DRAFT: Surveillance and Management Plan for Chronic Wasting Disease in Free-ranging Cervids in Minnesota

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"*In any moment of decision, the best thing you can do is the right thing, the next best thing is the wrong thing, and the worst thing you can do is nothing*."

- Theodore Roosevelt

Introduction

Chronic wasting disease (CWD) belongs to a family of infectious diseases, called transmissible spongiform encephalopathies (TSE), which alter the morphology of the central nervous system, resulting in a "sponge-like" appearance of this tissue. Chronic wasting disease only affects members of the cervidae family including elk (*Cervus canadensis*), mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), moose (*Alces alces*), and caribou/reindeer (*Rangifer tarandus*). The etiological agent of CWD is an infectious protein, called a prion, which accumulates in nervous and lymphatic tissues and has been detected in a variety of tissues and fluids throughout infected animals. Infectious prions have been found in cervid urine, saliva, blood, feces, and antler velvet (Mathiason et al. 2006, Haley et al. 2011, Pulford et al. 2012). Incubation time of the disease, from infection to clinical signs, can range from 1.5 to nearly 3 years (Williams et al. 2002). Clinical signs are non-specific and may include a loss of body condition and weight, excessive salivation, loss of fear of humans, loss of body control, tremors or staggering, drooping head or ears, and apparent confusion (Gilch 2016). There is no known treatment or vaccine for the disease and it is always fatal.

Chronic wasting disease was first discovered in captive mule deer in 1967 in Colorado and then recognized in captive white-tailed deer and elk in 1978. Within wild populations, CWD was historically confined to free-ranging deer and elk in the endemic area of northeastern Colorado and southeastern Wyoming. As of fall 2018, the disease has been detected in wild and captive cervids in 25 states across the US, three Canadian provinces, the Republic of Korea, Finland, and Norway.

The Centers for Disease Control (CDC) and other public health agencies have concluded there is no known link between CWD and any neurological disease in humans (MaWhinney et al. 2006), and transmission to humans is extremely unlikely (Kurt et al. 2015, Waddell et al. 2018). However, an ongoing study by the Canadian Food Inspection Agency has demonstrated that by orally consuming muscle from deer naturally infected with CWD under experimental conditions, the disease can be transmitted to macaques (*Macaca fascicularis*). This unpublished finding has sparked renewed concerns about potential human health risks of eating CWD-contaminated venison (Czub 2017). In separate work, also focused on susceptibility of macaques to CWD, Race et al. (2018) found no evidence of successful transmission. The reasons for this scientific ambiguity are unclear, but as a precaution both the CDC and the World Health Organization recommend that humans do not consume any part of a known positive animal.

Experimental and circumstantial evidence suggest that transmission of the disease is primarily through direct contact with infected animals, carcasses, saliva, or excrement (Miller and Williams 2003, Safar et al. 2008, and Haley et al. 2011). There is also evidence that CWD can be transmitted vertically from mother to offspring (Nalls et al. 2013). Theoretically, prions can be shed from infected animals soon after initial infection; in one experimental study prion shedding was detected in deer saliva three months post-inoculation (Henderson et al. 2015), and another study found that deer shed prions in their feces up to a year before showing signs of illness (Tamgüney et al. 2009).

Persistence of prions in the environment and resulting indirect transmission has been shown to occur (Miller et al. 2004, Johnson et al. 2007, and Maluquer de Motes et al. 2008). Prions readily bind with soil particles (Saunders et al. 2012) and other abiotic substances (Pritzkow et al. 2018), which can magnify CWD infectivity (Johnson et al. 2007). Furthermore,

plants have been shown to uptake prions from the soil making them available for consumption by herbivorous animals (Pritzkow et al. 2015). Conversely, a recent study found that humic acids in soil organic matter may decrease prion infectivity (Kuznetsova et al. 2018). These findings underscore the complex dynamics that prions have with the environment.

All cervids infected with CWD, regardless of their genetic makeup, will die from CWD-associated mortality because no genotype confers complete immunity. However, research has demonstrated that certain genotypes can extend the CWD incubation period and animal survival time, although these infected individuals may shed infectious prions for a longer amount of time (Johnson et al 2006, 2011; Robinson et al. 2012). Based on epidemiological modeling, deer with a more CWD-resistant genotype may have a selective advantage in the long term, although it is not clear if there are maladaptive traits associated with their presence (Robinson et al. 2012). More recently, there is evidence that there has been genetic selection among elk due to CWD, but it is unclear whether it is sufficient to mitigate negative population level impacts (Monello et al. 2017). There is much uncertainty regarding how CWD may drive the evolutionary dynamics of cervid populations, but it is clear that the recent discovery and potential for novel CWD strains adds additional complexity (Duque-Velásquez et al. 2015).

Hunting activities related to wild white-tailed deer drive the economic engine for the Minnesota Department of Natural Resources (MNDNR), Division of Fish and Wildlife. The discovery of CWD in wild cervid populations has negatively affected hunter numbers and local economies in areas where it exists (Vaske et al. 2004, Vaske and Lyon 2011). In fact, deer license sales in southeast Minnesota have declined 10% since 2016, which is inconsistent with prior year sales that were relatively stable. If CWD were to become established or if the disease is determined to impact human or domestic animal health, the MNDNR would realize substantial

reductions in license sales and Federal Aid reimbursements and experience significant changes in budget allocations and staffing levels. Needham et al. (2004) postulated that upwards of two-thirds of hunters would quit hunting if CWD was transmissible to humans. By extension, a reduction in deer hunters diminishes the capacity of state management agencies to effectively manage deer populations. The MNDNR is not unique, as license fees fund the operations of most state wildlife agencies, who are reliant on these fees and Federal reimbursements to deliver management and conservation activities for wildlife and their habitats (Organ et al. 2010). Since 2002, Minnesota has spent $7.1 million on its CWD response program[1], of which 96% were state funds (83% from license fees). Until such time as uncertainty is reduced (e.g., human health implications, long-term population concerns), the MNDNR should consider CWD response/management as the highest priority and all necessary resources should be directed to avoid the long-term consequences of an endemic infection.

