Rapid Qualitative Risk Assessment (RQRA) Summary:
SARS Coronavirus 2 (SARS-CoV-2) in White-Tailed Deer (*Odocoileus virginianus*)

Iteration #1: October 12, 2021

Event Summary and Risk Framing

Although SARS-CoV-2 (the virus that causes COVID-19) likely originated from an animal source, the current pandemic is being sustained through human-to-human transmission (OIE Q&A). The primary route for exposure of humans to SARS-CoV-2 is via other humans. However, spillover of the virus from humans to animals has been documented in several species (OIE events in animals), and several other species have been shown to be susceptible under experimental conditions (Government of Canada). There is currently uncertainty related to transmission of the virus in animals other than humans.

In late August 2021, the United States Department of Agriculture's (USDA) National Veterinary Services Laboratories (NVSL) announced confirmation of SARS-CoV-2 in wild white-tailed deer (*Odocoileus virginianus*) (WTD) from Ohio (United States Department of Agriculture, 2021). In addition, antibodies to SARS-CoV-2 were detected in 40% (152/385) of wild WTD sampled from four US states (Illinois, Michigan, New York, and Pennsylvania) between January-March 2021 (Chandler et al., 2021). Two experimental studies have also found that WTD inoculated with SARS-CoV-2 became infected, shed viable virus, transmitted infection to other WTD, and developed antibodies. Infected WTD showed minimal clinical signs or pathological changes (Cool et al., 2021; Palmer et al., 2021).

As a result of this information, One Health groups in Canada raised concerns regarding the potential risks posed to humans in contact with WTD (live and dead), and establishment of a wildlife reservoir and subsequent emergence of novel variants potentially adapted to other animal species or humans. Due to the uncertainty, rapidly evolving situation, and involvement of multiple disciplines, an iterative and joint rapid qualitative risk assessment (RQRA) process was initiated. It is intended to inform the development of communication products for people in contact with free-ranging or captive deer, policy guidance, and surveillance in wildlife and the game farming sector.

The source of risk assessed is WTD, including those that are free-ranging or captive (captive includes deer in game farms, rehabilitation centres, research facilities, or zoos), noting that within some legislation these definitions may differ. The RQRA will include other cervids in relation to research gaps and risk factors, without trying to include likelihood estimates for these species. This can be updated in future iterations as more information is available. The scope of the assessment includes all of Canada.

[This assessment was conducted by a multi-jurisdictional Emergency Collective Expert Appraisal Group. The methodology is intended to be used in situations where policy decisions need to be made in the face of high uncertainty. Given the minimal data available on surveillance, research, epidemiology and risk behaviours specifically related to SARS-CoV-2 in animals, the assessment was primarily informed by the group's collective professional knowledge on such topics as infectious diseases, virology, epidemiology, industry practices, and human-animal interactions. Assumptions, and sources of variability and uncertainty are detailed in the document. The findings and conclusions represent the consensual, but not necessarily unanimous, opinions of the group participants, and do not represent the views of the participants' respective organizations.]

Methodology

A multi-jurisdictional expert group (consisting of volunteers from federal, provincial and territorial departments of public health, animal health, wildlife and the environment, and academia) was formed to jointly complete all steps of the RQRA process. A scenario pathway diagram was created based on the risk questions (see Figure 1), and probabilities along these pathways were identified.

Probability and impact estimates were assessed qualitatively using a modified Delphi approach with the expert group: experts were individually surveyed for their initial estimates, the results were discussed as a group, and experts were then given the opportunity to modify their responses to the survey as they saw fit. The level of uncertainty associated with each probability and impact estimate was also assessed, and comments were provided by experts to justify their rationale for the estimate and describe sources of variability and uncertainty (see Appendix for definitions of estimates).

The assessment made a number of assumptions, including that: Canada continues to experience cases of COVID-19 in humans (primarily due to human-to-human transmission and primarily in unvaccinated individuals), vaccination will continue to be effective, and the use of personal protective equipment (PPE) and biosecurity measures is likely to be minimal and varied. The assessment may be updated as more information becomes available, or as assumptions change.

