: 1185–1193.

ESRI. 2009. ArcGIS Desktop: Release 9.3.1. Redlands, California, USA.

Heberlein, T. 2004. "Fire in the Sistine chapel": How Wisconsin responded to chronic wasting disease. Human Dimensions of Wildlife 9: 165-179.

Jenkins, D., J. Schaefer, R. Rosatte, T. Bellhouse, J. Hamr, and F. Mallory. 2007. Winter resource selection of reintroduced elk and sympatric white-tailed deer at multiple spatial scales. Journal of

Mammalogy 88: 614-624.

Johnson, C., J. Pedersen, R. Chappell, D. MacKenzie, and J. Aiken. 2007. Oral transmissibility of prion disease is enhanced by binding to soil particles. Plos Pathogens 3(7) doi: 10.1371/journal.ppat.0030093.

Joly, D., M. Samuel, J. Langenberg, J. Blanchong, C. Batha, R. Rolley, D. Keane, and C. Ribic. 2006. Spatial epidemiology of chronic wasting disease in Wisconsin white-tailed deer. Journal of Wildlife Diseases 42: 578-588.

Kahn, S., C. Dube, L. Bates, and A. Balachandran. 2004. Chronic wasting disease in Canada: Part 1. Canadian Veterinary Journal 45: 397-404.

Lang, K., and J. Blanchong. 2012. Population genetic structure of white-tailed deer: Understanding risk of chronic wasting disease spread. Journal of Wildlife Management 76: 832–840.

Magle, S., J. Chamberlin, and N. Mathews. 2012. Survival of white-tailed deer in Wisconsin's chronic wasting disease zone. Northeastern Naturalist 19: 67-76.

Manjerovic, M., M. Green, N. Mateus-Pinilla, and J. Novakofski. 2013. The importance of localized culling in stabilizing chronic wasting disease prevalence in white-tailed deer populations. Preventive Veterinary Medicine http://www.sciencedirect.com/science/ article/pii/S0167587713002894.

Mateus-Pinilla, N., H. Weng, M. Ruiz, P. Shelton, and J. Novakofski. 2013. Evaluation of a wild white-tailed deer population management program for controlling chronic wasting disease in Illinois, 2003–2008. Preventive Veterinary Medicine 110: 541–548.

Monello, R., J. Powers, N. Hobbs, T. Spraker, K. O'Rourke, and M. Wild. 2013. Efficacy of antemortem rectal biopsies to diagnose and estimate prevalence of chronic wasting disease in free-ranging elk (*Cervus elaphus nelsoni*). Journal of Wildlife Diseases 49: 270-278.

Needham, M., J. Vaske, and M. Manfredo. 2004. Hunters' behavior and acceptance of management actions related to chronic wasting disease in eight states. Human Dimensions of Wildlife 9: 211-231.

Northeast Association of Fish and Wildlife Agencies. 2006. Chronic wasting disease plan. Northeast Association of Fish and Wildlife Agencies, unpublished report. Available upon request by contacting OMNR at *mnr.nric.mnr@ontario.ca*.

Ontario Ministry of Natural Resources (OMNR). 1997. The snow network for Ontario wildlife. Ontario Ministry of Natural Resources unpublished report, Peterborough, Ontario, Canada. Available upon request by contacting OMNR at *mnr.nric.mnr@ontario.ca.*

Ontario Ministry of Natural Resources (OMNR). 2005. Ontario Chronic Wasting Disease surveillance plan. Ontario Ministry of Natural Resources, unpublished report, Peterborough, Ontario, Canada. Available upon request by contacting OMNR at *mnr.nric.mnr@ontario.ca.*

Ontario Ministry of Natural Resources (OMNR). 2007. Ontario's emergency preparedness for Chronic Wasting Disease. Ontario Ministry of Natural Resources unpublished report, Peterborough, Ontario, Canada. Available upon request by contacting OMNR at *mnr.nric.mnr@ontario.ca*.

Ontario Ministry of Natural Resources (OMNR). 2010. Moving forward on the Ontario Chronic Wasting disease (CWD) surveillance and response plan: Potential response options. Ontario Ministry of Natural Resources unpublished report, Peterborough, Ontario, Canada. Available upon request by contacting OMNR at *mnr.nric.mnr@ontario.ca.*

Ontario Ministry of Natural Resources (OMNR). 2012. Chronic wasting disease surveillance case study: integrating risk in OMNR. Ontario Ministry of Natural Resources unpublished report, Peterborough, Ontario, Canada. Available upon request by contacting OMNR at *mnr.nric.mnr@ontario.ca.*

Osnas, E., D. Heisey, R., Rolley, and M. Samuel. 2009. Spatial and temporal patterns of chronic wasting disease: fine-scale mapping of a wildlife epidemic in Wisconsin. Ecological Applications 19: 1311-1322.

Rees, E., E. Merrill, T. Bollinger, Y. Hwang, M. Pybus, and D. Coltman. 2012. Targeting the detection of chronic wasting disease using the hunter harvest during early phases of an outbreak in Saskatchewan, Canada. Preventative Veterinary Medicine 104: 149–159.

Rosatte, R. 2013. The restoration of elk (*Cervus elaphus*) in Ontario, Canada, 1998-2012: research and management implications. Pages 180-185 in P. S. Soorae, editor. Global Reintroduction Perspectives, IUCN, Re-introduction Specialist Group, Abu Dhabi.

Rosatte, R. 2014. Behaviour and dynamics of a restored elk (*Cervus canadensis manitobensis*) population in southern Ontario, Canada: 5-12 years post restoration. Canadian Wildlife Biology and Management 3: 1-18.

Rosatte, R., J. Hamr, J. Young, I. Filion, and H. Smith 2007. The restoration of elk (*Cervus elaphus*) in Ontario, Canada: 1998-2005. Restoration Ecology 15: 34-43.

Saunders, S., S. Bartelt-Hunt, and C. Jason. 2012. Occurrence, transmission, and zoonotic potential of Chronic Wasting Disease. Emerging Infectious Diseases 18: 369-376.

Schuler, K. L., J. Jenks, C. DePerno, M. Wild, and C. Swanson. 2005. Tonsillar biopsy test for chronic wasting disease: Two sampling approaches in mule deer and white-tailed deer. Journal of Wildlife Diseases 41: 820-824.

Seidl, A., and S. Koontz. 2004. Potential economic impacts of chronic wasting disease in Colorado. Human Dimensions of Wildlife 9: 241-245.

Sifton, E., and C. Stephen. 2002. Translocation of elk from Elk Island National Park, Alberta to Ontario: a risk assessment for

chronic wasting disease. Center for Coastal Health, Nanaimo, B.C. Unpublished report. Available upon request by contacting OMNR at *mnr.nric.mnr@ontario.ca.*

Storm, D., M. Samuel, R. Rolley, P. Shelton, N. Keuler, B. Richards, and T. Van Deelen. 2013. Deer density and disease prevalence influence transmission of chronic wasting disease in White-tailed Deer. Ecosphere 4: 1-14.

Stratus Consulting. 2004. Potential economic impacts of chronic wasting disease on Ontario's economy. Unpublished report, Boulder, Colorado, USA. Available upon request by contacting OMNR at *mnr.nric.mnr@ontario.ca.*

Thorne, T., E. Williams, W. Samuel, and T. Kistner. 2002. Diseases and parasites. In: D. Toweill D and J. W. Thomas, editors. North American elk, ecology and management. Smithsonian Institution Press, Washington, DC, USA.

Williams, E. S. 2005. Chronic wasting disease. Veterinary Pathology 42: 530-549.

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