History of CWD in Minnesota

To date (February 2019), CWD has been diagnosed in 8 captive cervid herds within the state of Minnesota, including 3 elk herds, 4 white-tailed deer herds, and 1 European red deer (*Cervus elaphus*) herd. Two of the elk herds (Stearns and Aitkin counties) were discovered in 2002 and depopulated with no additional CWD positive animals found. In spring 2006, a captive white-tailed deer was found infected with CWD from a mixed deer/elk herd in Lac Qui Parle County. That herd was also depopulated without additional CWD cases being detected. In early 2009, a third captive elk herd (Olmsted County) of >600 animals was found infected with CWD. Following depopulation, a total of 4 elk were confirmed with the disease and the United States Department of Agriculture (USDA) determined there was an apparent longstanding infection

[1] Total is through fiscal year 2018. An additional $1.3 million is expected to be spent in fiscal year 2019.

within the herd. In mid-2012, a captive European red deer was found infected with CWD in a herd of approximately 400 animals in North Oaks (Ramsey County). This marked the first time CWD was discovered in this species (Schwabenlander et al. 2013). Also in 2012, the USDA discontinued funding to depopulate CWD-infected herds; thus the North Oaks herd was quarantined for several years until depopulation finally occurred in 2015 (with no additional CWD positive cases found). In 2016, two adult female white-tailed deer were detected with CWD from a captive mixed white-tailed and mule deer herd in Crow Wing County. This facility is still under quarantine as the owner chose not to depopulate the herd; it continues to operate as a shooting pen, although CWD was again detected in this facility in fall 2018. Trace out movements from this facility to a herd in Meeker County in 2017 revealed another infected adult female white-tailed deer, which was found dead in the facility and confirmed to have CWD. This herd of 15 deer was depopulated with 5 animals (33% prevalence) testing positive for CWD. Most recently, in November 2017, CWD was detected in an adult male white-tailed deer that died in a Winona County captive deer facility. An additional adult male harvested in the facility in December 2017 was also confirmed infected with CWD. The remaining seven animals in this facility were depopulated in early 2018 and all deer tested positive for CWD (100% prevalence).

In response to the initial discovery of CWD in wild white-tailed deer of Wisconsin and the first Minnesota CWD-positive captive elk herd in 2002, the MNDNR developed a comprehensive wild deer CWD surveillance program. This included surveillance of hunter-harvested and opportunistically encountered vehicle-killed and clinical-suspect deer, elk, or moose. A clinical-suspect cervid is defined as exhibiting physical signs, behavioral abnormalities, and/or locomotor difficulties consistent with CWD infection (Gilch 2016). From 2002–2004, nearly 28,000 deer were tested for CWD statewide with no positive results.

Sampling occurred at the deer permit area (DPA) level with 95% confidence that the disease would have been detected if present in ≥1% of the deer population in each DPA. Following completion of statewide surveillance, and no evidence of a long-standing infection in Minnesota, the MNDNR adjusted surveillance efforts and focused sampling of wild cervids in response to elevated risk factors. These risk factors include 1) detection of CWD-positive animals in a captive cervid facility in Minnesota, 2) proximity of positive CWD cases in wild deer in neighboring states, and 3) testing of clinical-suspects of CWD and other special wild cervid cases. These elements constitute the MNDNR's risk-based approach to CWD surveillance in Minnesota and permit more efficient use of finite resources (financial and personnel), as opposed to continuous statewide sampling. Since 2005, the MNDNR has tested an additional 43,000 deer for CWD using risk-based surveillance.

The first wild white-tailed deer found infected with CWD in Minnesota occurred in fall 2010, during the second year of risk-based surveillance efforts surrounding the CWD-positive captive elk facility in Olmsted county in 2009. From 2011–2013, MNDNR implemented the 2011 CWD Response Plan (MNDNR 2011) and over 4,000 deer were tested in this immediate area; no additional positives were detected (Hildebrand et al. 2013). The MNDNR concluded the disease was either found early enough to prevent establishment or occurred at an undetectable level in the local deer population. The CWD Management Zone that had been created through the response plan was dissolved in 2014, and harvest regulations and zone boundaries returned to what they were prior to the discovery of CWD.

In fall 2016, surveillance efforts were again prompted by a risk-based approach as detections of CWD in wild deer from western Wisconsin and northeastern Iowa increased and further encroached on Minnesota borders. As a result of this effort, three adult males were found

infected with CWD in Fillmore County (DPA 348). Again, MNDNR implemented the 2011 CWD Response Plan and additional samples were collected during winter 2016-2017, which resulted in eight more CWD-positive deer found in a small geographic area near Preston, Minnesota. Initial disease prevalence was estimated at 0.7% within the newly established CWD Management Zone (DPA 603), with nearly all CWD cases found within a 64mi^2 core area (2.1% sample prevalence). Testing within DPA 603 during fall 2017 resulted in six additional CWD-infected deer and sample prevalence was estimated at 0.4%, with possible disease spread approximately 8 miles west of the core area into Forestville State Park. Surveillance efforts in fall 2018 detected an additional 17 CWD-positive deer within DPA 603, increasing our sample prevalence to 0.9% within our CWD Management Zone. Further, the first cases of disease were found outside the DPA 603 boundary in 2 deer in DPA 347 and 2 deer in DPA 346. To date, a total of 46 deer have been confirmed to have CWD in southeastern Minnesota since 2016. Efforts are currently underway this winter (January-March 2019) to determine the significance of this recent increase in both disease prevalence and geographic spread through additional harvest opportunities utilizing special hunts, landowner shooting permits, and target culling. Ongoing surveillance and aggressive management in DPA 603 will determine if MNDNR's response actions were successful in reducing or eliminating CWD, or if the disease will continue to persist and require adaptive management responses.

In late-January 2019, an emaciated deer was found dead 0.5 miles from a CWD-positive captive cervid facility in Crow Wing County; the deer (adult female) was confirmed to have CWD. This was the first wild deer detection in an area that has been under DNR's risk-based surveillance program since 2017, after the facility was found infected in December 2016.

Immediate steps through spring 2019 are to work with landowners to remove wild deer from around the facility in order to remove potentially positive animals from the population.

Risk-based Surveillance for CWD in Wild Cervids of Minnesota

The MNDNR goal for CWD surveillance in wild cervids is to detect the disease, if it is present, as early as possible since introduction. Since 2005, the MNDNR has relied on a risk-based surveillance approach that identifies risk factors related to CWD introduction into wild cervids, which include:

1. Discovery of CWD in a Minnesota captive cervid facility.
2. Recent detection or significant spread of CWD in wild cervids in a bordering state.
3. Detection of CWD through testing of clinical-suspects or other special cervid cases.

When these risk factors are identified, MNDNR will initiate a series of actions to conduct precautionary CWD surveillance. As a general rule, the MNDNR will alert tribal authorities once a CWD-positive detection has been confirmed or if there is significant CWD risk from a bordering state; federal resource managers, non-governmental organizations, and other stakeholders in the affected area will also be notified about surveillance plans. This will enable effective partnering to support CWD surveillance goals.