Scenario Pathway

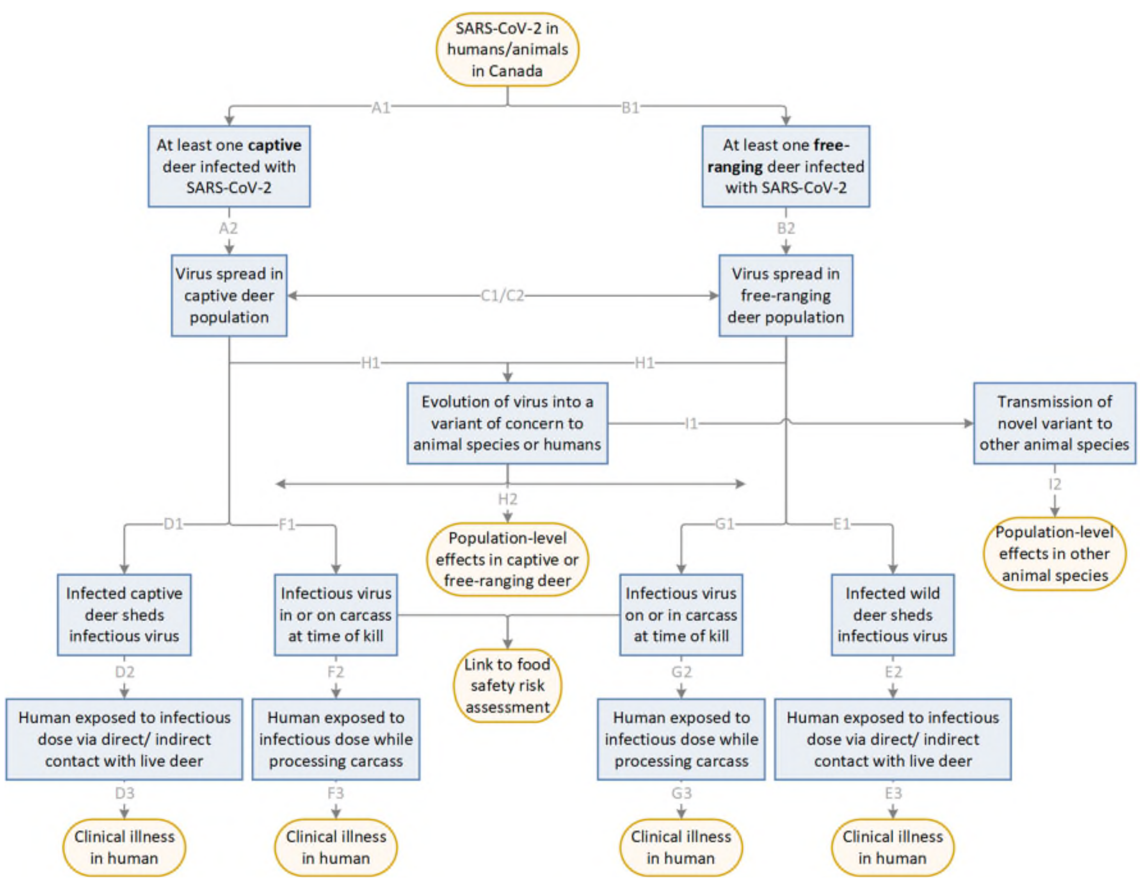

Figure 1: Hypothetical scenario pathway illustrating potential clinical illness in a person in Canada due to SARS-CoV-2 as a result of contact with WTD (Question 1), and establishment and evolution of SARS-CoV-2 in the WTD population in Canada with subsequent effects (Question 2). Probabilities corresponding to the letters A-I were assessed by the expert group.

WTD in Canada

WTD are the most abundant and widely distributed ungulate in Canada, occupying diverse habitats across the country. WTD continue to expand their range, and increased population estimates have been attributed to an ability to use human-modified landscapes (e.g., agriculture, forestry, human development) (Idaho Department of Fish and Game, 2019). However, WTD populations can undergo large population fluctuations due to climate variability (e.g., population die-backs in severe winters or expansion in mild winters) (Norton et al., 2021). In most regions where they are present in Canada, wild WTD density estimates range from <1 to 3 deer/km^2, though this is higher in certain regions of Quebec (Government of Alberta, Saskatchewan Ministry of Environment, Manitoba Fish and Wildlife, CBC Radio-Canada, Nova Scotia Department of Lands and Forestry).