For all MNDNR CWD surveillance efforts, the data collection process will include the extraction of both medial retropharyngeal lymph nodes, determination of sex and age class for each animal, and identification of the harvest location. Typically, sampling effort is focused on yearling (between 1 and 2 years of age) and adult (>2 years of age) cervids. Generally, fawns (<1

year of age) will not be tested for CWD given the low probability of testing positive, however, there may be exceptions to this general rule. All samples will be inventoried, entered into a database, and sent to an accredited laboratory for enzyme-linked immunosorbent assay (ELISA) testing. Positive ELISA samples will be considered "suspect-positive," until confirmatory testing using immunohistochemistry testing (IHC) is performed at either the accredited laboratory or the National Veterinary Services Laboratory in Ames, Iowa.

Discovery of CWD in a Minnesota Captive Cervid Facility

If CWD is detected in a captive cervid facility in Minnesota, the Minnesota Board of Animal Health (BAH) has the lead role of response inside the facility, including further testing of captive animals, determining the source population, and testing/managing trace-out facilities. The MNDNR will determine if wild cervids in the surrounding area are infected with CWD by conducting precautionary surveillance in the immediate area for a minimum of 3 consecutive years, which may include hunter-harvested surveillance, special hunts, landowner shooting permits, and agency-directed culling.

The following activities will occur as quickly as possible, regardless of the time of year the discovery is made:

- Where possible (e.g., outside the forest), complete an aerial survey in the immediate area surrounding the CWD-positive facility, once adequate snow conditions occur, to estimate wild cervid population density and distribution on the landscape.
- Implement a recreational feeding ban to reduce contract rates and decrease disease transmission potential until surveillance in wild cervids has been completed. At a minimum, this area would include the county containing the infected facility and all immediately surrounding counties.

- Establish a CWD surveillance area around the infected captive cervid facility. During the initial response year, this would include the DPA containing the infected facility and all surrounding DPAs. If an adequate sample is collected and disease is not detected in a wild cervid the first year, the surveillance area may be reduced to a more localized area around the facility in subsequent years.

Following these initial steps, a surveillance strategy will be designed to determine if CWD is present in the wild cervid population. The sampling method(s) will be dependent upon multiple factors, such as 1) the wild cervid density and distribution surrounding the positive facility, 2) the history of wild cervid surveillance in the area, 3) expected volume of hunter-harvested deer in the area, 4) the overall compliance of the infected facility to regulations intended to minimize CWD transmission risks, and 5) the timing of the discovery relative to the next hunting season. After evaluating each of these factors, the decision will be made whether to obtain samples for CWD testing from hunter-harvest efforts and/or other mechanisms such as special hunts, landowner shooting permits, or agency-directed culling. Further, there will be increased efforts to sample clinical-suspect and vehicle-killed wild cervids, when possible. Any confirmed positive CWD cases in wild cervids discovered through these efforts will trigger transition from precautionary surveillance to our initial response to CWD detection in wild cervids. The precautionary surveillance period will occur for 3 consecutive years, the maximum observed incubation period of the disease in cervids under experimental settings. In each of these years, MNDNR will collect adequate samples to ensure at least 95% confidence that CWD would be detected if prevalence is ≥1% in the underlying wild cervid population. After 3 years, MNDNR would reevaluate the risk and determine if continued surveillance is necessary.

Recent Detection or Significant Spread of CWD in Wild Cervids in a Bordering State

Currently, CWD has been found in wild cervids in all the US states surrounding Minnesota, but not the Canadian provinces of Manitoba or Ontario. In the Dakotas, CWD has been found in mule deer, white-tailed deer, and elk but the infection remains in the western portions of these states with low risk of spread into Minnesota from natural wild cervid movements. However, CWD has been found in wild white-tailed deer in northeastern Iowa and western Wisconsin, where the potential for disease spread into Minnesota through natural deer movements is an ongoing concern.

Wildlife professionals in the surrounding states and provinces routinely exchange information on CWD surveillance and detections in their jurisdictions. These ongoing communications help MNDNR assess risk of disease incursion into wild cervid populations at our borders. When new cases of CWD are found near Minnesota's borders or there has been significant spread of the disease from an endemic area towards Minnesota, the MNDNR's risk-based surveillance efforts will be implemented. The surveillance response will include:

- Sampling of hunter-harvested wild cervids in the DPA or DPAs closest to encroaching CWD cases in the neighboring state or province. An adequate sample will be collected to ensure at least 95% confidence that CWD would be detected if prevalence is ≥1% in the underlying cervid population.
- Increased efforts to sample clinical-suspect and vehicle-killed wild cervids, when possible, in the DPAs closest to encroaching CWD cases in the neighboring state or province.

Any confirmed positive CWD cases in wild cervids discovered through these efforts will trigger transition from precautionary surveillance to our initial response to CWD detection in wild

cervids. If the disease is not detected, MNDNR will evaluate the need for continued surveillance beyond 1 year.

Detection of CWD through Testing of Clinical-suspects or Other Special Cervid Cases.

Year-round and across Minnesota, clinical-suspect wild cervids found exhibiting symptoms consistent with CWD infection will be tested for CWD when possible. In some cases, cervids found dead that exhibit emaciation, in the absence of observed abnormal behaviors, may also be tested for CWD. Although clinical symptoms of CWD infection are non-specific and may be due to other diseases or health conditions, these suspect animals have been shown to have a higher probability of CWD infection compared with apparently healthy deer in areas with established CWD infection (Walsh and Miller 2010, Jennelle et al. 2018). In areas where CWD is not known to exist or has gone undetected, samples from cervids exhibiting clinical signs associated with CWD are considered high-value, and are a useful albeit opportunistic source for detecting the disease. For example, in Illinois the first documented wild white-tailed deer with CWD was detected in 2002 after sampling a clinical-suspect; the adult female from Boone County had aspiration pneumonia, food impaction, and behavioral abnormalities (Illinois DNR 2013). Furthermore, in Arkansas during February 2016, along with a CWD-positive hunter-harvested elk, a clinical-suspect white-tailed deer tested positive for CWD; these animals heralded the discovery of CWD in Arkansas (Arkansas Game and Fish Commission 2018). Clinical-suspect cervids are reported opportunistically to MNDNR when they are encountered by the public, law enforcement, hunters, or field staff, and in most cases emaciation is the primary cause for concern. Since 2002, MNDNR has tested >1,000 clinical-suspect cervids throughout the state.

Northern Minnesota is home to small populations of wild elk and moose. Limited hunting opportunities sometimes occur for these species and MNDNR will screen harvested animals for CWD as a precautionary measure. From 2004-2014, 115 hunter-harvested elk were tested in northwestern Minnesota for CWD with no detections (Carstensen et al. 2015). While these species have very small population sizes in Minnesota, their range overlaps with wild white-tailed deer throughout parts of northwest Minnesota. Elk, in particular, also undergo short-distance migratory movements into Canada and perhaps North Dakota, thus increasing contact rates with cervids outside of our jurisdiction.