Home range sizes in free-ranging WTD can be highly variable and are related to a variety of factors (i.e., body size, sex, age, reproductive status, season, resources, landscape and intra- and interspecific competition). Home range size may vary from less than 1 km^2 to more than 10 km^2 (DeYoung & Miller, 2011). Typical movements of WTD include relatively short (i.e., tens to hundreds of meters) daily and weekly movements, occasional excursions outside their home ranges, dispersal, and seasonal migration when in harsh landscapes (Moll et al., 2021). Of note, some WTD populations are migratory while others are not, depending on the habitat and climate of a given area (Sabine et al., 2002). Dispersal is most often undertaken by young males (DeYoung & Miller, 2011).

Contact rates are thought to be higher during feeding, particularly in areas with agricultural crops where different groups congregate for food (KjÆR et al., 2008). During late winter and early spring, WTD are often seen feeding in large groups that comprise several social groups. However, between-group contact among individuals is limited (Magle et al., 2013). Even though social group sizes are poorly documented, long-term studies of marked deer have estimated doe social group sizes of 2-12 individuals (DeYoung & Miller, 2011). To summarize social behavior of female deer, Koen et al. (2017) defined three seasons: (1) gestation (Jan 1 ± May 14), when female WTD occur in matrilineal social groups and larger groups of deer tend to aggregate to feed; (2) fawning (May 15 ± Aug 31), when adult female WTD tend to be solitary; (3) the rut (Sep 1 ± Dec 31), when female WTD tend to re-establish matrilineal social groups, with an increase in contact rates. Male-male proximity events peak during pre-rut when they establish their dominance using displays that occur in very close proximity (Mejía-Salazar et al., 2017).

In Canada, farmed WTD are almost exclusively raised for trophy hunt males, with some females raised for sale as breeding stock. There were approximately 63 WTD farms across the country (2019 and 2020 data). WTD are sometimes slaughtered on farm for sale as venison (mostly cull does). Due to their small carcass, they are rarely sent through the federal slaughter system. Depending on the province, meat may be sold directly off the farm with no provincial or federal inspection. Unlike elk and red deer, WTD are not cut for velvet antler. WTD semen may be collected and sold. Their urine may be collected, packaged and sold commercially as an attractant for hunting purposes. Shed hard horn is sold to trophy collectors, as well as craftsmen that make chandeliers and other art (A. McIsaac, personal communication, August 26, 2021).

Although infrequent, clear evidence has been documented of direct contact between wild and captive cervids (wild and farmed elk, wild and farmed WTD) through single woven-wire fence. Direct contacts included nose-to-nose, touching (nose to other body part), and sparring (Vercauteren et al., 2007a; b). Given that wild deer and captive deer are not part of the same social group, little direct contact is expected. However, contacts could increase during the rut period. Single perimeter fencing can be more vulnerable to breaches which could allow the ingress and egress of cervids, resulting in potential contact (Kincheloe et al., 2021).

Conclusions

Question 1: What is the likelihood and impact of at least one person in Canada becoming clinically ill due to SARS-CoV-2 as a result of contact with WTD within the next 12 months?

The level of exposure of WTD in Canada to SARS-CoV-2 to date is unknown. No cases have been reported to date, but very little surveillance has been conducted and clinical signs appear to be minimal in cases reported from elsewhere to date.

If a WTD is infected, the **probability** that a human will be exposed to an infectious dose and become clinically ill due to SARS-CoV-2 as a result of contact with WTD within the next 12 months is:

- Most likely **very low** (free-ranging) to **low** (captive) for contact with **live WTD**, with a moderate (free-ranging and captive) to high (captive) level of uncertainty.
    - The highest risk of exposure for humans is other humans. The only evidence of animal to human spread has been with farmed mink. This type of transmission is most likely to occur in situations of close contact, and the frequency of these events is not going to be very high with WTD, even with captive WTD.
    - The probability of exposure to an infectious dose is highest for the following groups, particularly if they do not wear PPE and/or are not vaccinated: people working in rehabilitation facilities, farm workers or veterinarians during times of husbandry or at slaughter, and government/park officials or biologists doing wildlife management activities or field research.
    - Close contact between the general public and WTD is less frequent but may include the public hand-feeding deer in backyards and parks, or at petting zoos.
    - The probability of clinical illness after exposure is highest for: unvaccinated individuals; elderly, immunocompromised, and those with co-morbidities; and Indigenous communities (due to variable vaccination coverage in communities, and co-morbidities).