In cases when a captive cervid(s) escapes from a facility and is reported running at large to MNDNR, efforts will be made to recover or euthanize and test these animals for CWD as a precautionary rule-out for the disease. The escaped cervid(s) may be euthanized by the owner and testing will occur through established BAH protocols. Often, MNDNR is asked to assist in dispatching of these animals and samples are collected for CWD testing; test results are shared with BAH. See the MNDNR/BAH Escape Captive Protocol for additional information.

CWD Detection in Wild Cervids: Initial Response, Management of Persistent Infection, and Management of Endemic Disease in Minnesota

Once CWD has been detected in a wild cervid(s), MNDNR will engage aggressively in a series of actions to eliminate the disease if possible, prevent or minimize disease spread, and detect spread if it occurs. If MNDNR determines that CWD is unlikely to be eliminated from an area, using a set of pre-defined triggers, we will transition to the containment and management of a persistent infection on the landscape. If MNDNR determines that CWD is established in an area and the disease cannot be eliminated, we will transition to the management of endemic

infection. The suite of available actions will generally progress through a process outlined in the following stages:

1. Initial Response to CWD Detection in Wild Cervids.
2. Management of Persistent CWD Infection in Wild Cervids.
3. Management of Endemic CWD Infection in Wild Cervids.

Initial Response to CWD Detection in Wild Cervids

In the event that CWD is identified in a wild cervid in Minnesota, the goals of MNDNR's initial management response to CWD detection are to: 1) act aggressively to eliminate the disease, if possible, 2) prevent or minimize disease spread, 3) collect adequate samples to monitor disease prevalence and spread, and 4) engage stakeholders and provide accurate and current information about CWD to agency personnel, partners (e.g., Tribal Authorities), the public, and Legislators. To meet these goals, the following actions will occur as soon as possible and include:

a. Conduct outreach activities related to CWD discovery, meet with stakeholders, and schedule a public meeting to inform interested individuals of the MNDNR short-term response plan.
b. Where possible, complete an aerial survey in the immediate area surrounding the CWD-positive detection(s), once adequate snow conditions occur, to estimate wild cervid population density and distribution on the landscape.
c. Create a CWD Management Zone (no less than 15 miles around positive detection), the size of which will depend on the locations and distribution of infected cervids as well as the density, distribution, and understanding of seasonal movements of the

local cervid population. It is expected this zone will increase in size as new information becomes available.

d. Implement a cervid recreational feeding and attractant ban to reduce contact rates and decrease disease transmission potential. At a minimum, this area would include the entire CWD Management Zone, as well as all surrounding counties.
e. Institute and enforce carcass movement restrictions out of the CWD Management Zone of deer >1 year of age, and only allow certain parts (i.e., quarters or other portions of meat with no part of the spinal column or head attached) to leave prior to receiving test results.
f. Reduce wild deer density within the CWD Management Zone and, more specifically, around locations of CWD-positive deer to reduce opportunities for transmission.
g. Conduct mandatory CWD sampling at adequate levels to monitor changes in prevalence and disease spread.
h. Develop a communications and outreach plan to the public and stakeholder groups.

The sampling method will be dependent upon the timing of the discovery in relation to the next upcoming hunting season. If there are fewer than six months until the next hunting season, then hunting opportunities will be liberalized and hunter-harvested surveillance will be used as the primary method of determining the disease prevalence and spatial distribution. Regulations will mandate the presentation of the carcass of any cervid harvested within the CWD Management Zone at officially designated sites within the CWD Management Zone. Sample collection methods will be similar to those previously described in the risk-based surveillance methods; however, for adult cervids, a front incisor may be extracted to determine exact age by cementum

annuli. A muscle sample for genetic analysis may also be collected. Hunter-harvest surveillance will become an annual occurrence and be designed to monitor changes in the magnitude and spatial distribution of the disease. Hunting opportunities within the CWD Management Zone will be liberalized to increase harvest and ensure adequate numbers of cervids are available for sampling. Regulatory alternatives could include, 1) increased or unlimited bag limits, 2) elimination of special rules that protect specific classes of deer (e.g., antler point restrictions [APR]), 3) allow cross-tagging of bucks, 4) institute special hunts, 5) allow harvest of multiple antlered deer per hunter, 6) conduct agency-directed culling, and 7) issue landowner shooting permits. If numbers of hunter-harvested deer are not sufficient to provide an adequate estimate of disease prevalence and spatial distribution, the MNDNR will consider additional options to collect supplemental samples. These options may also include establishing taxidermist networks to obtain high value CWD samples (adult male deer) and agency-directed culling. Following annual surveillance, locations of positive cervids will be evaluated and the boundaries of the CWD Management Zone will be adjusted, if necessary.

If there are more than six months between the discovery of a CWD positive wild cervid and the next hunting season, the MNDNR will assess disease prevalence and spatial distribution through the use of any or all of the following tools, 1) designating special hunts, 2) offering landowner shooting permits, and 3) agency-directed culling. In addition, efforts will be made to raise awareness and encourage reporting of clinical-suspect cases. These efforts will be followed up by liberalized hunting opportunities and hunter-harvest surveillance during the following fall hunting season.

The MNDNR will continue hunter-harvest surveillance in the affected area and the surrounding DPAs for a minimum of three consecutive years with an adequate sample during

each year following initial detection. Efforts will be made to provide on-site quartering tents and disposal options (dumpsters) at central locations within the CWD Management Zone to reduce the risk of potential transport of CWD-infected carcass material outside the zone. If additional CWD-positives are found, the response efforts will continue and MNDNR will determine if a trigger has been met to transition into management of a persistent infection. If no additional CWD-positive wild cervids are found over this 3-year surveillance period, the MNDNR will reevaluate the risk and determine if continued surveillance is necessary. At such a time, the CWD Management Zone may be dissolved and DPA boundaries would revert back to their original designation. Any established deer population goals will be suspended until such time as the CWD Management Zone is dissolved.

Transition to Management of a Persistent CWD Infection

Wildlife disease control strategies must be based on an understanding of specific disease etiology and epidemiology, and the dynamics of the cervid population(s). Where infectious diseases exist at a significant prevalence or over a wide-spread area, they may be impossible to eliminate from wild animal populations and the environment. CWD has a long incubation period and coupled with its ability for lateral transmission and environmental contamination, once endemic in wild deer in Minnesota, the disease may only be managed to minimize its impacts and limit spread to new areas of Minnesota. Therefore, MNDNR has identified 4 primary triggers that would signal the shift from response of initial CWD detection to the management of persistent CWD infection in wild cervids:

1. Apparent CWD prevalence is >1% of deer sampled in the CWD Management Zone during the initial sampling effort, which would suggest the disease is not new and may already be established in the affected area.