- Most likely **low** (captive and free-ranging) for contact with a **WTD carcass**, but ranging to **moderate** for certain groups in certain situations. The level of uncertainty is moderate to high.
    - This type of transmission has been documented from infected mink to pelters and the use of PPE in situations involving WTD is likely limited; however, it would be an occupational hazard for a limited group.
    - The probability of exposure to an infectious dose is highest for the following groups, if they do not wear PPE and are not vaccinated: hunters, producers, farm workers, veterinarians, butchers, and taxidermists. In particular those who: handle the carcass directly after kill, work in confined spaces, process large numbers of animals, or use power tools for slaughter.
    - Probability may also be higher in Indigenous communities (due to likelihood of encountering deer and variable vaccination coverage) and during hunting season.

- Regardless of whether virus is present in or on meat/muscle, **food safety** risk assessment conducted by Canadian federal food safety partners has determined that the likelihood of human exposure to SARS-CoV-2 by ingestion or contact with mucosa is considered **negligible** to **very low** (Locas et al., 2021). They also concluded that there is currently no comprehensive epidemiological evidence of confirmed cases of SARS-CoV-2, or its variants, causing COVID-19 from transmission through food or food packaging.

The overall national scale **impact** of this scenario is considered to be **very low to low**. This is because the effects vary from indiscernible to minor at the national level but could be higher in some directly affected parties (e.g., people in remote and indigenous communities may have more impact due to more limited health care supports). The level of uncertainty associated with this is considered to be low. It would be difficult to discern these cases in the human population from the cases caused by human-to-human transmission.

Question 2: What is the likelihood and impact of establishment and evolution of SARS-CoV-2 in the WTD population in Canada, and subsequent:

a) **Population-level effects in free-ranging WTD?**
b) **Population-level effects in captive WTD?**
c) **Population-level effects in other animal species?**
d) **Transmission of a novel variant to humans?**

As mentioned in Question 1, the level of exposure of WTD in Canada to SARS-CoV-2 to date is unknown. The probability that transmission to WTD in Canada from humans or other animal species occurs in the next 12 months, if it has not occurred already, is highly variable and difficult to determine. Risk factors include human case levels in the area and over time, extent of captive and free-ranging WTD in the area, handling practices, and human behaviours. The highest probability for this transmission is at rehabilitation centres, especially those handling orphaned fawns, due to prolonged close contact. For farmed cervids, this transmission is most likely to occur during management procedures (such as animal identification procedures, physical exams, treatment, vaccination, transport, surveillance sampling, or use of bait stations on some premises). Other risk factors include research involving animal handling, baiting, winter feeding of free-ranging WTD by the public, nuisance wildlife control and translocation, and WTD in peri-urban areas.

The most likely scenario if a captive WTD is infected with SARS-CoV-2 is limited-time transmission within the facility only, or limited-time transmission within the region if a free-ranging WTD is infected. There is variation in this probability due to population density, time of the year (i.e., breeding, winter, parturition, migration), scarcity of food sources and its effect on congregation, human activities (e.g., baiting, farmed feed storage locations), viral strain, and immunity. The probability is considered highest within matrilineal groups, during rutting season, and in winter (when animals congregate, and the virus is better able to persist in the environment). The probability of spread between captive and free-ranging populations is low to moderate (moderate to high uncertainty) and is more likely to go from captive to free-ranging than the reverse. This will depend on the level of biosecurity (e.g., fencing and how feed is stored), size and density of free-ranging WTD populations in the vicinity of captive WTD facilities, and environmental conditions. The probability of establishment of an ongoing virus reservoir in captive or free-ranging WTD is most likely low, but with a high level of uncertainty.

The probability that a novel variant of the virus evolves in WTD that is of concern to wildlife species or humans was considered too uncertain to assess at this point in time. It is impossible to know without a better understanding of viral dynamics in deer. SARS-CoV-2 mutates over time, as has been seen in humans and farmed mink; however, in most instances, mutations have no or little direct impact (Harvey et al., 2021; World Health Organization et al., 2021).

a) For impacts to occur in free-ranging WTD, the virus would have to evolve to the point that there was sufficient transmission and clinical disease to cause population-level effects. The probability of this and the associated effects were considered **too uncertain to assess**. Such an evolution to causing severe clinical disease would involve many factors. However, it is very difficult to predict the characteristics of a novel variant. As a result, various scenarios were explored:
    - If deer are dying of the disease in large numbers, and a large proportion of the population is impacted, it would have a huge impact on deer management. If causing high levels of morbidity and mortality, sick or vulnerable animals would be easier for predators to catch.
    - If deer are only mildly ill and there is some impact on birth rates or survival that is low, the population may still be able to persist and thrive, and modifications can be made to hunting allocations.
    - If deer are only clinically ill for a short time period and recover, the impacts may not be significant.

b) The probability and associated effects of a novel variant in captive WTD were also considered **too uncertain to assess**. However, some of the potential effects were explored, including:
    - A lack of public confidence in farms and farmed products.
    - If mitigating measures were put in place to reduce impact, they could be costly to the producer.
    - There may be effects on animal importation and exportation, affecting producers and North American markets.
    - There could be financial and mental health consequences for cervid farmers.
    - There would be a higher impact on those provinces and territories that have a large captive deer industry.

c) The probability and associated effects of a novel variant in other animal species were also considered **too uncertain to assess**. However, the other species most likely to be exposed to free-ranging WTD include other cervids (though their susceptibility is unknown), predators (canids most common, but cougars suspected to be more susceptible), scavengers (not including birds), and species that share the same food sources or would be attracted to the same baits. Susceptible species housed in the same facilities as captive infected WTD would also be at higher risk. Effects could include illness in wild felids (such as cougars), resulting in a decrease in their hunting abilities. However, the most concern would be situations in which mortality rates exceed the ability for a population to recover, or if novel variants affect species that are threatened, vulnerable, or endangered (e.g., caribou).

d) If a novel variant were to evolve in WTD that was a variant of concern (VOC) for humans, transmission back to humans would be more likely for the groups already identified above. The probability of transmission and impact of vaccination would depend on the characteristics of the novel variant. Nonetheless, there has been evolution of this virus in humans and animals since the start of the pandemic, and few of these variants develop into VOCs for public health. Those that have become VOCs for public health have primarily developed in humans. The magnitude of the effects on public health would also depend on the characteristics of the variant and were considered **too uncertain to assess**. Potential impacts were explored, including:

- There is a limited ability to control a virus in wild populations.
- There could be a significant impact on wildlife activities (e.g., hunting, outfitting, carcass butchering, game farming, rehabilitation), with a goal of trying to mitigate public health impacts, especially if the novel variant that developed was a VOC. This could result in significant economic losses.
- If a VOC develops in WTD that is significantly different from those developing in humans, it could have a larger impact.

As a result of the uncertainty and the potential impacts, the importance of monitoring the virus in WTD populations was highlighted.

These estimates could be updated as more information becomes available. It is strongly recommended that risk assessments be conducted on a case-by-case basis, as required, using this scenario pathway as a guide, particularly for those individuals that must have very close contact with WTD (e.g., rehabilitation workers, producers, farm workers, veterinarians, government/park officials, biologists, hunters, butchers, taxidermists, Indigenous communities).

Key Knowledge Gaps

- Epidemiological data on the current viral situation in WTD
  - Previous exposure of WTD in Canada since the beginning of the pandemic
  - Movement of exposed WTD from the USA across the border into Canada
  - Source of infection for the WTD in the USA
- Environmental persistence
  - Amount of live viable virus present in human environments
  - Duration of viral survival in the environment and on fomites in the vicinity of WTD
- Further study of the pathology of SARS-CoV-2 infection in WTD in different host-environment circumstances, particularly after natural infection
  - Duration of shedding in WTD
  - Viral distribution, viral load, and viral persistence in various tissues and secretions
  - Duration of viremia
  - Nature of immunity and reinfection in WTD, including maternal immune response
  - Percentage of sub-clinical infections
- Deer movements and connectivity of deer populations
  - Effect of clustering or deer densities in disease transmission and prevalence
  - Extent of direct fence-line contact between captive and free-ranging WTD
  - Efficiency of transmission between captive and free-ranging WTD
- Information on other species
  - Susceptibility of other cervid species, especially caribou, mule deer, and black-tailed deer
  - Data on wild animal interactions with WTD
  - Presence of SARS-CoV-2 in susceptible predators and scavengers that have a high probability of interacting with deer
- The effect of new variants on all the above

References

Chandler JC, Bevins SN, Ellis JW, Linder TJ, Tell RM, Jenkins-Moore M,[…] Shriner SA, 2021. SARS-CoV-2 exposure in wild white-tailed deer (Odocoileus virginianus). bioRxiv. https://doi.org/10.1101/2021.07.29.454326

Cool K, Gaudreault NN, Morozov I, Trujillo JD, Meekins DA, McDowell C,[…] Richt JA, 2021. Infection and transmission of SARS-CoV-2 and its alpha variant in pregnant white-tailed deer. bioRxiv. https://doi.org/10.1101/2021.08.15.456341

DeYoung RW & Miller KV, 2011. White-tailed deer behavior. In: Hewitt DG (ed.), Biology and management of white-tailed deer. Boca Raton, FL: CRC Press.