2. Apparent CWD prevalence is <1% of deer sampled in the CWD Management Zone during initial sampling effort, but increases and includes more infected females during consecutive years of surveillance.
3. The spatial extent of the disease expands substantially beyond the initial affected area.
4. Apparent CWD prevalence is low (e.g. <1% in adult deer) in the CWD Management Zone during the initial sampling effort and remains low during consecutive years of surveillance, but is not decreasing and disease is found in younger animals (e.g., deer < 2 years old) indicating active transmission.

Management of Persistent CWD Infection in Wild Cervids

If CWD is determined to be persistent in wild cervids, the MNDNR will implement additional mechanisms to manage the disease and prevent spread. The goals for managing persistent CWD infection in wild cervids will include, 1) contain CWD infections within the CWD Management Zone, 2) minimize the impact of the disease statewide, 3) reduce the prevalence in affected areas, 4) collect adequate samples to monitor disease prevalence and spread, 5) provide accurate and current information about CWD to the public, agency personnel, and stakeholder groups, and 6) engage in applied research to better understand the epidemiology, transmission, and management of CWD. To meet these goals, the following actions will occur as soon as possible:

a. Manage for a younger age structure in the CWD Management Zone to maintain a higher rate of population turnover through liberalized harvest opportunities and elimination of any special rules to protect specific classes of deer, if they exist (e.g., APR, buck cross-tagging).
b. Increase antlered deer harvest (e.g., allowing harvest of multiple antlered deer per

hunter), as adult bucks have a greater chance of having CWD.

c. Emphasize harvest efforts in optimum habitat(s) where deer movement is most likely to occur, such as riparian drainages.

d. Per statute (97A.045, subdivision 11), issue a replacement license to hunters that have harvested a CWD-positive wild cervid.

e. Reduce overall deer density in the CWD Management Zone in order to lower emigration rate and distance traveled by dispersing deer from the CWD Management Zone (mitigating potential disease spread outside the zone).

i. Continue the cervid recreational feeding and attractant ban to reduce disease transmission opportunities, which at a minimum should include the entire CWD Management Zone, as well as all surrounding counties.

f. Continue to enforce deer carcass movement restrictions out of the CWD Management Zone and expand this to include fawns as well. Only allow certain parts (i.e., quarters or other portions of meat with no part of the spinal column or head attached) to leave the zone prior to receiving test results.

g. Designation of CWD Core Area(s), defined as areas where multiple CWD-positive cervids have been detected in close geographic proximity. CWD Core Areas will be designated by a 2-mile buffer of surrounding sections (1 mi^2) where a positive deer(s) was detected (Appendix B). These areas represent the known highest risk for CWD transmission between wild deer and through contamination of the environment with infectious prions, and will take priority for intensive management actions to mitigate disease spread.

h. Consider the use of incentives for landowners and hunters to remove CWD-positive deer from the CWD Management Zone and Core Areas. These incentives, which may be

financial or non-financial (e.g., cash rewards, life-time deer hunting licenses, hunting-related merchandise, donation to local charities, etc.) may be given to hunters, landowners, and/or the communities where CWD positive cervids are detected. Hunter and landowner surveys conducted in the CWD Management Zone (and surrounding areas) will help inform the acceptance and feasibility of the array of possible incentives.

i. If efforts to significantly reduce deer numbers in CWD Core Areas are insufficient through recreational hunting (regular and special seasons), agency-directed culling will likely occur to increase the probability of removing infected individuals from the landscape and reduce disease transmission. Culling efforts may include removal of social groups associated with adult female CWD-positive deer because research has demonstrated that fine-scale group removal can be effective for managing CWD in wild deer.
j. Establishment of a CWD Control Zone, which will be recognized as a buffer zone around the CWD Management Zone and at a minimum would include all of the DPAs immediately surrounding the CWD Management Zone (Appendix B).
k. Prohibit export of whole cervid carcasses originating from within the CWD Control Zone; intrazone movement would be permitted. Only allow certain parts (i.e., quarters or other portions of meat with no part of the spinal column or head attached) to leave the zone.
l. Reduce deer density in the CWD Control Zone to create a population sink and reduce emigration from and immigration to the CWD Management Zone.
m. Develop a communications and outreach plan to the public and stakeholder groups.

As with initial response actions, following implementation of these additional CWD

management mechanisms, the prevalence and spatial distribution of the disease will be assessed through the sampling of wild cervids. All sampling and testing procedures, as well as data collected and databases maintained, will be consistent with initial management efforts.

Transition to Management of an Endemic CWD Infection

There is a lot of uncertainty surrounding the determination of when CWD is established in the affected population and no effective management strategy will eliminate the disease from the landscape. Functionally, this new reality could be phrased as "living with CWD". There is no disease management handbook in existence that clearly defines when a CWD outbreak has achieved endemic status. However, through statistically valid disease surveillance that provides and adequate sample over multiple years, and includes a representative sample of all sex and age cohorts, inferences can be made as to when a CWD infection is endemic. MNDNR has identified 3 surveillance thresholds that would signal the shift from either initial CWD response or persistent CWD management to managing for endemic CWD in wild cervids:

- Apparent CWD prevalence is >5% of deer sampled in the CWD Management Zone during the initial sampling effort, which would suggest the disease was established in the affected area when discovered.
- Apparent CWD prevalence is <5% of deer sampled in the CWD Management Zone during initial sampling effort, but increases over a 3 year monitoring period to exceed 5%, and infected individuals include more adult females, and yearlings, or fawns of either sex.
- The targeted removal of deer in CWD Core Areas had been utilized as a management action; however, has not effectively reduced disease prevalence within the CWD

Management Zone. We assume disease transmission is now both lateral (animal-to-animal) and indirect, as environmental contamination has become significant with a high prevalence of disease on the landscape. In this case, the continued targeted removal of social groups is unlikely to break transmission cycles, as uninfected individuals immigrating into the affected area have a high probability of exposure to CWD through prions found in contaminated soil, plants, or other substrates.

Management of Endemic CWD Infection in Wild Cervids

If CWD is determined to be endemic in wild cervids, the MNDNR will reduce efforts to aggressively manage this disease within the CWD Management Zone and shift focus and resources to preventing spread to new areas of the state. The goals for managing an endemic CWD infection in wild cervids will include, 1) minimize the impact of the disease statewide, 2) collect adequate samples to monitor disease prevalence and spread, 3) utilize liberal harvest regulations to reduce the prevalence in the endemic area, 4) aggressively respond to new detections of disease outside of the endemic area, 5) provide accurate and current information about CWD to the public, agency personnel, and stakeholder groups, and 6) apply adaptive management to adjust efforts as new information on successful CWD mitigation strategies emerge. To meet these goals, the following actions will occur as soon as possible:

a. Aggressively respond to any new detection of CWD outside the CWD Management Zone, by utilizing hunters, landowners, and agency-directed culling to reduce deer numbers within a 2-miles radius of this detection.
b. Continue to manage for a younger age structure in the CWD Management Zone to maintain a higher rate of population turnover through liberalized harvest opportunities.
c. Implement voluntary surveillance options for deer harvested within the CWD

Management Zone, such as self-service, sampling kiosks and self-mailing test-kits. Implement mandatory testing of deer harvested in the CWD Control Zone, to maximize likelihood of detecting disease spread.

d. Continue the cervid recreational feeding and attractant bans to reduce disease transmission opportunities, which at a minimum should include the CWD Management Zone, the CWD Control Zone, as well as all surrounding counties.
e. Continue to enforce deer carcass movement restrictions for any deer out of the CWD Management Zone and CWD Control Zone. Only allow certain parts (i.e., quarters or other portions of meat with no part of the spinal column or head attached) to leave the zone prior to receiving test results.
f. Develop a communications and outreach plan to the public and stakeholder groups.

Supporting Strategies and Evidence

Most states across the US that have discovered CWD have implemented some type of response or management plan. No single state has been successful in eliminating the disease from wild cervids once it has become endemic, but Illinois has been successful in controlling CWD prevalence with localized intensive management (Manjerovic et al. 2014) and efforts to remove entire social groups of deer (Tosa et al. 2016). The key factor is the level of infection determined in the cervid population at the time of initial detection. For example, when Wisconsin first discovered CWD in wild deer in the southwestern part of the state in 2002, it was assumed to be a recent introduction of the disease and management strategies initially focused on disease eradication. However, subsequent surveillance revealed that the disease was already widespread at the time of discovery and modeling suggested that CWD had been on the landscape for at least 20 years (Jennelle et al. 2014).

From 2002– 2017, Wisconsin tested about 210,000 wild deer, of which 4,200 tested positive. Wisconsin has two regional clusters of disease infection, one in the southwestern part of the state, and one in the southeast (contiguous with a CWD area in northern Illinois); however, since 2002 the disease has been detected in wild deer in 25 counties, or 35% of the state.

Despite an initial policy of CWD eradication when the disease was discovered in 2002, Wisconsin essentially relaxed their intensive CWD management efforts after 2007 due to political and social pressures mounting against how the agency was managing the disease (Holsman et al. 2010). The consequences of this passive approach to CWD management in wild cervids are demonstrated to result in high endemic levels of CWD prevalence that can have negative impacts on populations. CWD prevalence within core areas of Wisconsin have shown an overall increasing trend in all sex and age classes. During the past 16 years, the trend in prevalence in adult males has risen from 8-10% to 35% and in adult females from 3-4% to nearly 15%. During that same time, the prevalence trend in yearling females and males has increased from 2% to 10%. Simulation modelling suggests that sustained intensive harvest of antlered deer could eventually reduce prevalence (Jennelle et al. 2014), but may severely disrupt the hunting culture in Wisconsin. Moreover, reports of clinical-suspect deer on the Wisconsin landscape are on the rise. In earlier years (2007-2011) the Wisconsin Department of Natural Resources (WDNR) responded to an average of 22 CWD suspect deer per year in the Southern part of the state with about 30% of those suspect deer testing positive. In recent years (2011-2014) WDNR has responded to an average of 44 CWD suspect deer in this area with about 45% testing positive. Most recently, WDNR tested 127 suspect deer from across the state from

April 1, 2017 to March 31, 2018, and 90 were CWD-positive (71%).

In some cases, when CWD is first detected in wild cervids, the extent of disease impacts may be far-reaching. For example, in northwestern Arkansas in February 2016, CWD was detected in both a hunter-harvested elk and a clinical-suspect white-tailed deer in Newton County. Initial sampling efforts in the vicinity of these cases revealed 23% CWD sample prevalence, which suggests that the disease had been present in the underlying deer population for many years. Further sampling in the surrounding counties has resulted in additional CWD detection in wild deer, and it is clear that Arkansas is dealing with an established and growing CWD cluster. Finding such an advanced disease condition in the underlying deer population greatly reduces the chances for disease eradication, and warrants a policy of disease containment.

Studies from Colorado and Wyoming demonstrate the disease can ultimately cause deer population declines. Prevalence in adult male mule deer on winter ranges in Colorado more than doubled within a 6-year period, reaching levels of 25-40%, and researchers concluded that high prevalence and low survival of infected deer was sufficient to have caused a population decline (Miller et al. 2008). A recent study of a white-tailed deer population in southeastern Wyoming from 2003-2010 documented a 10.4% annual decline due to CWD (prevalence rates were 32 - 44%), where infected deer were 4.5 times more likely to die annually than non-infected deer (Edmunds et al. 2016). A study of a mule deer population in Wyoming experiencing more than 20% CWD prevalence, was found to be declining annually by 21% under the best supported models (DeVivo et al. 2017). Further, preliminary results of the first year of study on the impacts of CWD on deer survival in Wisconsin’s endemic area showed collared deer with CWD died at three times the rate of

uninfected animals (WNDR 2018). This important project is providing unequivocal evidence of CWD-associated mortality of white-tailed deer, which previous modeling has suggested (Samuel and Storm 2016).

Several examples do exist where CWD was detected in wild deer and did not become established in the local deer population. New York discovered CWD in a wild deer that was geographically associated with a CWD-positive captive cervid facility. Initial surveillance in 2005 indicated <0.1% prevalence in wild deer surrounding the captive facility (only one positive deer was found) and subsequent surveillance efforts have failed to detect more positives in the wild. In New York's situation, the swift response taken by the wildlife agency appears to have occurred prior to CWD becoming endemic in the wild population. Similarly, MNDNR's first occurrence of CWD in a wild deer in Olmsted County in 2010 was found in close association (2 miles) from a CWD-positive captive cervid (elk) facility. Through aggressive surveillance actions over the next 3 years, no additional infection was found and the disease did not appear to have become established. Lastly, a single CWD-infected doe was found in Washburn County in northwestern Wisconsin in 2011, hundreds of miles from known endemic areas within the state. Nearly 3,000 additional deer were sampled in that county from 2012-2017, with no additional positives found.