Harvey, W.T., Carabelli, A.M., Jackson, B., Gupta, R.K., Thomson, E., Harrison, E.M., Ludden, C., Reeve, R., Rambaut, A., 2021. SARS-CoV-2 variants, spike mutations and immune escape. Nat Rev Microbiol. 19: 409–424. https://doi.org/10.1038/s41579-021-00573-0

Idaho Department of Fish and Game, 2019. Idaho WTD Management Plan 2020-2025. Available at: https://idfg.idaho.gov/sites/default/files/plan-deer-white-tailed-2020-25.pdf.

Kincheloe JM, Horn-Delzer AR, Makau DN & Wells SJ, 2021. Chronic Wasting Disease Transmission Risk Assessment for Farmed Cervids in Minnesota and Wisconsin. Viruses 13 (8): 1586. https://doi.org/10.3390/v13081586

KjÆR LJ, Schauber EM & Nielsen CK, 2008. Spatial and Temporal Analysis of Contact Rates in Female White-Tailed Deer. The Journal of Wildlife Management 72 (8): 1819-1825. https://doi.org/10.2193/2007-489

Koen EL, Tosa MI, Nielsen CK & Schauber EM, 2017. Does landscape connectivity shape local and global social network structure in white-tailed deer? PLOS ONE 12 (3): e0173570. https://doi.org/10.1371/journal.pone.0173570

Locas A, Brassard J, Rose-Martel M, Lambert D, Green A, Deckert A & Illing M, 2021. A comprehensive risk pathway of the qualitative likelihood of human exposure to SARS-CoV-2 from the food chain. Journal of Food Protection. https://doi.org/10.4315/JFP-21-218

Magle SB, Samuel MD, Van Deelen TR, Robinson SJ & Mathews NE, 2013. Evaluating Spatial Overlap and Relatedness of White-tailed Deer in a Chronic Wasting Disease Management Zone. PLOS ONE 8 (2): e56568. https://doi.org/10.1371/journal.pone.0056568

Mejía-Salazar MF, Goldizen AW, Menz CS, Dwyer RG, Blomberg SP, Waldner CL,[…] Bollinger TK, 2017. Mule deer spatial association patterns and potential implications for transmission of an epizootic disease. PLOS ONE 12 (4): e0175385. https://doi.org/10.1371/journal.pone.0175385

Moll RJ, McRoberts JT, Millspaugh JJ, Wiskirchen KH, Sumners JA, Isabelle JL,[…] Montgomery RA, 2021. A rare 300 kilometer dispersal by an adult male white-tailed deer. Ecology and Evolution 11 (9): 3685-3695. https://doi.org/10.1002/ece3.7354

Norton AS, Storm DJ & Van Deelen TR, 2021. White-Tailed Deer, Weather and Predation: a New Understanding of Winter Severity for Predicting Deer Mortality. The Journal of Wildlife Management 85 (6): 1232-1242. https://doi.org/10.1002/jwmg.22083

Palmer MV, Martins M, Falkenberg S, Buckley A, Caserta LC, Mitchell PK,[…] Diel DG, 2021. Susceptibility of white-tailed deer (Odocoileus virginianus) to SARS-CoV-2. Journal of Virology. https://doi.org/10.1128/JVI.00083-21

Sabine D, Morrison S, Whitlaw H, Ballard W, Forbes G & Bowman J, 2002. Migration Behavior of White-Tailed Deer under Varying Winter Climate Regimes in New Brunswick. The Journal of Wildlife Management 66: 718. https://doi.org/10.2307/3803137

United States Department of Agriculture, 2021. Confirmation of COVID-19 in Deer in Ohio. August 27, 2021. Available at: https://www.aphis.usda.gov/aphis/newsroom/stakeholder-info/sa_by_date/sa-2021/sa-08/covid-deer (last accessed 31 August 2021).