Based upon the current understanding of CWD in wild cervids, eradication of the disease, once established as an endemic infection in the wild population, is not a realistic management objective within the infected area. However, as New York, Wisconsin, and Minnesota's past experience has shown (for both CWD and bovine Tuberculosis), if the disease is detected in wild cervids before it has become established in the area, an

aggressive approach can help limit its growth and spread. Research on disease transmission, susceptibility to infection, and management strategies continues in many states. In fact, Minnesota is actively collaborating with Wisconsin DNR, Michigan DNR, and the National Wildlife Health Center on data and protocol sharing for deer research projects related to CWD.

Adaptive Management

The MNDNR has adopted an adaptive management strategy in its approach to wildlife disease outbreaks, which is structured to facilitate learning from management activities and allows flexibility to alter disease management activities depending on effectiveness of the methods applied, future research results, and public acceptance. This is in accordance with recommendations for adaptive management of CWD created by the Western Association of Fish and Wildlife Agencies (WAFWA 2017) and Best Management Practices (BMPs) for prevention, surveillance and management of CWD created by the Association of Fish and Wildlife Agencies (AFWA 2018).

As an example of the concept of adaptive management, deer management practices will be influenced by new and ongoing research aimed at demonstrating how CWD spreads on the landscape by wild cervids. Based on extension of recent work modeling the spread (i.e., diffusion) of disease across the landscape (Hefley et al. 2017), preliminary results suggest that the rate of CWD spread is accelerated along riparian drainages and riverine habitat. This supports the notion of emphasizing deer harvest efforts along these strategically important and preferred habitats for deer (Norbert et al. 2016, Edmunds et al. 2017) to minimize CWD spread outside the management and buffer zones.

What the Discovery of CWD Means for Minnesota's Hunters

Ultimately, deer hunters in Minnesota will be an integral component of the CWD response plan and deer population management. Although the CDC and other public health agencies have concluded there is no known link between CWD and any neurological disease in humans (MaWhinney et al. 2006, Sandberg et al. 2010), it will be the hunter and their families' decision to consume the meat of a confirmed-positive animal.

Hunters can expect increased surveillance throughout the CWD Management Zone, CWD Control Zone, and surrounding DPAs. The testing in designated CWD Management Zones will be provided free of charge to hunters and will be flexible enough to accommodate sampling during all deer seasons (archery, firearm, and muzzleloader). The MNDNR will also work with taxidermists to obtain samples from high value deer (adult males) for surveillance in our designated areas so the cape or shoulder mount of the animal will not be destroyed. The discovery of CWD in wild deer will have an impact on deer population numbers and hunting opportunities. In the short term, there may be an expansion of opportunities in the form of special hunts and more liberal bag limits. In the long-term, hunters can expect fewer and younger deer in localized areas as densities must be kept low to minimize disease spread. There will also be more regulations regarding the import/export of whole deer carcasses and carcass parts. To help minimize risk of any infected carcasses leaving the CWD Management Zone, dumpsters will be strategically placed for hunters to properly dispose of carcass remains. There will also be quartering or butchering tents set-up near these dumpsters, allowing hunters to quarter their deer and leave the CWD Management Zone prior to receiving their test result. The deer donation program will be expanded to allow hunters an option for additional harvest of deer in areas critical for CWD management. Additionally, recreational deer feeding will be banned in the

CWD Management Zone and surrounding counties as well. Artificial and natural deer attractants, will also be banned in the CWD Management Zone and surrounding counties to reduce risks of disease transmission.

Applied Research

Management of CWD will require a more thorough understanding of the disease and underlying deer populations, including how it is spread and how we can optimize control strategies that ensure a healthy deer population and provide recreational opportunities for hunters. The MNDNR will support and conduct, on a priority basis, applied research that will facilitate continued understanding of CWD dynamics in white-tailed deer. The MNDNR will continue to monitor research that is occurring on CWD and other TSEs to ensure the most current and comprehensive information is utilized. Research will be aimed at improving the management of the disease. Specific research objectives may include:

1. Research on the epidemiology and population effects of CWD on Minnesota's wild deer population.
2. Research on deer movement in the local deer population to better predict potential disease spread.
3. Research to evaluate the effectiveness of specific management strategies.
4. Continue research on the relatedness of CWD-infected individuals to assess control strategies that include removal of family groups in CWD Core Areas.
5. Construction of epidemiological models to better predict how CWD will behave on the landscape, and guide management actions.
6. Human dimension research on attitudes and beliefs of landowners, hunters, and the general public on CWD management actions.

CWD Communications

Chronic wasting disease is of interest to both the hunting and non-hunting communities at the local, national, and international level. As the public agency charged with managing CWD in Minnesota's wild deer population, the MNDNR has an obligation to provide timely, complete, and accurate information about all aspects of the disease to the public. To ensure effective and transparent communication with the general public, tribal authorities, stakeholder groups (including federal resource managers, non-governmental organizations, and others), and the media about CWD, the MNDNR will develop and follow a communication plan. This will include updates on MNDNR's website, news releases, brochures, videos, podcasts, articles in local newspapers or magazines, social media messaging, and public meetings or informal workshops related to CWD. Resources about CWD on MNDNR's website will include current surveillance and CWD-positive detection status, future surveillance plans, information about CWD, videos about how to quarter a harvested deer or collect samples for CWD testing, and the ability for hunters to look up CWD test results. Furthermore, the MNDNR is partnering with the University of Minnesota to conduct human dimensions surveys pertinent to understanding stakeholder beliefs about CWD management, which will help inform communication strategies.

Effective and timely communication is critical for successful CWD management response efforts; it provides transparency for agency actions, builds relationships between the agency and stakeholders, and lays the foundation for informing and educating the public and partners involved. The MNDNR has recently added a position dedicated to working with landowners, hunters, and recreational resources users on CWD-related information and education. A human dimensions research scientist was also hired to focus specifically on deer, and CWD will be a significant portion of that work. Furthermore, the MNDNR will continue to

partner with hunting groups, such as Bluffland Whitetails Association, the Minnesota Deer Hunters Association, and the Quality Deer Management Association, to engage with stakeholders about past, current, and future scientific products that are driving our collective understanding of the management of CWD in wild cervids.

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Appendix A. Glossary of Terms

Adaptive Management: A systematic approach for improving resource management activities and policies by learning from alternative management approaches. The idea of learning from experience and modifying subsequent behavior in light of that experience.

Agency-directed culling: Removal of cervids from a focused area carried out by trained professionals. On private property, this activity is not undertaken without the clear consent and the signing of a contract between the private landowner and contractor (e.g., United States Department of Agriculture-Wildlife Services).

Apparent CWD prevalence: The proportion of confirmed CWD-positive cervids from a total sample of cervids tested in a specific area and time frame.