Vercauteren KC, Lavelle MJ, Seward NW, Fischer JW & Phillips GE, 2007a. Fence-Line Contact Between Wild and Farmed Cervids in Colorado: Potential for Disease Transmission. The Journal of Wildlife Management 71 (5): 1594-1602. https://doi.org/10.2193/2006-178

Vercauteren KC, Lavelle MJ, Seward NW, Fischer JW & Phillips GE, 2007b. Fence-Line Contact Between Wild and Farmed White-Tailed Deer in Michigan: Potential for Disease Transmission. The Journal of Wildlife Management 71 (5): 1603-1606. https://doi.org/10.2193/2006-179

World Health Organization, Food and Agriculture Organization of the United Nations & World Organisation for Animal Health., 2021. SARS-CoV-2 in animals used for fur farming: GLEWS+ risk assessment, 20 January 2021. World Health Organization. https://apps.who.int/iris/handle/10665/339626. License: CC BY-NC-SA 3.0 IGO

Appendix

Table 1 - Likelihood Definitions[1]

Likelihood of event occurring	Descriptive Definition	Likelihood of event NOT occurring
Negligible	The situation described in the question is almost certain not to occur but could occur under exceptional circumstances. The likelihood is virtually zero.	High
Very low	The situation described in the question is very unlikely to occur.	Moderate
Low	The situation described in the question is unlikely to occur.	Low
Moderate	The situation described in the question is fairly likely to occur.	Very low
High	The situation described in the question is likely to occur.	Negligible

Table 2 – Uncertainty categories[2]

Uncertainty category	Interpretation
Low	There are reliable data and information available; strong evidence is provided in multiple references, and authors report similar conclusions. Several experts have multiple experiences of the event, and there is a high level of agreement between experts.
Moderate	There are some gaps in availability or reliability of data or information; evidence is provided in a small number of references, and/or authors report conclusions that vary from one another. Experts have limited experience of the event and/or there is a moderate level of agreement between experts.
High	There are scarce or no reliable data or information available, and/or authors report conclusions that vary considerably between them. Very few experts have experience of the event and/or there is a very low level of agreement between experts. Results are based on educated guess or crude speculation.
Too high to allow assessment	The estimate is just as likely to be negligible as high, and estimates would not provide any useful information to risk managers at this stage. [If more than 10% of experts choose this option, especially if the remainder are mostly high, then the group may choose to provide only comments on that component, without providing an estimate.]

Table 3. Description of the magnitude of the effects[3]

Magnitude of the effect	Description of the effect
Indiscernible	Not usually distinguishable from normal day-to-day variation
Minor	Recognisable, but marginal, insignificant and/or reversible
Moderate	Serious and substantive consequences on the health of the population and health system, but usually reversible
Severe	Extremely serious and/or irreversible

[1] Adapted from: Tripartite JRA Operational Tool; and CFIA Animal Health Risk Assessment Methodology.

[2] Adapted from: Tripartite JRA Operational Tool; and Fournie G, Jones BA, Beauvais W, Lubroth J, Njeumi F, Cameron A & Pfeiffer DU, 2014. The risk of rinderpest re-introduction in post-eradication era. *Prev Vet Med* 113 (2): 175-184.

[3] Adapted from: Tripartite JRA Operational Tool; and Biosecurity Australia, 2009. Draft Import risk analysis report for horses from approved countries: final policy review [Internet]. Available at: http://www.daff.gov.au/__data/assets/pdf_file/0018/1410651/2009_28_Horses_draft_IRA_report.pdf

Table 4. Guidelines for determining the overall, national-scale impact of establishment and/or spread[4]

Overall impact	Description of impact
Extreme	The effects are likely to be severe at the national level. Implies that economic stability, societal values or social well-being would be significantly affected.
High	The effects are likely to be moderate at the national level and severe within affected zones. Implies that the effects would be of national concern. However, moderate effects on economic stability, societal values or social well-being would be limited to a given zone.
Moderate	The effects are likely to be minor on a national level and moderate within affected zones. The effects are likely to be severe for directly affected parties.
Low	The effects are likely to be minor within affected zones and moderate to directly affected parties. The effects are likely to be minor at the national level.
Very low	The effects are likely to be minor to directly affected parties. The effects are likely to be indiscernible at any other level.
Negligible	The effects are likely to be indiscernible at any level within Canada.

[4] Modified from: Biosecurity Australia, 2009. Draft Import risk analysis report for horses from approved countries: final policy review [Internet]. Available at: http://www.daff.gov.au/__data/assets/pdf_file/0018/1410651/2009_28_Horses_draft_IRA_report.pdf (last accessed 2014-04-04).