Clinical CWD suspect: A cervid that exhibits physical signs, behavioral abnormalities, and/or locomotor difficulties consistent with CWD infection. Although clinical signs of CWD infection are non-specific, they may include a loss of body condition and weight, excessive salivation, loss of fear of humans, loss of body control, tremors or staggering, drooping head or ears, and apparent confusion.

Confirmed CWD-positive: A cervid that has tested positive for both the first-round screening test for CWD infection (enzyme-linked immunosorbent assay - ELISA) and the confirmatory test for CWD infection (Immunohistochemistry - IHC), which is a gold standard test certified by the USDA.

CWD Control Zone: A buffer zone created around a CWD Management Zone, which includes at a minimum all of the Deer Permit Areas (DPA) immediately surrounding the CWD Management Zone. The function of this zone is to limit disease spread across the landscape by prohibiting carcass movements, reducing deer densities, and reducing the likelihood of deer immigration into the CWD Management Zone and deer emigration from the CWD Management Zone.

CWD Core Area: A defined area where multiple CWD-positive cervids have been detected in close geographic proximity. They are designated by a 2-mile buffer of surrounding sections (1 mi^2) where CWD-positive deer have been detected. These areas represent the known highest risk for CWD transmission between wild deer and through contamination of the environment with infectious prions, and will take priority for intensive management actions to mitigate disease spread.

CWD-Management Zone: A defined area no less than 15 miles around a CWD-positive detection, the size of which will depend on the locations and distribution of infected cervids as well as the density, distribution, and understanding of seasonal movements of the local cervid population. This Zone will be the basis for CWD management efforts which will include carcass movement restrictions, deer density reduction, agency-directed culling, special hunts, landowner permits, etc.

Deer Permit Area: A spatial unit that is defined by special deer harvest regulations that are determined by previous harvest rates, estimated population density, and stake-holder inputs.

ELISA: Enzyme-linked Immunosorbent Assay, which is a specialized initial screening test for CWD infection in a cervid. This assay uses an antibody, and the intensity of the antibody binding is read by an instrument that assigns a numerical value to the amount of binding. Intensity values over a predetermined threshold indicate the presence of CWD prions.

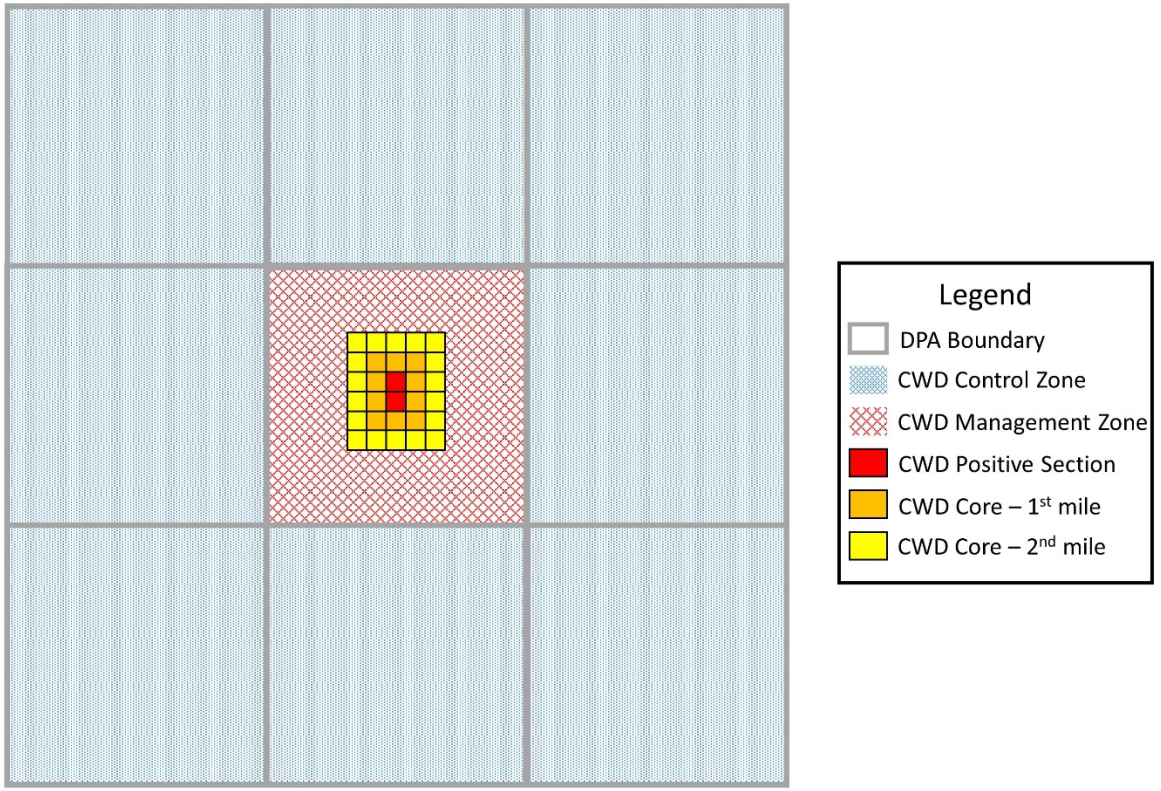
Endemic CWD Infection: This term means that CWD is established in the affected population and is maintained without external inputs. The disease prevalence and spatial extent of infection is consistent and has the potential to increase in the affected area. Transmission between deer is efficient and constantly occurring, and more young deer (yearlings and fawns) are found infected through sampling efforts annually. Once CWD is endemic, existing efforts may not be sufficient to eliminate CWD from the area.

IHC: Immunohistochemistry, which is a specialized confirmatory test for CWD infection in a cervid. It involves the staining of infectious prions in a very thinly sliced tissue sample (either medial retropharyngeal lymph nodes or obex) and magnification via a microscope.

Initial CWD detection: An initiating event when CWD is detected in a wild cervid for the first time in an area. Detection will likely occur through our risk-based surveillance, meaning the animal was sampled through a planned hunter-harvested surveillance effort or through on-going testing of clinical suspects statewide.

Persistent CWD Infection: A CWD management phase that means CWD continues to exist in the wild, despite actions that may/may not have occurred to eliminate the disease through the initial response phase. The disease remains on the landscape but has not yet been determined to be endemic.

Appendix B. Conceptual representation of CWD Management Zone, (at minimum) surrounding DPAs designated as the Control Zone, and a CWD Core Area. A Core Area within the CWD Management Zone is defined as a section (1 mi^2) within which at least one wild cervid has been confirmed positive with CWD and the surrounding 2 mile buffer. Note that there may be multiple CWD Core Areas within a CWD Management Zone.



Appendix C. Stages of CWD Response and Key Management Actions.